A management-oriented approach for coupled human-environmental systems:

MSE in fisheries science

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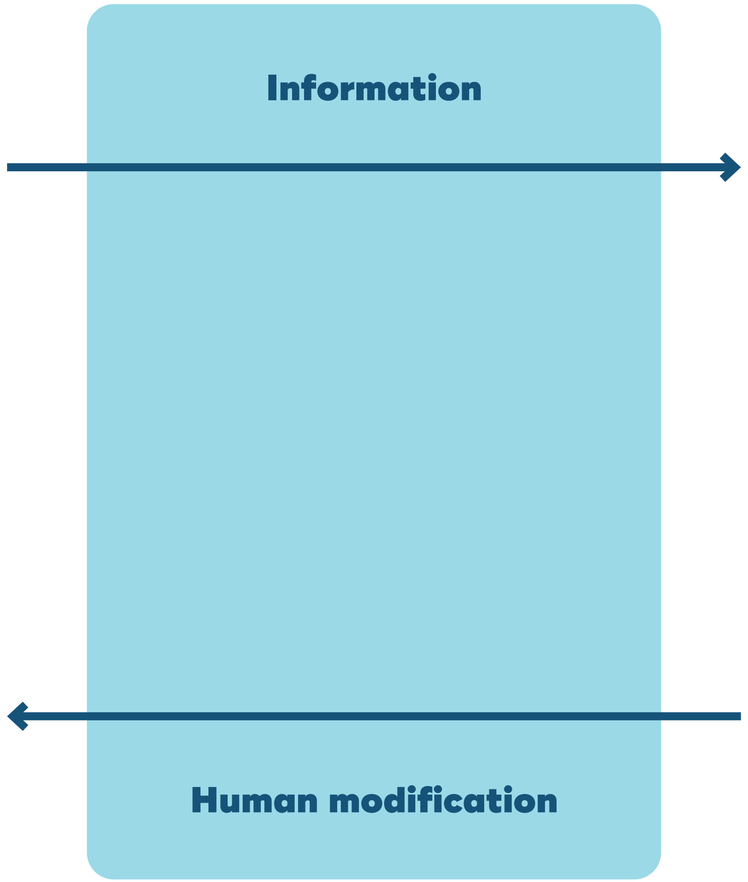
July 26, 2023

Coupled Human–Environment System

Complex Natural system

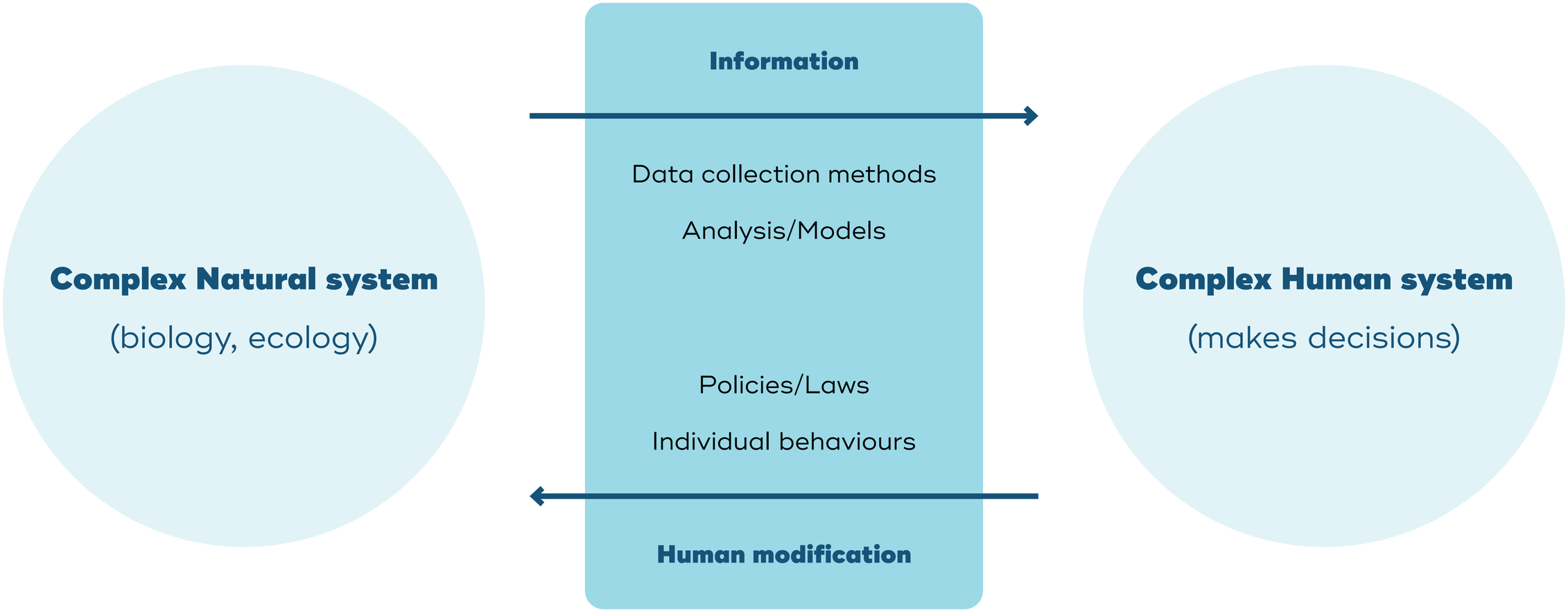
(biology, ecology)



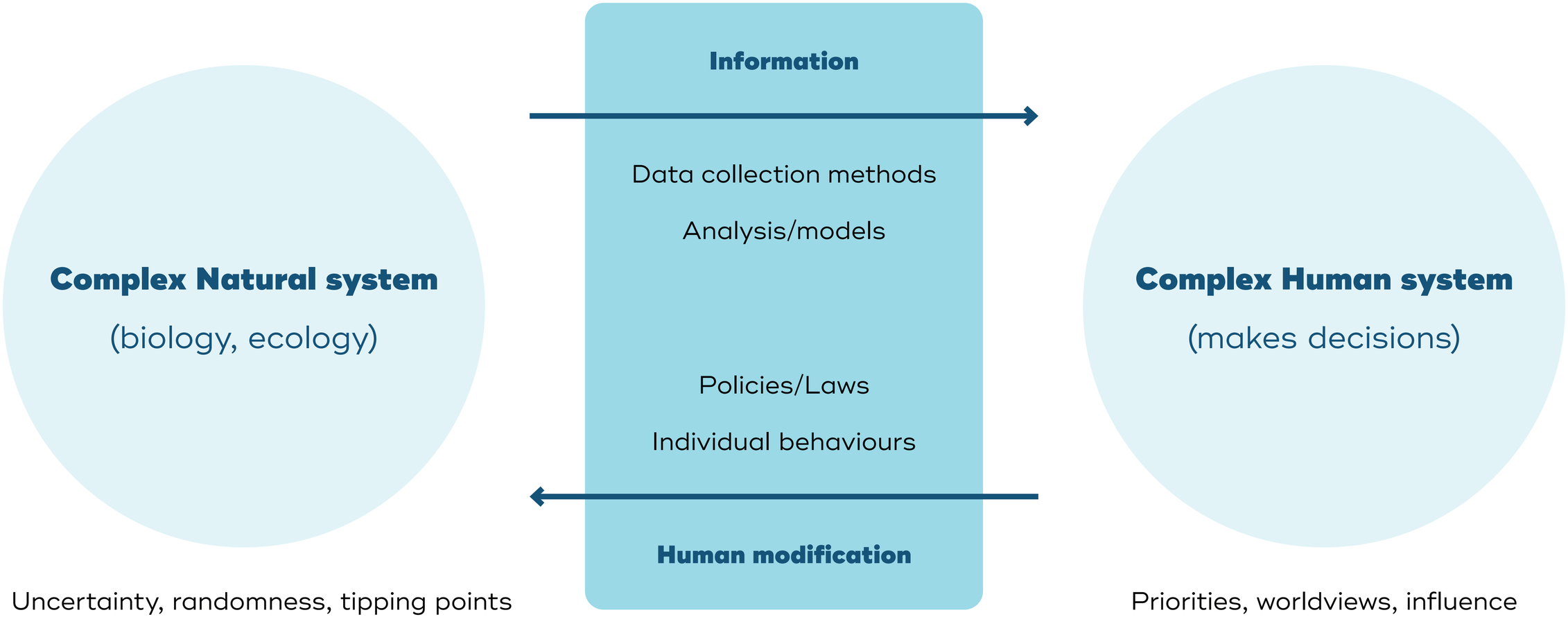
Complex Human system

(makes decisions)

Coupled Human–Environment System



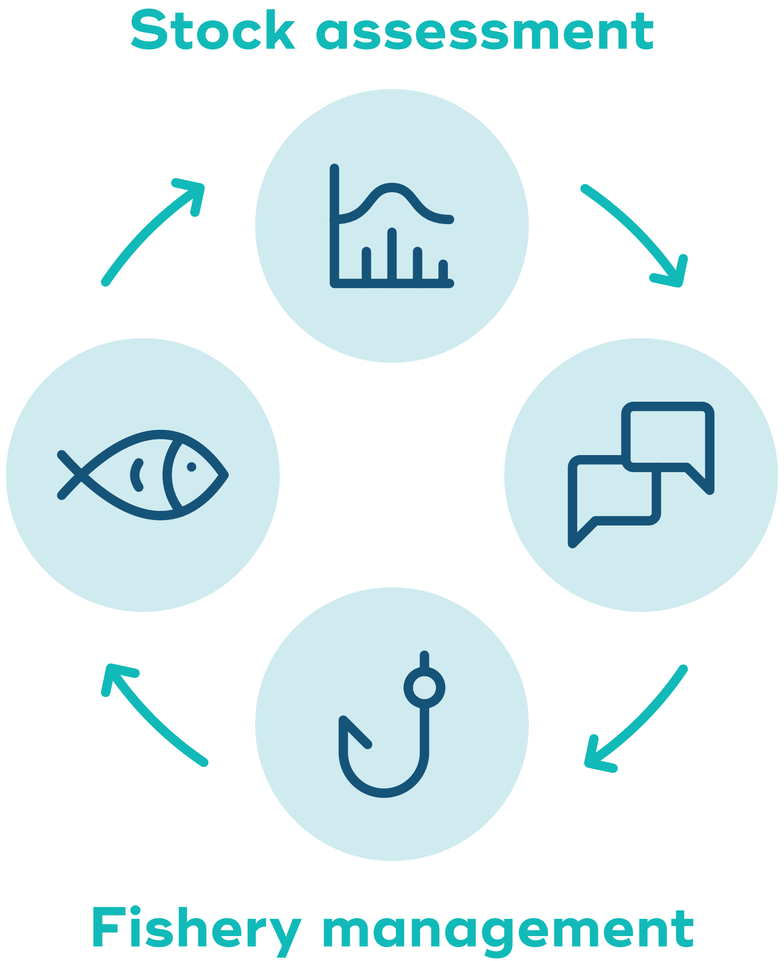
Coupled human–environment system



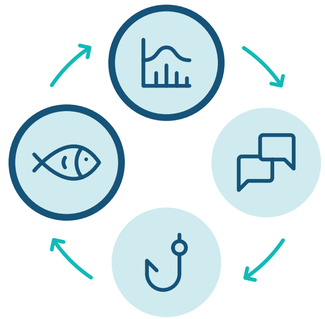
Coupled human–environment system

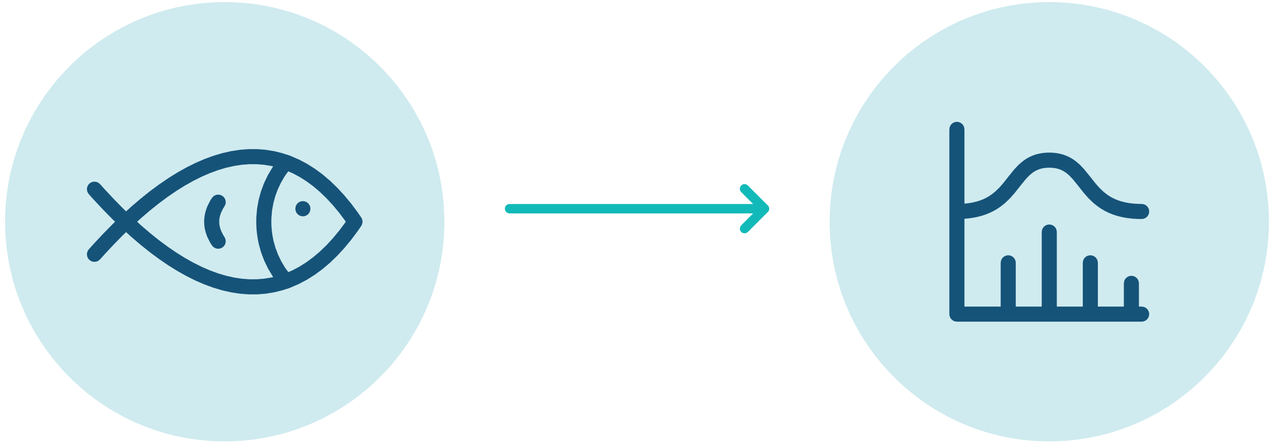
Coupled human–environment system

Fishery science



Types of data





Types of data

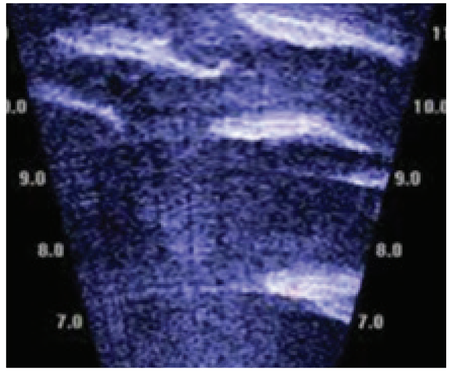
Fishery-dependent data:

Catch and biological data reported by on-board observers, automated monitoring systems, portside surveys, creel surveys, historical landing records, log books

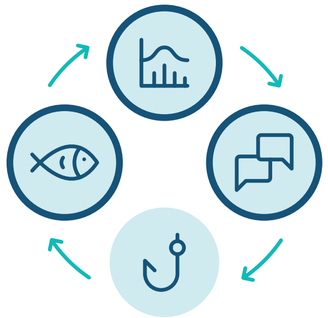
Types of data

Fishery-independent data:

Research surveys including different types of fishing nets, hydro-acoustic arrays, videos, manual counting of spawning fish or carcasses, mark-recapture estimates, telemetry, fish tagging and many more.



Simple stock assessment example



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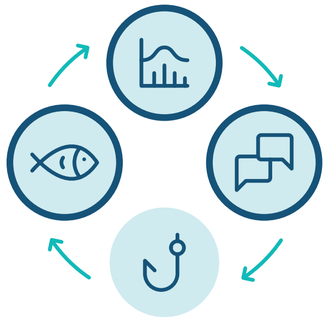

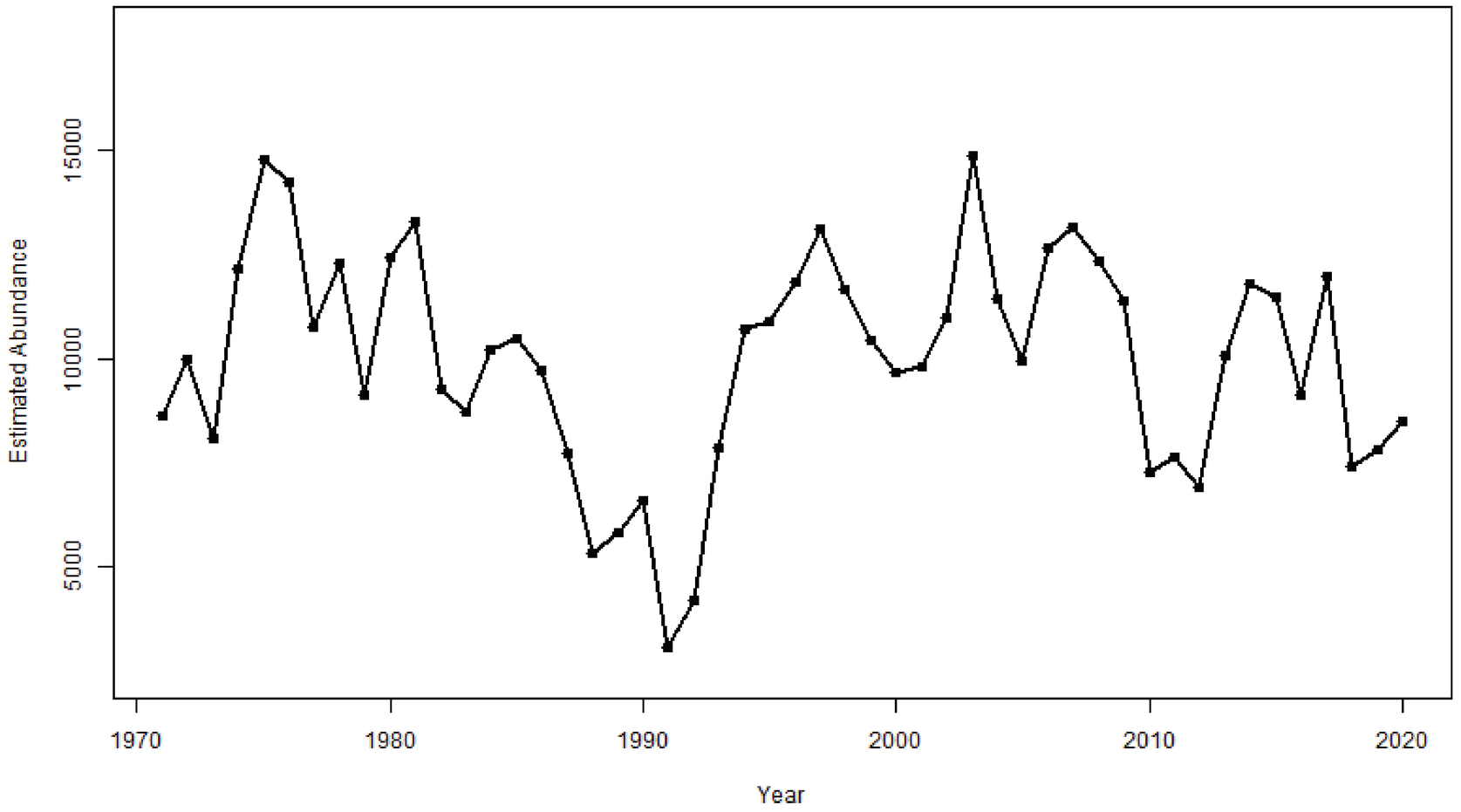

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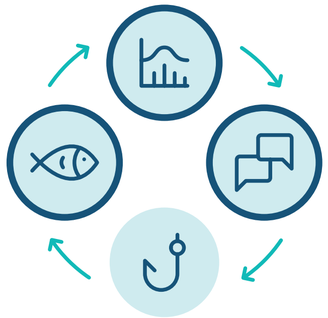

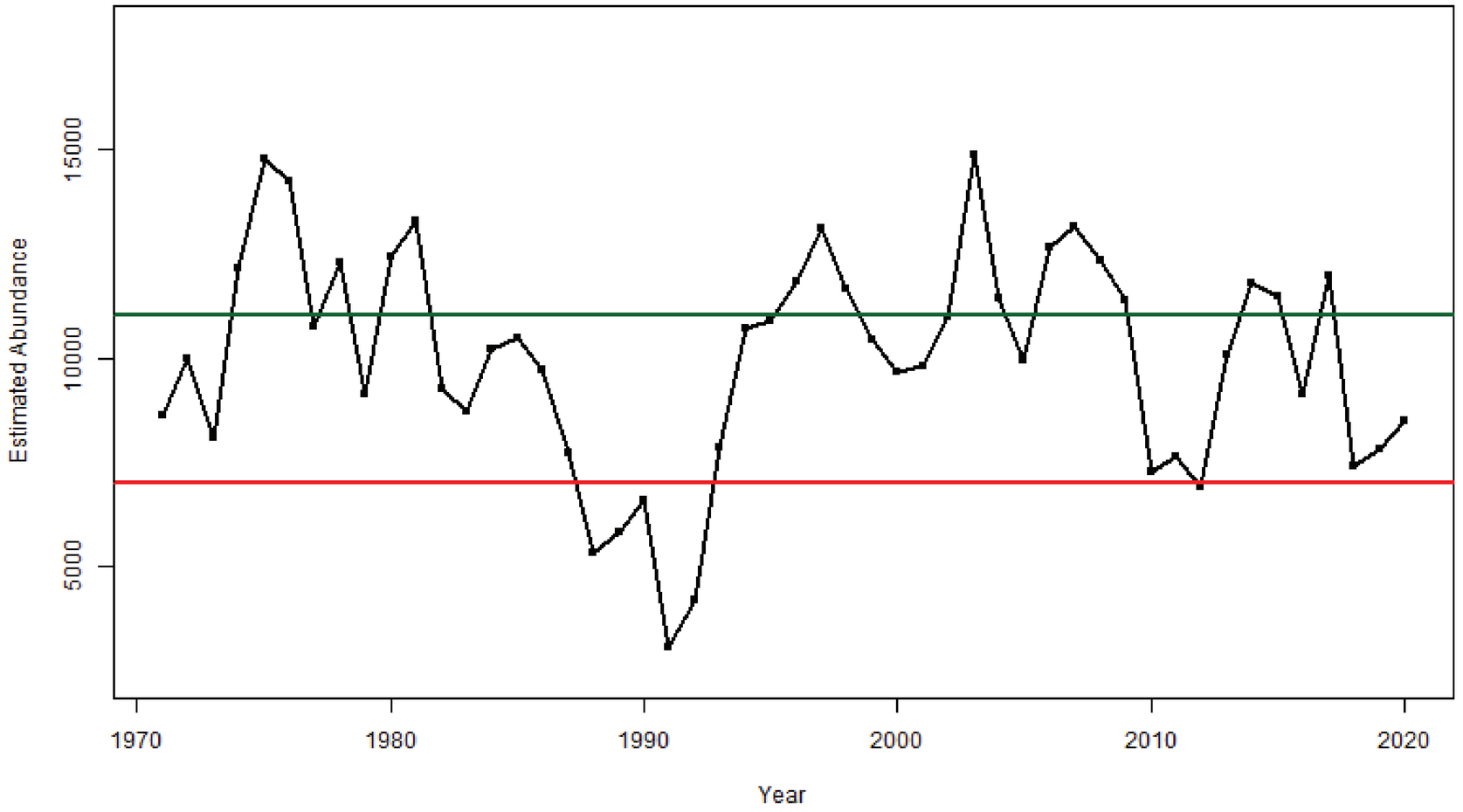

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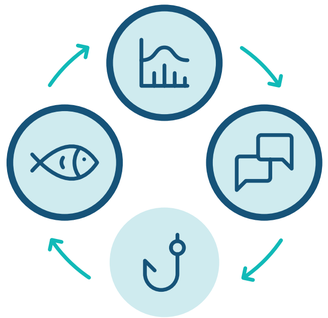
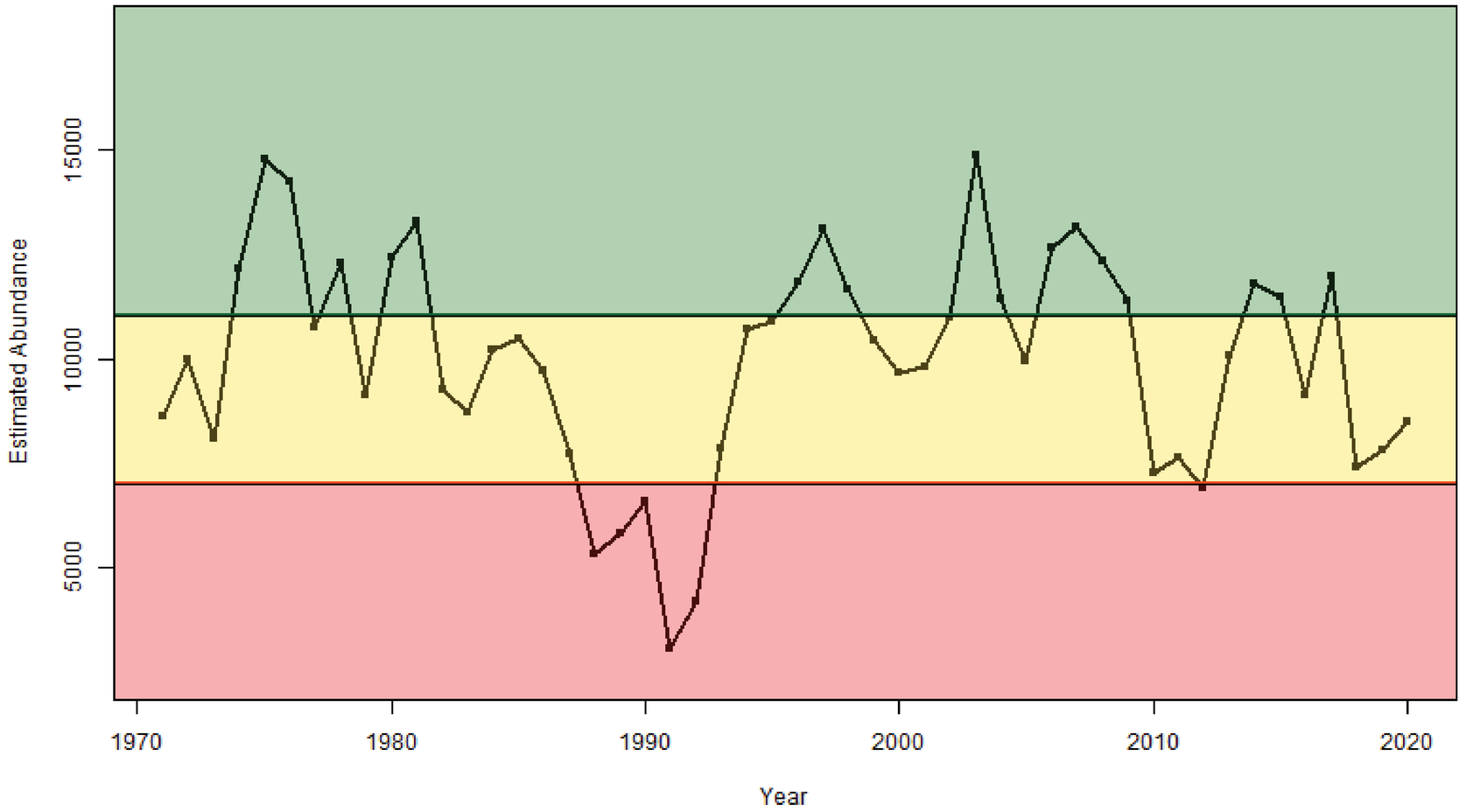
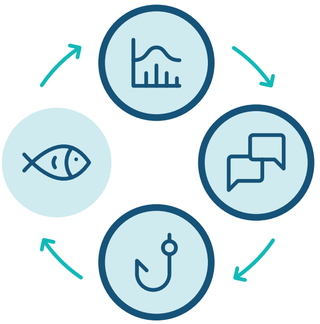
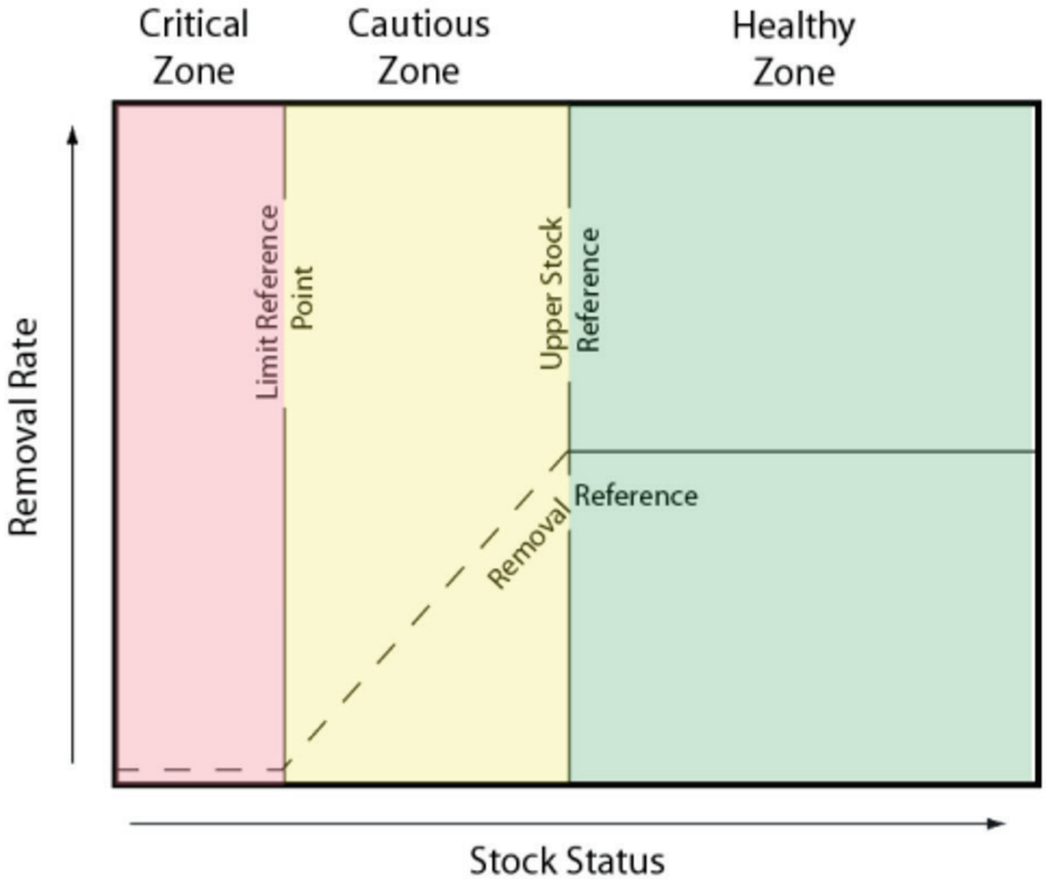


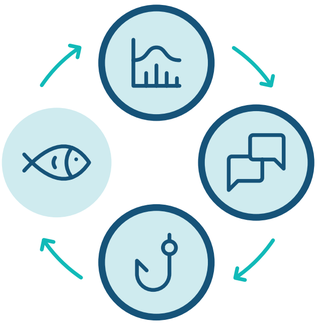


Stock assessment to fisheries planning

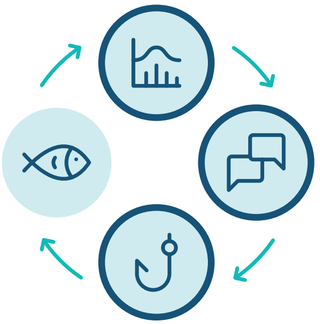


DFOs sustainable fisheries framework

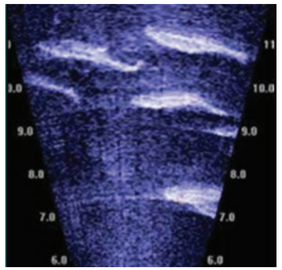


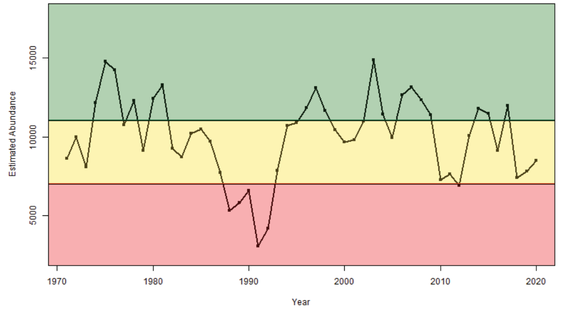


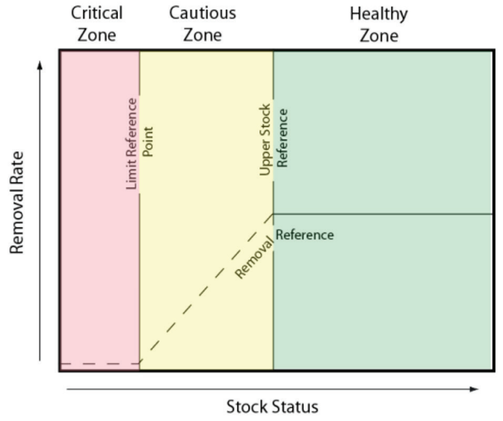
Amended Fisheries Act
Fish stocks provisions



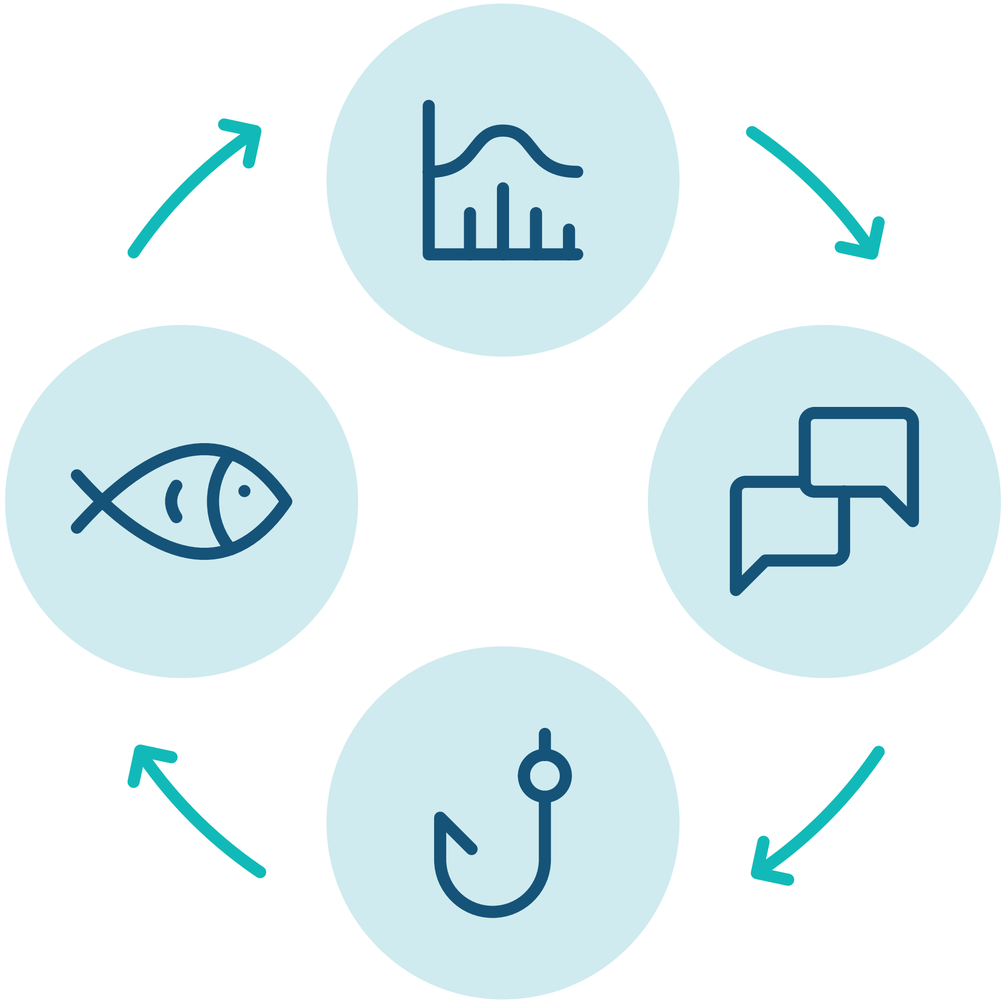
- Fish stocks must be managed at sustainable levels
- Stocks that fall below their lower reference point (LRP) require rebuilding plans
- LRP’s should be adequately precautionary as to avoid serious harm


11
10.0
9.0
8.0
7.0
6.0


Estimated Abundance
15000
10000
5000
1970
1980
1990
2000
2010
2020
Year


Critical Zone
Cautious Zone
Healthy Zone
Removal Rate
Limit Reference Point
Upper Stock Reference
Removal
Reference
Stock Status

- Bias in data
- Missing data (weather, budget, pandemic)
- Stocks changing rapidly—unprecedented climate



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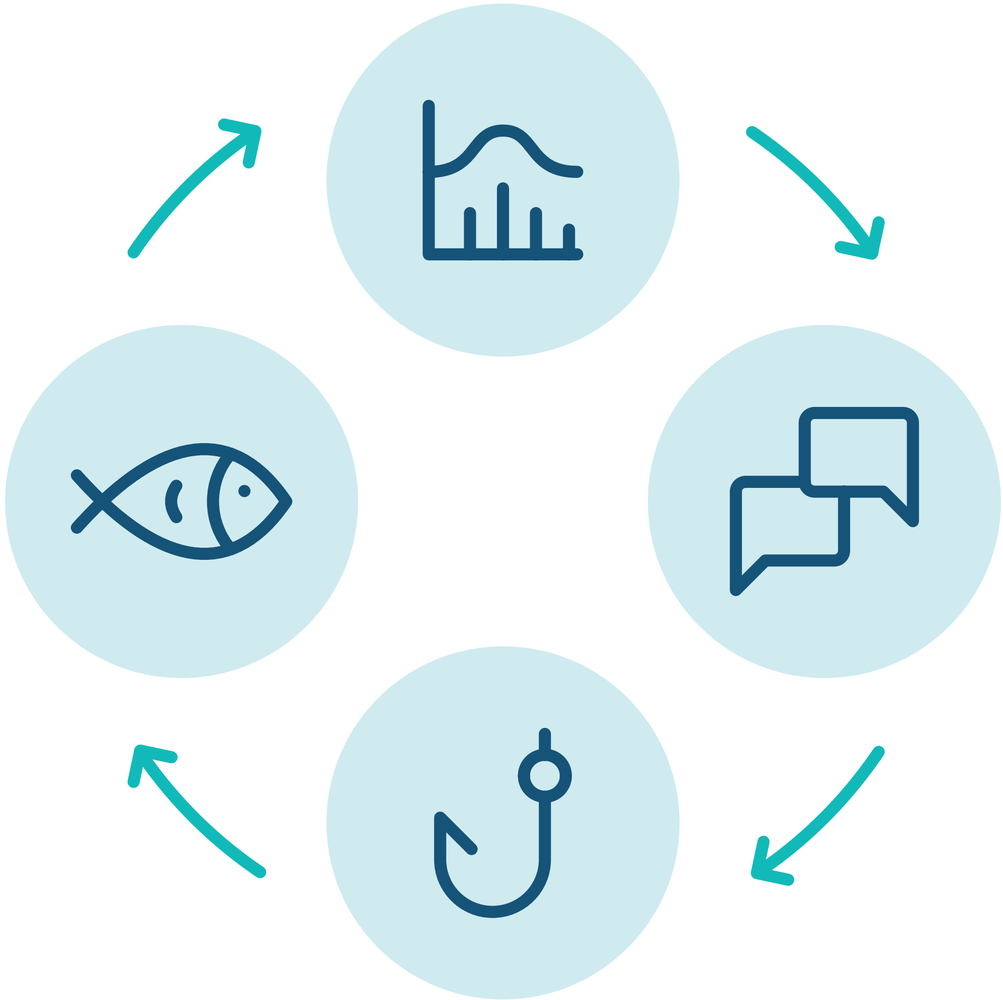

- Poorly fitting or very uncertain models
- Ineffective communication between scientists and decision makers

- Bias in data
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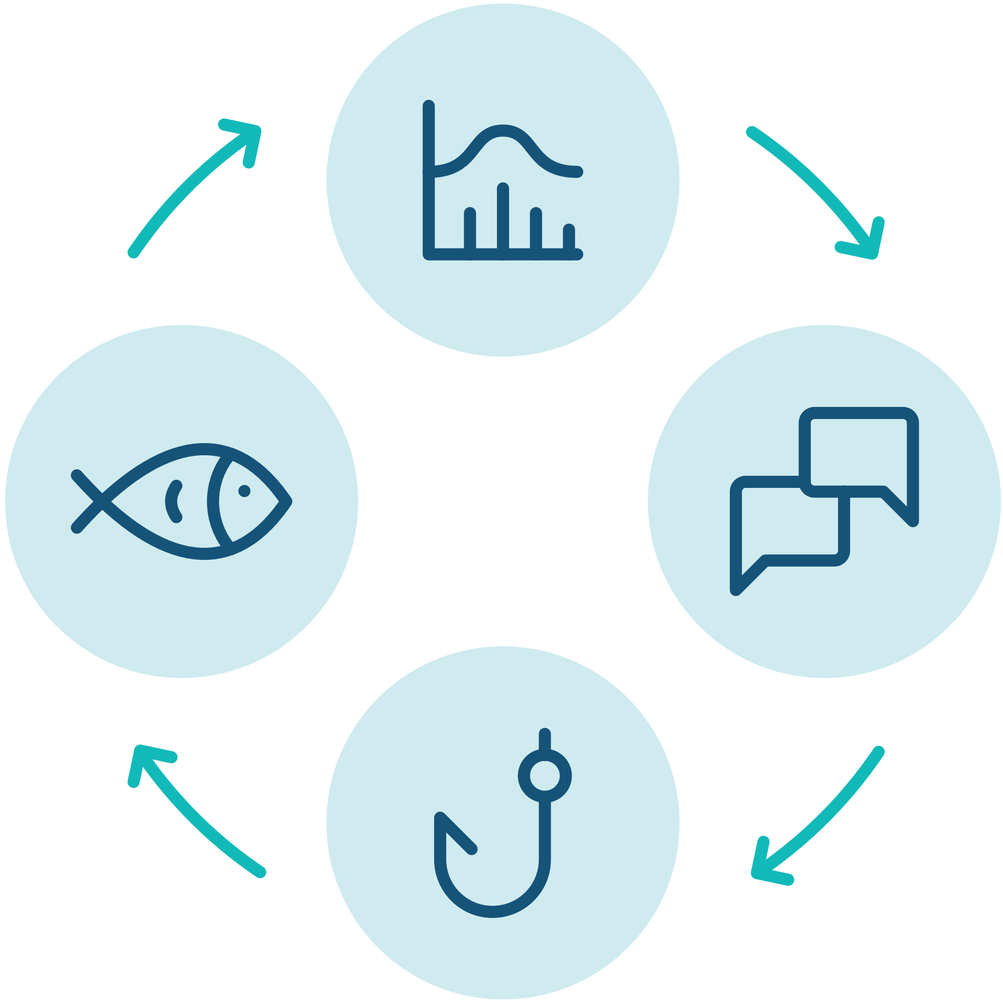
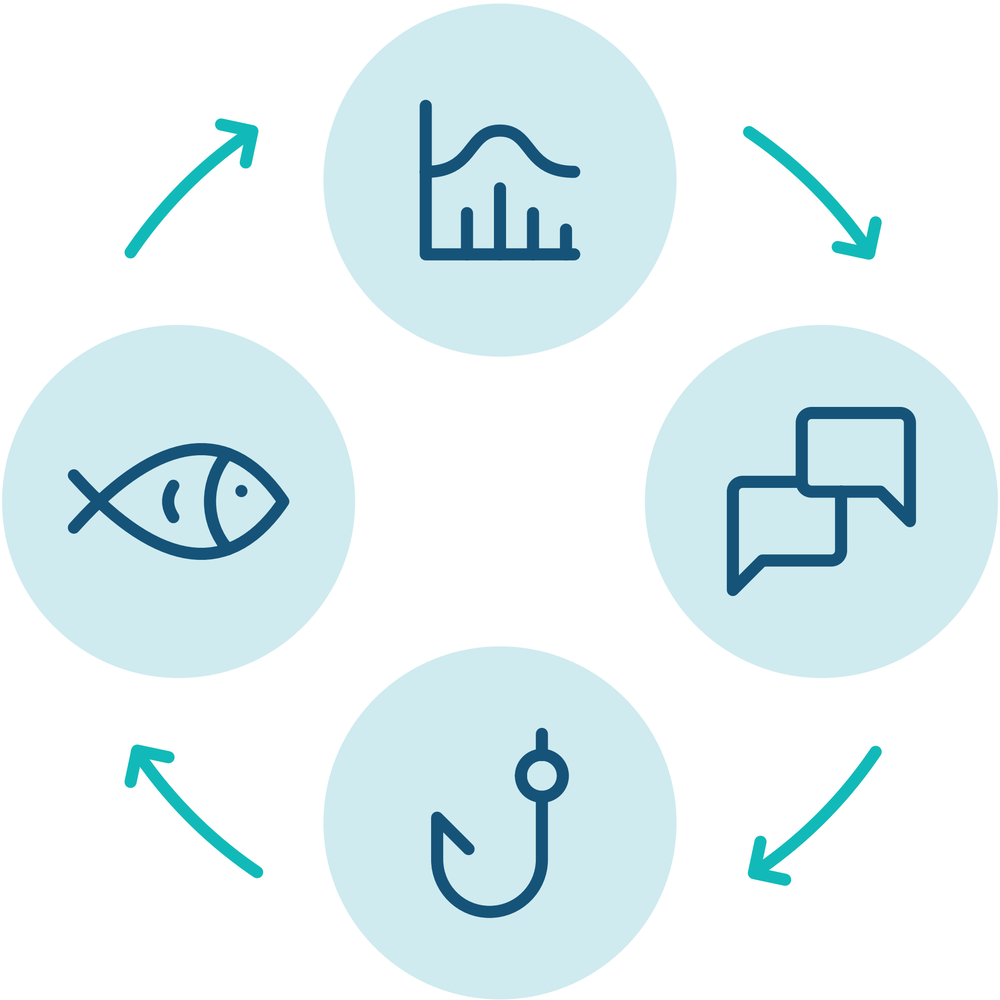


- Poorly fitting or very uncertain models
- Ineffective communication between scientists and decision makers

- Outside influences weighed against science
- Conflicting objectives

- Bias in data
- Missing data (weather, budget, pandemic)
- Stocks changing rapidly—unprecedented climate



- Poorly fitting or very uncertain models
- Ineffective communication between scientists and decision makers

- Imperfect application of regulations

- Outside influences weighed against science
- Conflicting objectives

Your system here

Surprise! Exercise starts now
1-2-4-All

Liberating structures exercise for idea development

- **2 minutes alone**, generating ideas
- **4 minutes in a pair**, sharing ideas, giving feedback
- **4 minutes foursome**, each spending 1 minute talking about what you've come up with

1-2-4-All

Identify a paired human-environment system you have some familiarity with.

Fill in each node of this cycle, and describe what flows between each.

Identify one challenge for each link, that could cause management to break down

2 minutes alone

4 minutes pair

4 minutes foursome

1-2-4-All

Any different challenges than ones I identified?

What tweaks did you make following the pair and foursome sharing?

Did anyone have a realization about their system from this?

Anything else to share?

Ideally, management frameworks should:

1. Be objective and transparent
2. Adequately protect the natural system from undesired outcomes
3. Balance objectives of affected stakeholders
4. Take into account uncertainty, at each step
5. Ideally, can be tested without having to experiment on real natural systems
6. Look ahead, not just at the current “state”

Management-oriented approaches

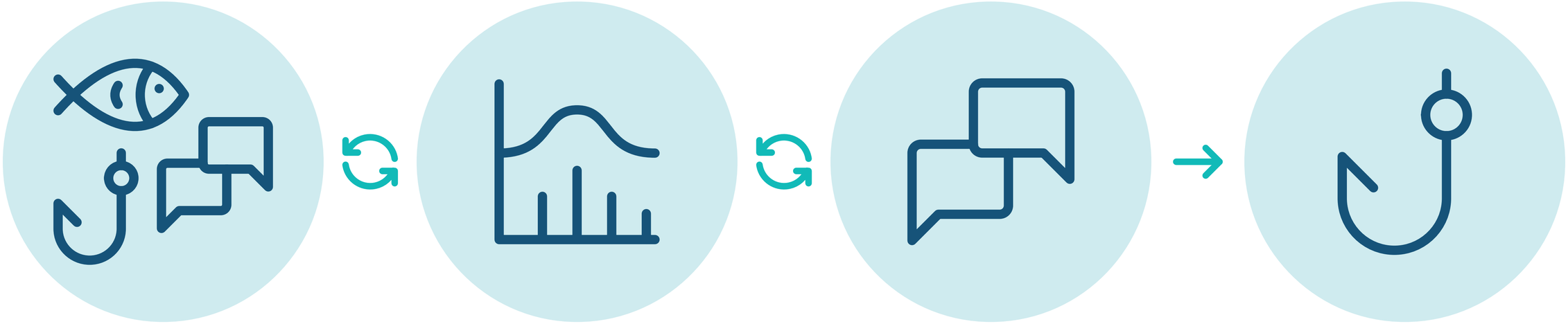
Rather than focusing on estimation of **indicator metrics**, and trying to keep up with **current status** of the system, and responding to that on some time-step—focus on identifying **management procedures** that perform best when it comes to **policies and objectives**.

Management strategy evaluation

MSE is a participatory decision-making process that allows us to **test-drive** management procedures using **forecasting** and **scenario testing**.

What does this look like?

MSE is intended to be an iterative process that involves dialogue between scientists, managers, and stakeholders.



Gather information on whole system and ID objectives

Scientists simulate the entire system and report on scenario outcomes

Stakeholders and managers review results

Managers implement an action

Who is involved?

Scientist-manager working groups

Scientists and tech's familiar with the data, modelers, resource managers

Representative stakeholders

Recreational/sport fishery interest groups, Indigenous groups, conservation NGOs, commercial fisheries representatives

What information do we need?

Population dynamics

- Stock assessment data & models

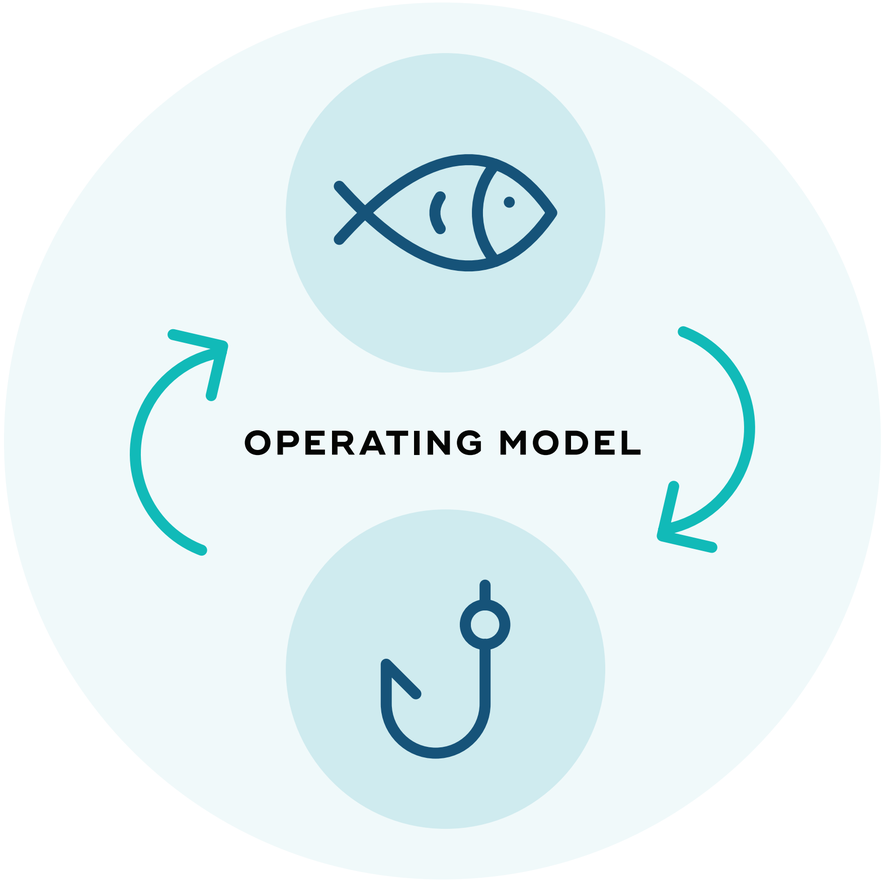
Fishery dynamics

- Catch information
- Fleet dynamics

Management objectives (examples)

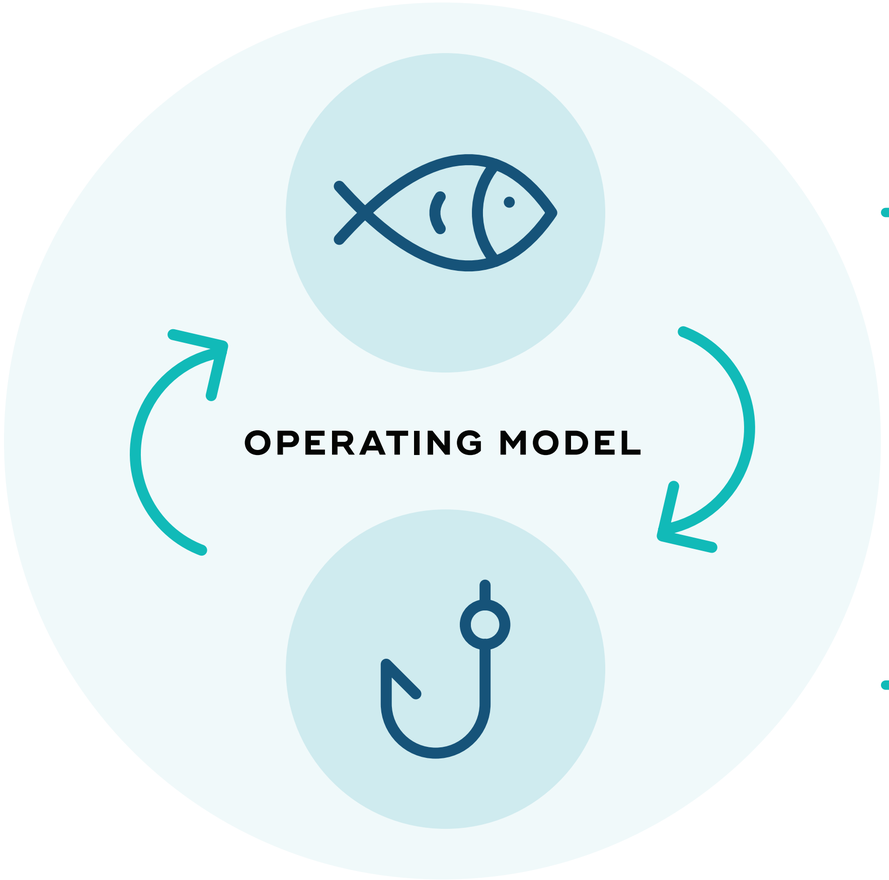
- Achieve maximum sustainable yield
- Prevent overfishing/conservation concern
- Catch Stability
- Conserve population structure
- Meet allocation and/or treaty requirements

Closed-loop simulations



- The “true” abundance of the stock, and “true” catch of the fishery is simulated forward
- This is there the “forecasting” happens at each time step

Closed-loop simulations



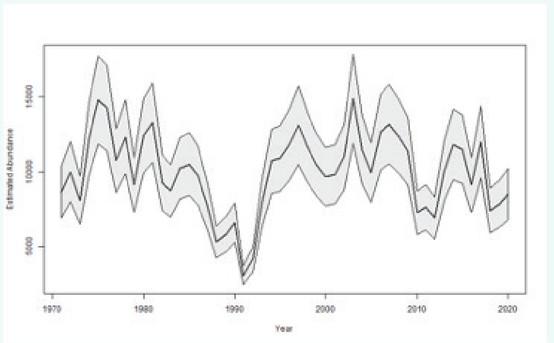
Survey data

Observation error

Fishery-dependent data

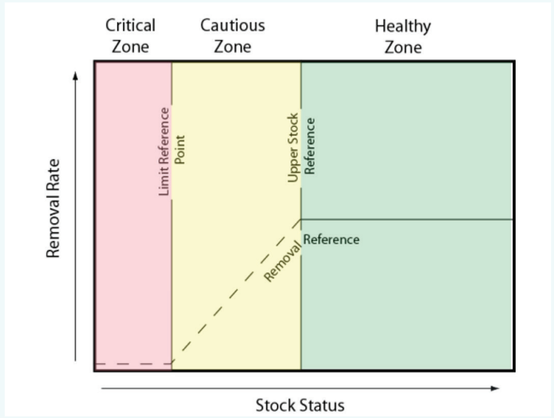
Observation error

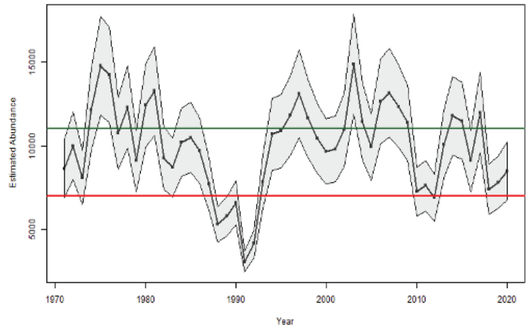
STOCK ASSESSMENT



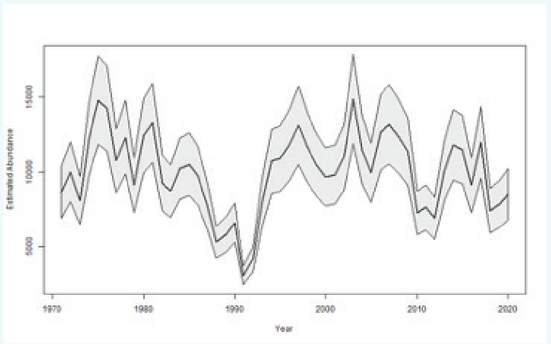
Closed-loop simulations

HARVEST CONTROL RULE

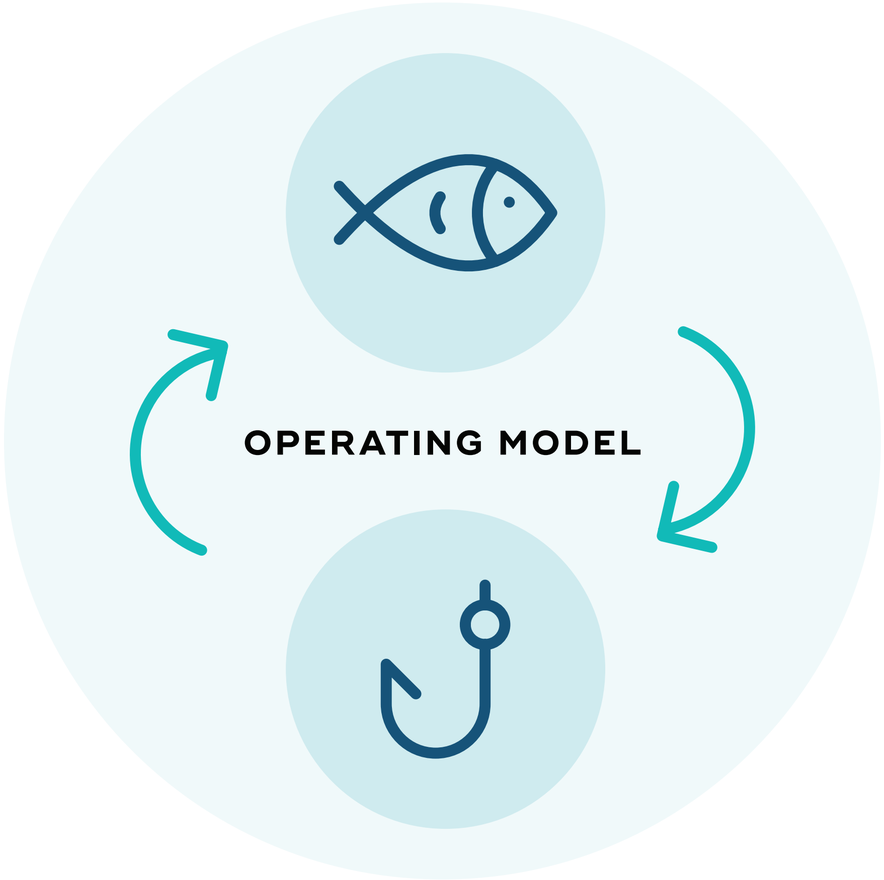




STOCK ASSESSMENT



Closed-loop simulations



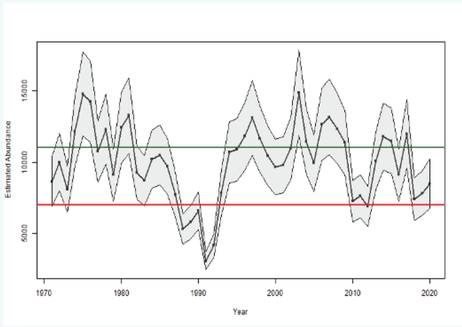
Data

Observation error

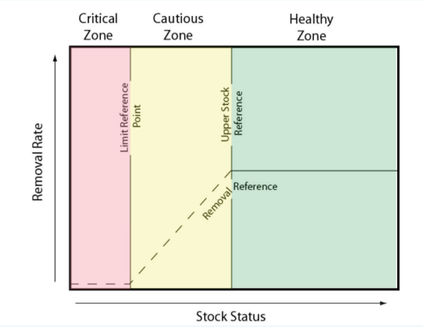
Harvest policy

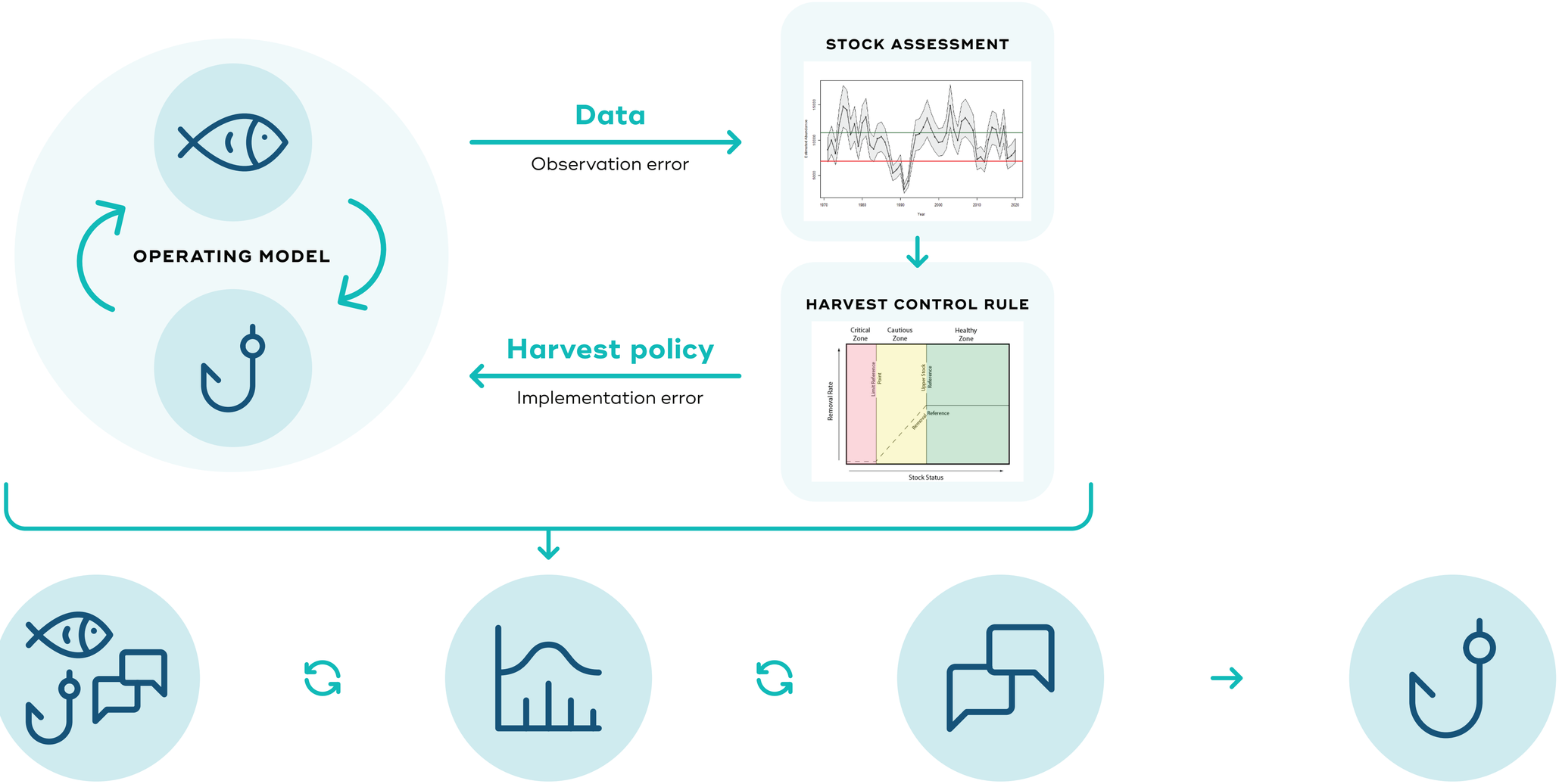
Implementation error

STOCK ASSESSMENT

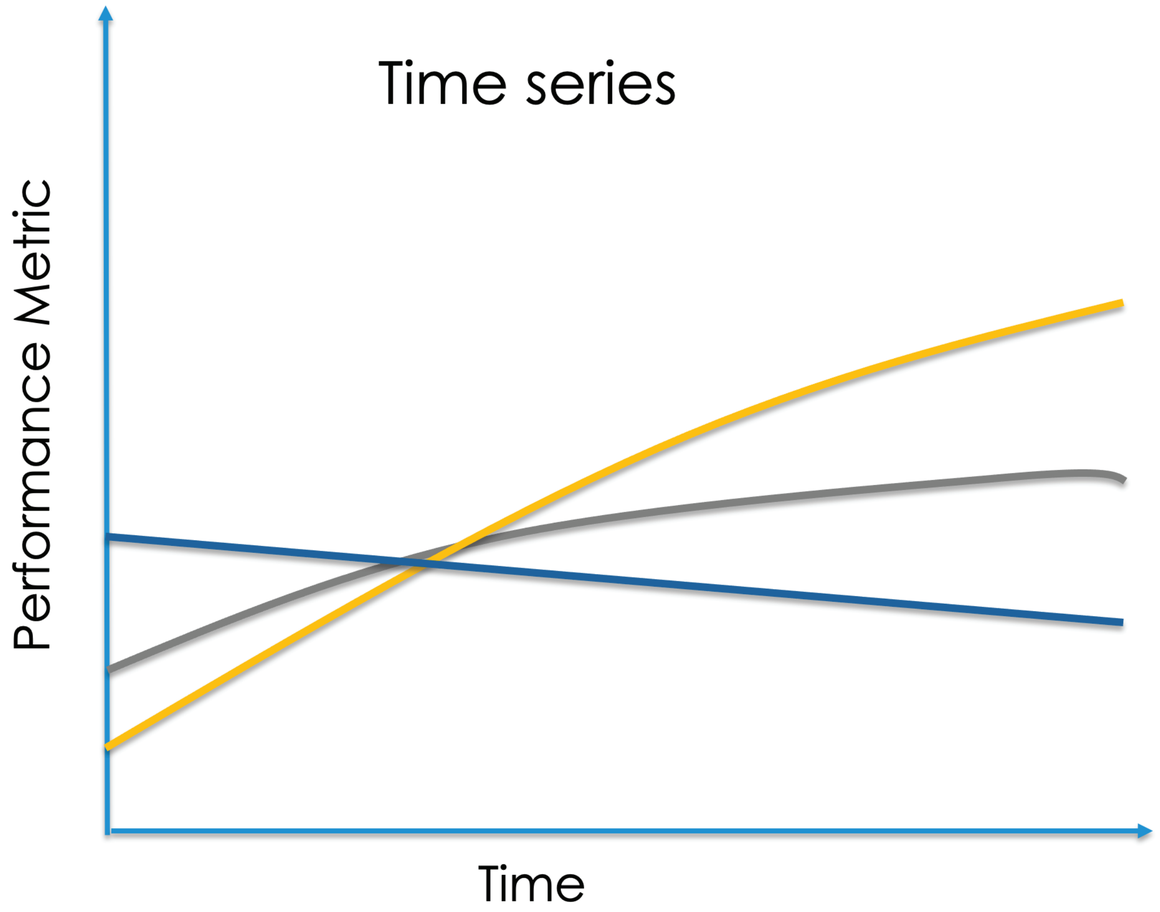


HARVEST CONTROL RULE

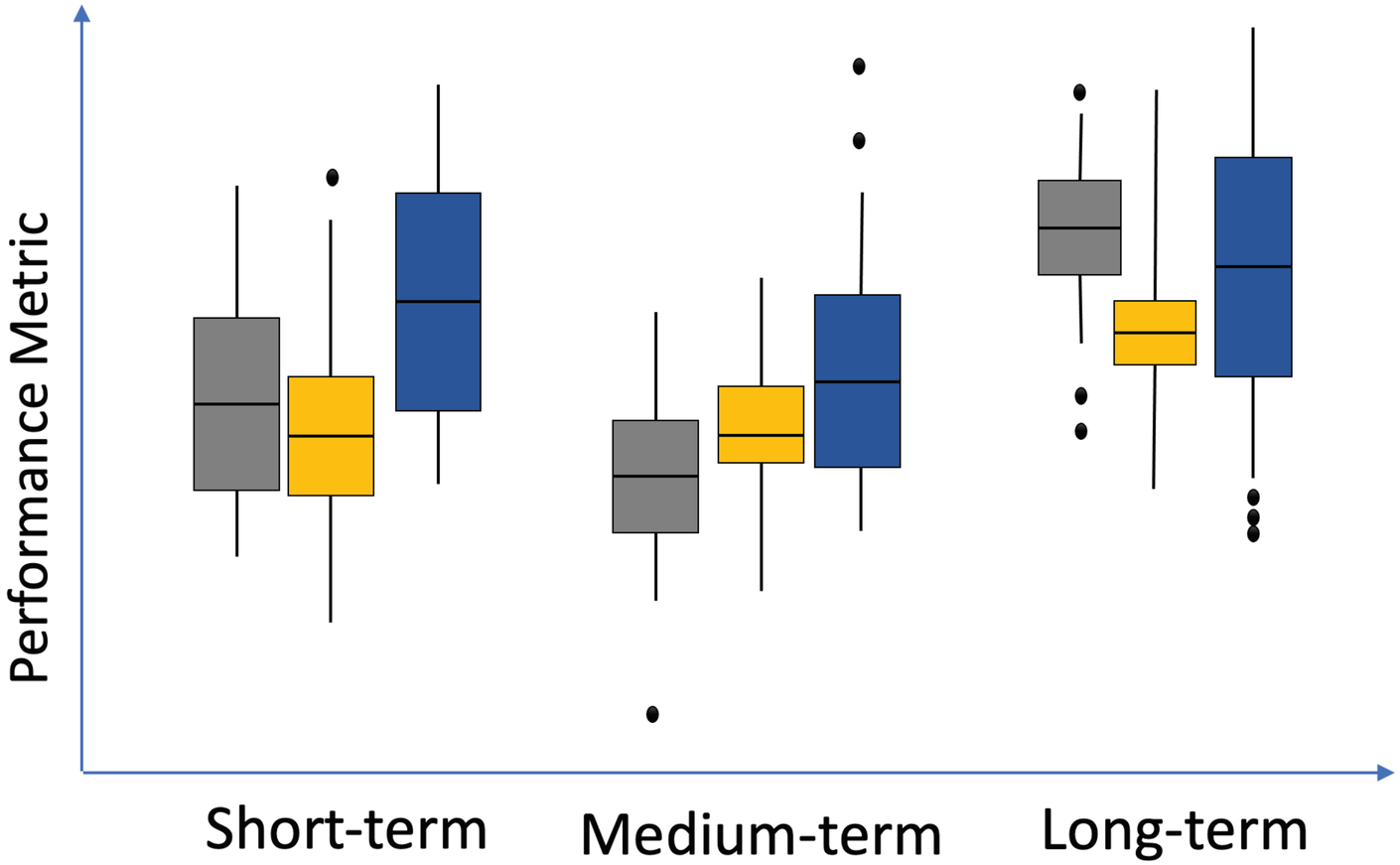



OPERATING MODEL
Data
Observation error
STOCK ASSESSMENT
Year
HARVEST CONTROL RULE
Critical Zone
Cautious Zone
Healthy Zone
Limit Reference Point
Upper Stock Reference
Reference
Removal Rate
Stock Status
Harvest policy
Implementation error
Stakeholders and managers ID desired outcomes
Scientists simulate the entire system and report on scenario outcomes
Stakeholders and managers review results
Managers implement an action

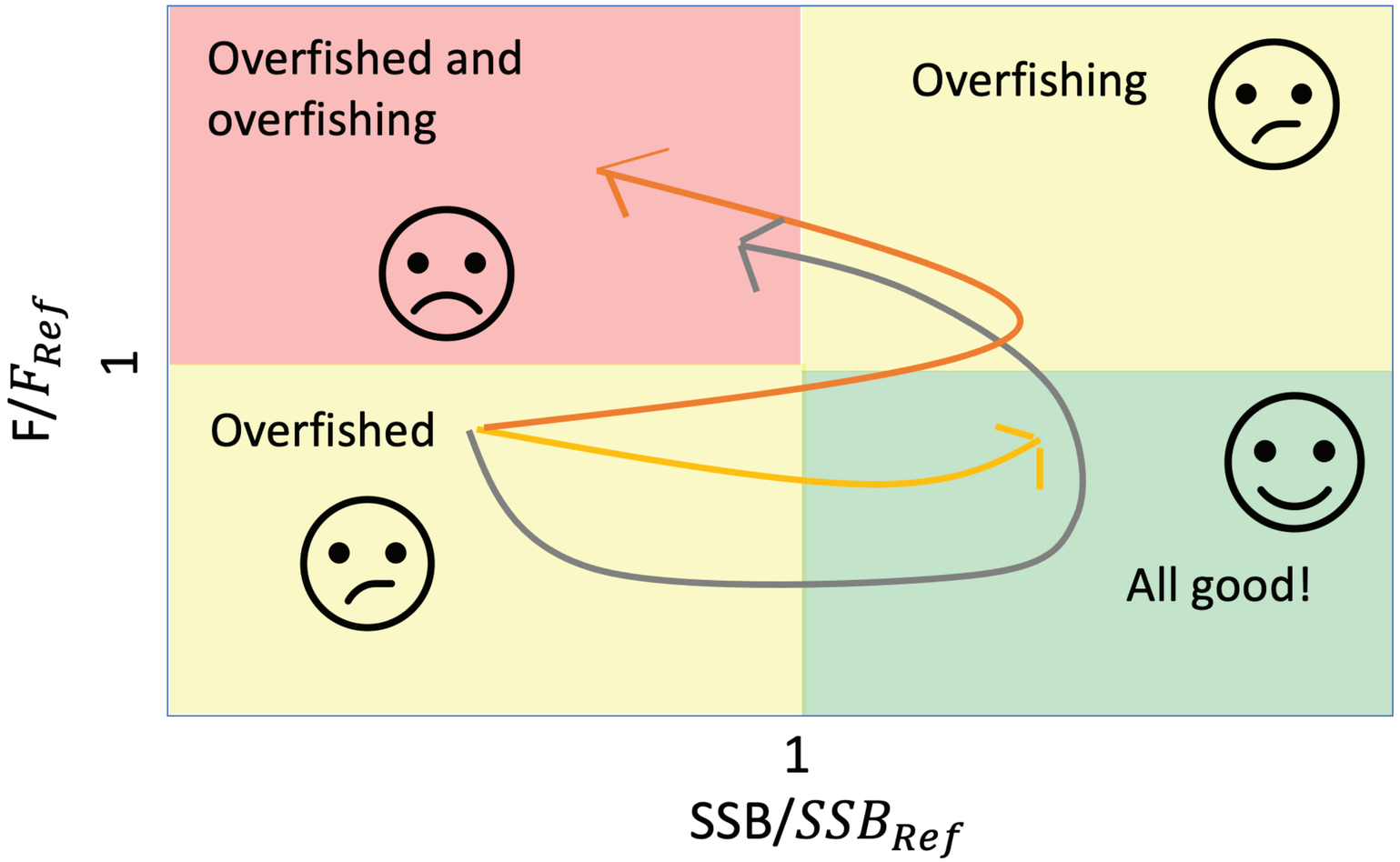
Performance metrics



What do outputs look like?



Kobe plot


Overfished and overfishing
Overfishing
Overfished
All good!
F/F_{Ref}
1
1
SSB/SSB_{Ref}

Weighing objectives

Healthy ecosystems

Food security

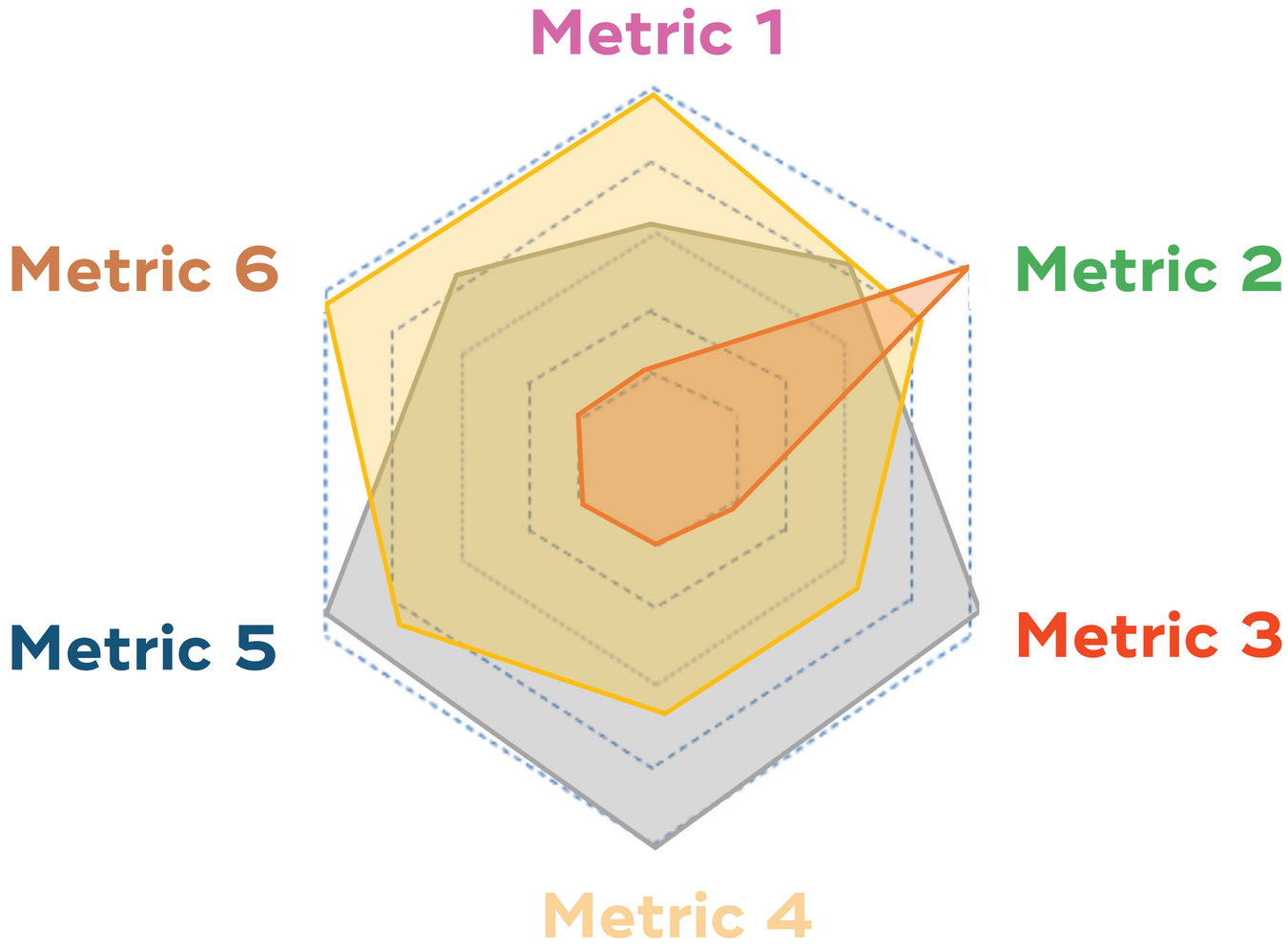
High catch

Healthy fish stocks

Meeting Legislative requirements

Stable catch

Assessing trade-offs



Does this tick the boxes?

Ideally, management frameworks should:

1. Be objective and transparent
2. Adequately protect the population from conservation risk
3. Balance objectives of multiple stakeholders
4. Take into account uncertainty
5. Ideally, can be tested without having to experiment on real populations
6. Look ahead, not just at the current “state”

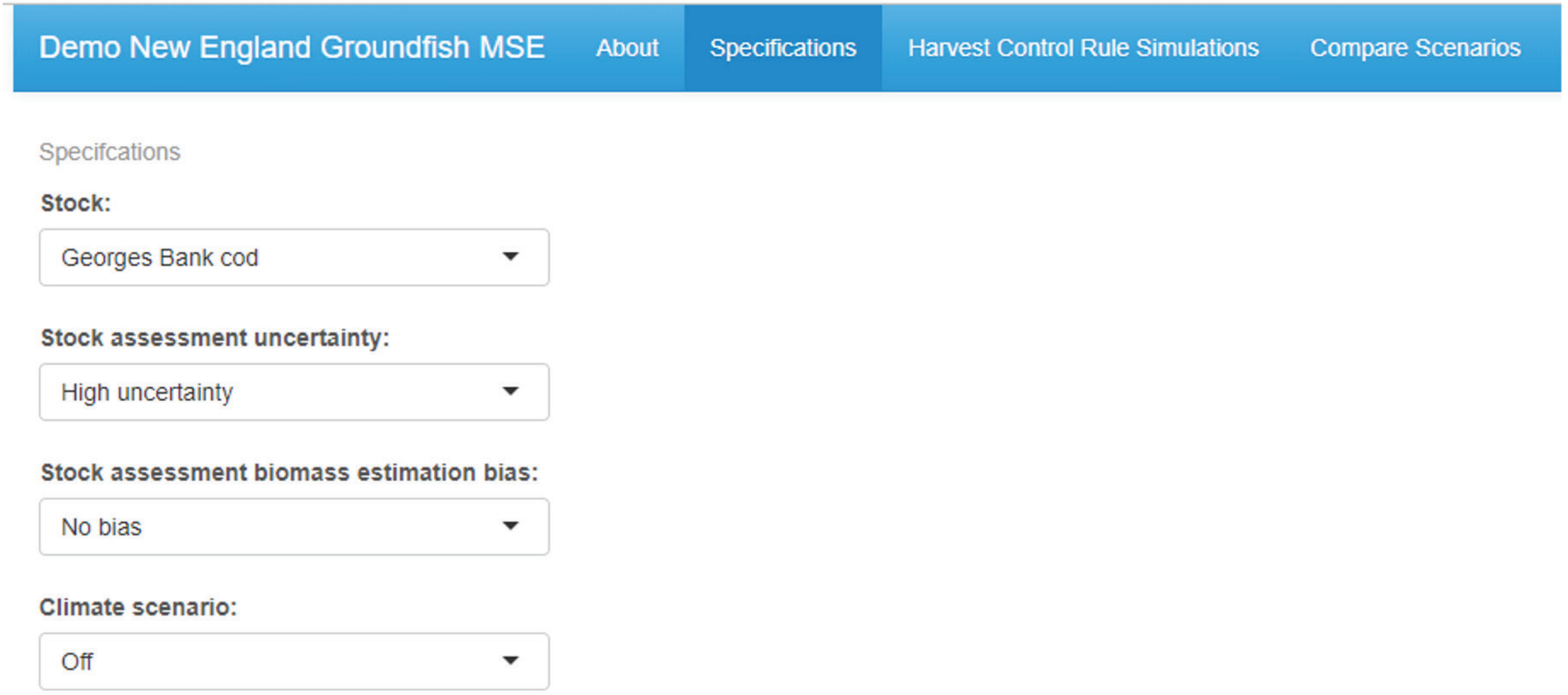
Other benefits

But, it’s no silver bullet!

- Requires buy-in from stakeholders
  - Trust, relationships, time, effort, $$
- Complex human system, complex natural system needs to be tractable
  - Transboundary stocks, mixed-stock fisheries, complex ecosystem feedbacks
  - Tipping points, chance events, other things?

Let’s play!

Demo New England Groundfish MSE (shinyapps.io)


Demo New England Groundfish MSE
About
Specifications
Harvest Control Rule Simulations
Compare Scenarios
Specifcations
Stock:
Georges Bank cod
Stock assessment uncertainty:
High uncertainty
Stock assessment biomass estimation bias:
No bias
Climate scenario:
Off

Demo New England Groundfish MSE | About | Specifications | Harvest Control Rule Simulations | Compare Scenarios

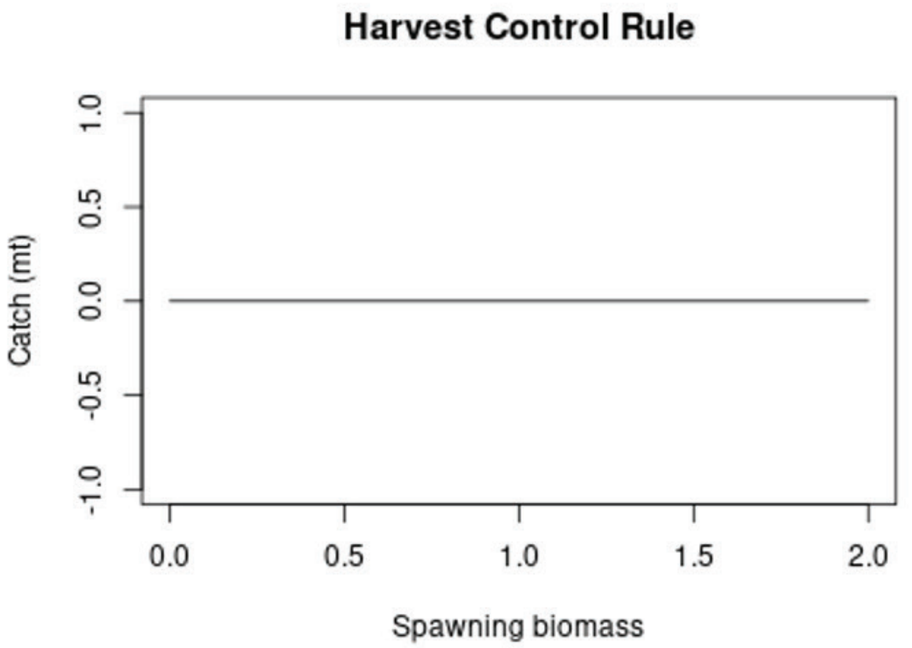
Harvest control rule

Type of harvest control rule:

Constant catch

Catch (mt)

0



Do projections

Comparison 1

Compare constant catch at O and 3OOOmt, do the results make sense?

Omt constant catch

+

3OOOmt constant catch

Comparison 2

Add ramped scenario, re-do comparison so have three scenarios to compare

Omt constant catch

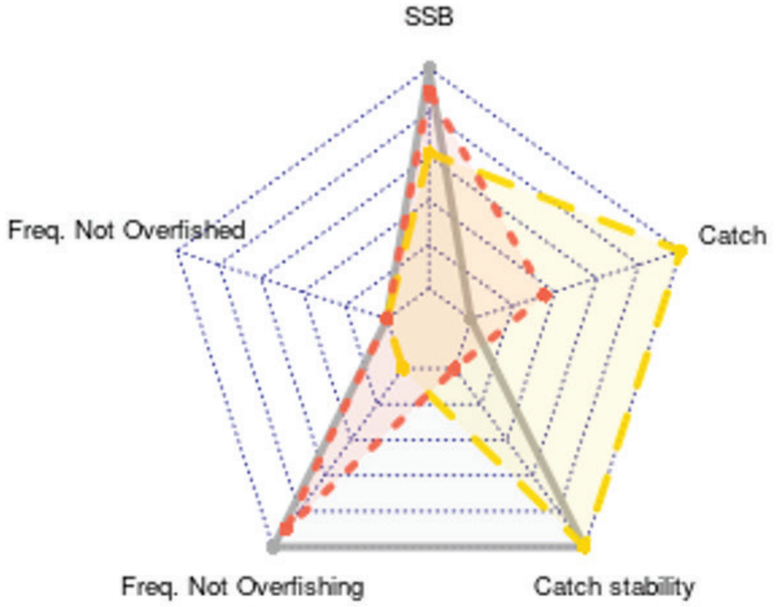
+

3OOOmt constant catch

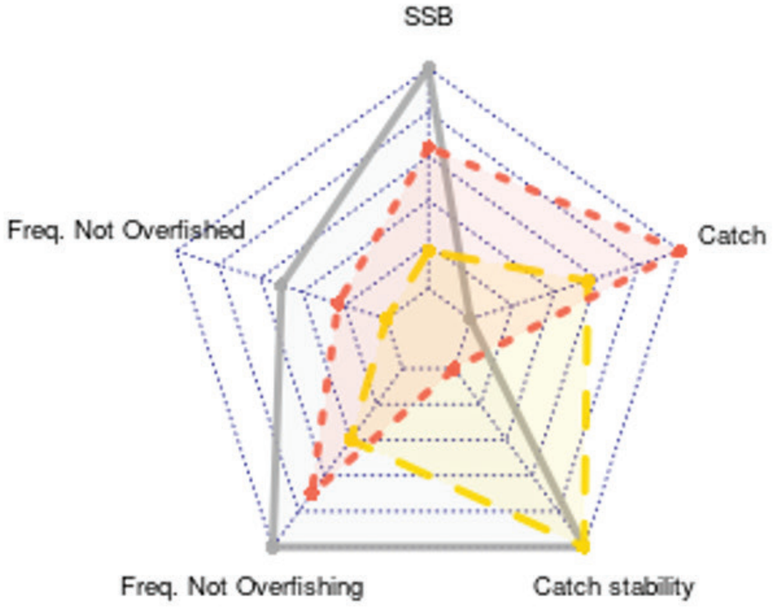
+

Ramped catch

Short-term



Long-term



Comparison 3

Two different stakeholders suspect that our stock assessment method is biased. Fishers think it's underestimating (neg bias), conservation biologists think it's overestimating (pos bias), due to their own anecdotal evidence. Let's compare those scenarios under the same ramped catch harvest control rule.

Ramped scenario as baseline

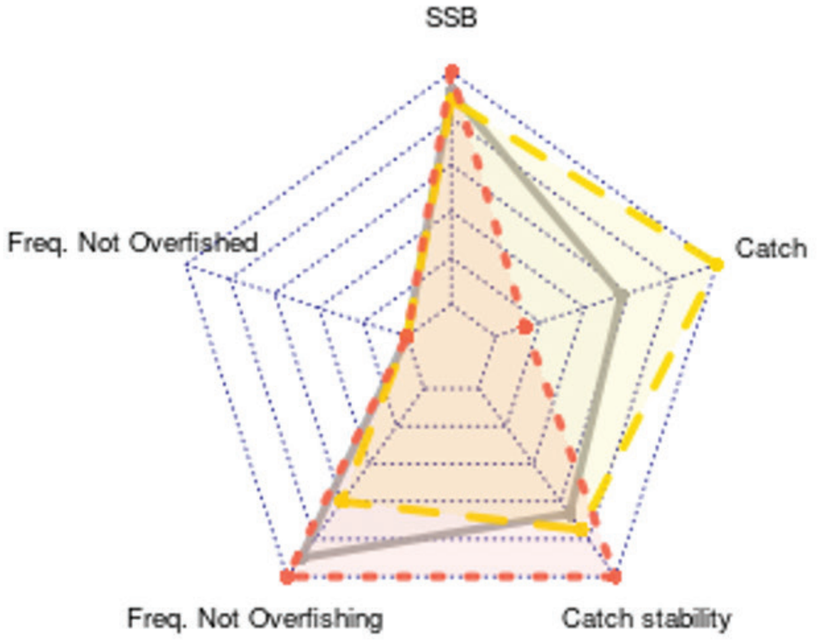
+

Overestimation bias

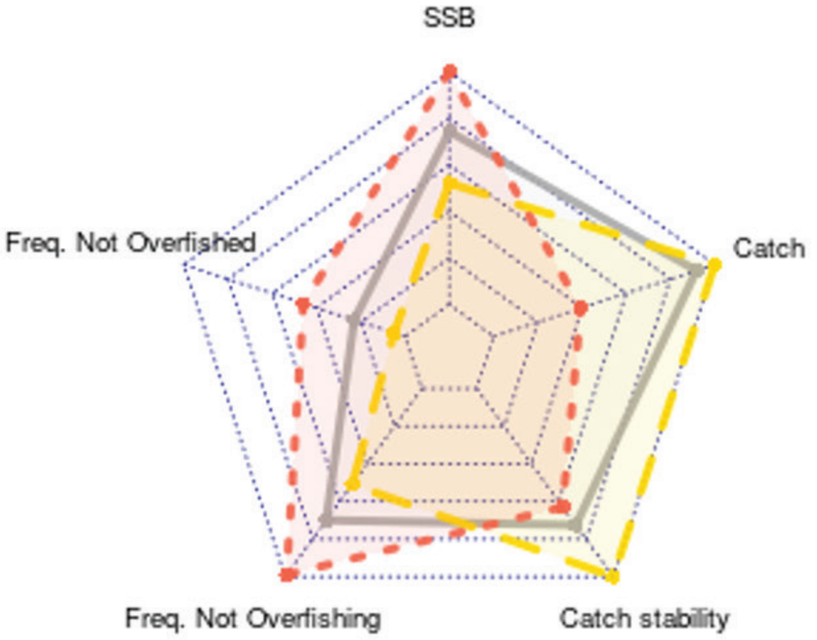
+

Underestimation bias

Short-term



Long-term



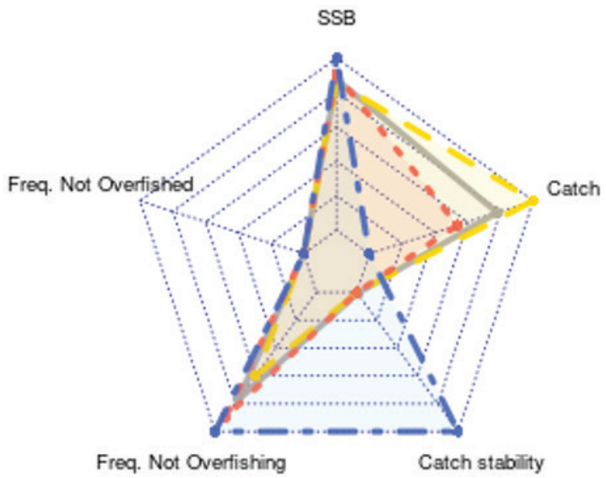
Challenge

Choose a persona—Fisher or Conservationist and with your assumption about bias, can you find a harvest control rule you like better than the standard “ramped”?

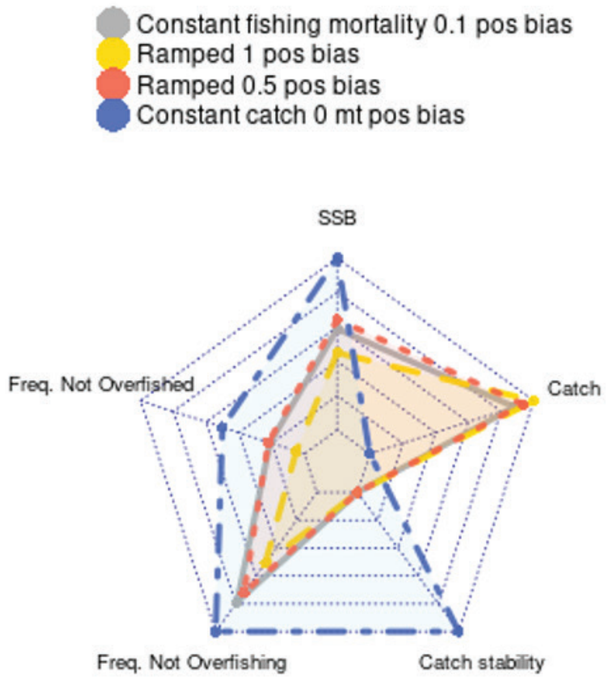
10 minutes to play

Conservation-focused

Short-term

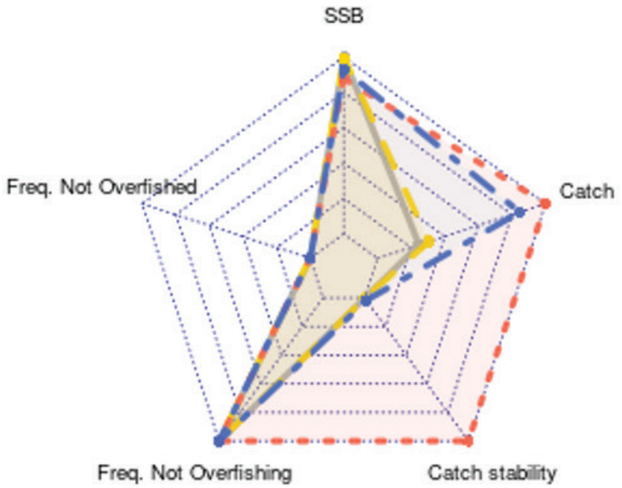


Long-term

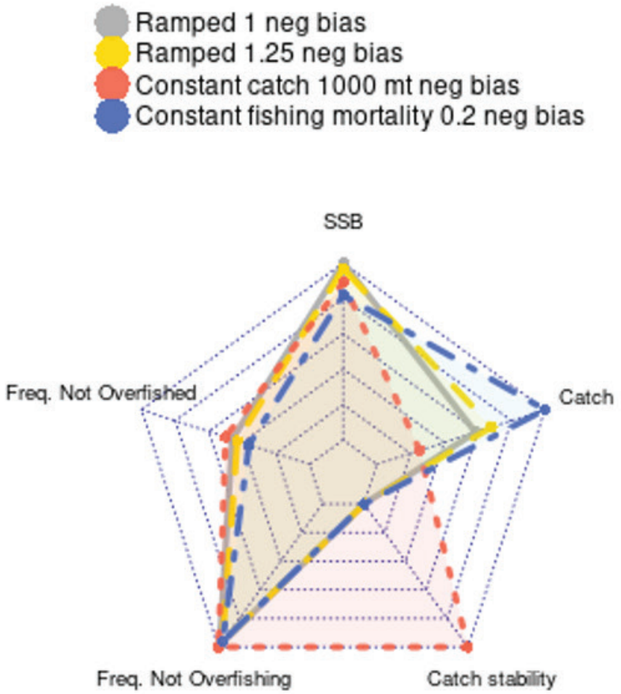


Fisheries-focused

Short-term

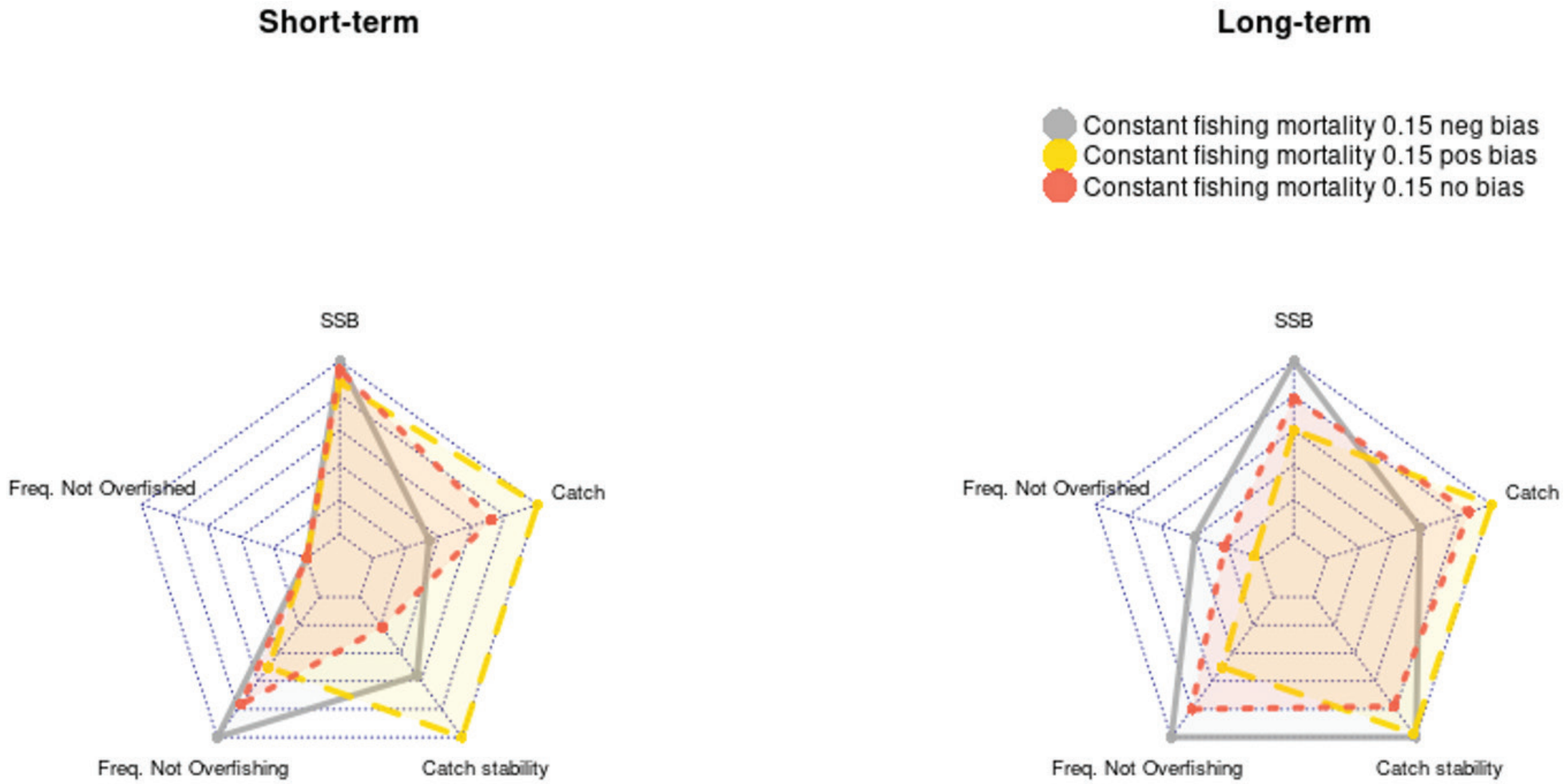


Long-term

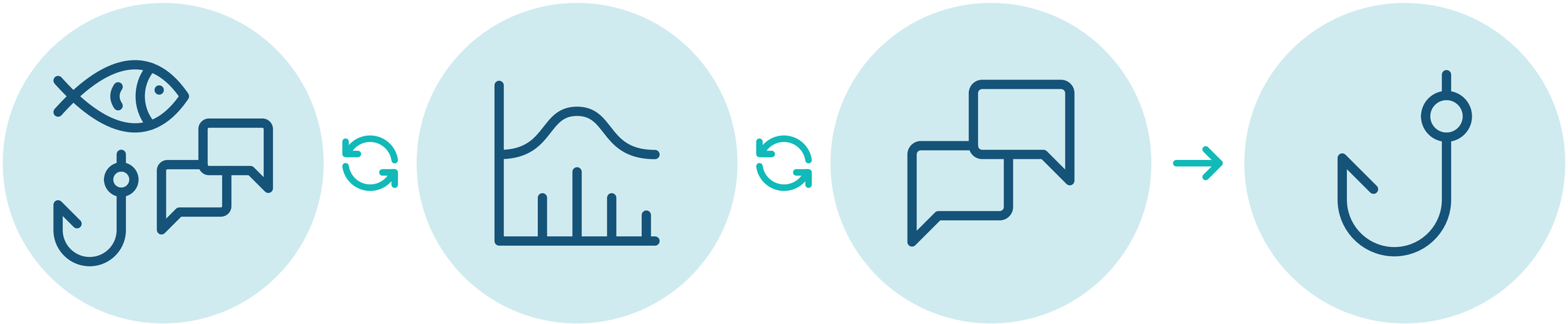


Could maybe be robust to bias

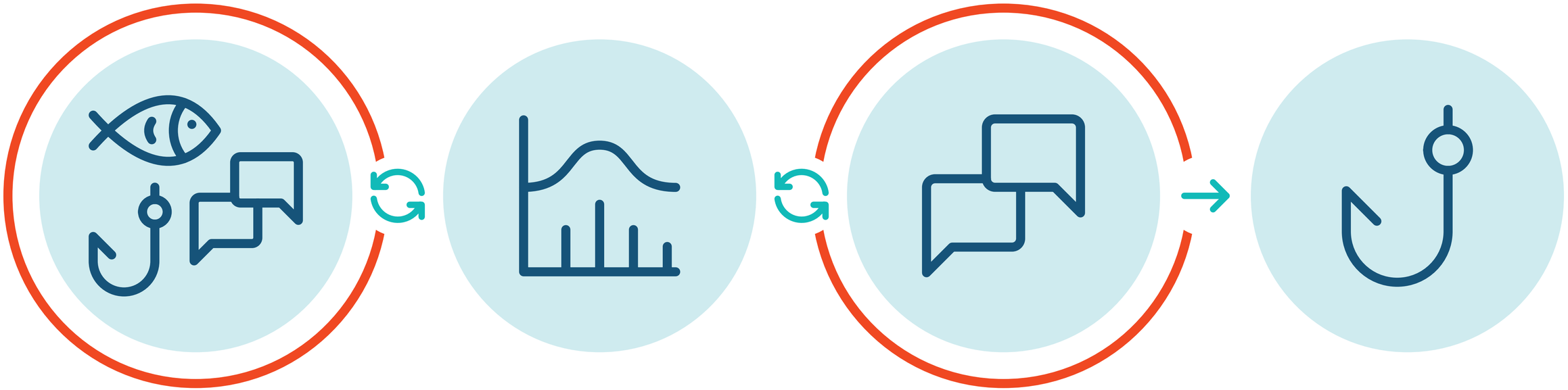
(at least long-term)?



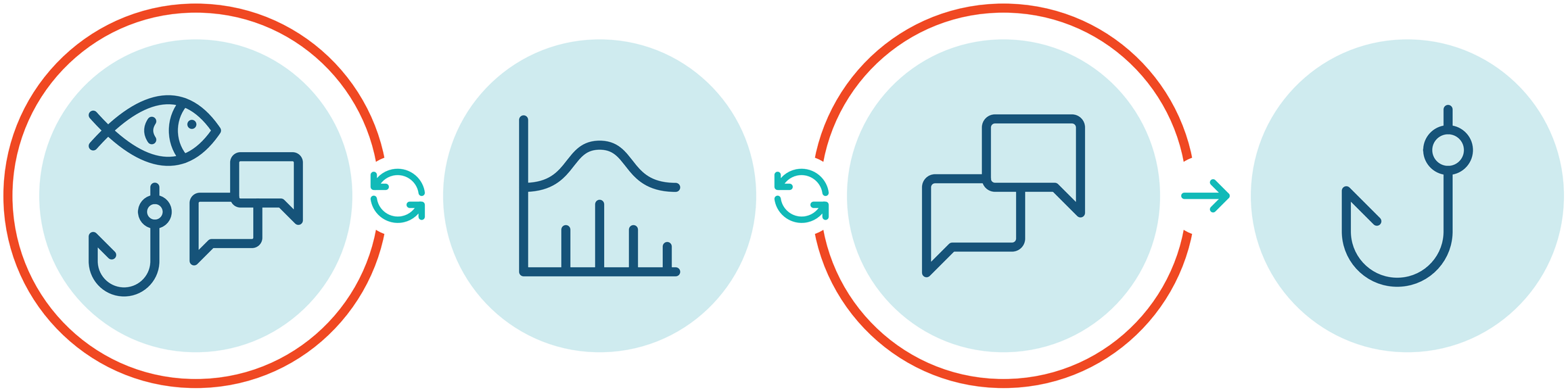
Management-oriented approach for your system



Management-oriented approach for your system

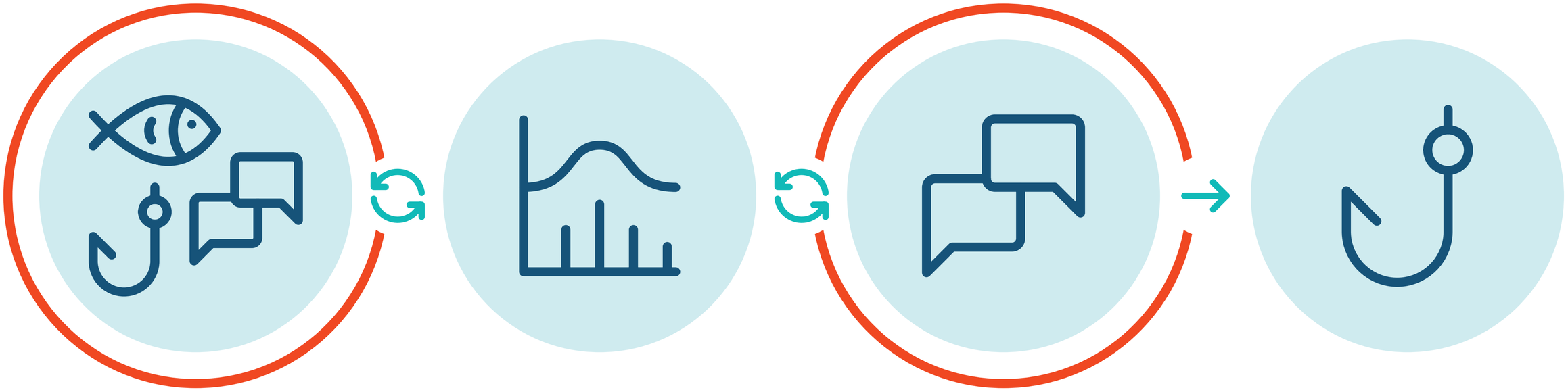


Management-oriented approach for your system



ID the stakeholder groups and one (or more) objective for each

Management-oriented approach for your system



ID the stakeholder groups and one (or more) objective for each

ID a measurable performance metric for each objective

Management-oriented approach for your system

1-2-4-All

1 ID the stakeholder groups and one (or more) objective for each

2 ID a measurable performance metric for each objective

1 minute alone, generating ideas

2 minutes in a pair, sharing ideas, giving feedback

4 minutes foursome, each spending 1 minute talking about what you've come up with

Management-oriented approach for your system

1-2-4-All

1. ID the stakeholder groups and one (or more) objective for each
2. ID a measurable performance metric for each objective

Did anyone struggle to ID stakeholders?

Did anyone ID stakeholders that are currently excluded from consultations or decision-making?

Can someone share a case where objectives were directly conficting?

Can someone share a case where they discovered shared obectives?