

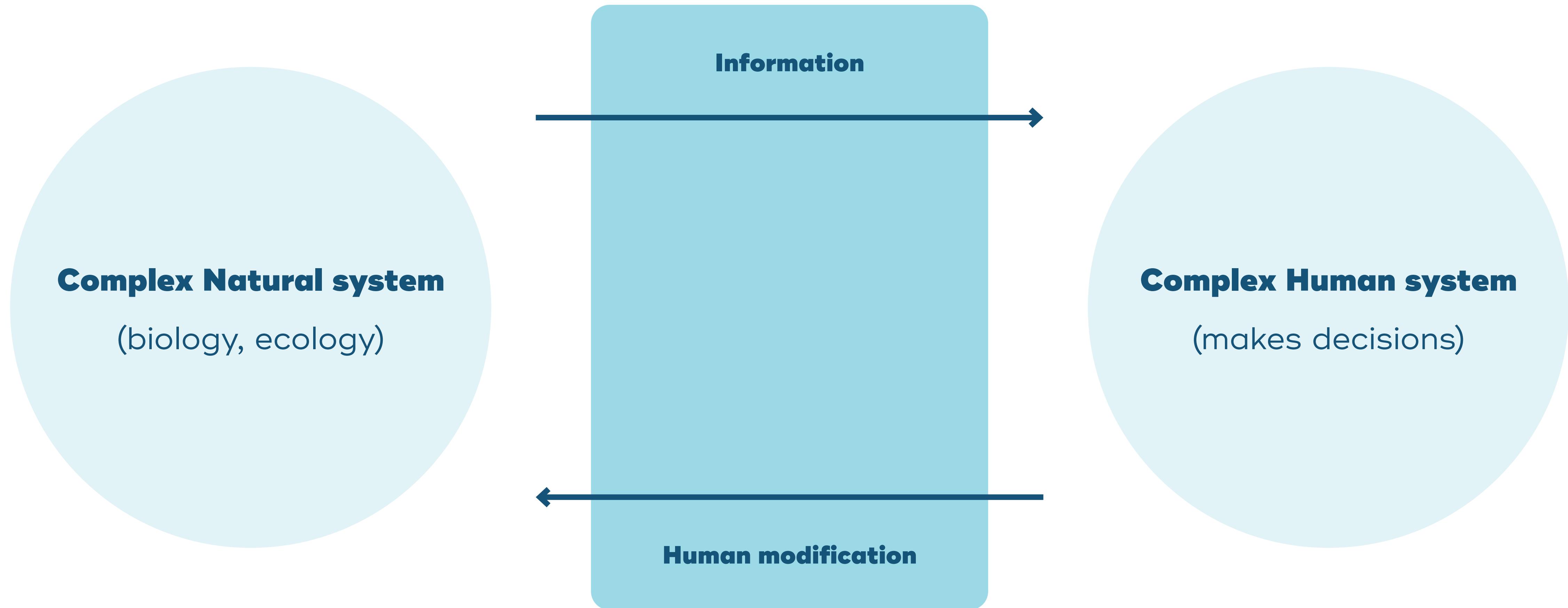
# **A management-oriented approach for coupled human-environmental systems:**

**MSE in fisheries science**

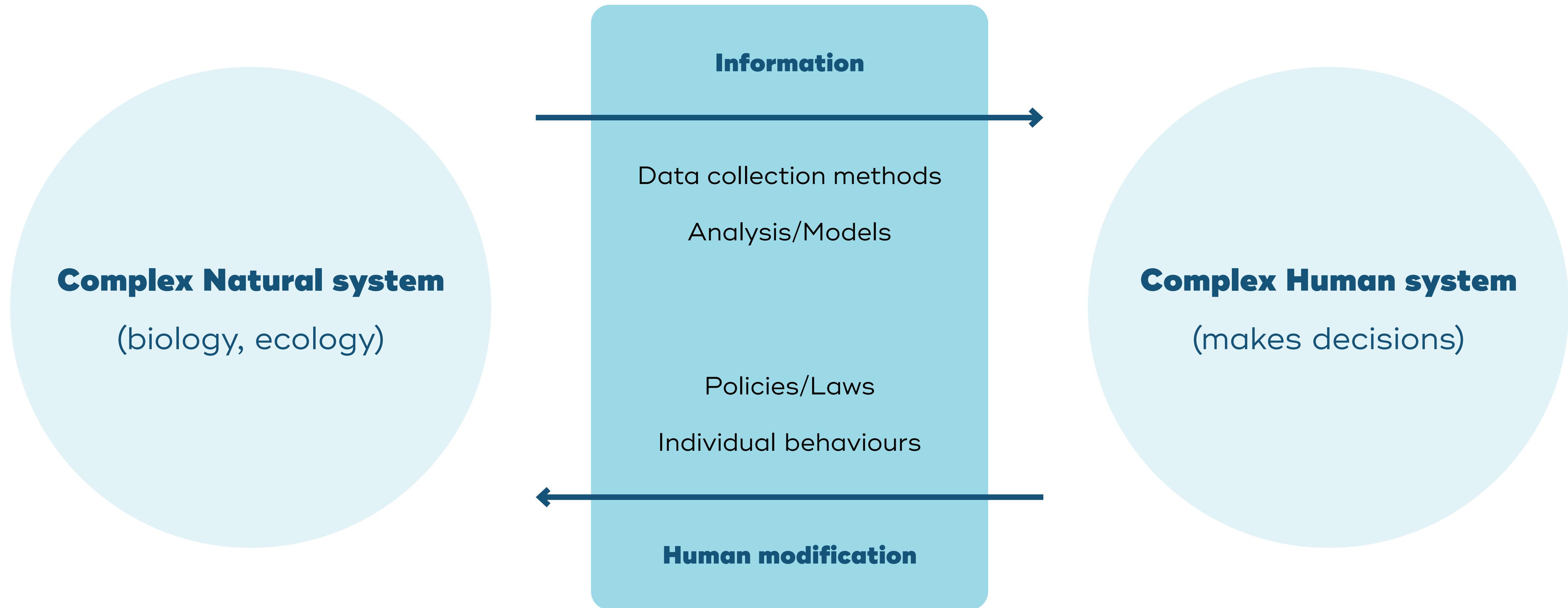
Brooke Davis

July 26, 2023

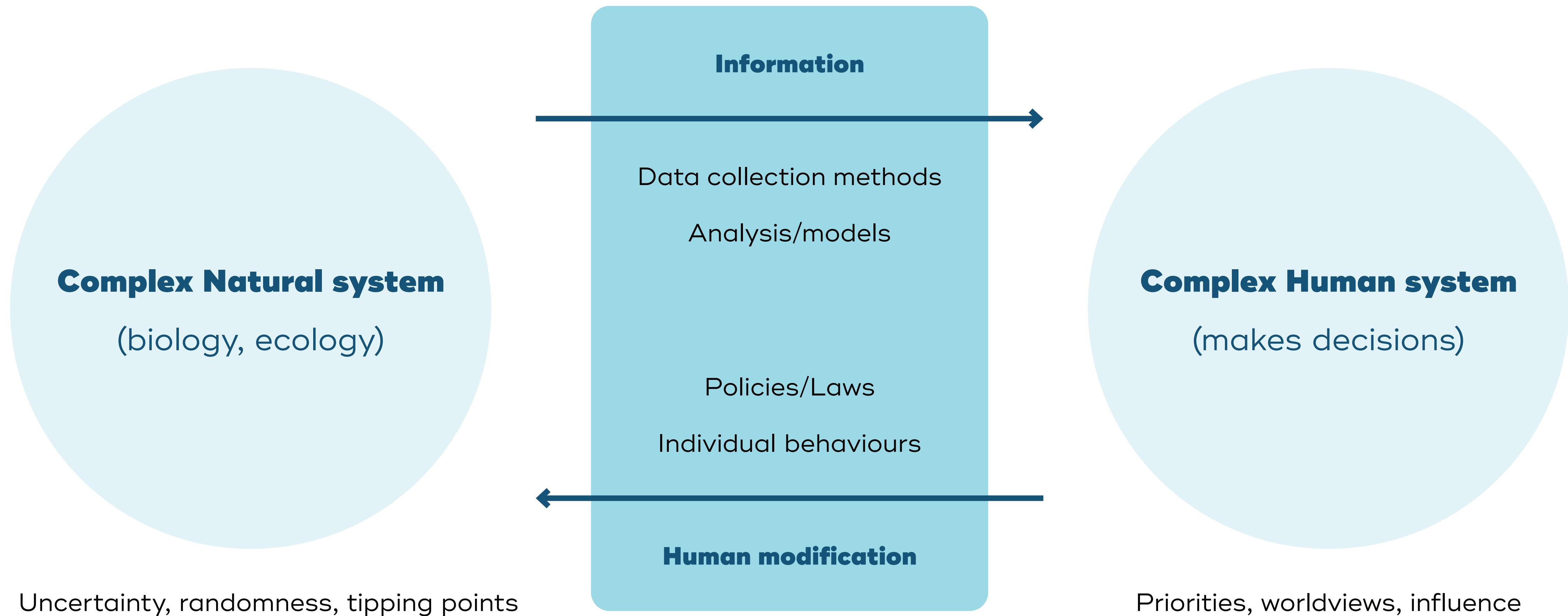
# Coupled Human-Environment System



# Coupled Human-Environment System



# Coupled human–environment system



# Coupled human–environment system

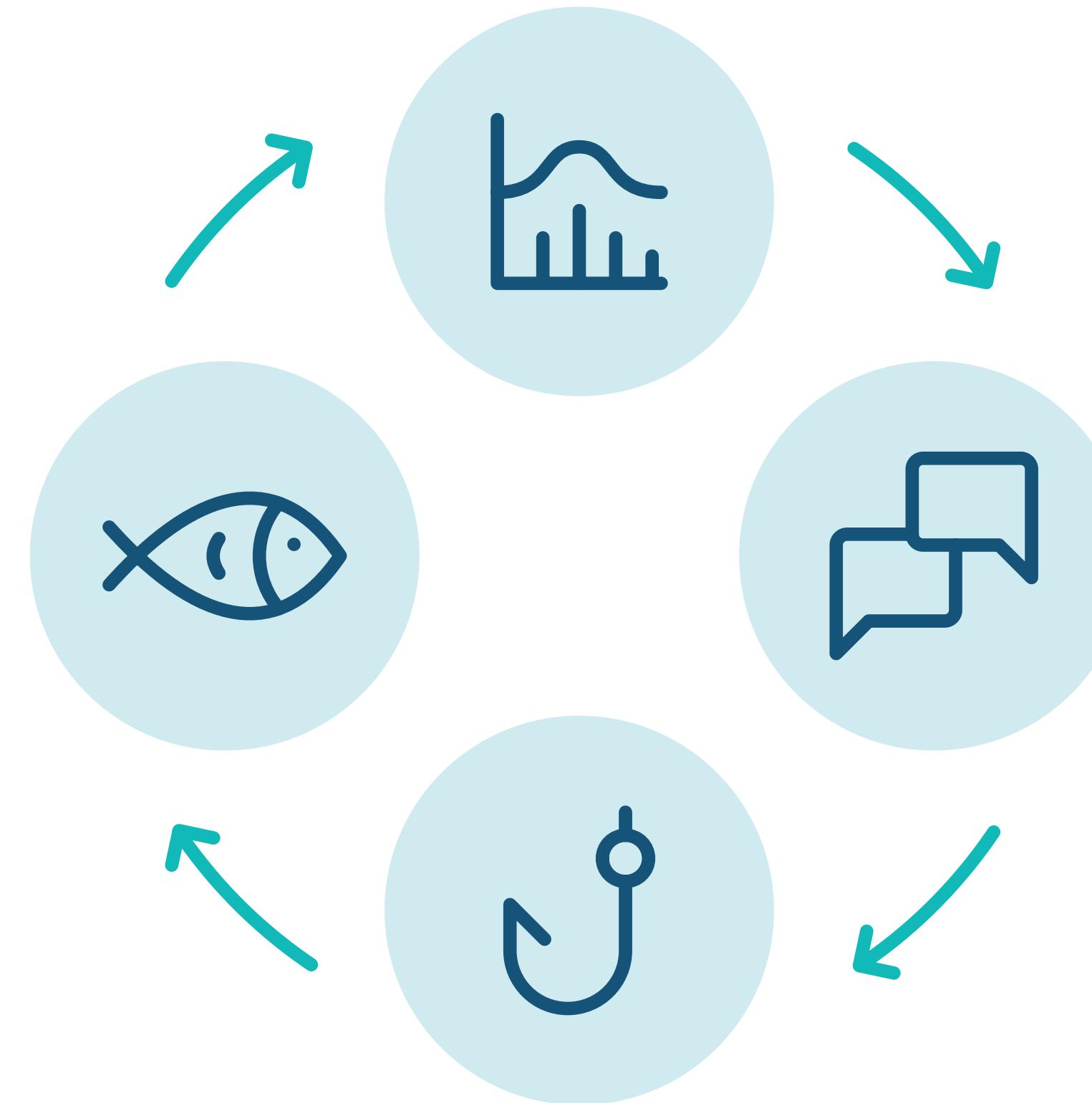


# Coupled human–environment system



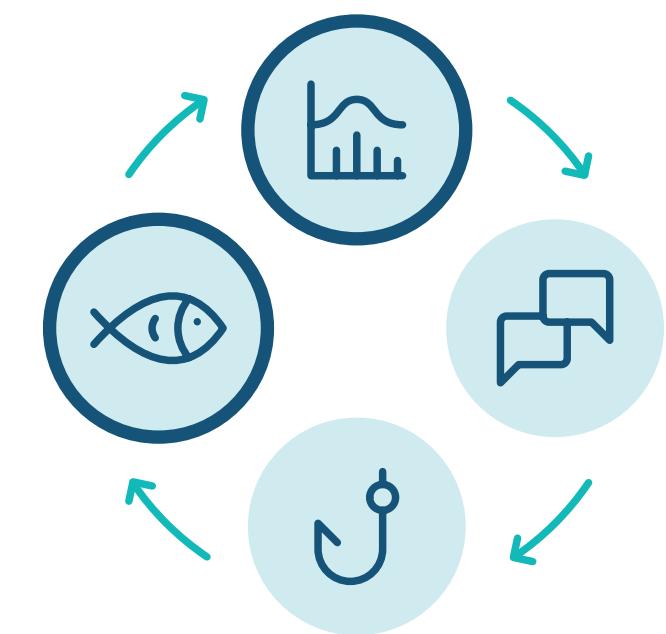
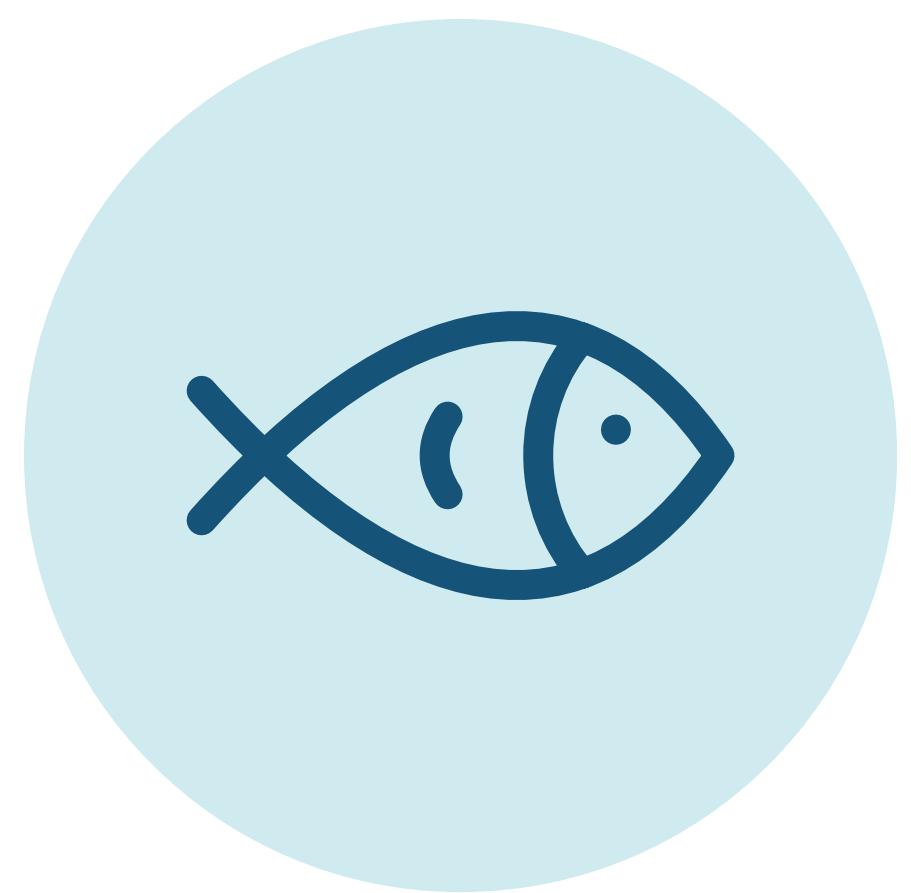
# Fishery science

## Stock assessment



## Fishery management

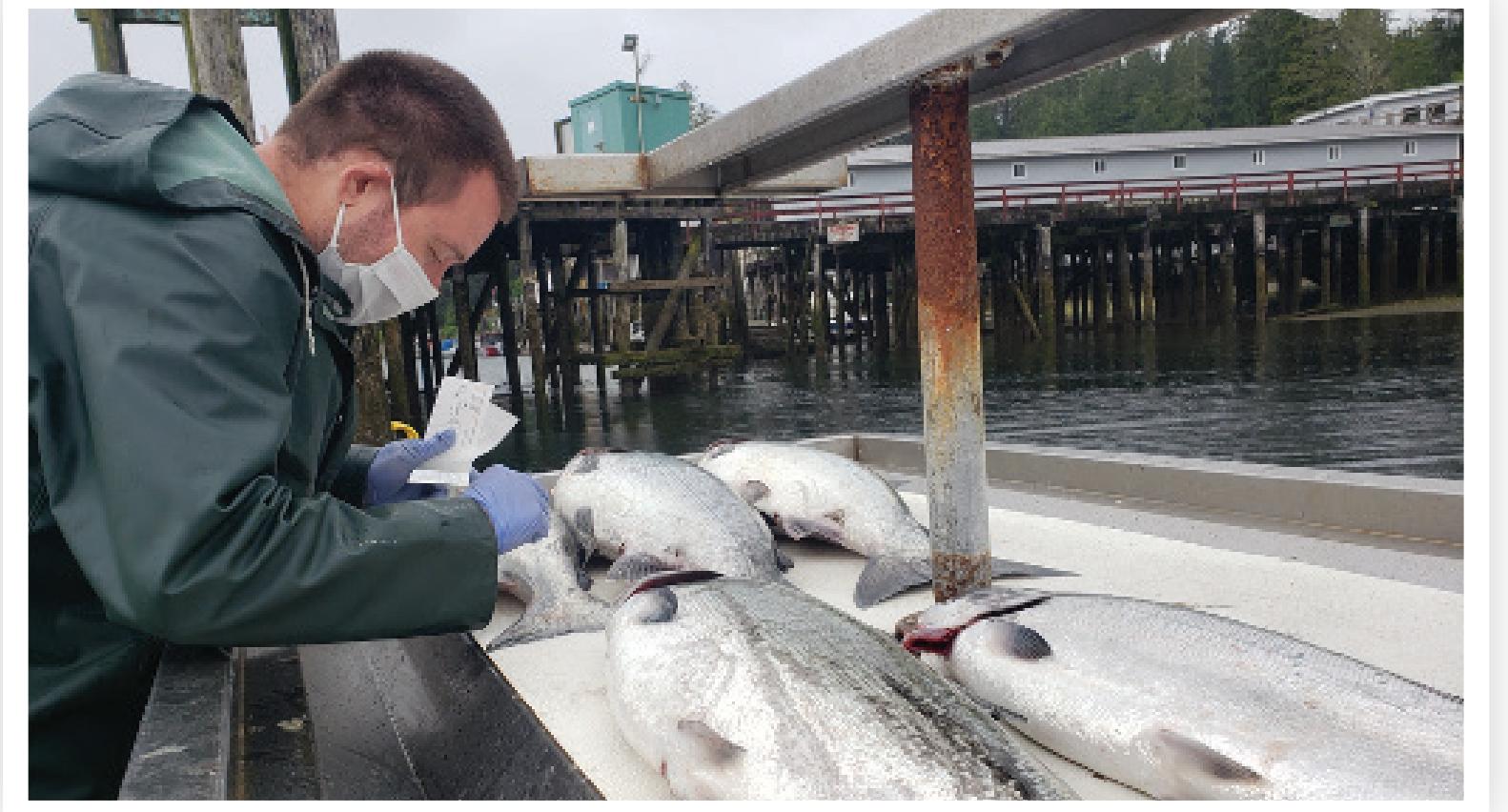
# Types of data



# Types of data

## Fishery-dependent data:

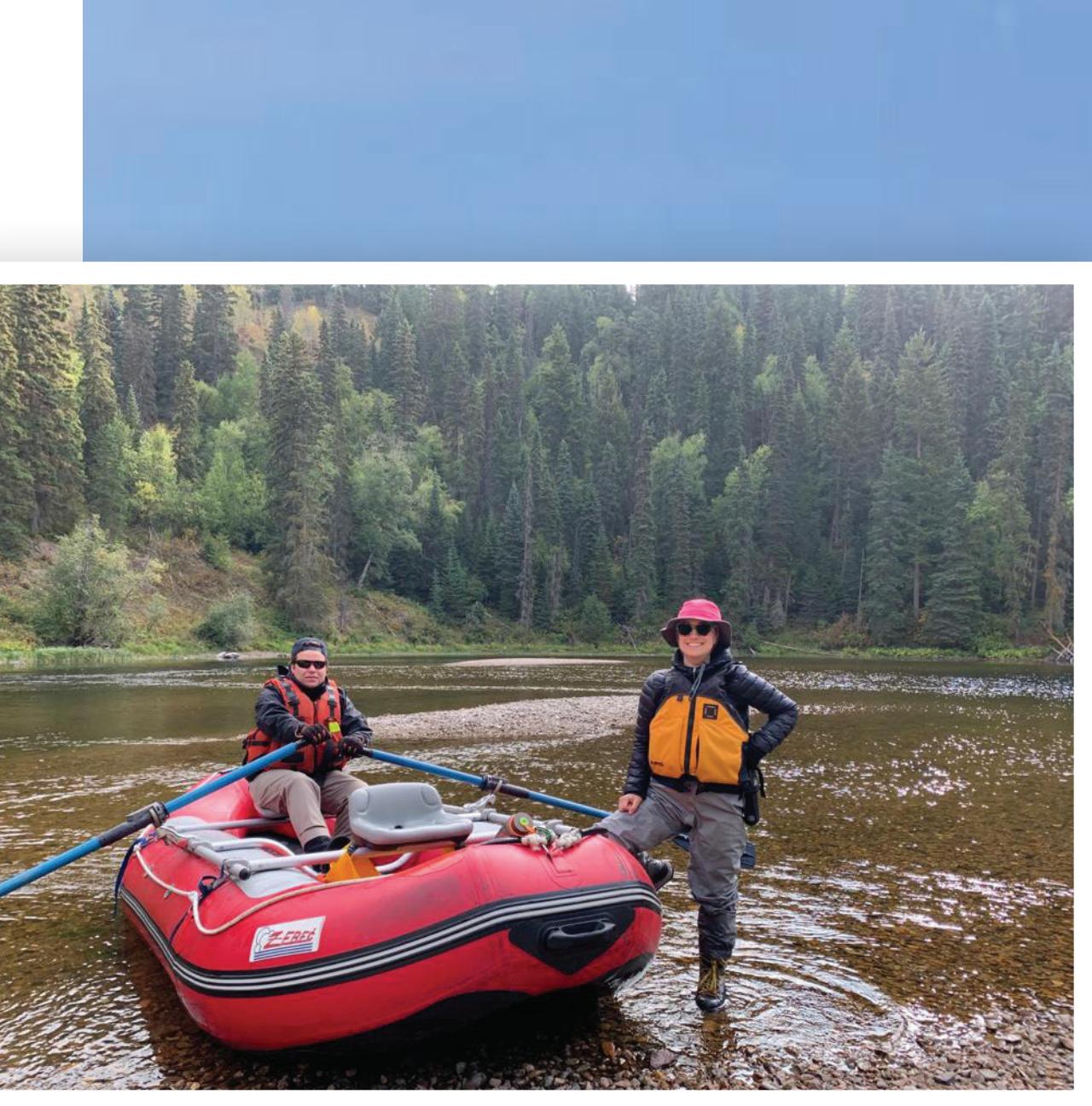
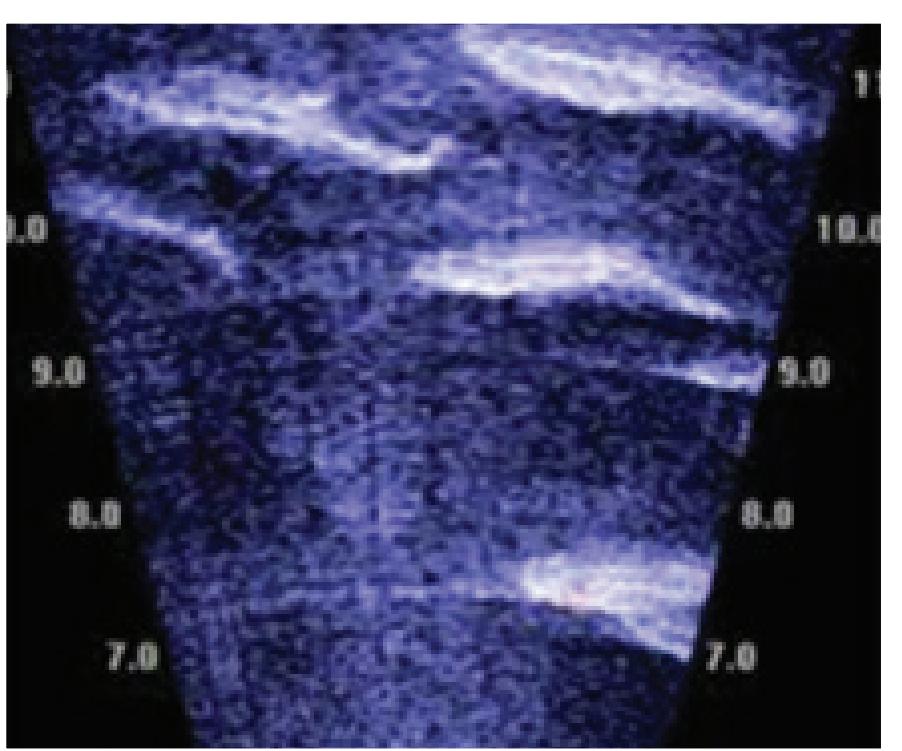
Catch and biological data reported by on-board observers, automated monitoring systems, portside surveys, creel surveys, historical landing records, log books



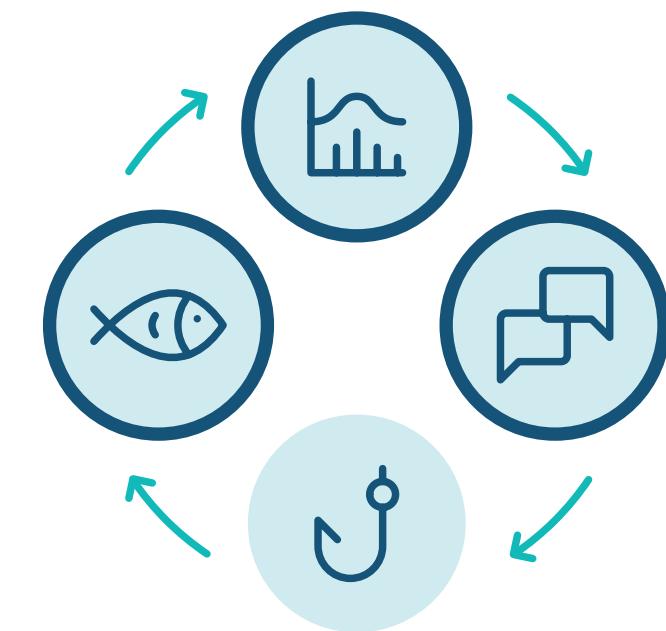
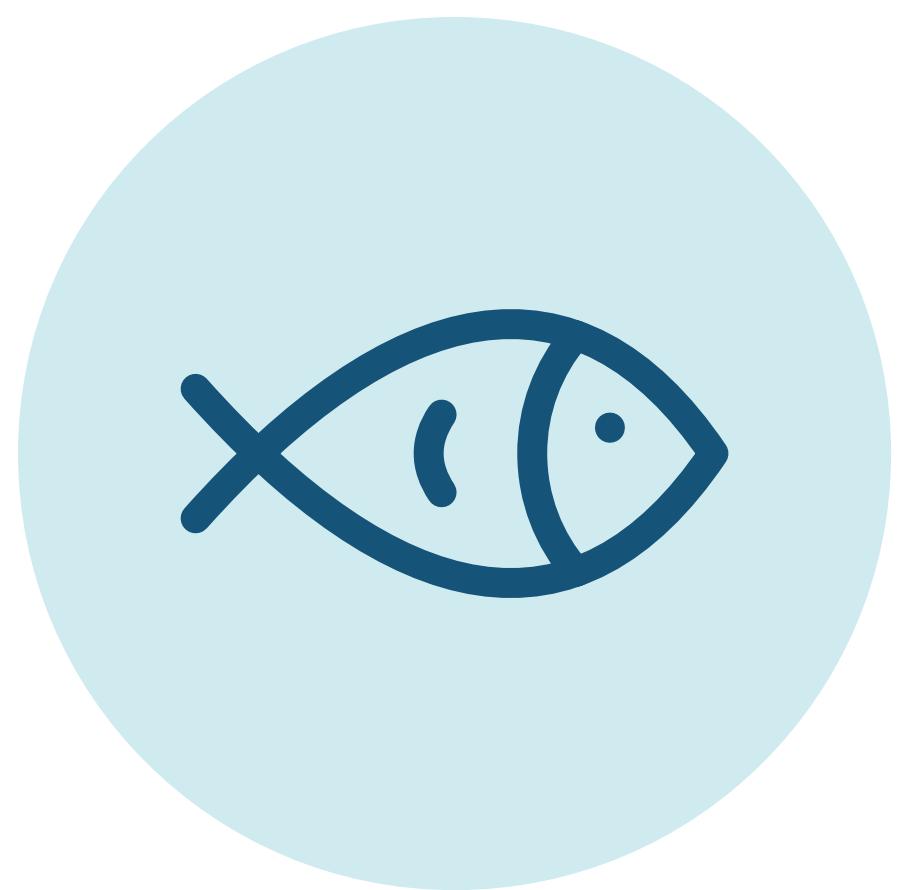
# Types of data

## Fishery-independent data:

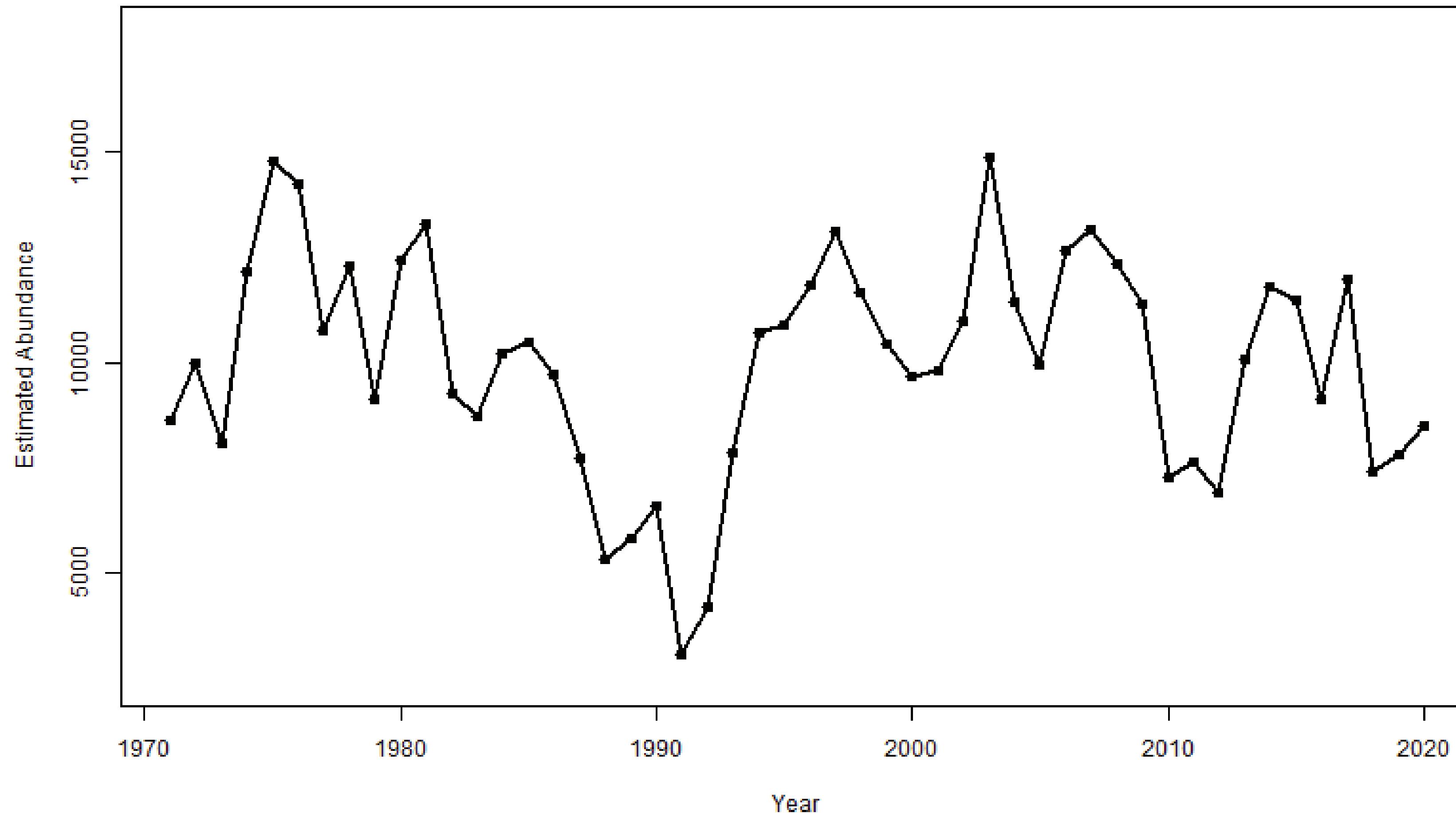
Research surveys including different types of fishing nets, hydro-acoustic arrays, videos, manual counting of spawning fish or carcasses, mark-recapture estimates, telemetry, fish tagging and many more.



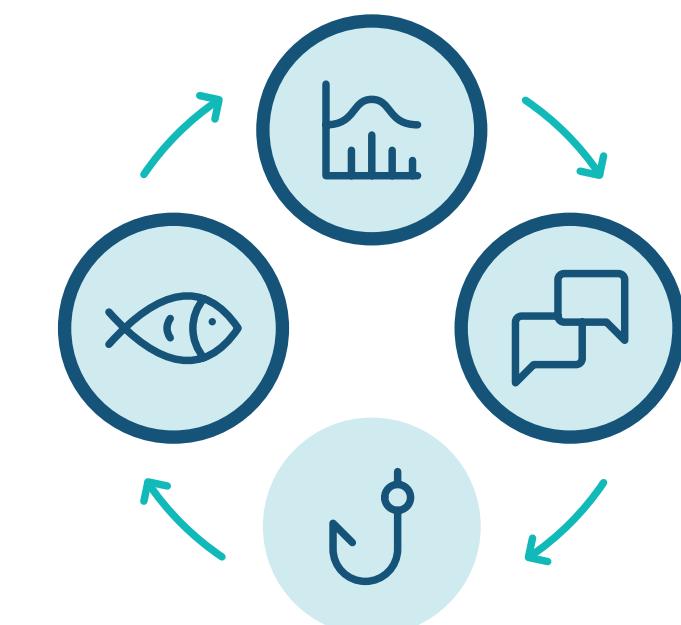
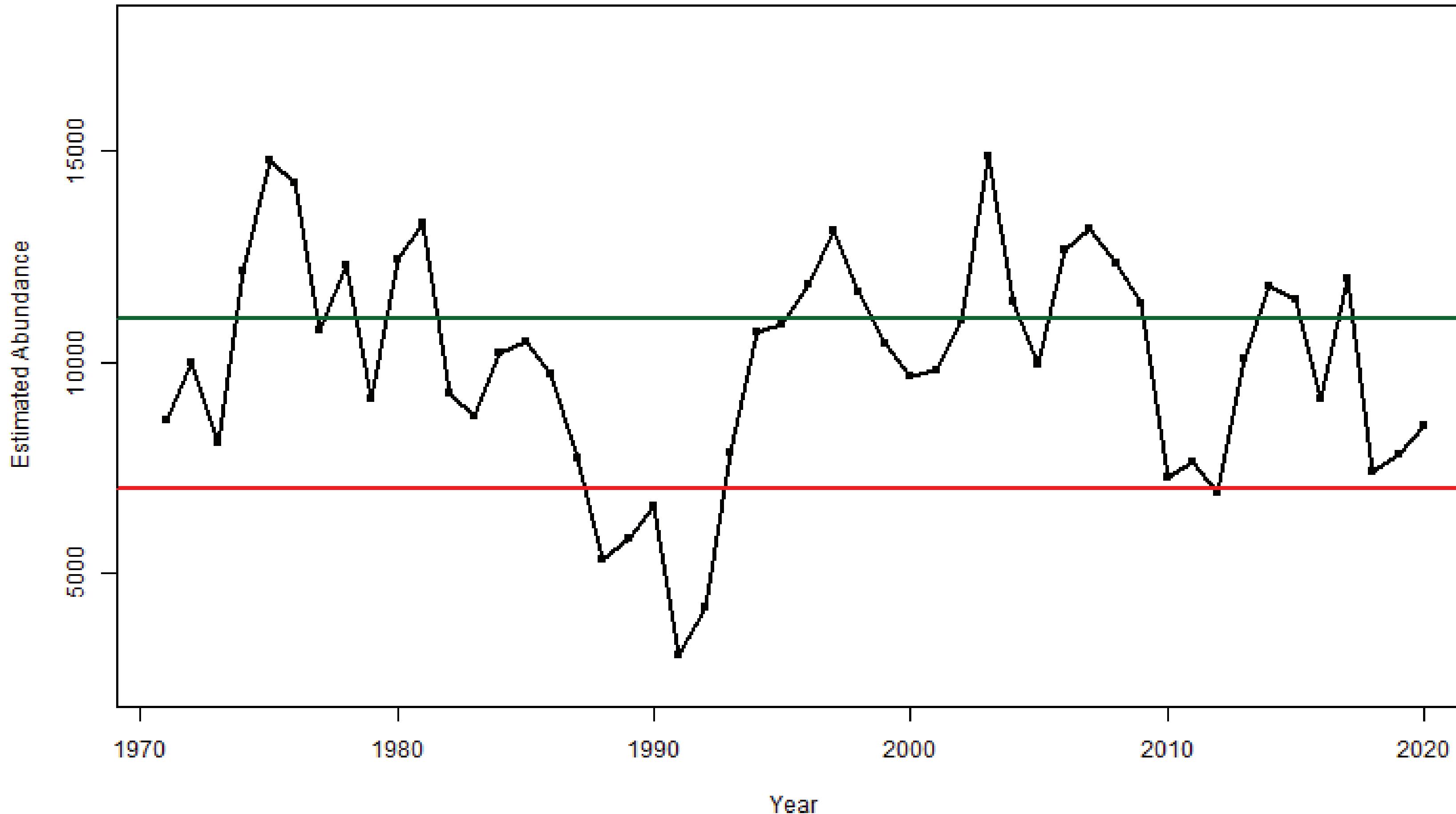
# Simple stock assessment example



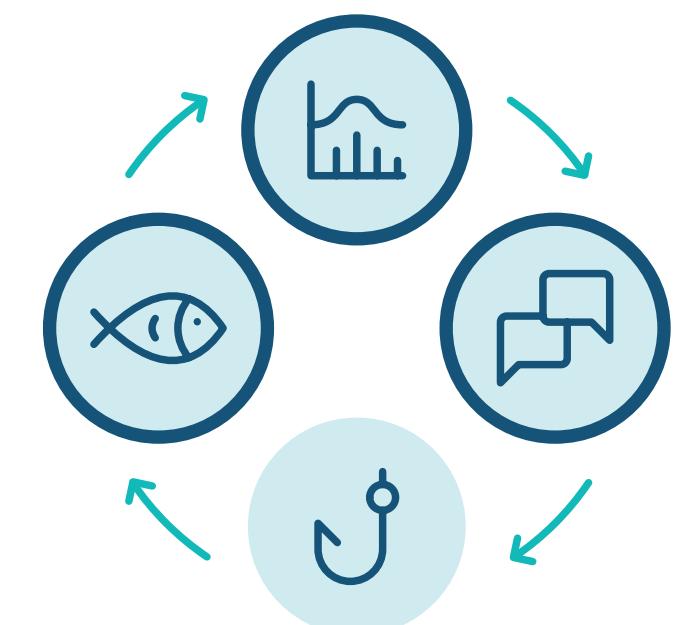
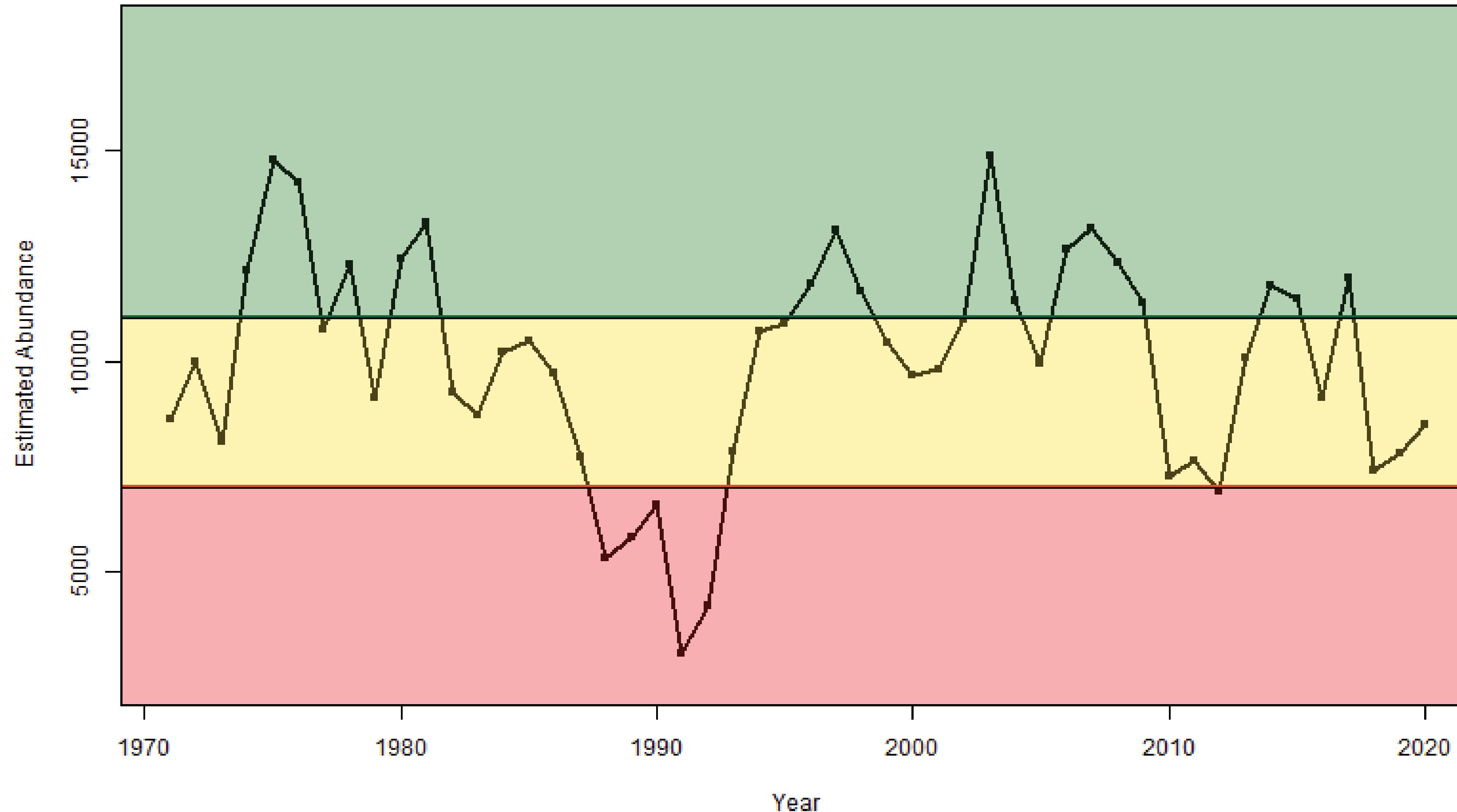
# Simple stock assessment example



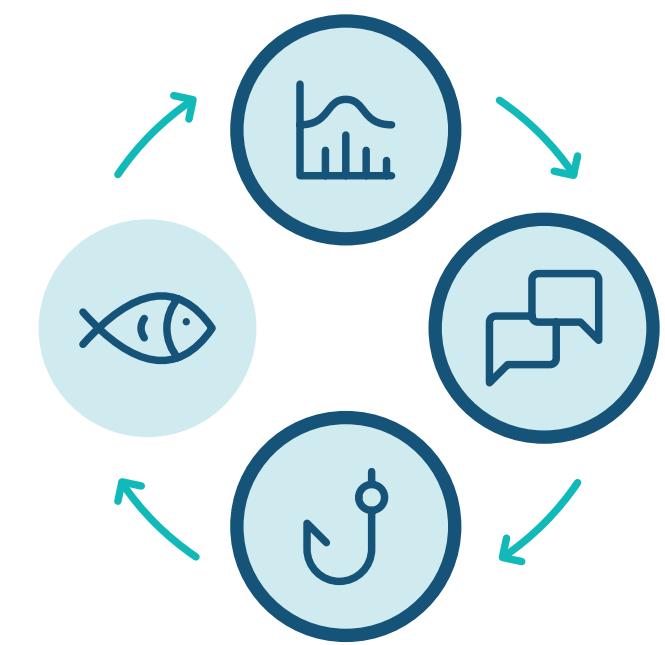
# Simple stock assessment example



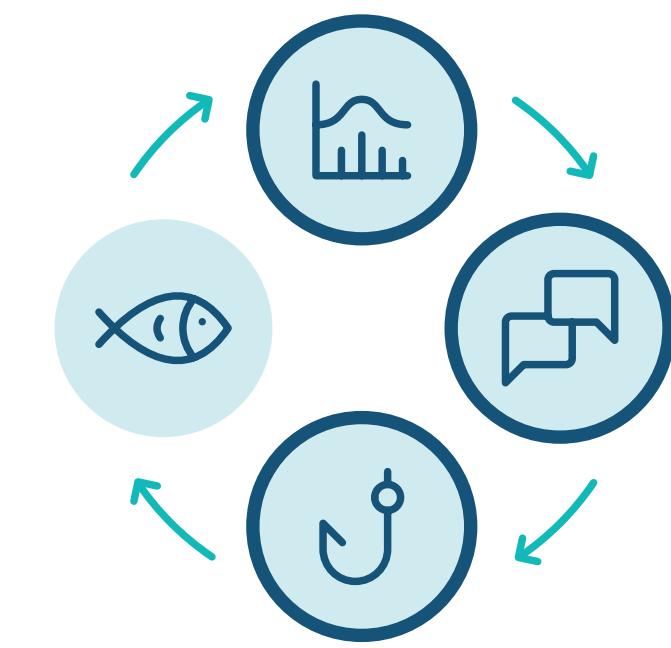
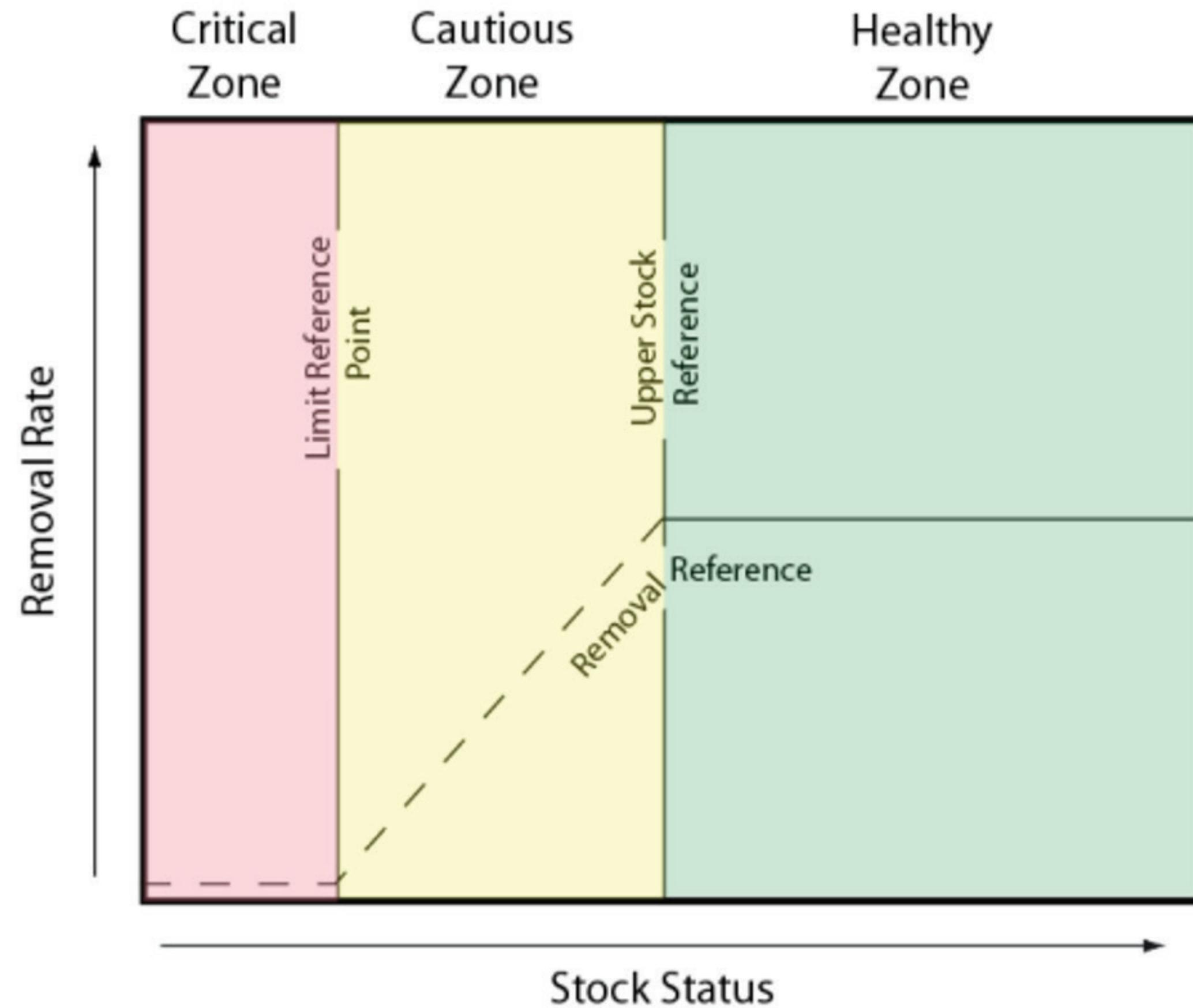
# Simple stock assessment example



# Stock assessment to fisheries planning

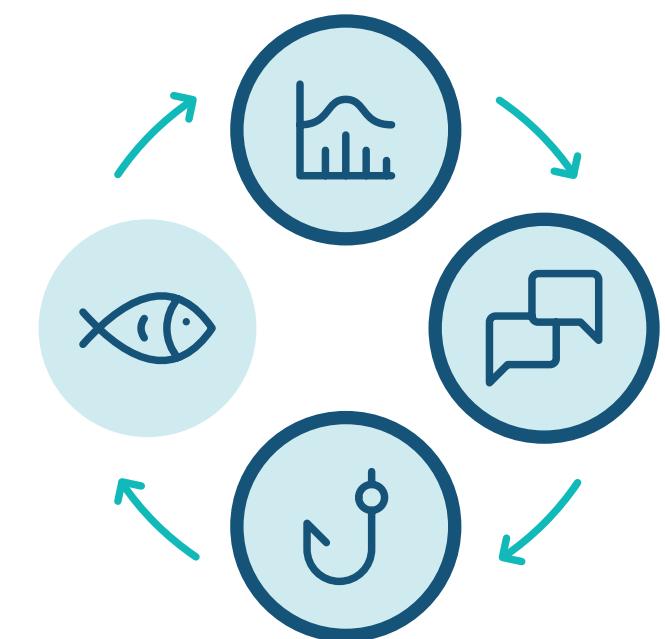


# DFOs sustainable fisheries framework

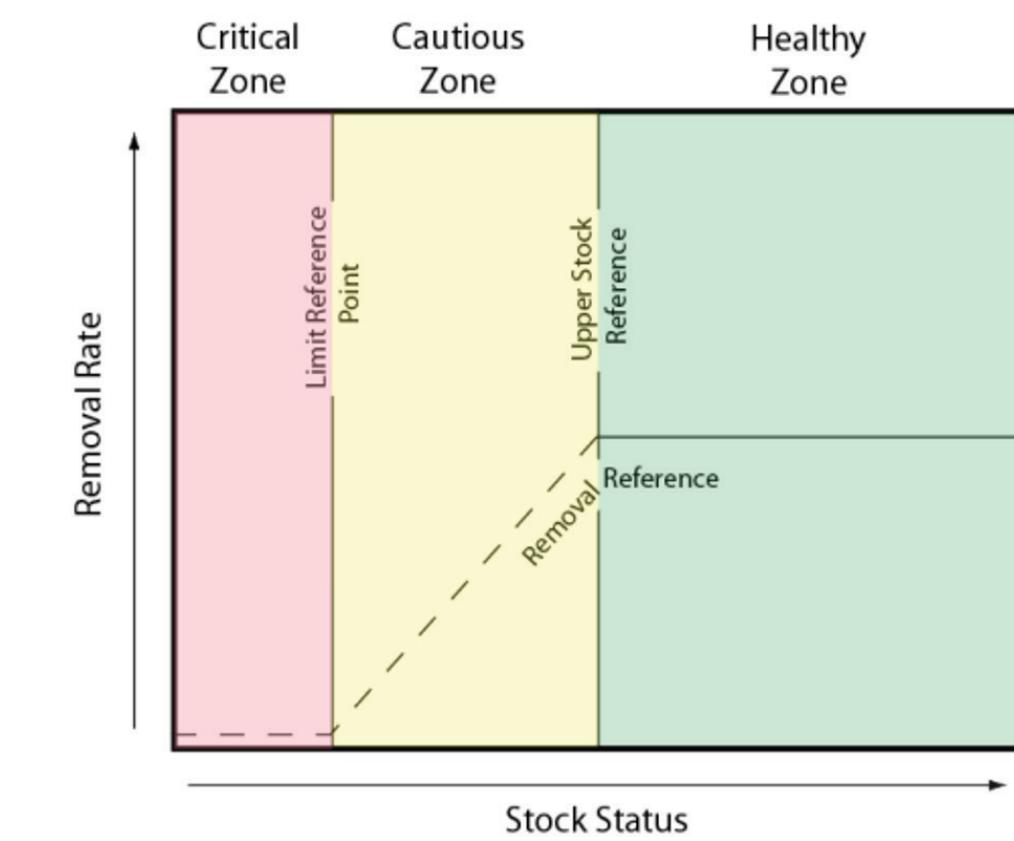
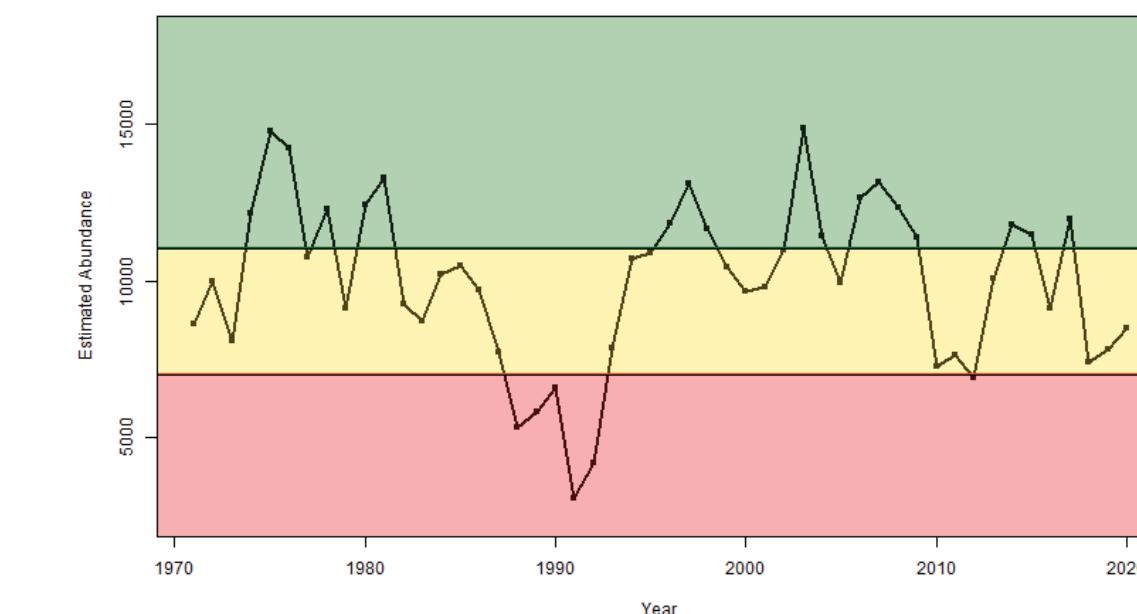
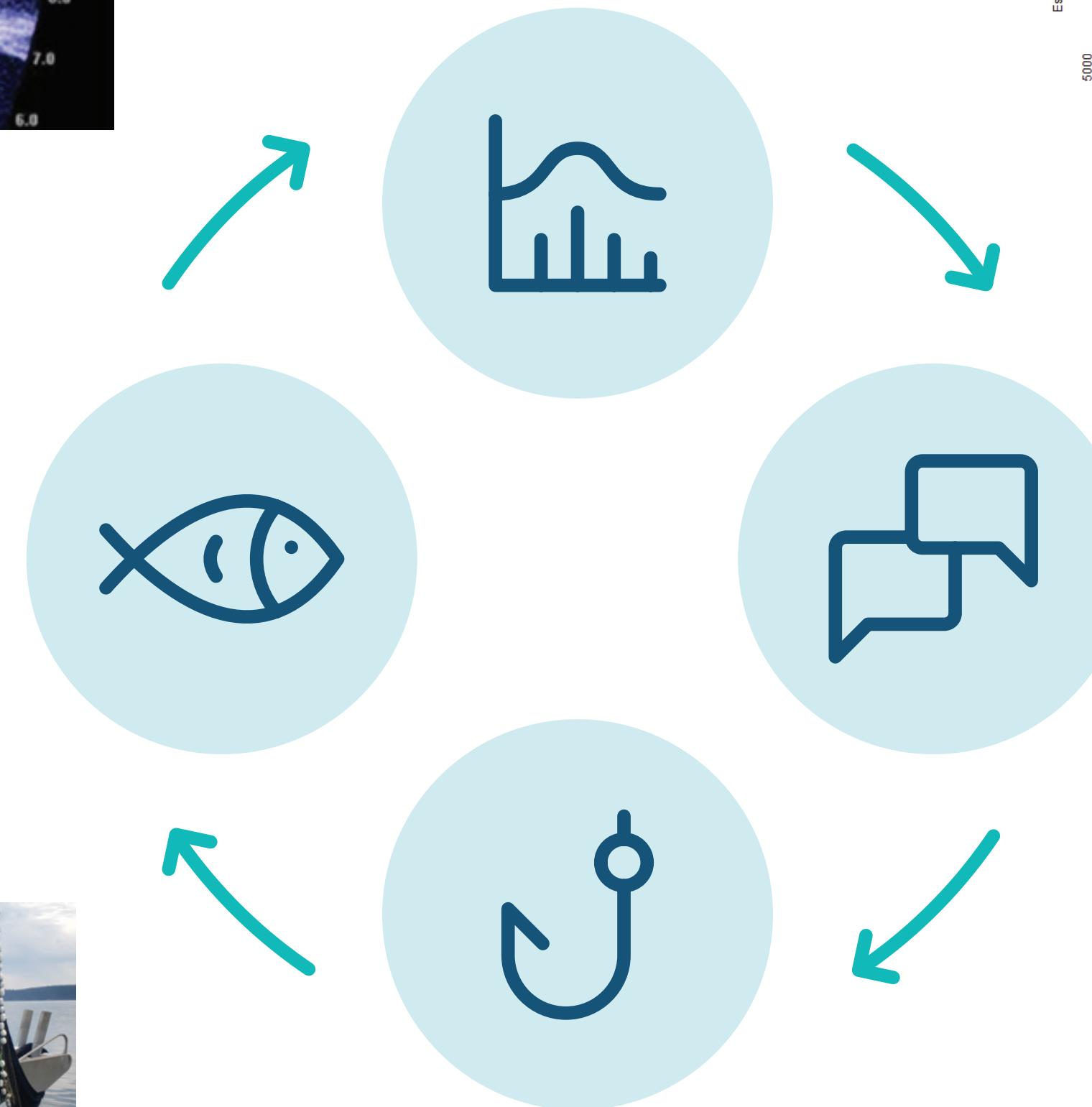
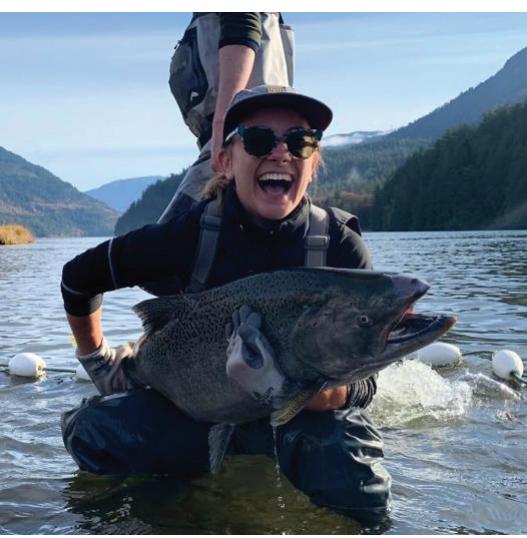
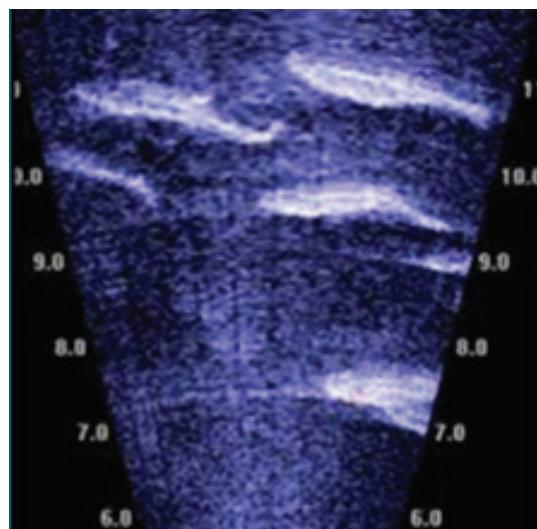


# **Amended Fisheries Act**

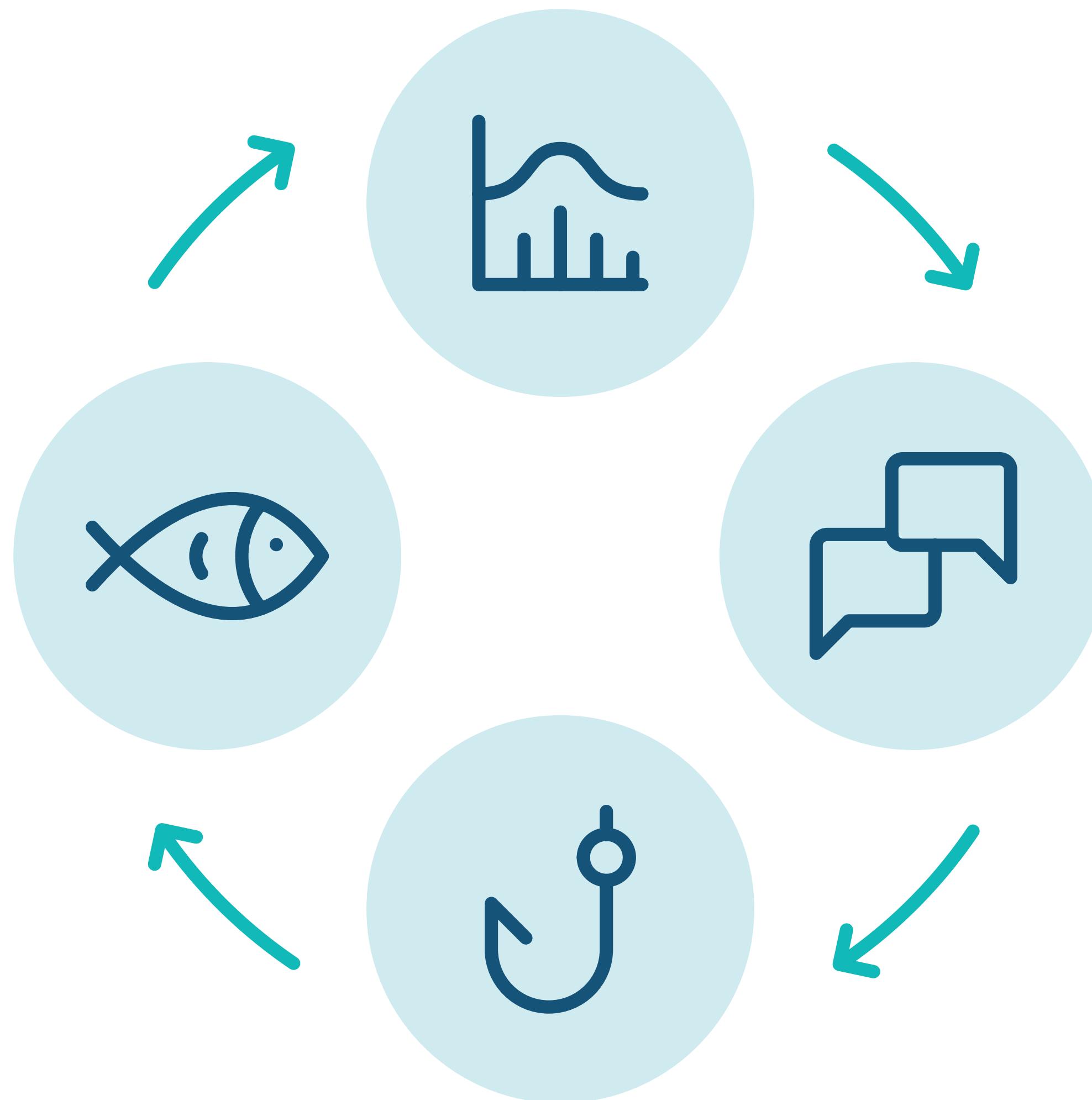
## **Fish stocks provisions**



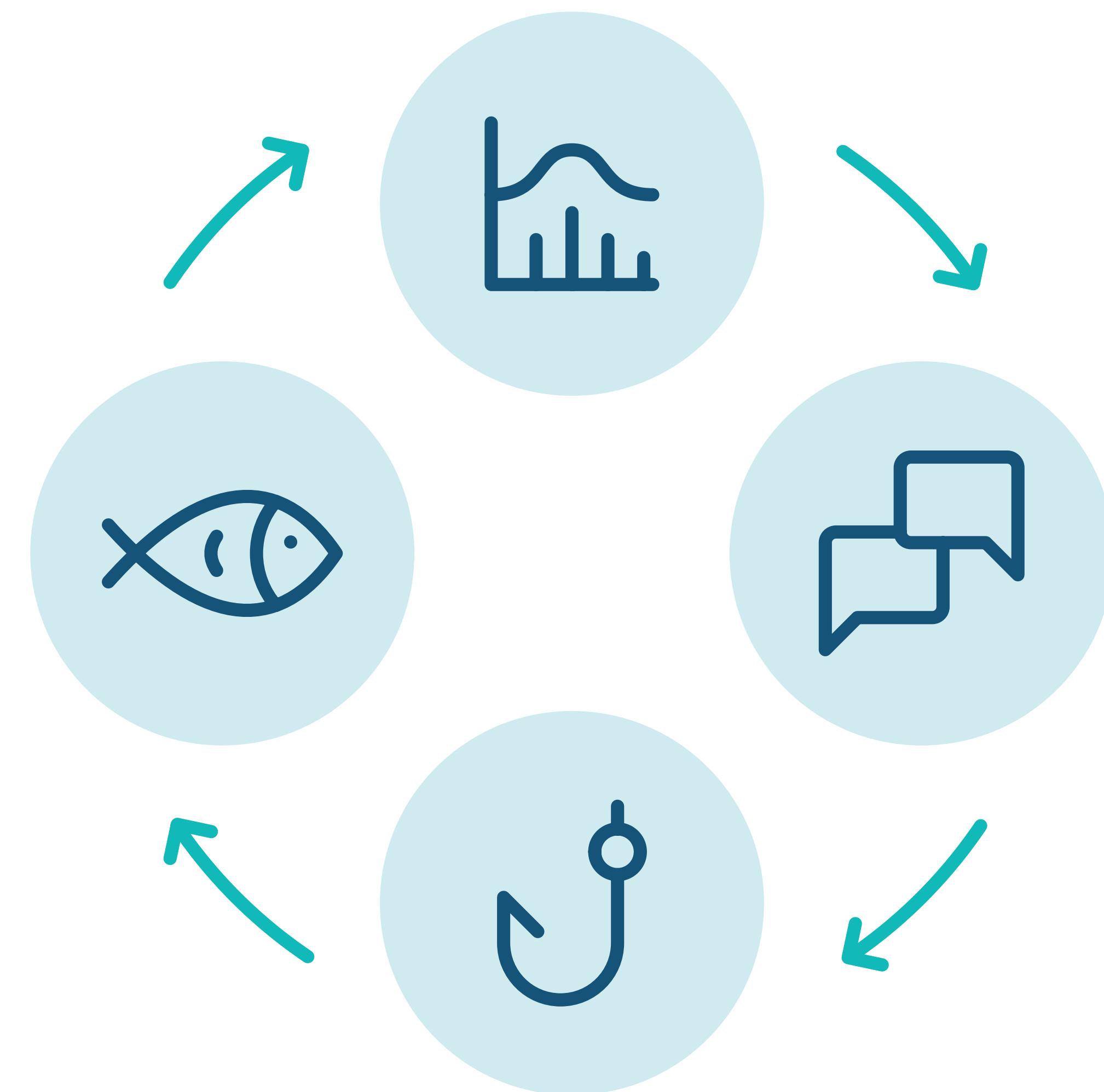
- Fish stocks must be managed at sustainable levels
- Stocks that fall below their lower reference point (LRP) require rebuilding plans
- LRP's should be adequately precautionary as to avoid serious harm



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

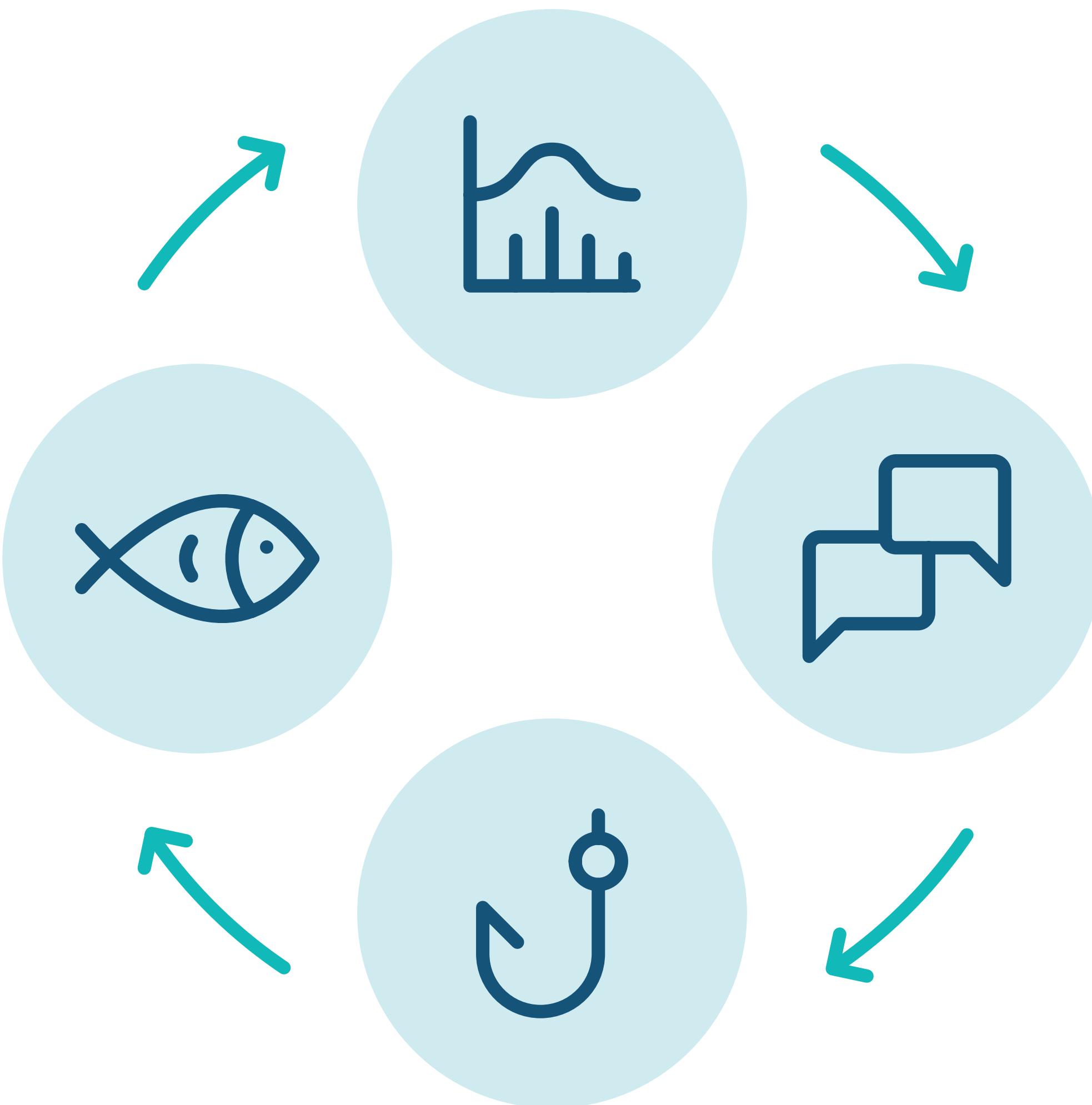


- Bias in data
- Missing data (weather, budget, pandemic)
- Stocks changing rapidly—unprecedented climate



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

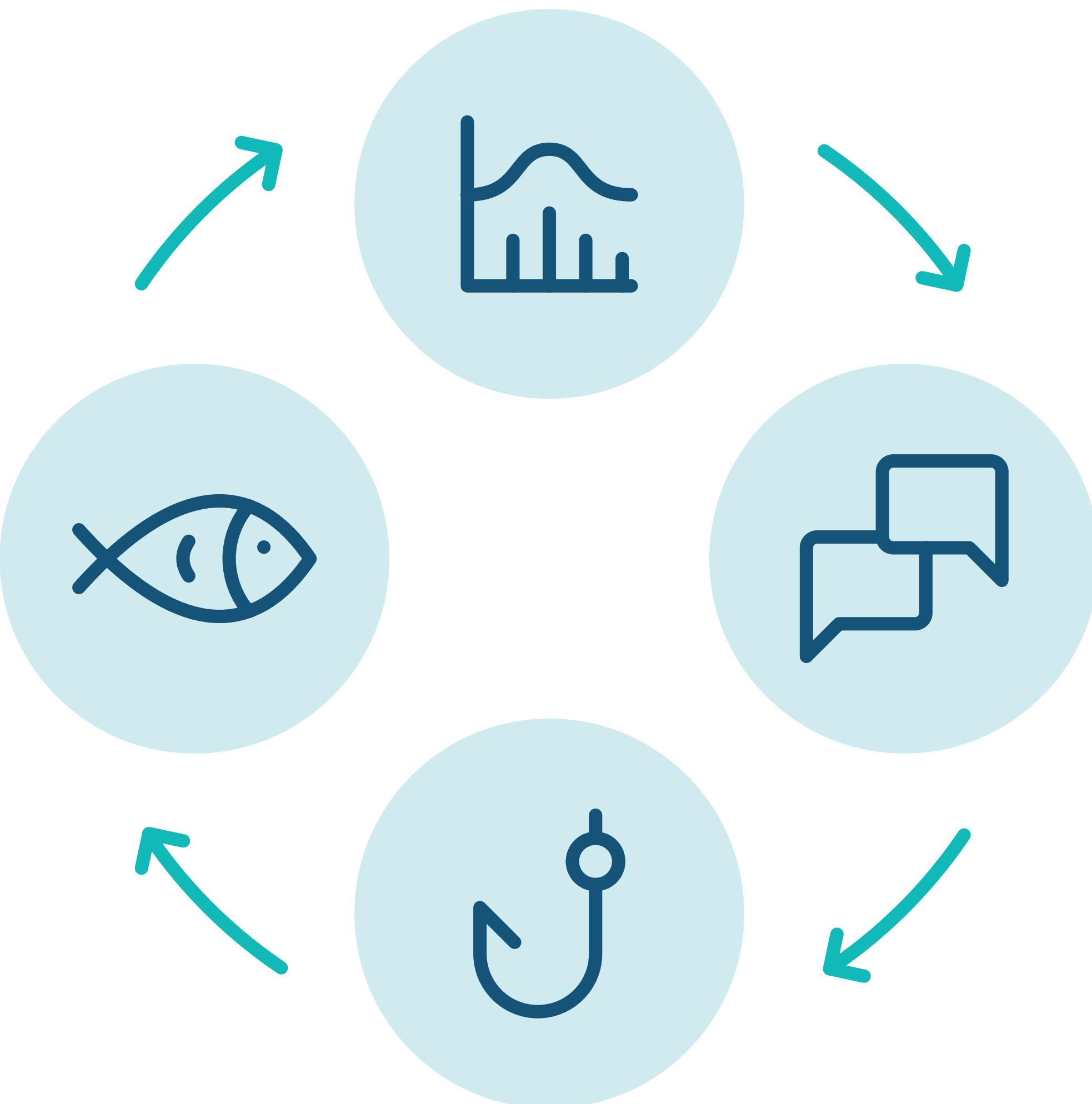
- Bias in data
- Missing data (weather, budget, pandemic)
- Stocks changing rapidly—unprecedented climate



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

- Outside influences weighed against science
- Conflicting objectives

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

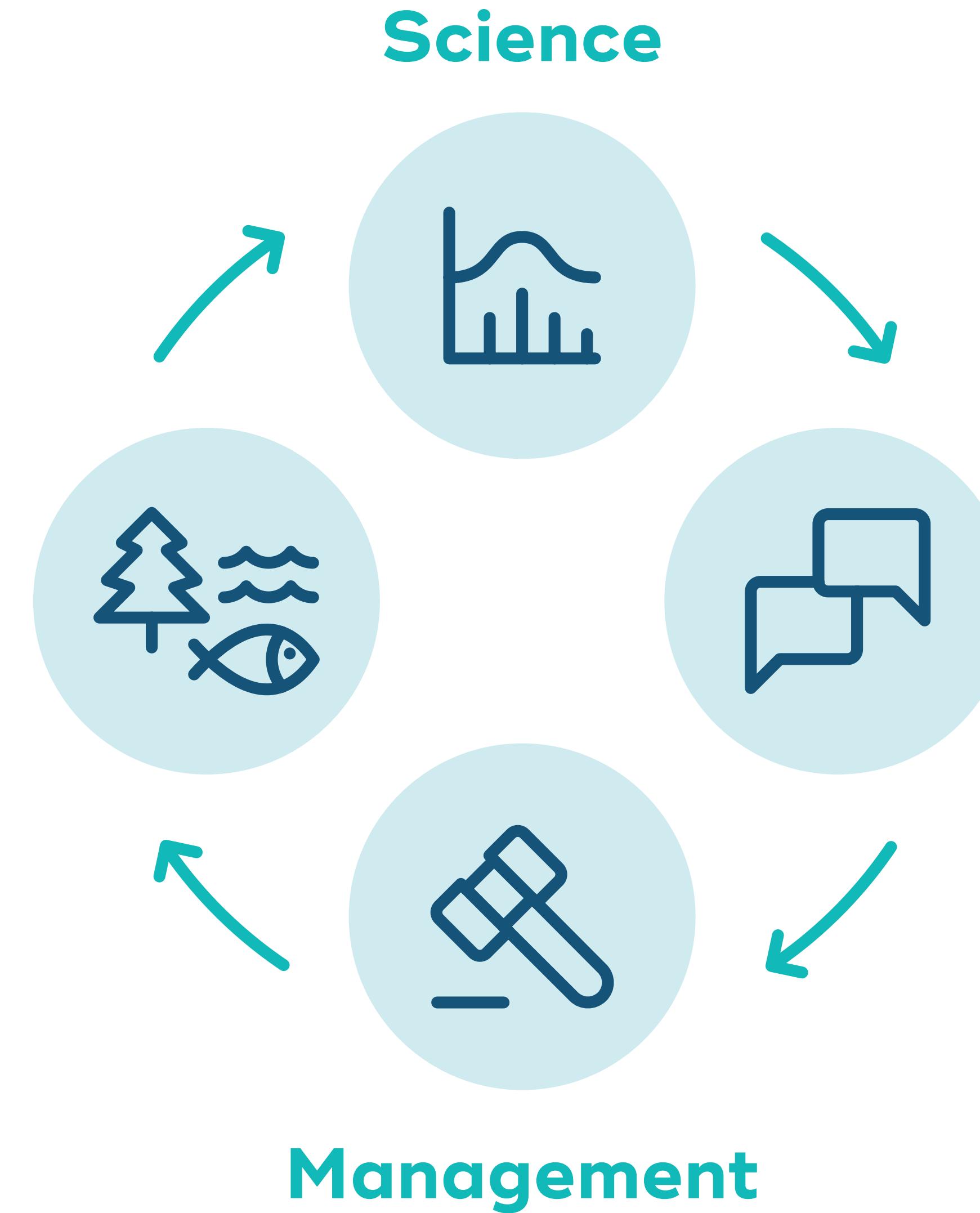


- Imperfect application of regulations

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

- 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.

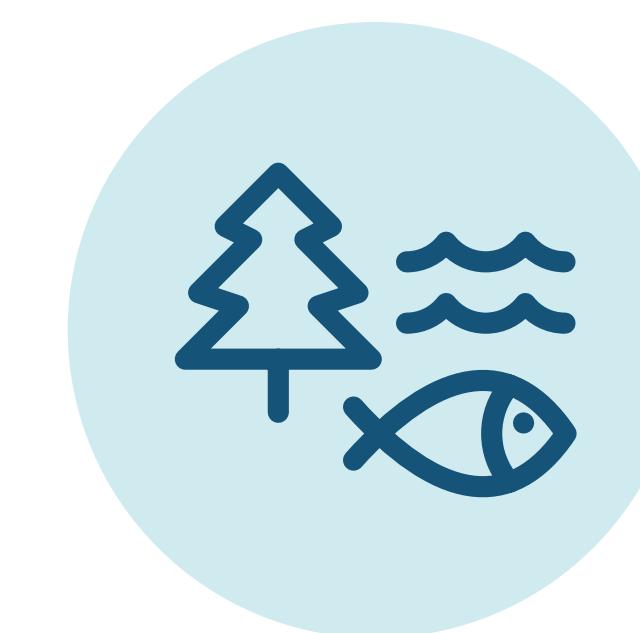
Identify one challenge for each link, that could cause management to break down

**2 minutes alone**

**4 minutes pair**

**4 minutes foursome**

Science



Management

# 1-2-4-All

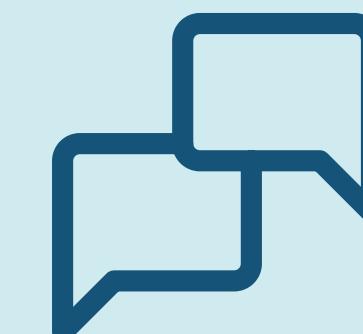
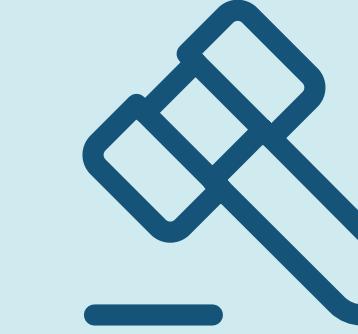
**Any different challenges than ones I identified?**

**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?**

**Science**



**Management**

# 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**.



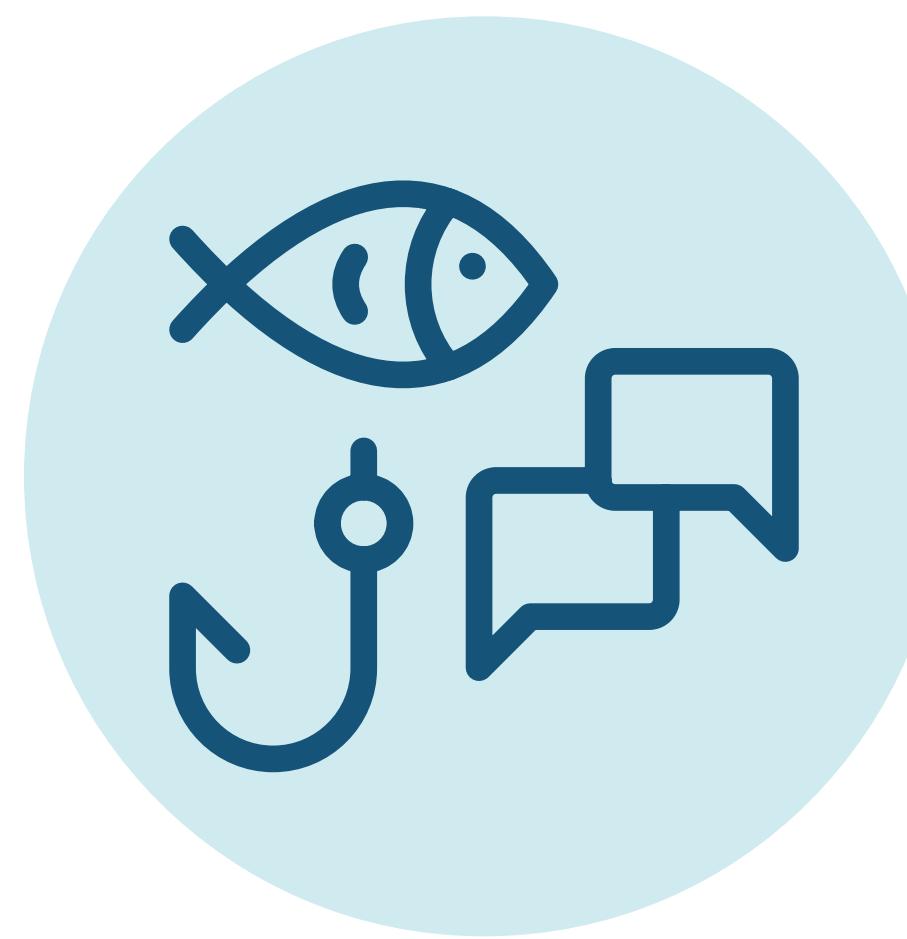


# Management strategy evaluation

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

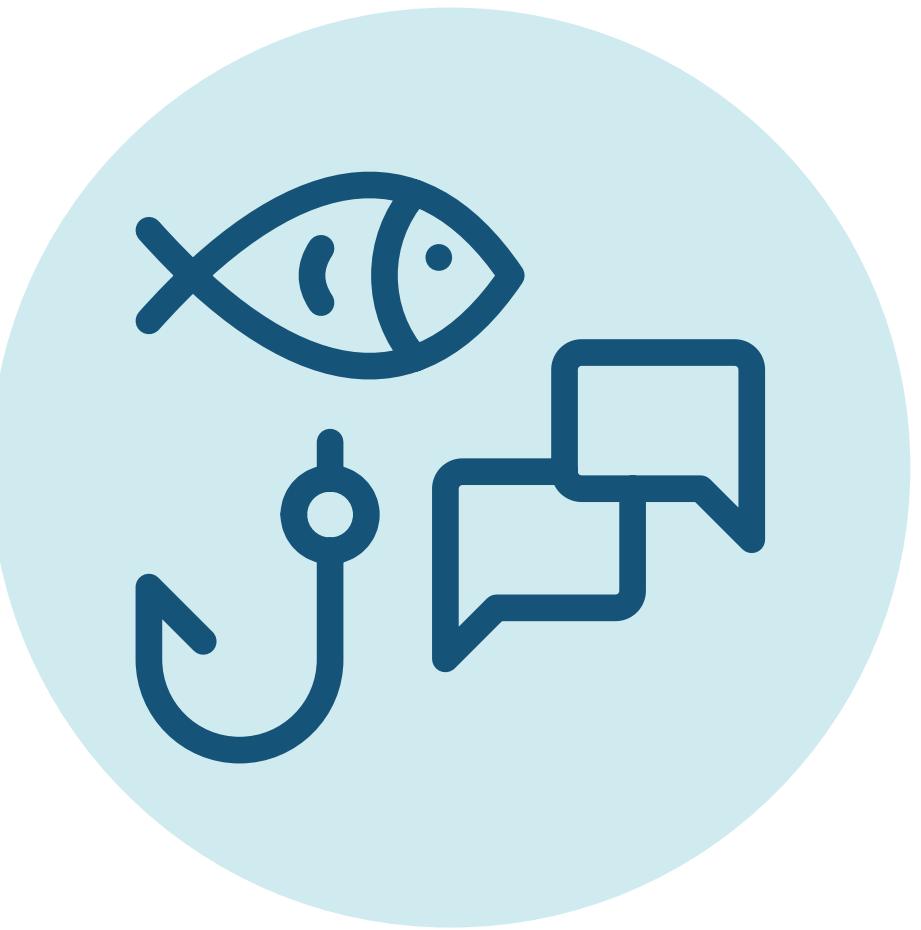
Recreational/sport fishery interest groups, Indigenous groups, conservation NGOs, commercial fisheries representatives



# What information do we need?

## Population dynamics

- Stock assessment data & models



## Fishery dynamics

- Catch information
- Fleet dynamics

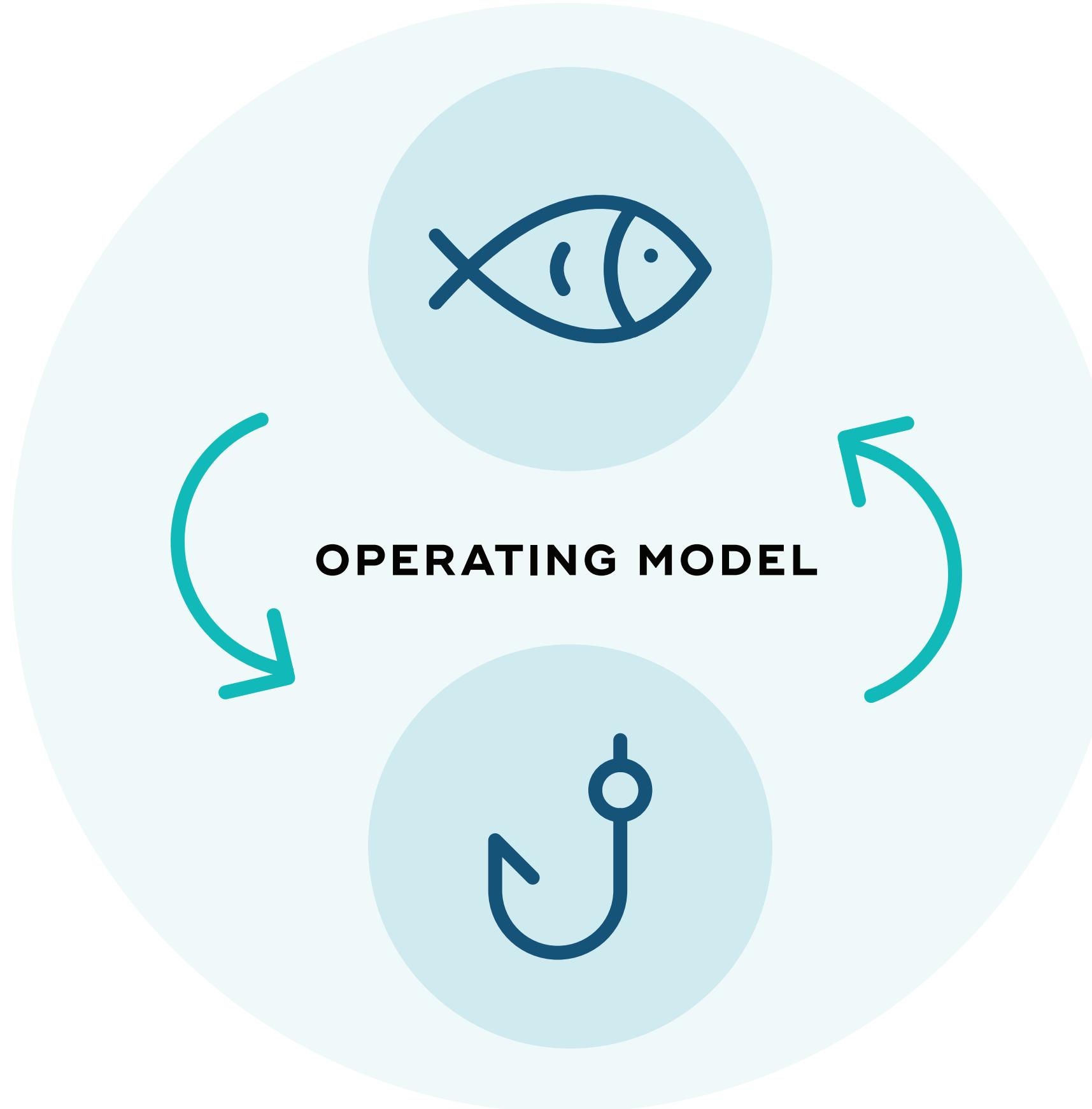


## Management objectives (examples)

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

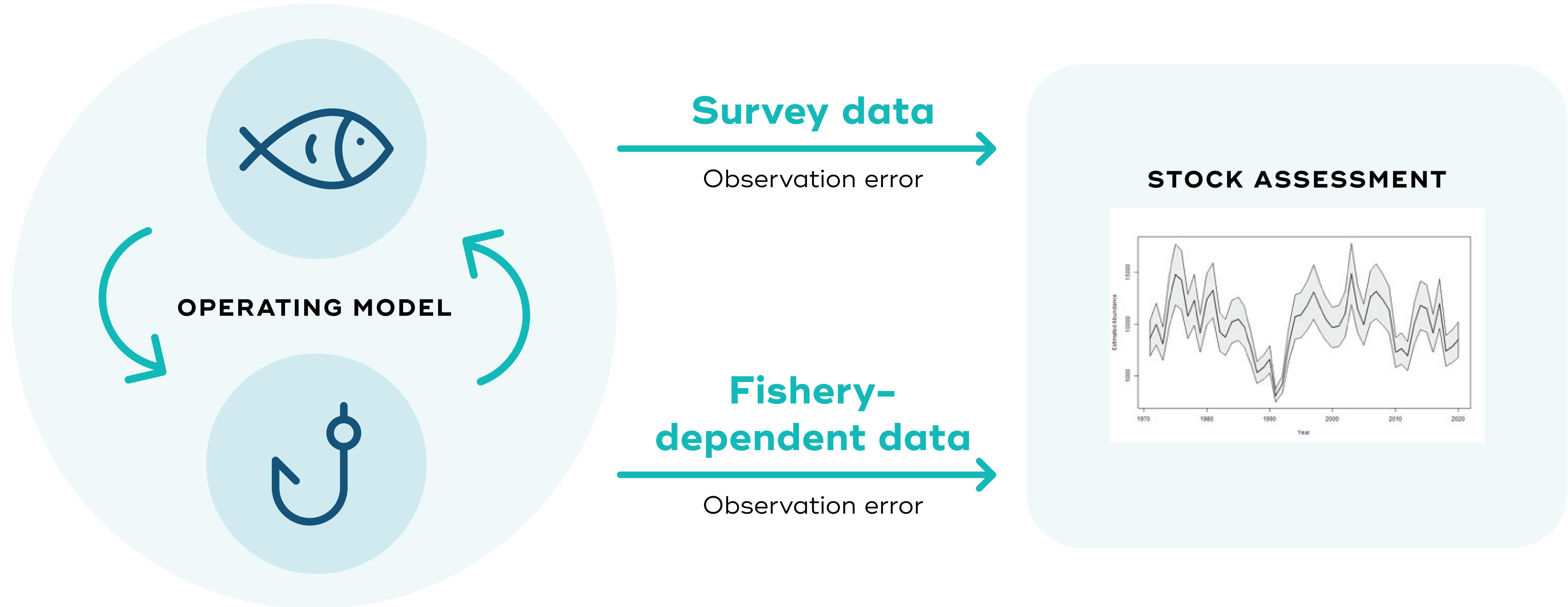


# Closed-loop simulations



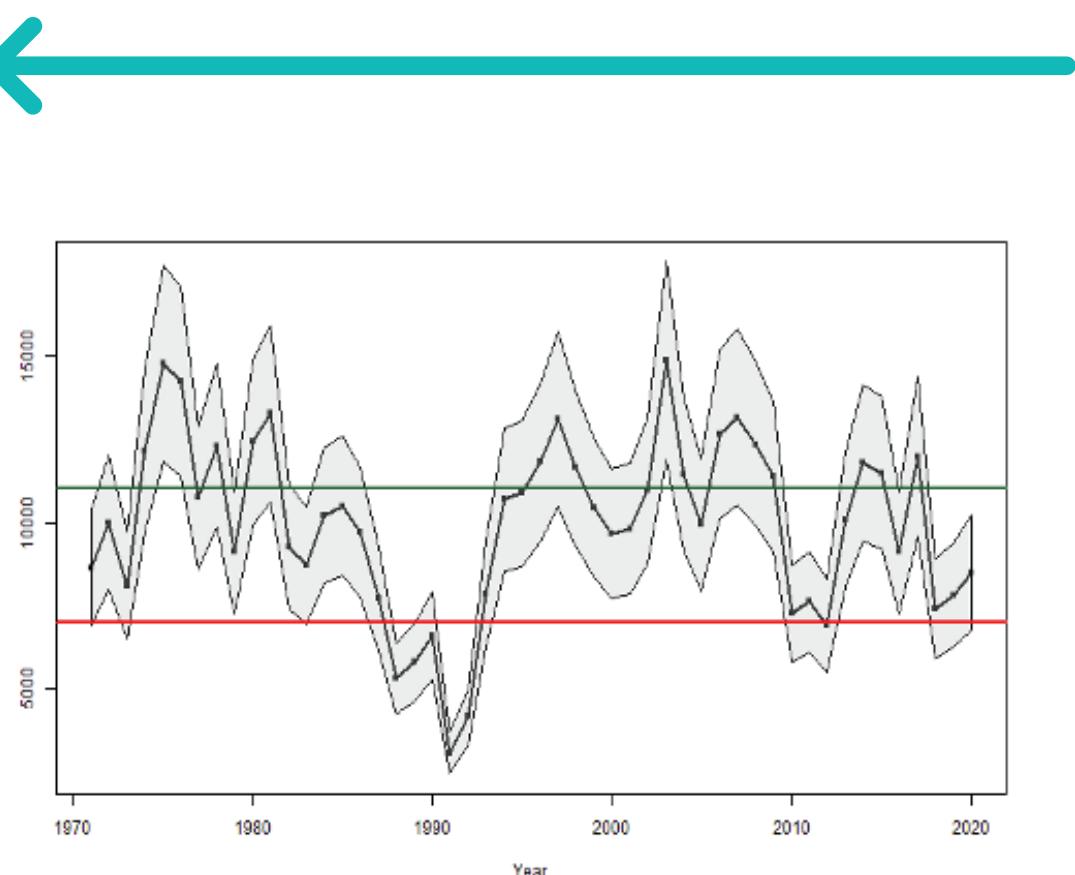
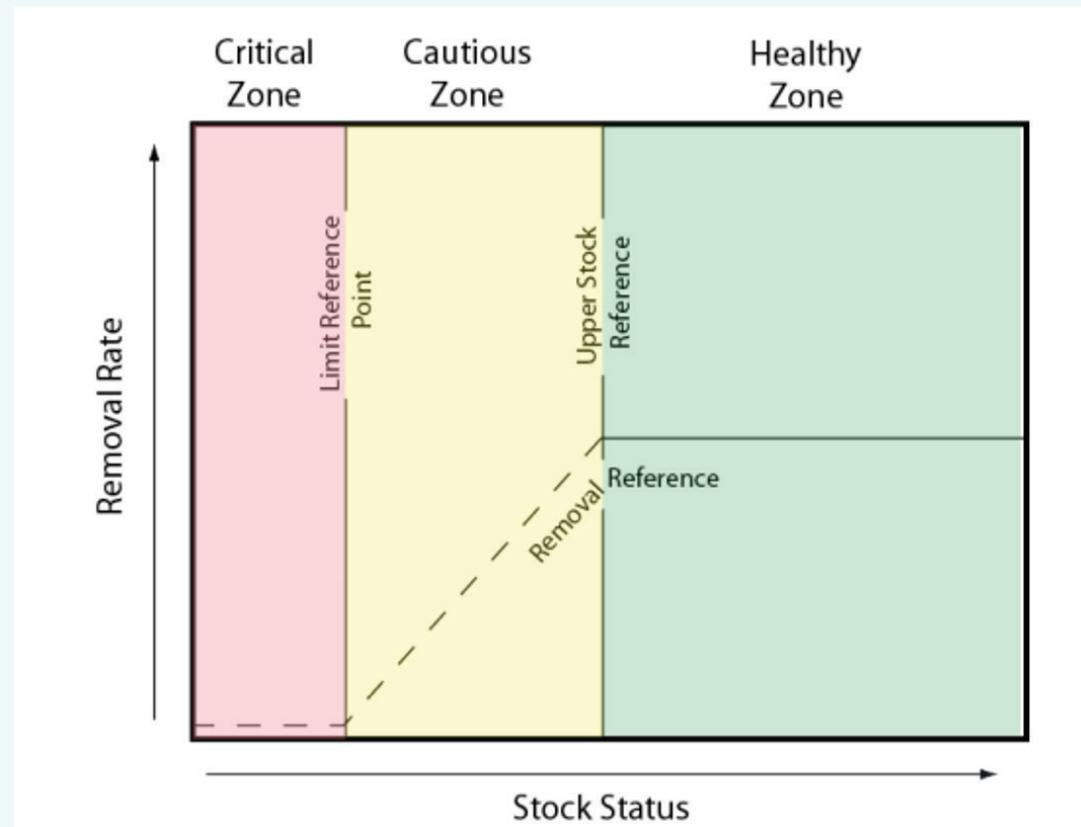
- The “true” abundance of the stock, and “true” catch of the fishery is simulated forward
- This is where the “forecasting” happens at each time step

# Closed-loop simulations

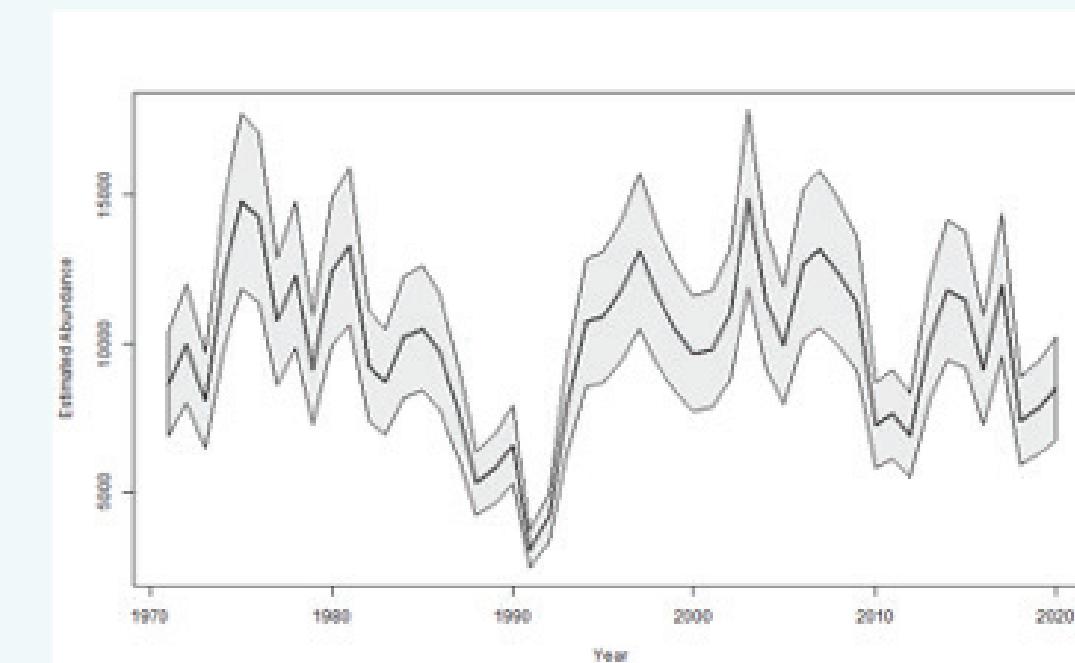


# Closed-loop simulations

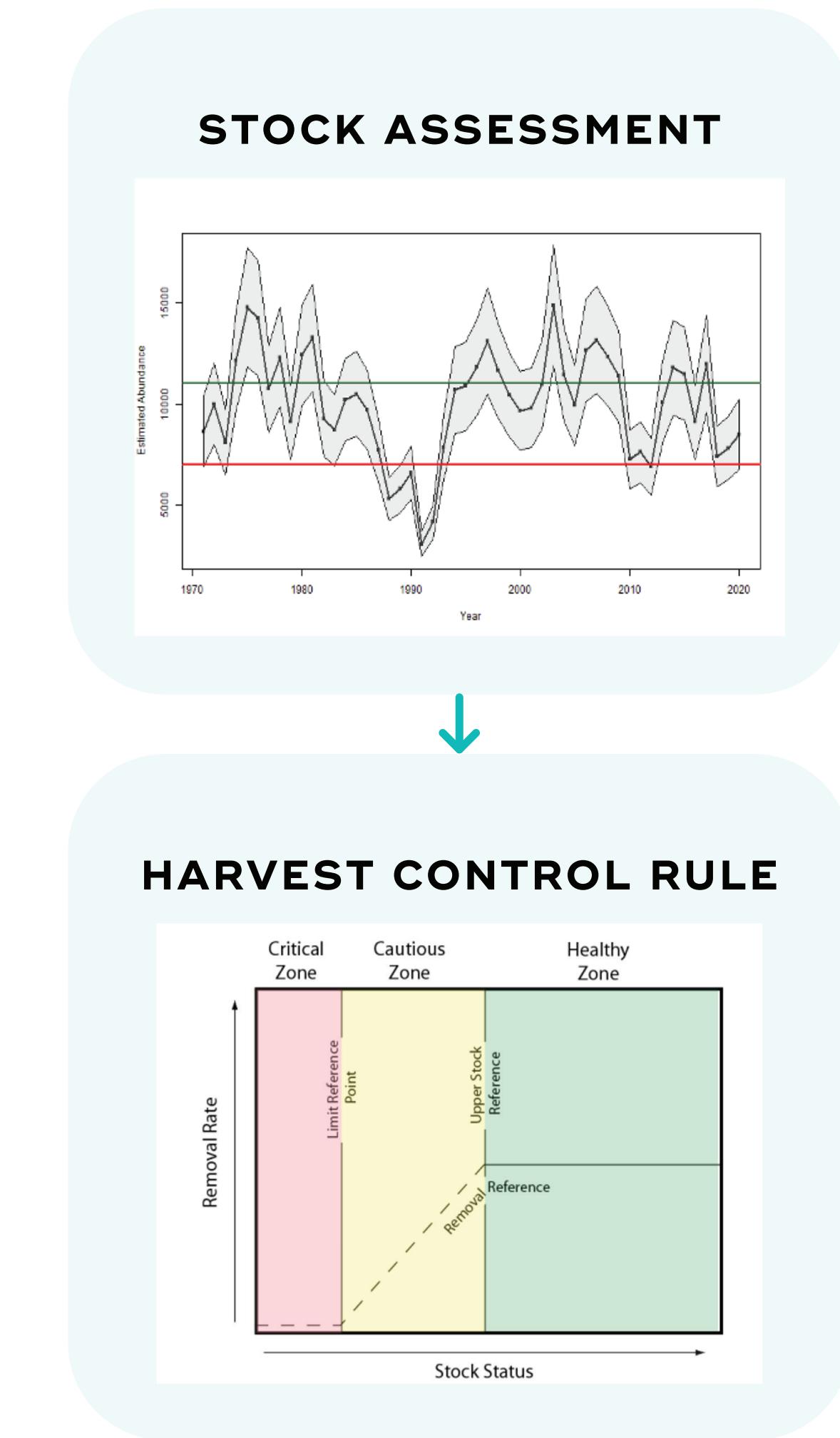
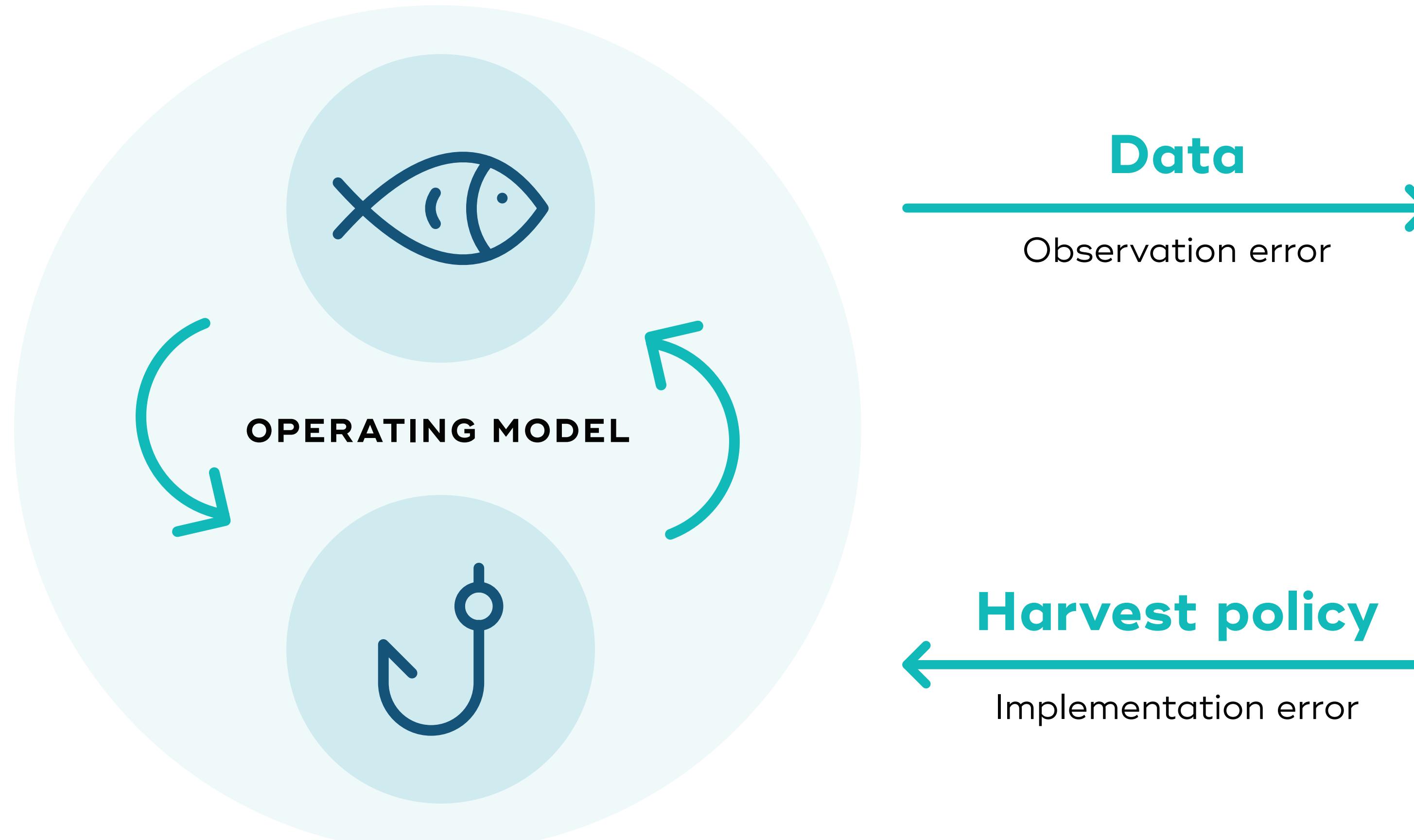
## HARVEST CONTROL RULE

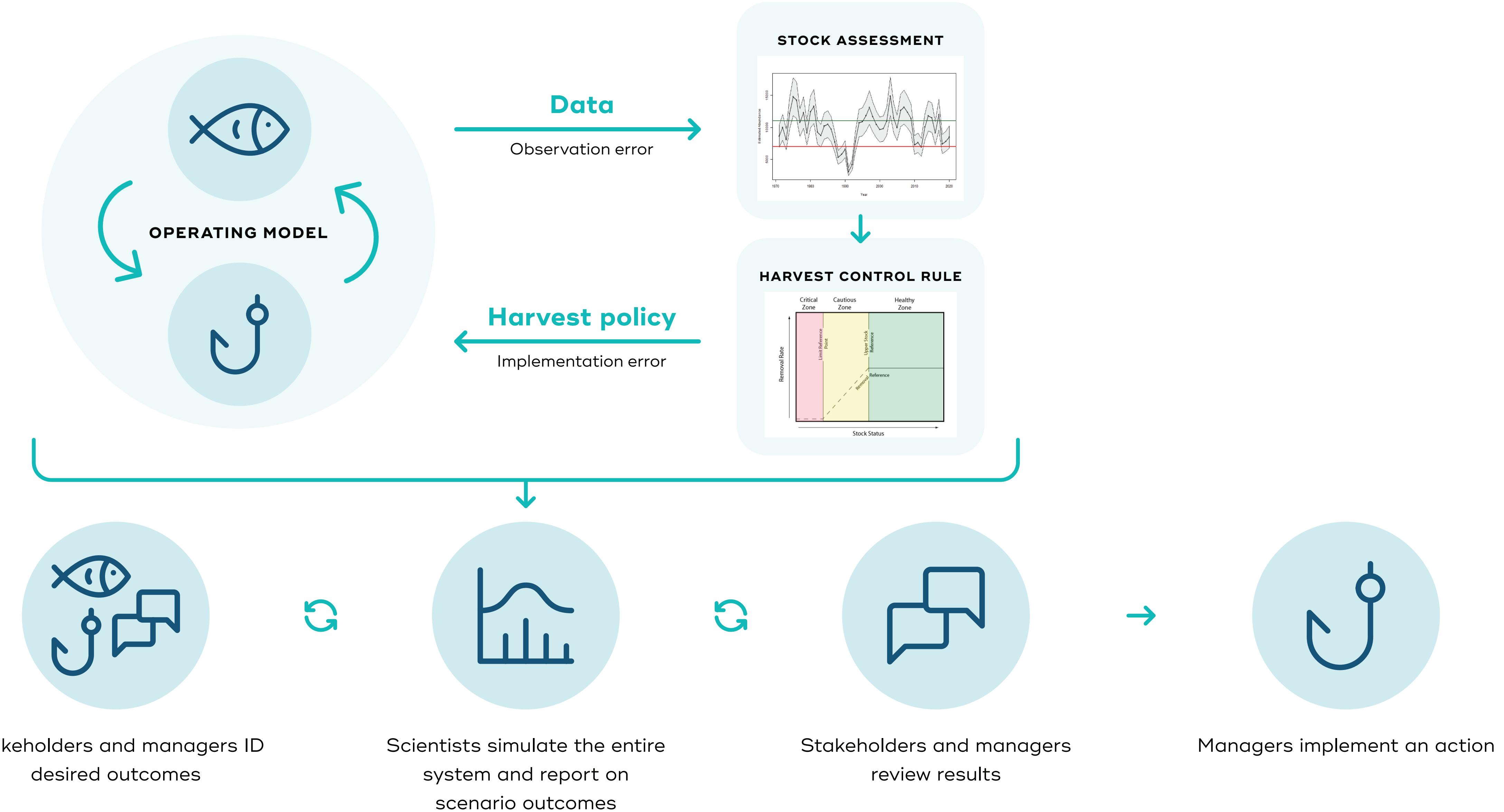


## STOCK ASSESSMENT

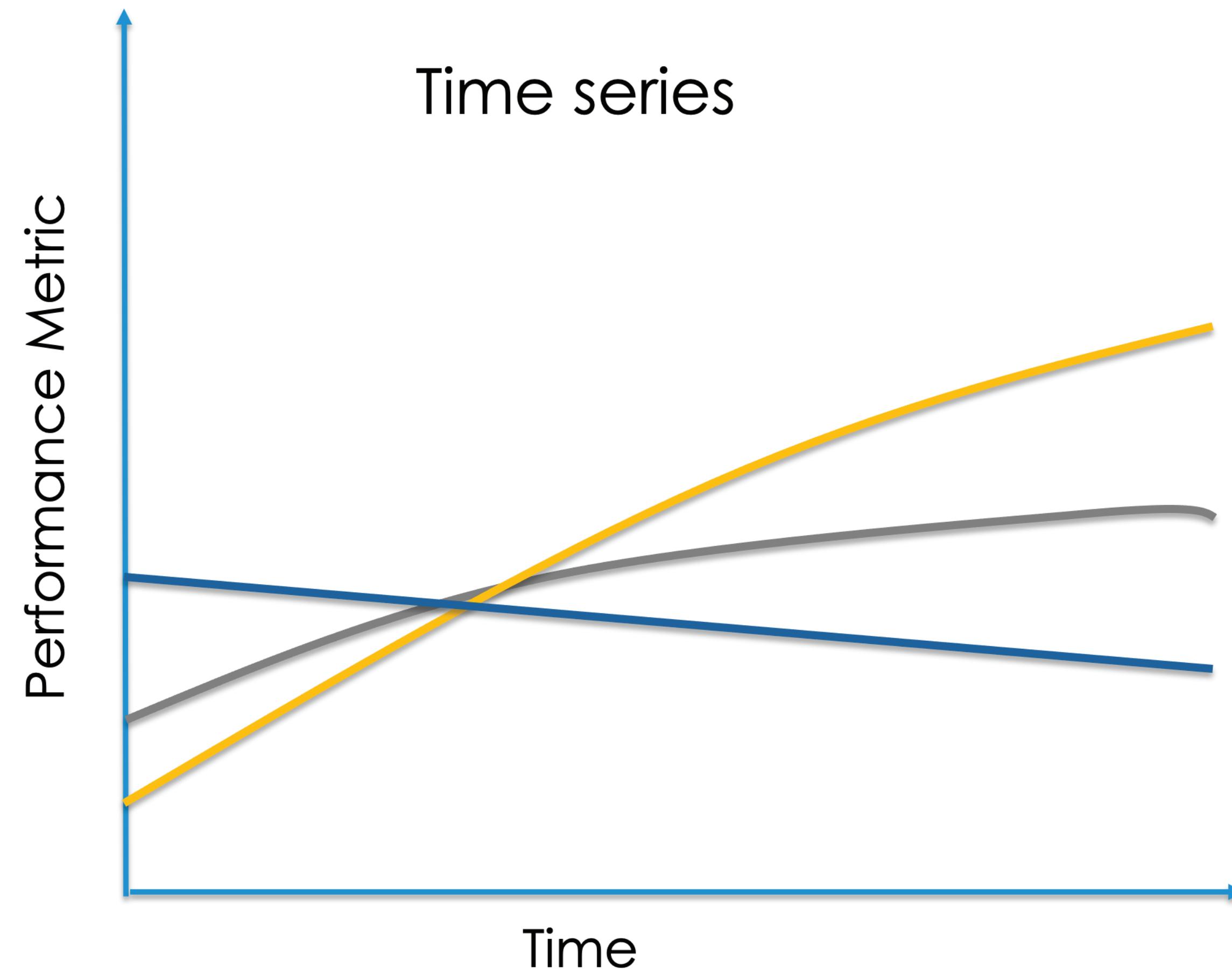


# Closed-loop simulations

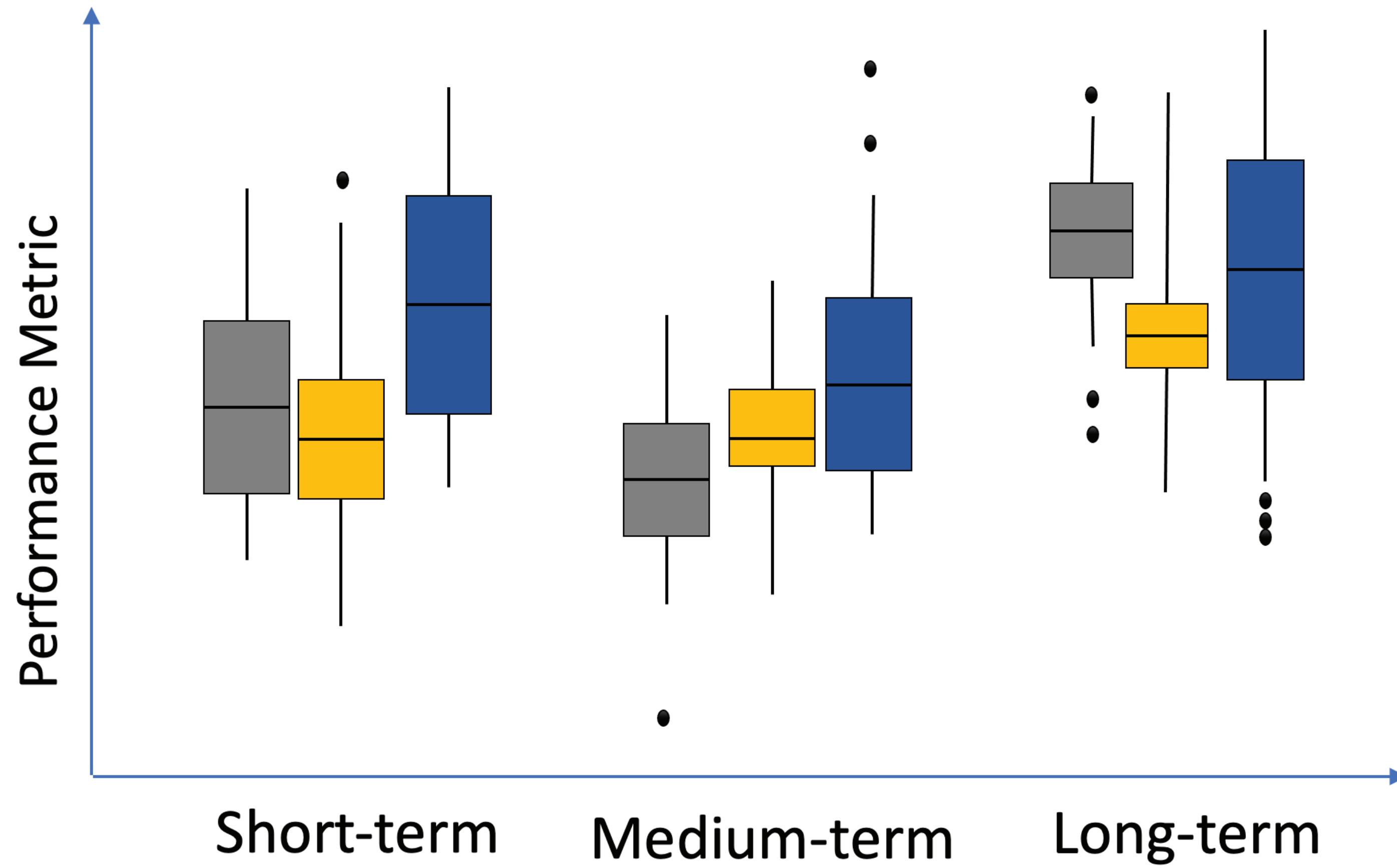




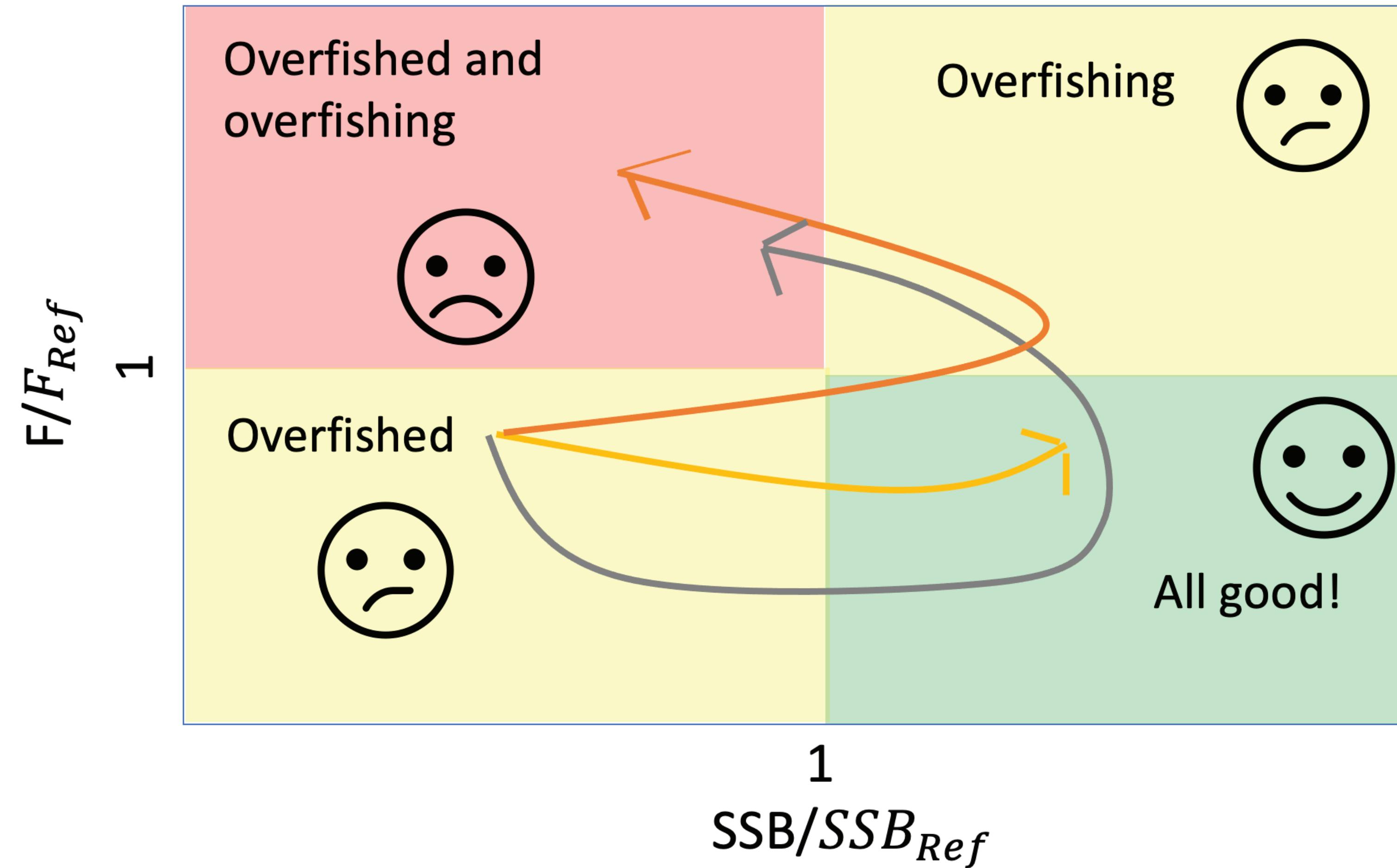
# Performance metrics



# What do outputs look like?



# Kobe plot



# Weighing objectives

**Healthy ecosystems**

**Food security**

**High catch**

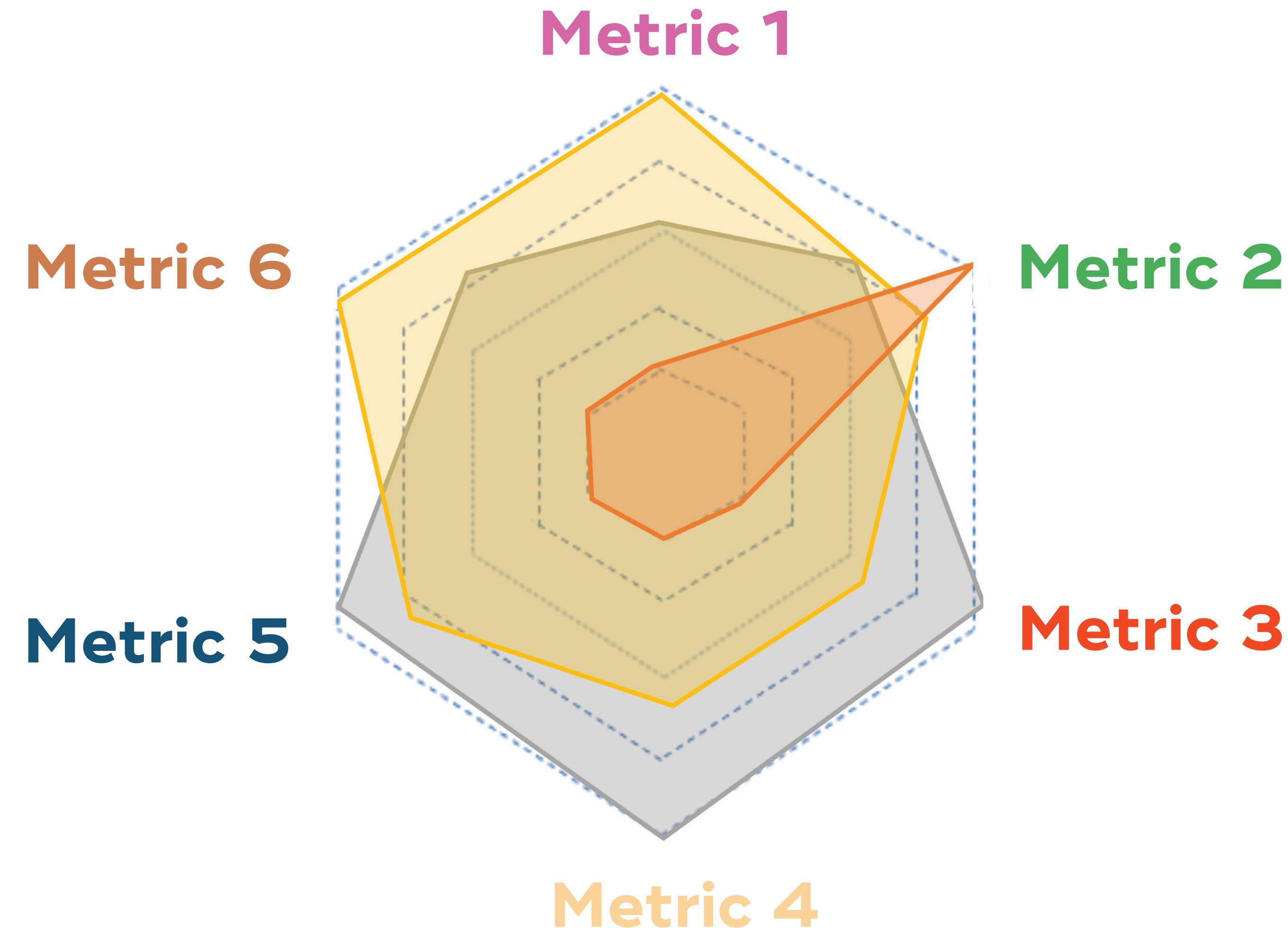


**Healthy fish stocks**

**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](https://shinyapps.io))**

## Specifications

**Stock:**

Georges Bank cod ▾

**Stock assessment uncertainty:**

High uncertainty ▾

**Stock assessment biomass estimation bias:**

No bias ▾

**Climate scenario:**

Off ▾

Harvest control rule

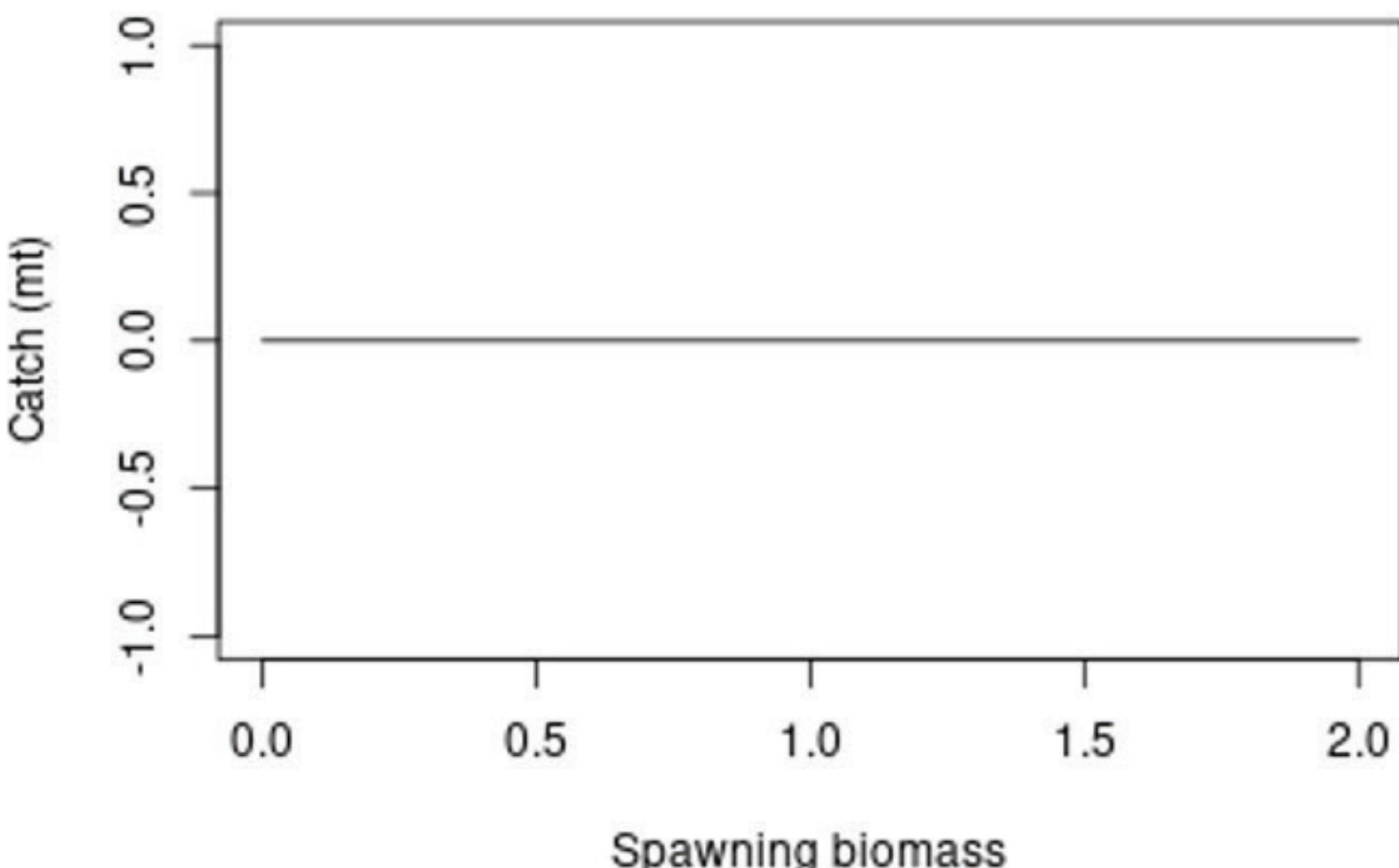
Type of harvest control  
rule:

Constant catch ▾

Catch (mt)

0

### Harvest Control Rule

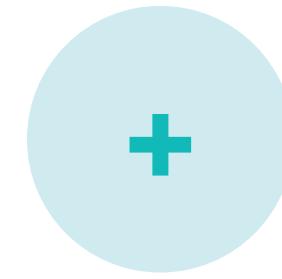


Do projections

# Comparison 1

Compare constant catch at 0 and 3000mt, do the results make sense?

Omt constant catch



3000mt constant catch

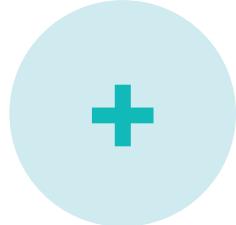
# Comparison 2

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

Omt constant catch

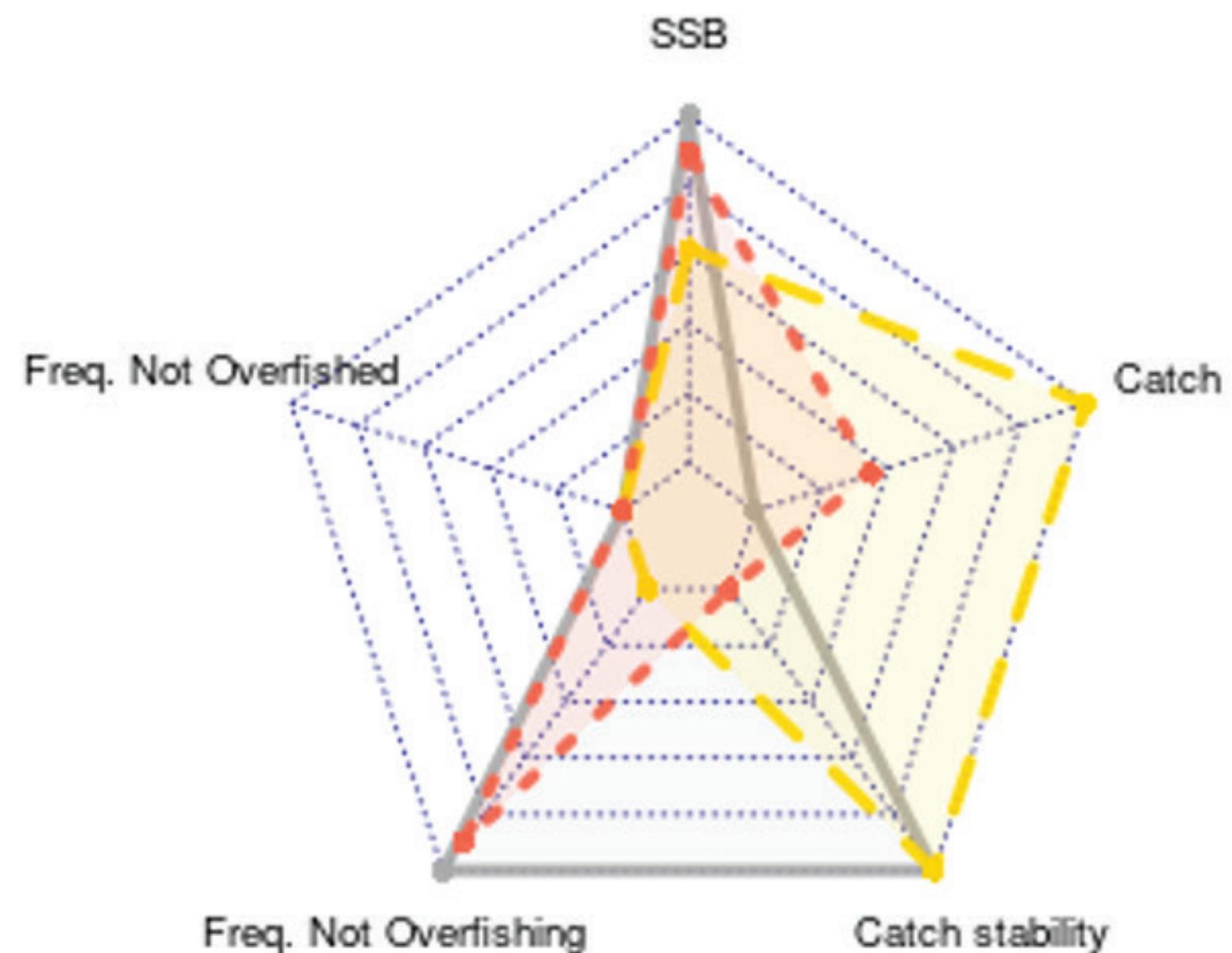


3000mt constant catch



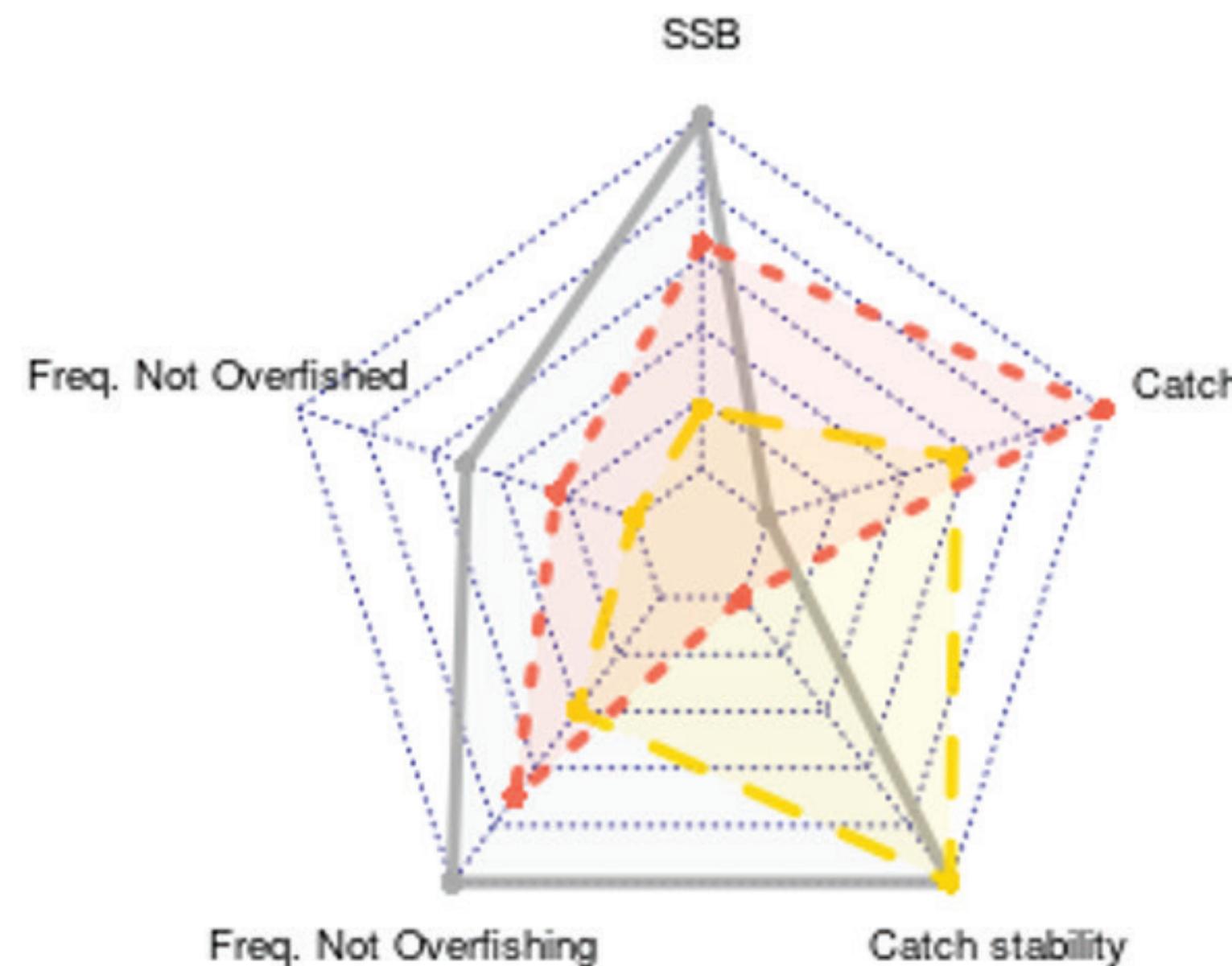
Ramped catch

## Short-term



## Long-term

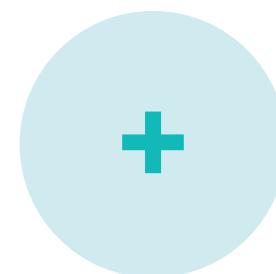
- Constant catch 0 mt no bias
- Constant catch 3000 mt no bias
- Ramped 1 no bias



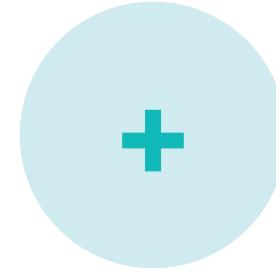
# Comparison 3

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**

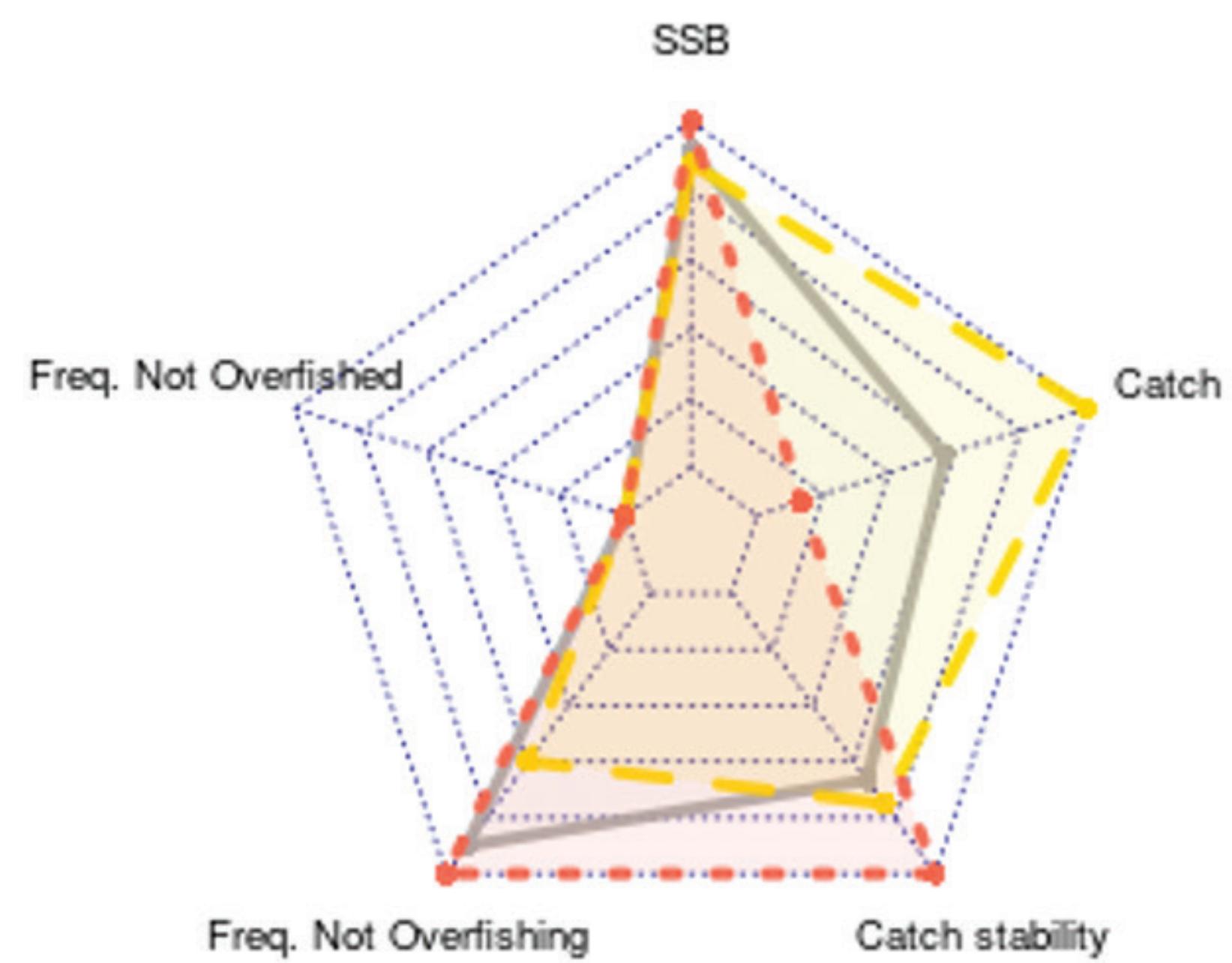


**Overestimation bias**

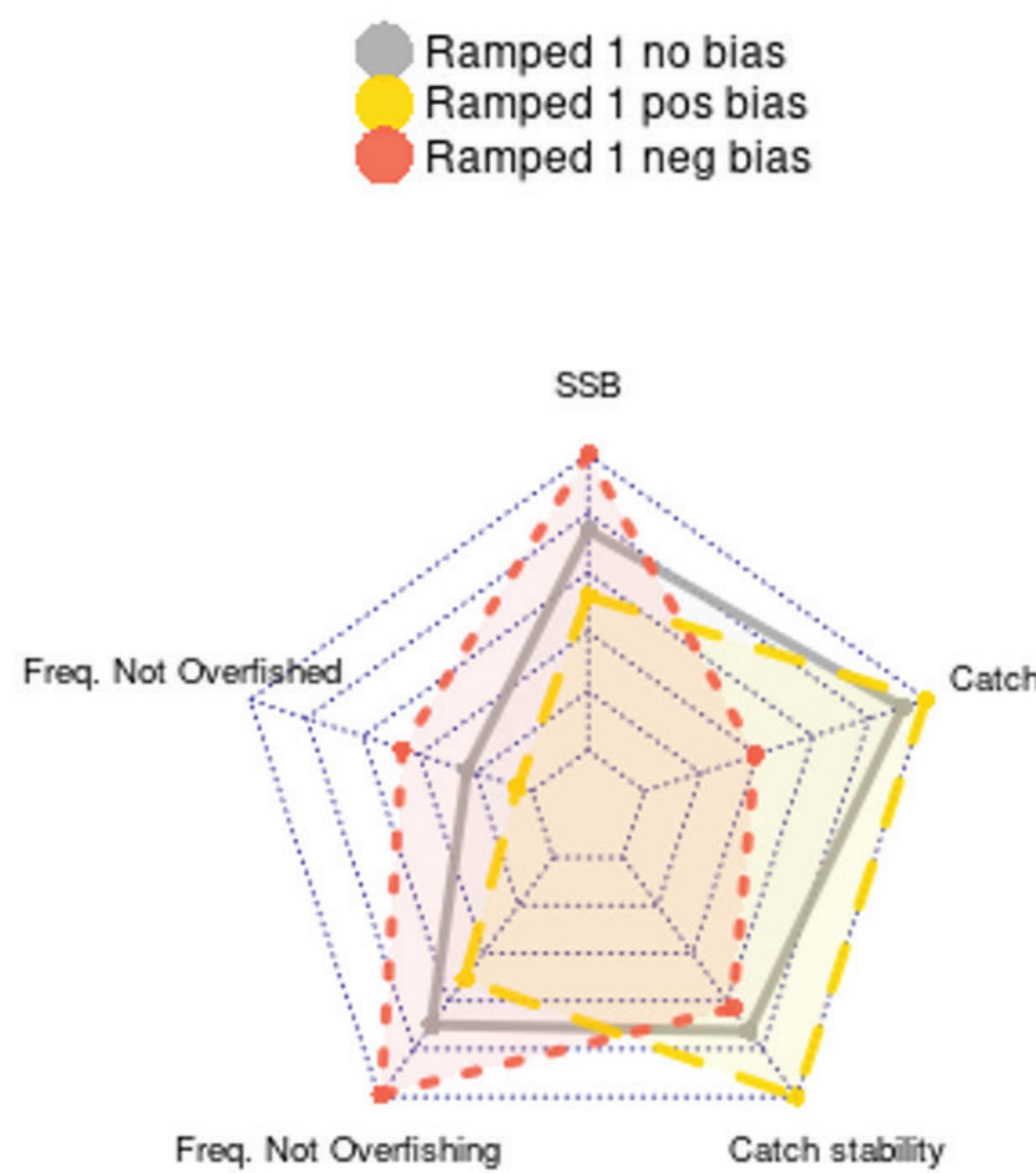


**Underestimation bias**

## Short-term



## Long-term

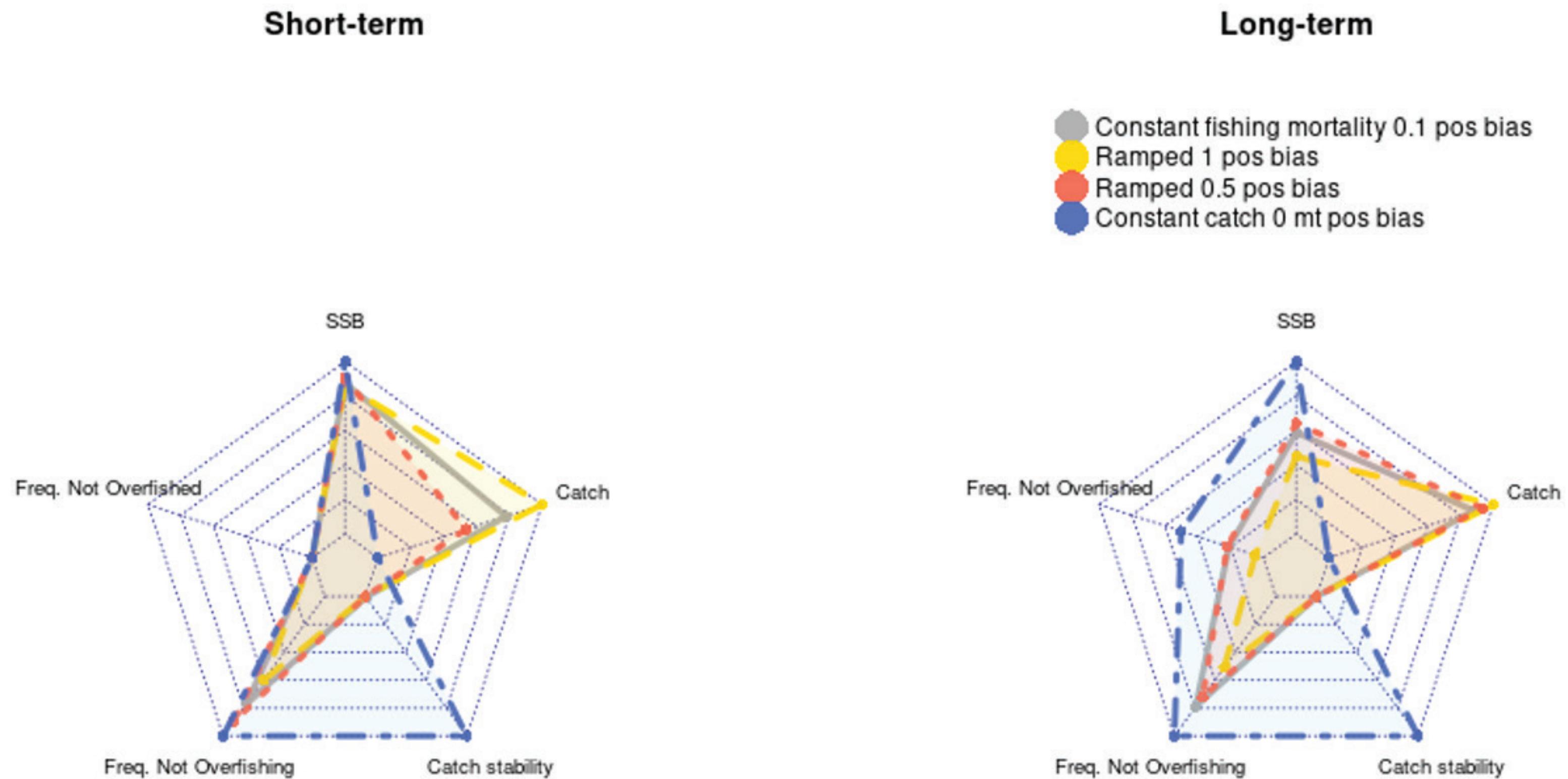


# Challenge

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”?

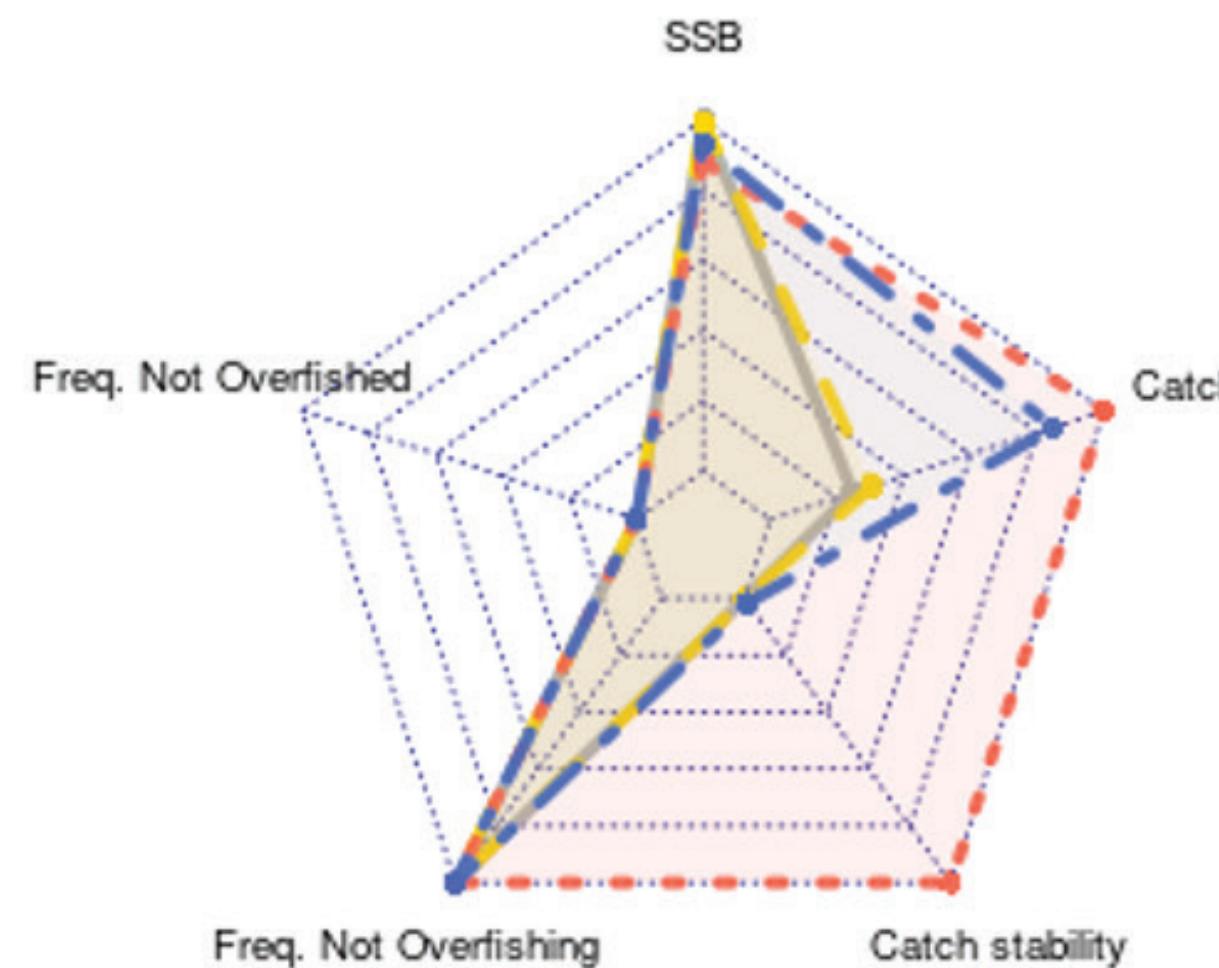
**10 minutes to play**

# Conservation-focused



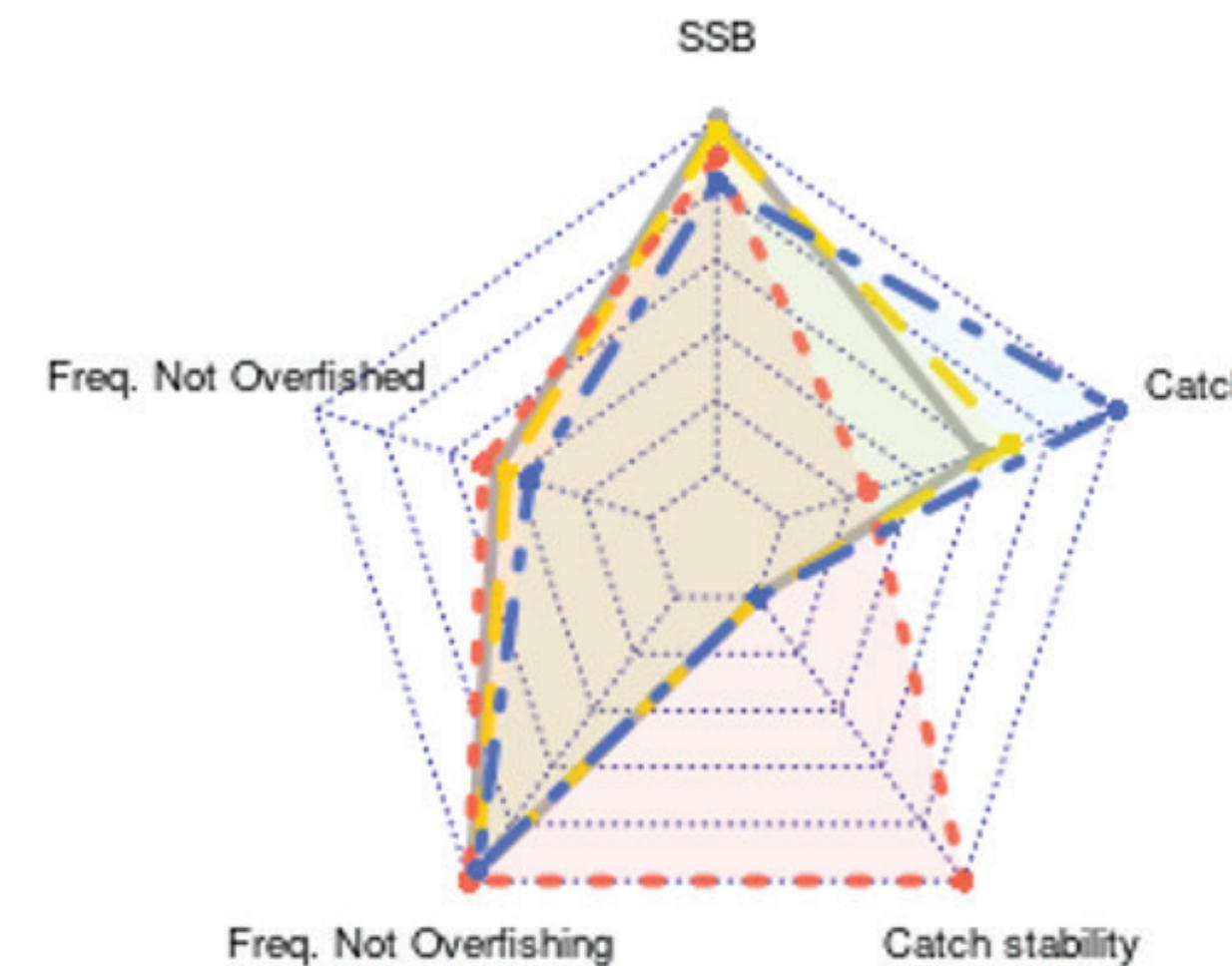
# Fisheries-focused

Short-term

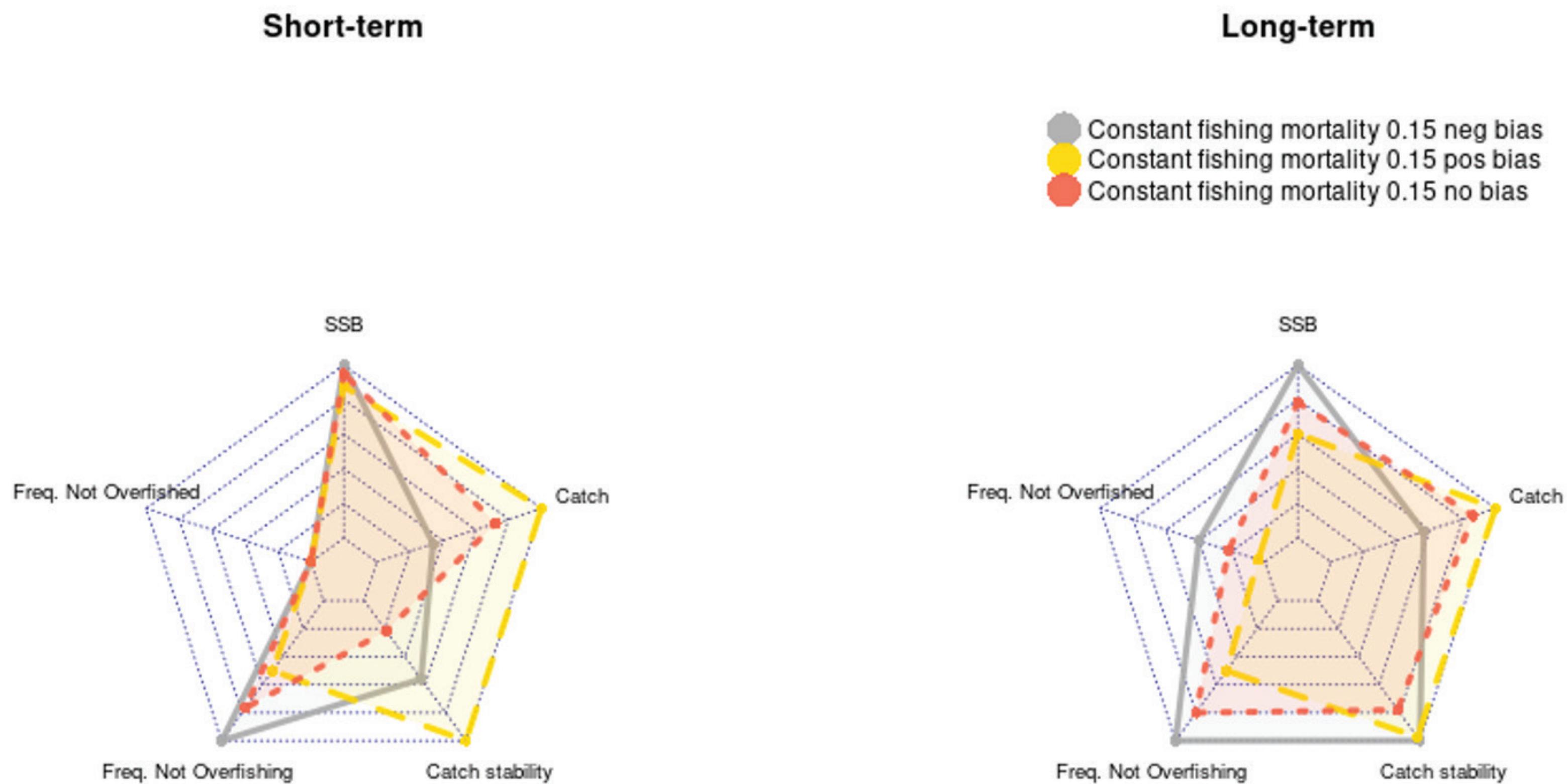


Long-term

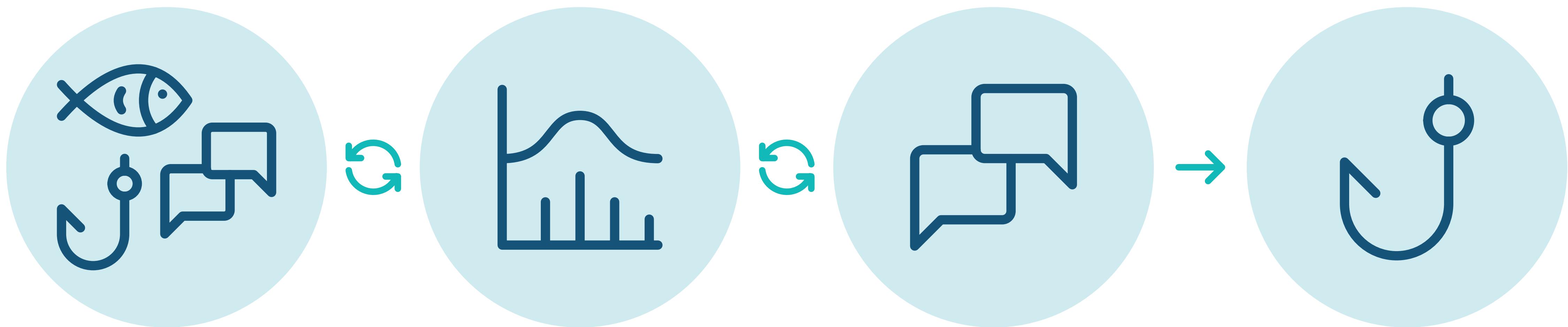
- Ramped 1 neg bias
- Ramped 1.25 neg bias
- Constant catch 1000 mt neg bias
- Constant fishing mortality 0.2 neg bias



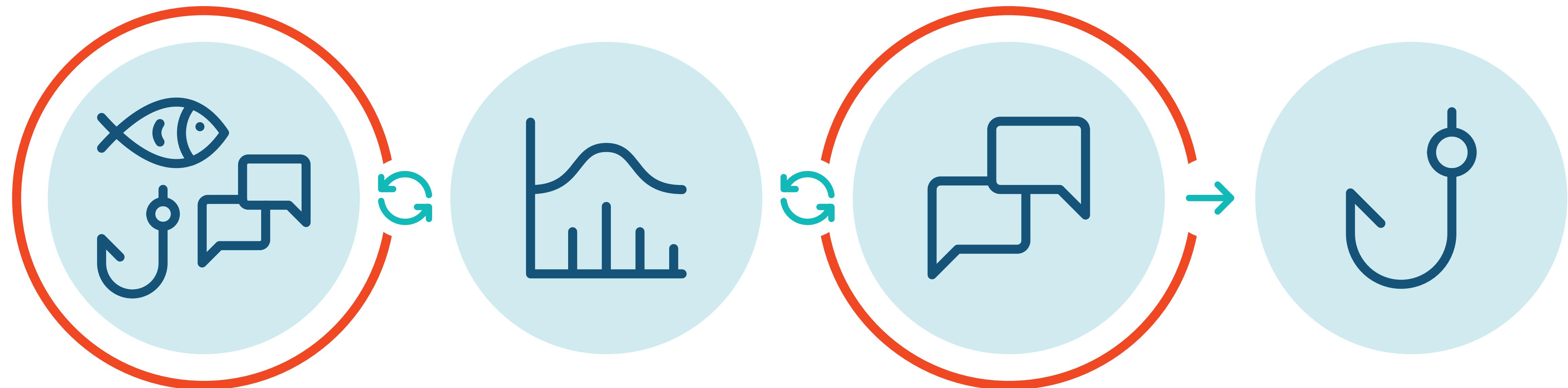
# Could maybe be robust to bias (at least long-term)?



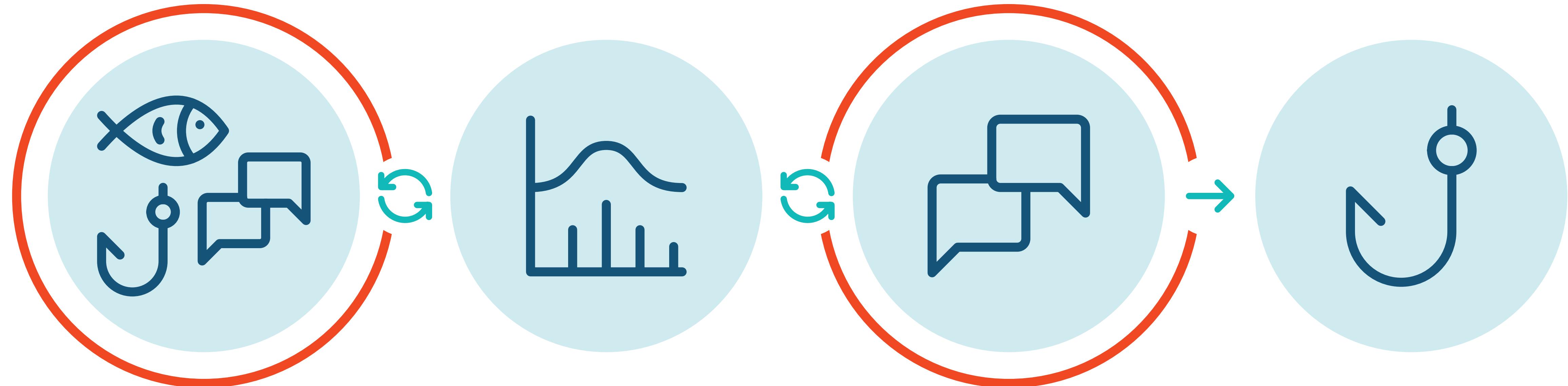
# Management-oriented approach for your system



# Management-oriented approach for your system

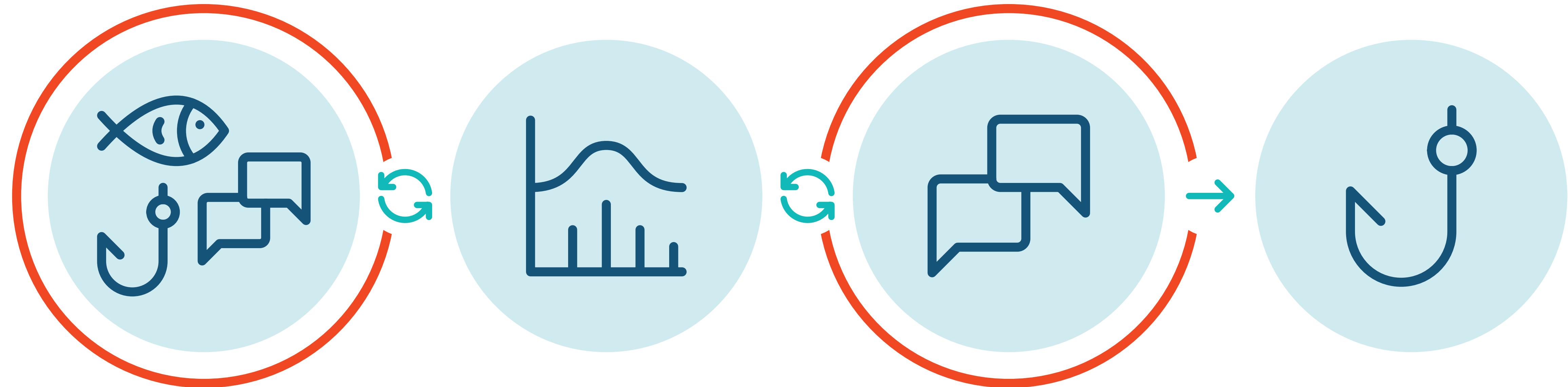


# Management-oriented approach for your system



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 conflicting?

Can someone share a case where they discovered shared objectives?