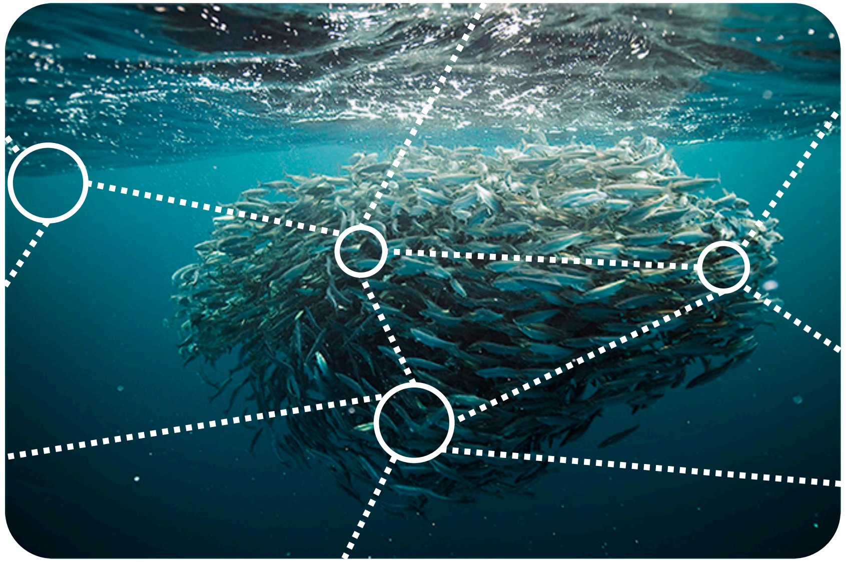
# Considering climate change in stock management strategy: the case-study of the Gulf of St. Lawrence herring

Washington, June 5th 2018



**Pablo Brosset & Stéphane Plourde**

Fisheries and Oceans Canada, Maurice Lamontagne Institute,
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Fisheries and Oceans Canada

Pêches et Océans Canada

# ECOSYSTEM APPROACH TO FISHERIES

Centered-vision on fishery

**Pair «fishermen-resource»**

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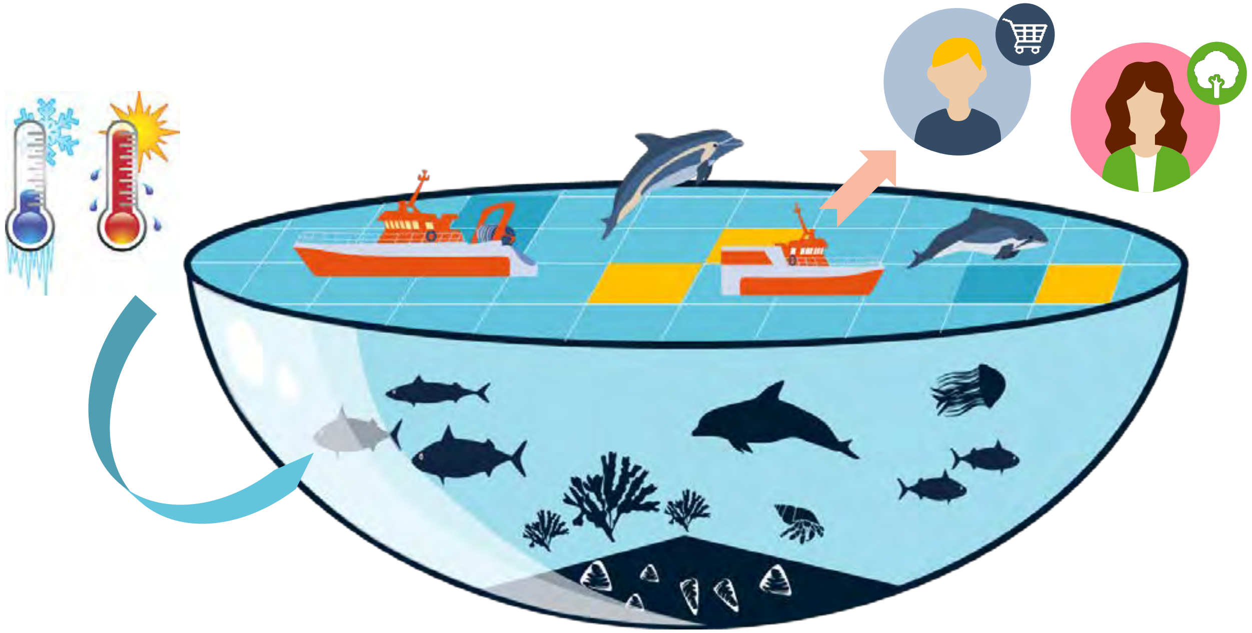
Ecosystem approach to fisheries

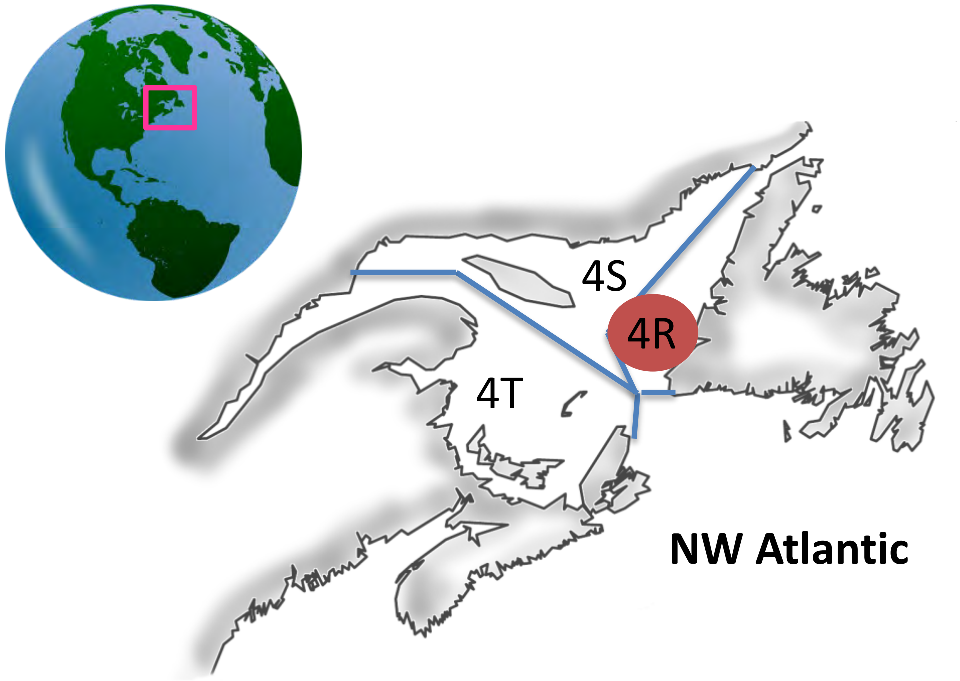


**Whole «ecosystem-society»**

Consider abiotic, biotic and human components

# GULF OF ST. LAWRENCE HERRING STOCKS

**Gulf of St. Lawrence**



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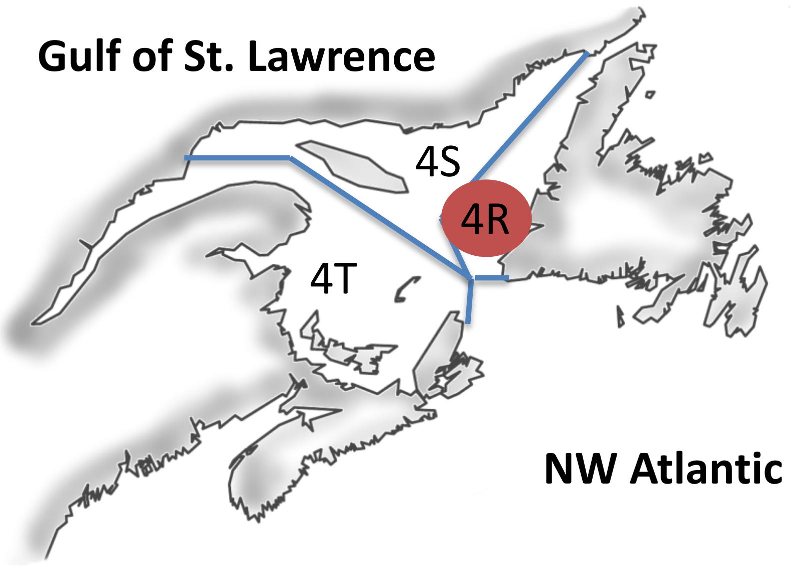


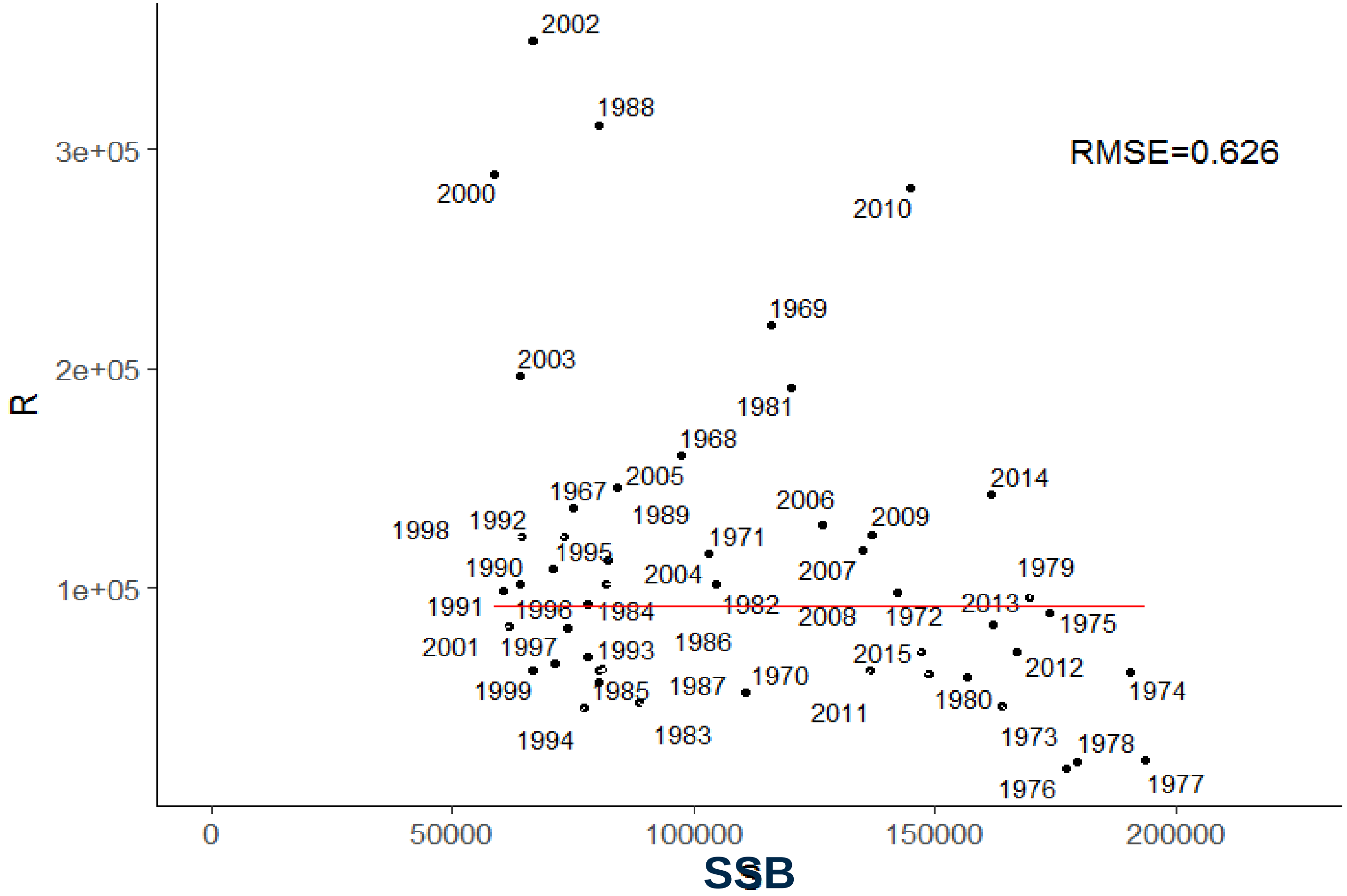


**No stock-recruitment relationship**

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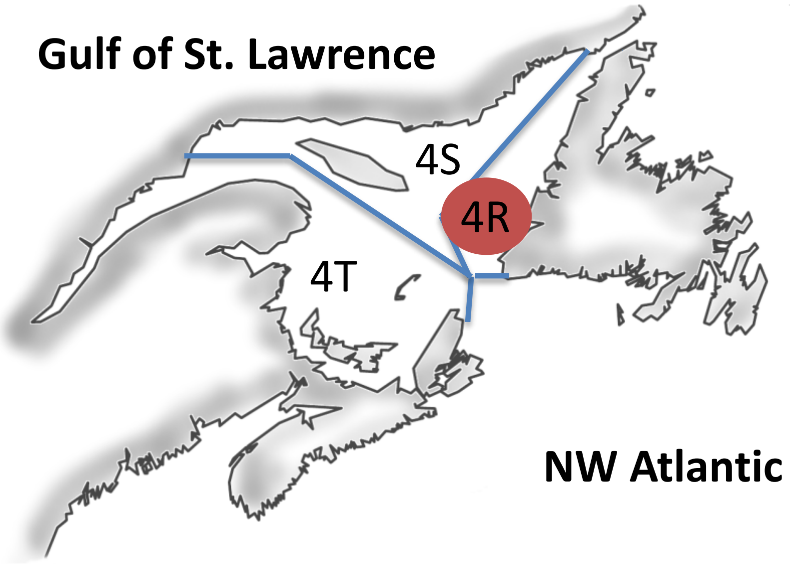



Oscillating reproductive strategies of herring in the western Atlantic in response to changing environmental conditions

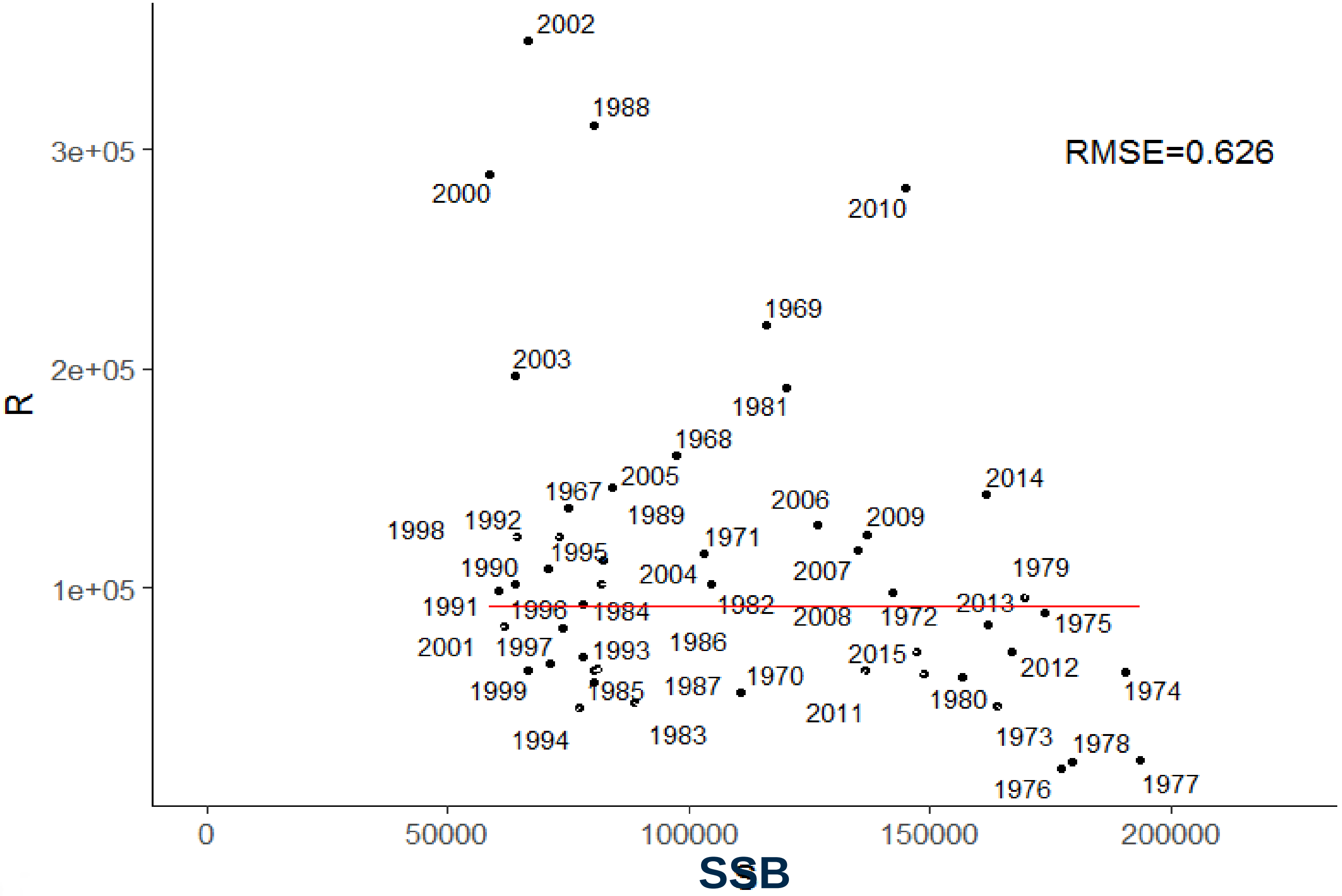
Gary D. Melvin, Robert L. Stephenson, and Michael J. Power

Broad-Scale Climate Influences on Spring-Spawning Herring (*Clupea harengus*, L.) Recruitment in the Western Baltic Sea

Joachim P. Gröger[1,2*], Hans-Harald Hinrichsen[3], Patrick Polte[4]

Recruitment dynamics of the Gulf of Riga herring stock: density-dependent and environmental effects

Tiit Raid, Georgs Kornilovs, Ain Lankov, Anne-Marin Nisumaa, Heli Shpilev, and Ahto Järvik




No stock-recruitment relationship

# HERRING RECRUITMENT vs ENVIRONMENT

**Spring** spawners

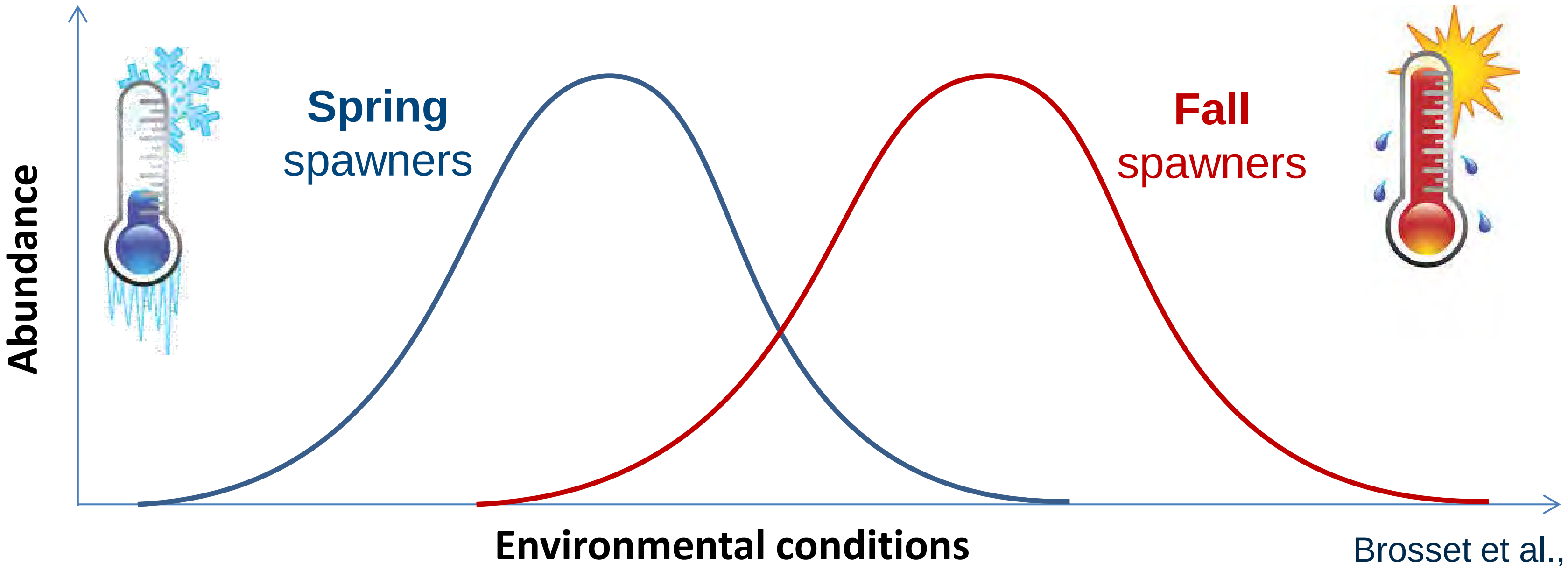
76% of the **recruitment** deviance explained

Cold water zooplankton community
Earlier zooplankton development

**Fall** spawners

75% of the **recruitment** deviance explained

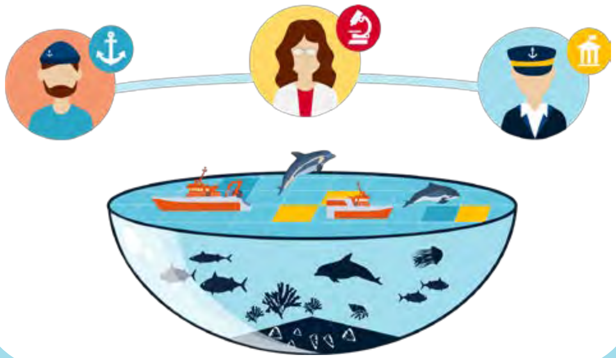
Warm water zooplankton community
Earlier zooplankton development




Brosset et al., 2018

# HERRING MSE

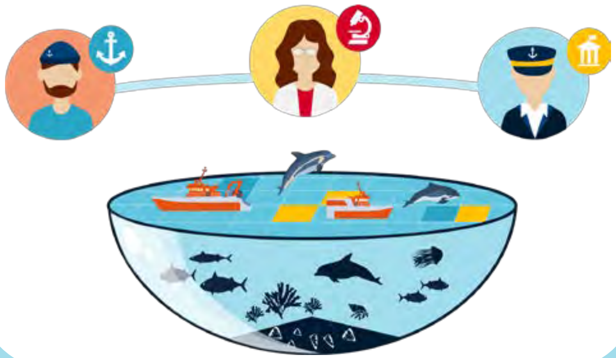
MSE



**MSE** : Framework to design and test harvest control-rules, assessment methods, and data used to set TACs

# HERRING MSE

**MSE**



**MSE** : Framework to design and test harvest control-rules, assessment methods, and data used to set TACs

**Modelling work**

Compare different **Management Strategies** under **different environmental scenarios**

How does this affect future:

- **Catches**?
- **Biomass**?

What objectives do we target?

# HERRING MSE

**State-space assessment SAM model**
(Nielsen and Berg, 2014)

- **No stock-recruitment relationship**

- **Can environmental variables help to model recruitment ?**

Add a factor X acting on recruitment:

$$\log(R_t) \sim Normal(\mu_t, \sigma^2)$$
$$\mu_t = \alpha + \beta X_t$$

**Physical long-term trend was chosen as a proxy of environmental conditions**

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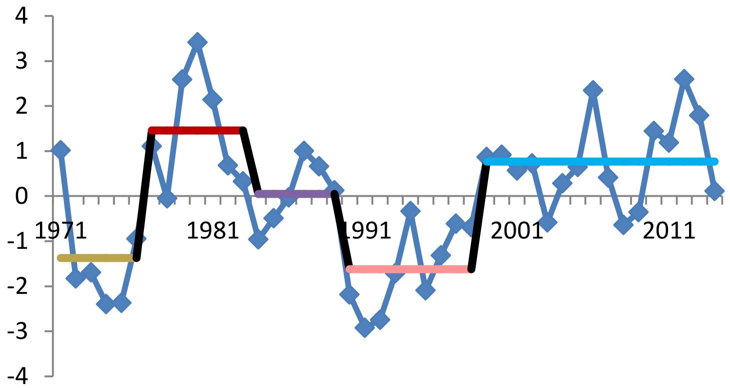
**Physical index as a proxy of environmental conditions**




Physical long-term trend as a proxy of environmental conditions

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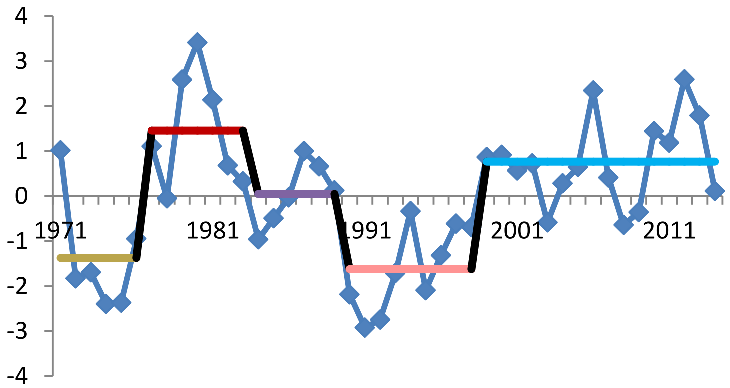
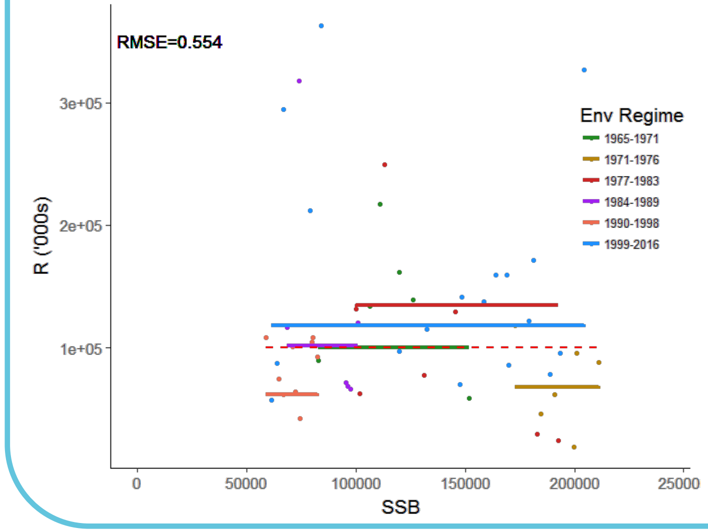



Physical long-term trend as a proxy of environmental conditions

## Different recruitment levels with environmental periods




RMSE Regime < No Env

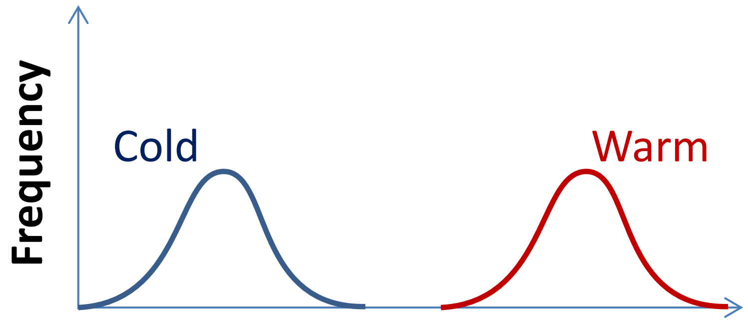
**Environmental regimes improve recruitment predictions**

# HERRING MSE

- **How to incorporate environment in projections?**

**Resampling of the environmental factor**

Associate an environmental factor depending on the scenario to predicted years.




Each predicted year:
Random sampling of an environmental value will increase or decrease recruitment

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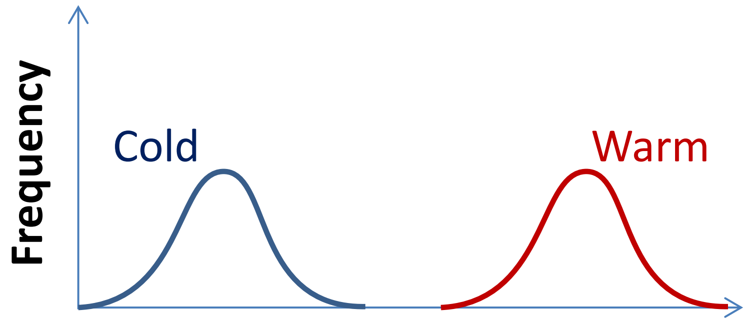


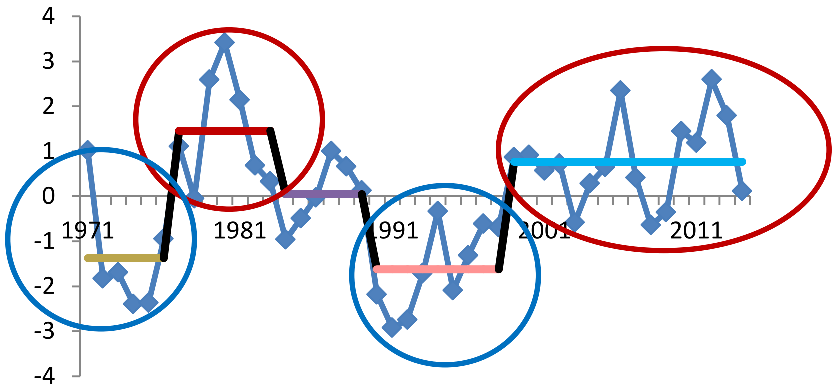


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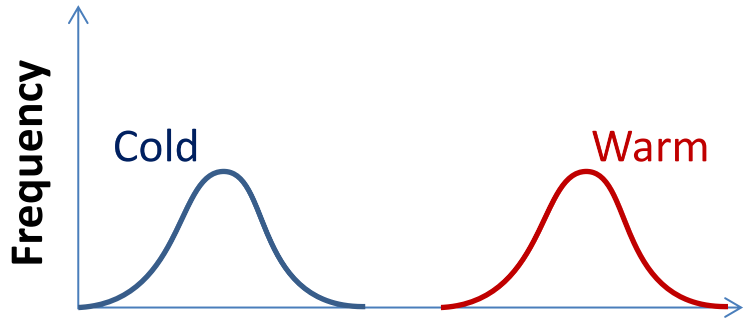
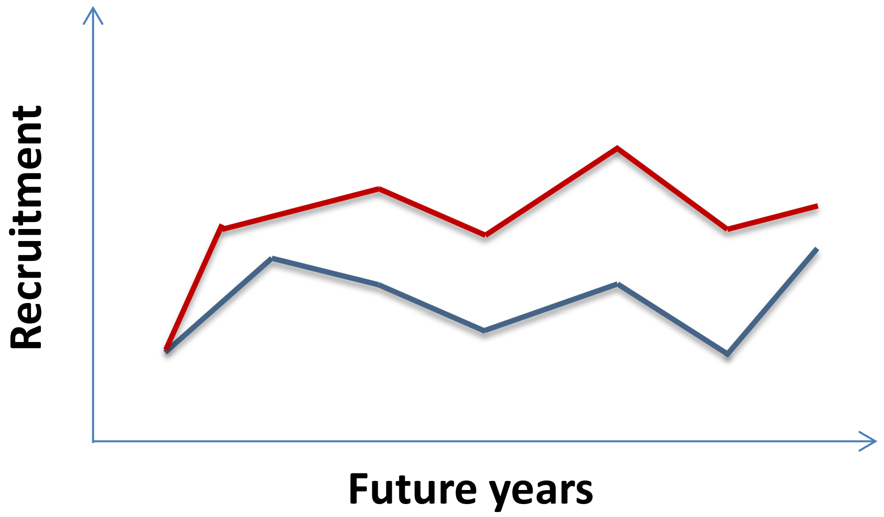



**Mean rec +**
**$\beta$*environmental value**

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# HERRING MSE

## Management strategies

No F: No fishing mortality, TAC set to 0

Const Catch: Keep constant TAC at the level of 2016 (20,000 t)

F40%: the fishing mortality that is expected to conserve 40% of maximum spawning potential

F50%: the fishing mortality that is expected to conserve 50% of maximum spawning potential

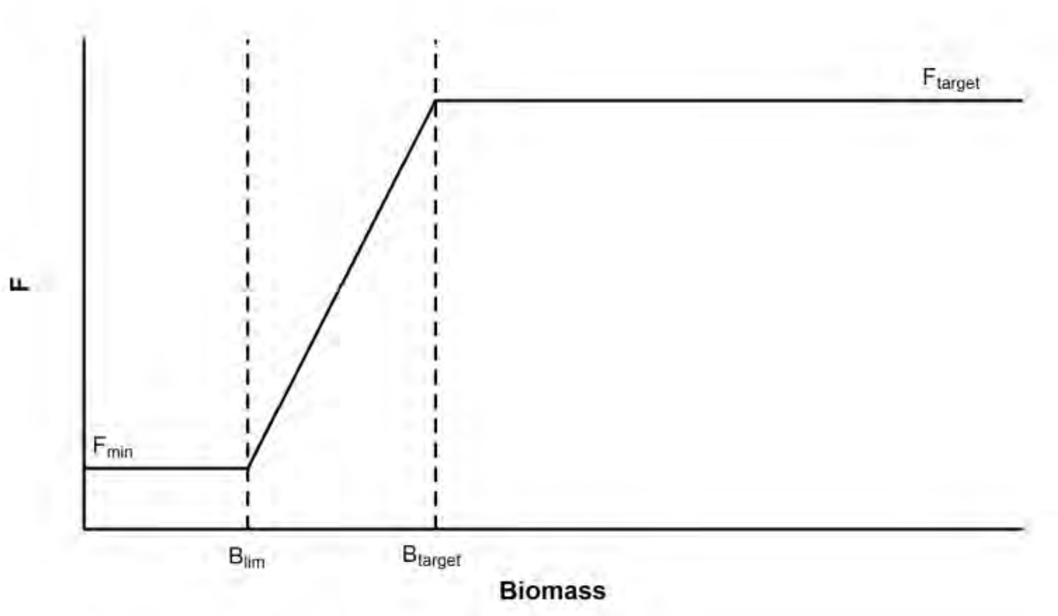
ConstF: Keep constant fishing mortality at the level of 2016 (0.18)

## Harvest control rules

TAC set to 100 t if SSB < $SSB_{lim}$ = 48,000t

TAC linearly decrease if $SSB_{lim}$ < SSB < $SSB_{target}$

No TAC reduction if SSB > $SSB_{target}$ = 62,000t



# HERRING MSE FORECASTS

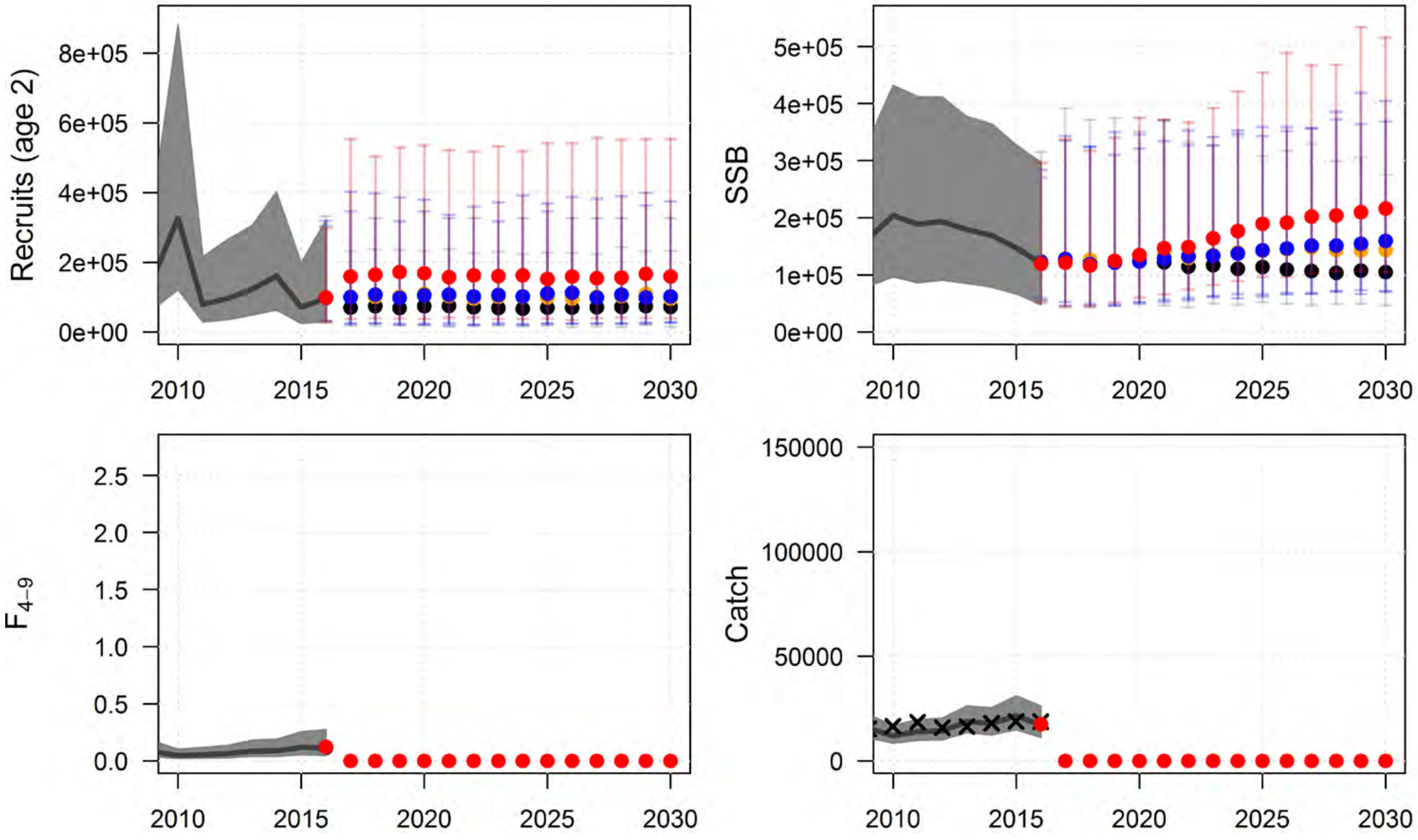
Management procedure

**No Fishing**

Recruitment estimate

**Environmental value**

- Min (cold)
- Mean
- Max (warm)
- NoEnv



# HERRING MSE FORECASTS

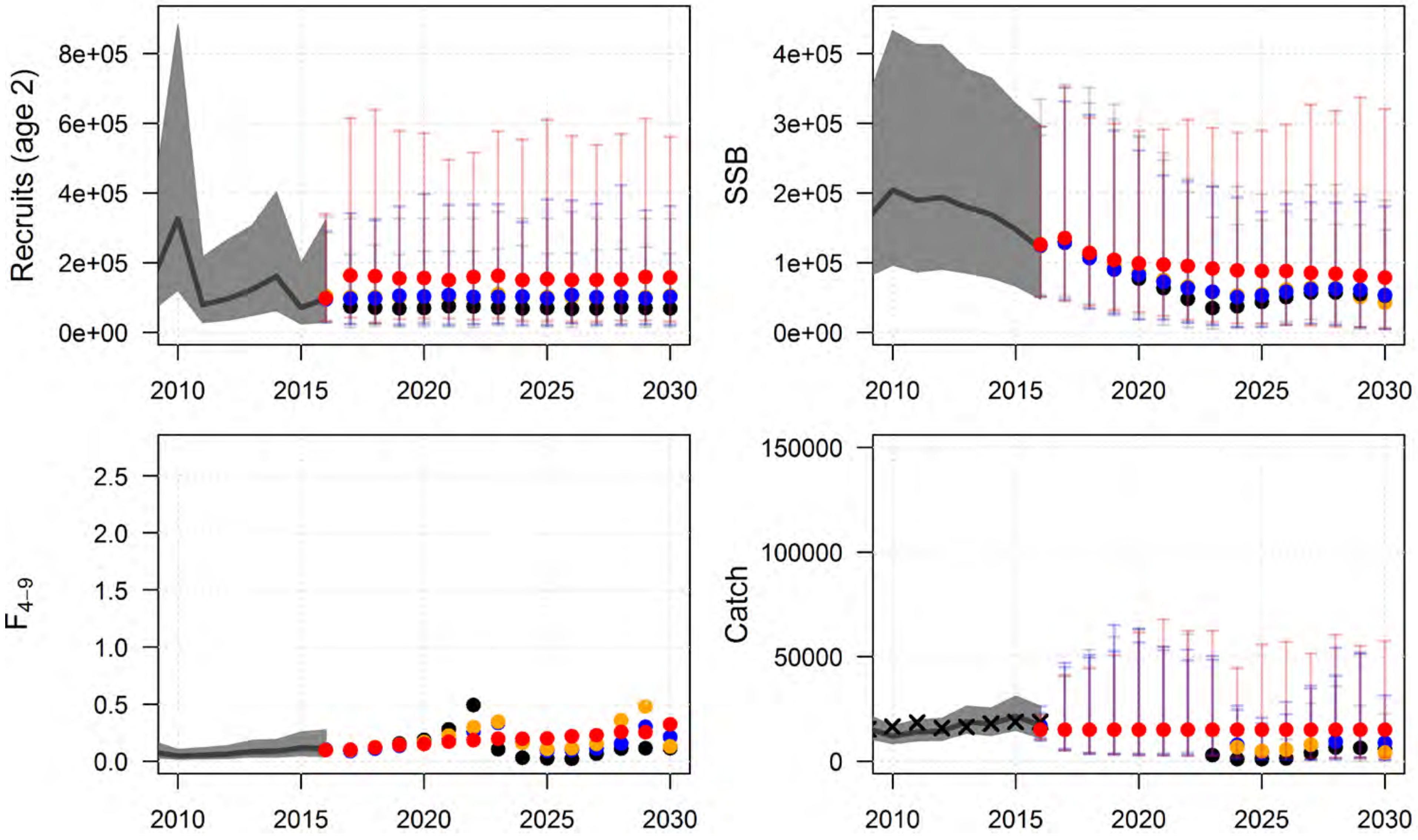
Management procedure

**Constant catches**

Recruitment estimate

**Environmental value**

- Min (cold)
- Mean
- Max (warm)
- NoEnv



# HERRING MSE FORECASTS

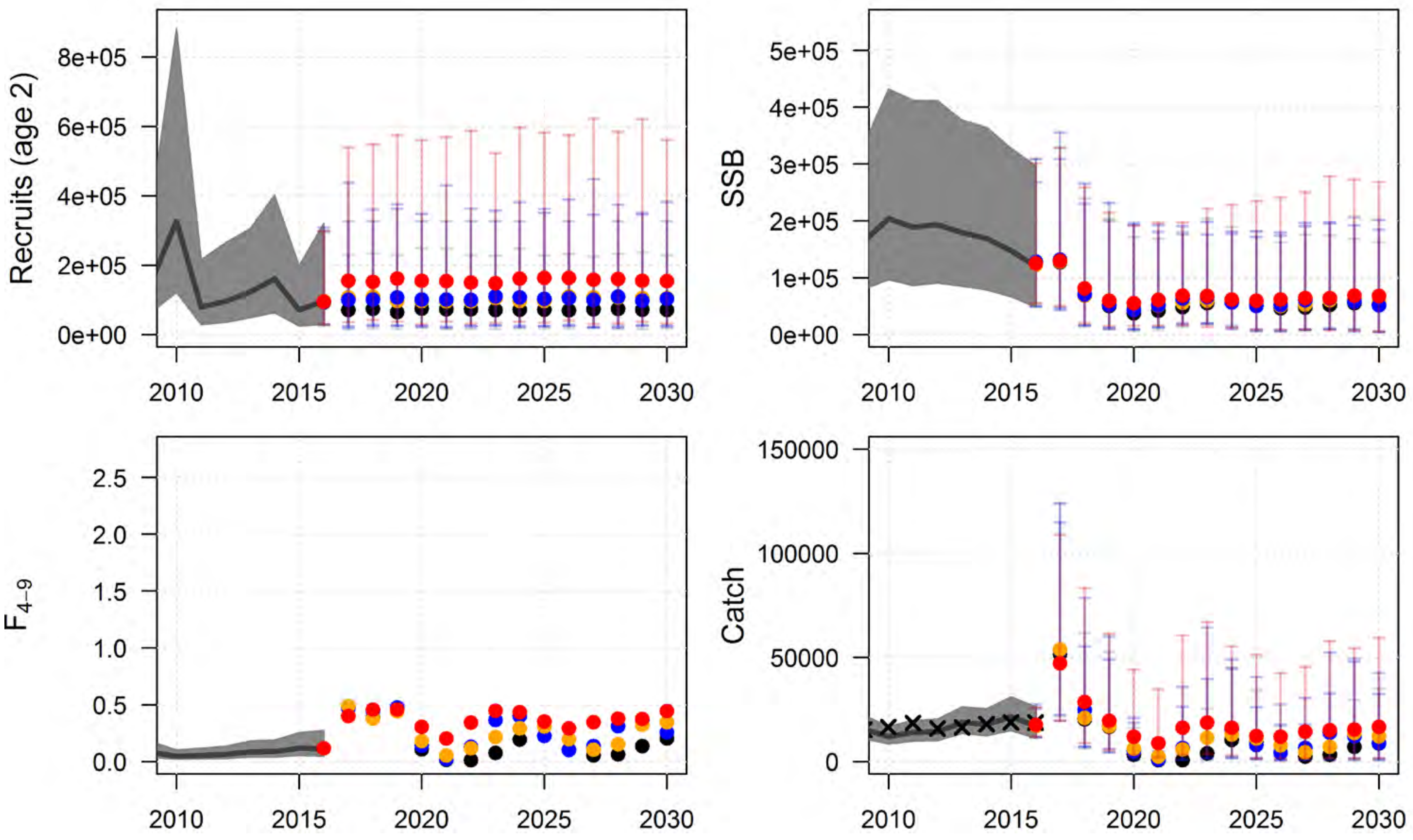
Management procedure

**F40% with a limit at $F_{max}$ = 0.5**

Recruitment estimate

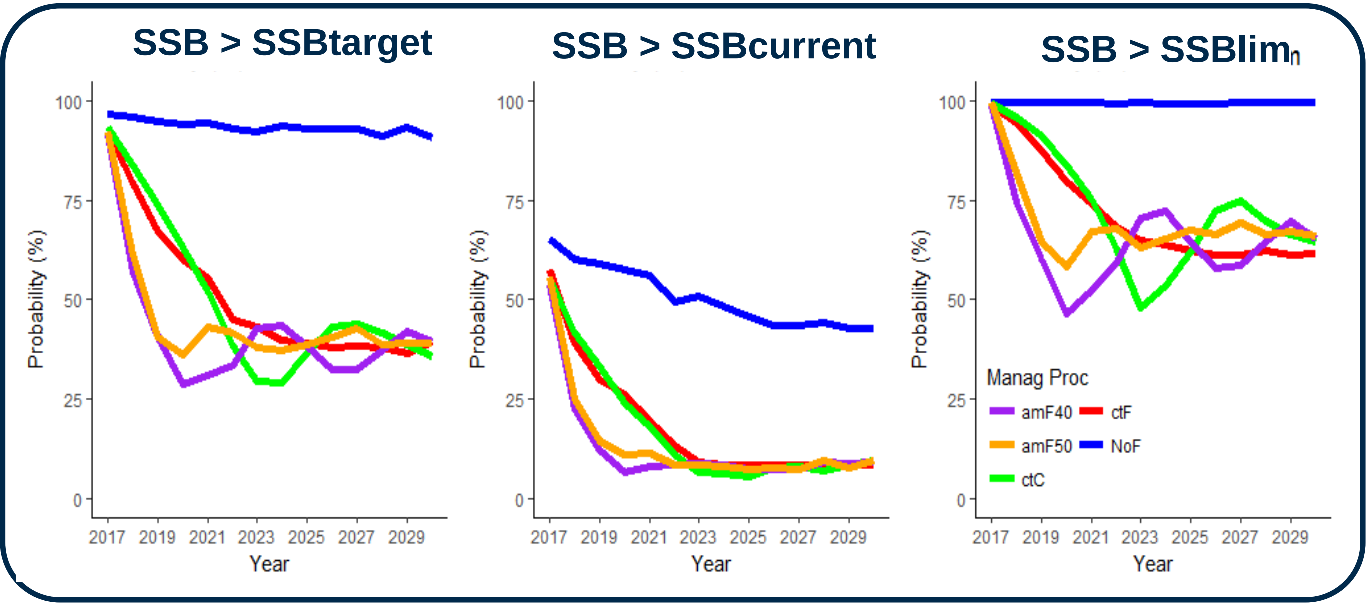
**Environmental value**

- Min (cold)
- Mean
- Max (warm)
- NoEnv



# HERRING MSE PERFORMANCE METRICS

**Future LOW herring productivity**




**No F**
**Const Catch**
**F40%**
**F50%**
**ConstF**

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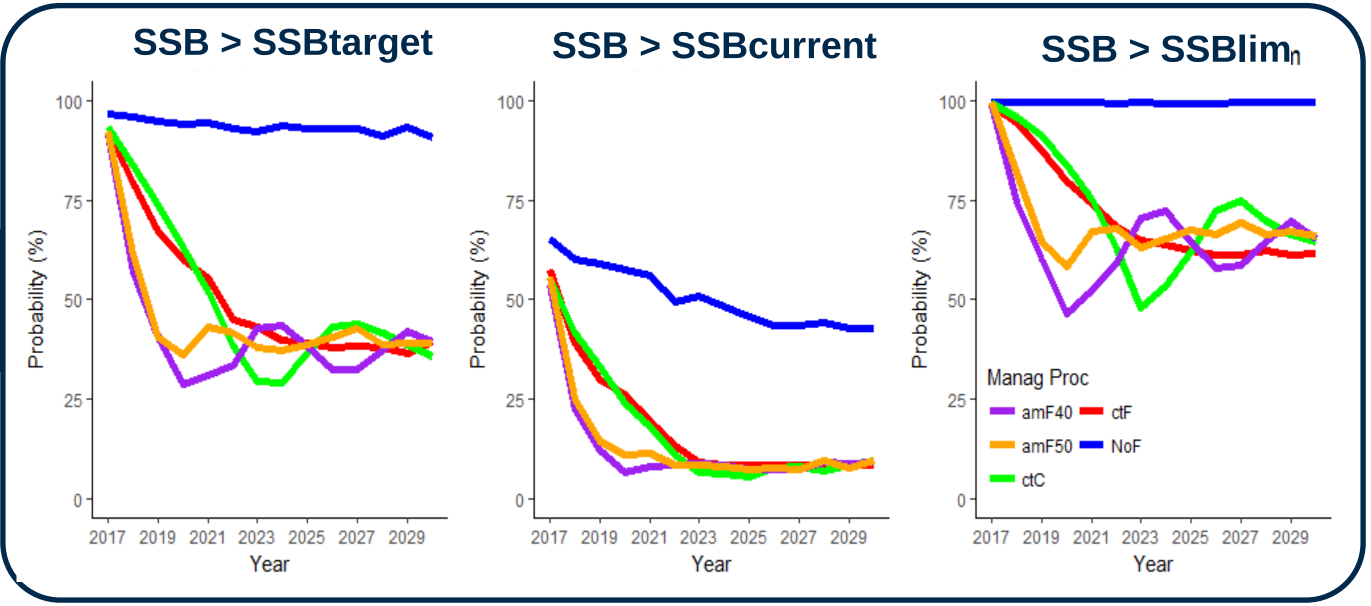


No F
Const Catch
F40%
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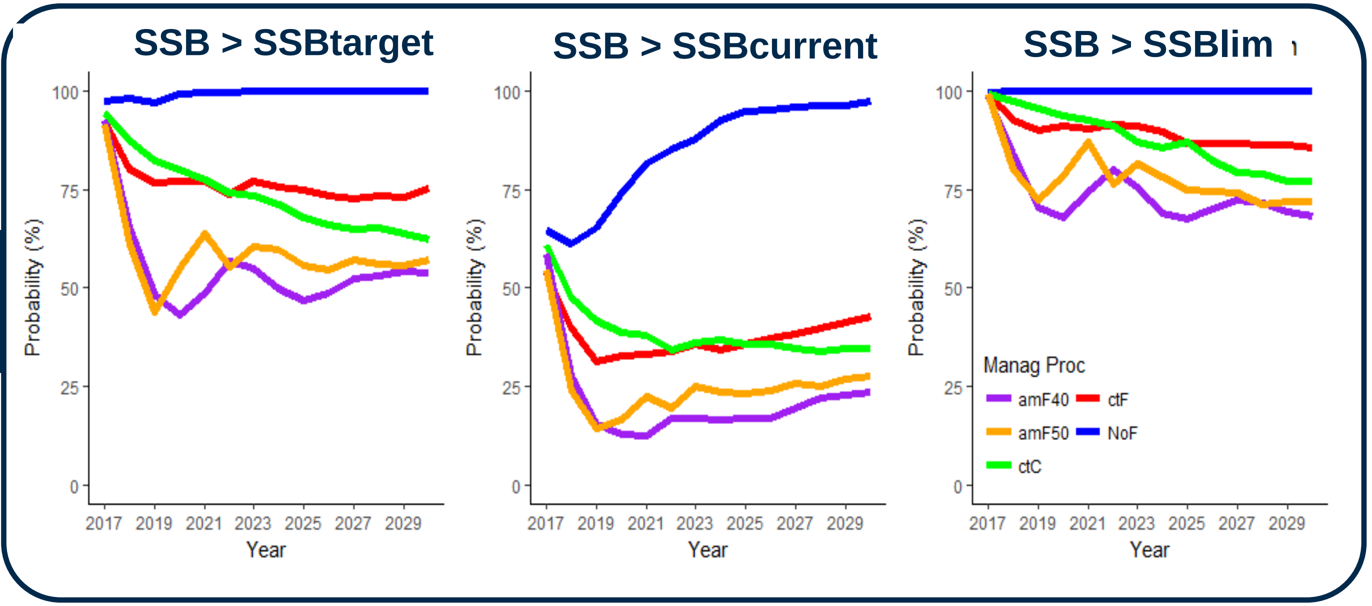
Future HIGH herring productivity



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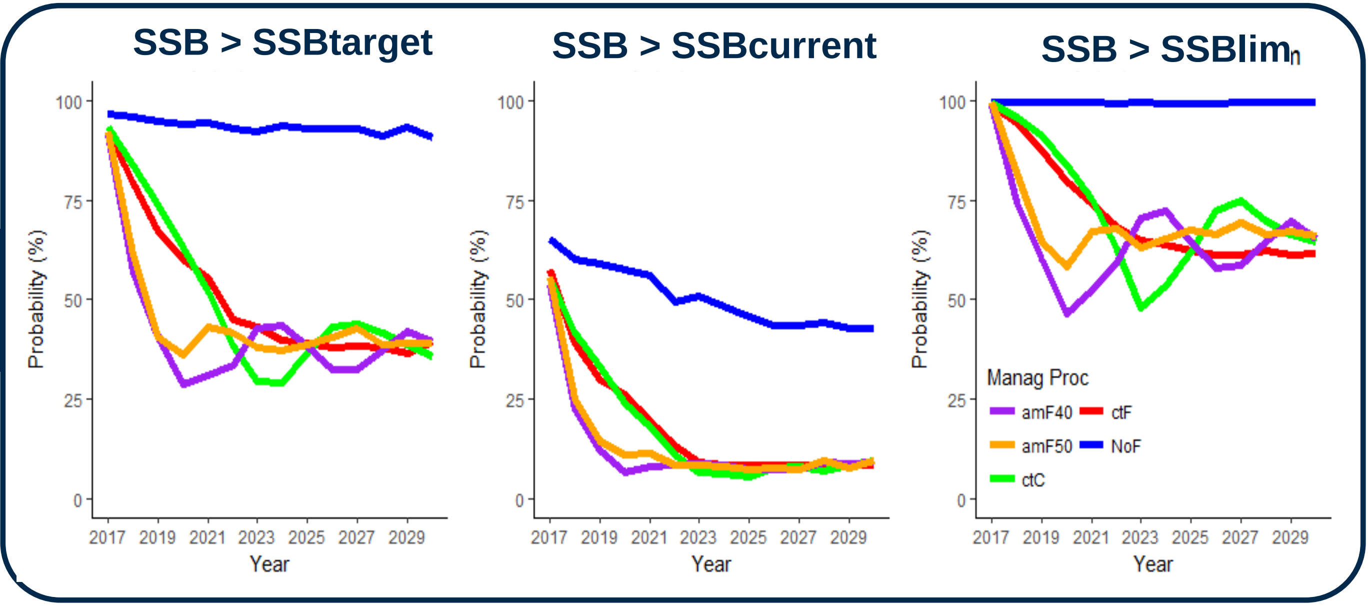


**No F**

**Const Catch**

**F40%**

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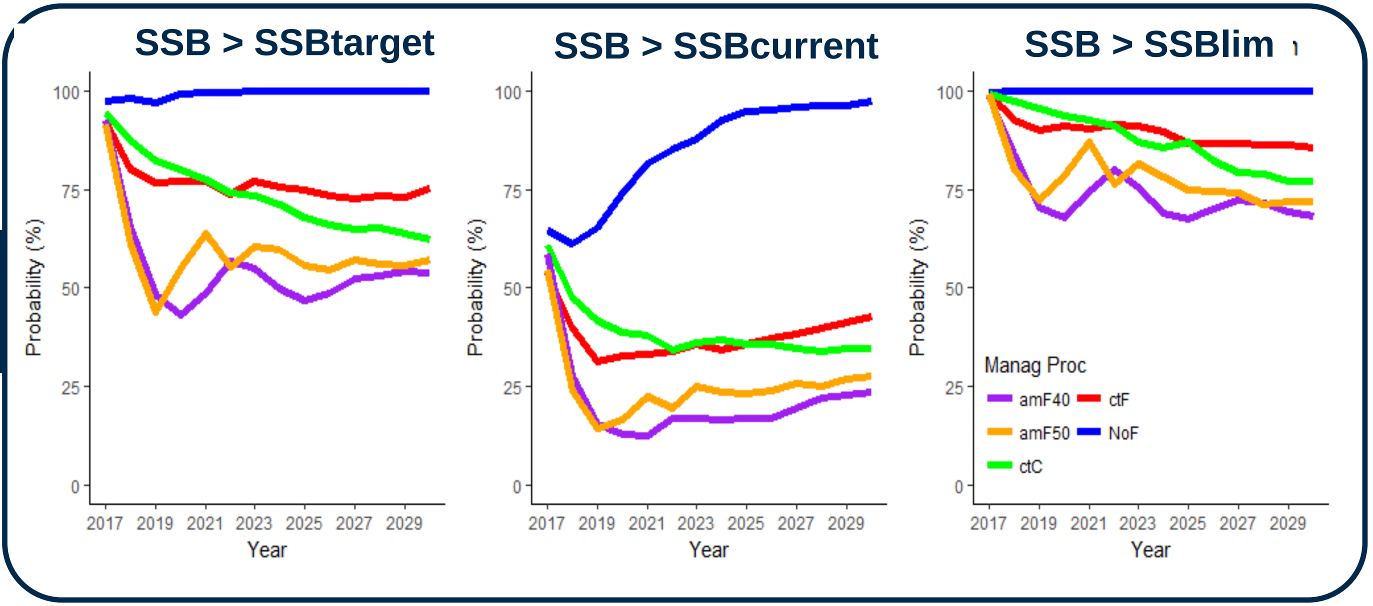
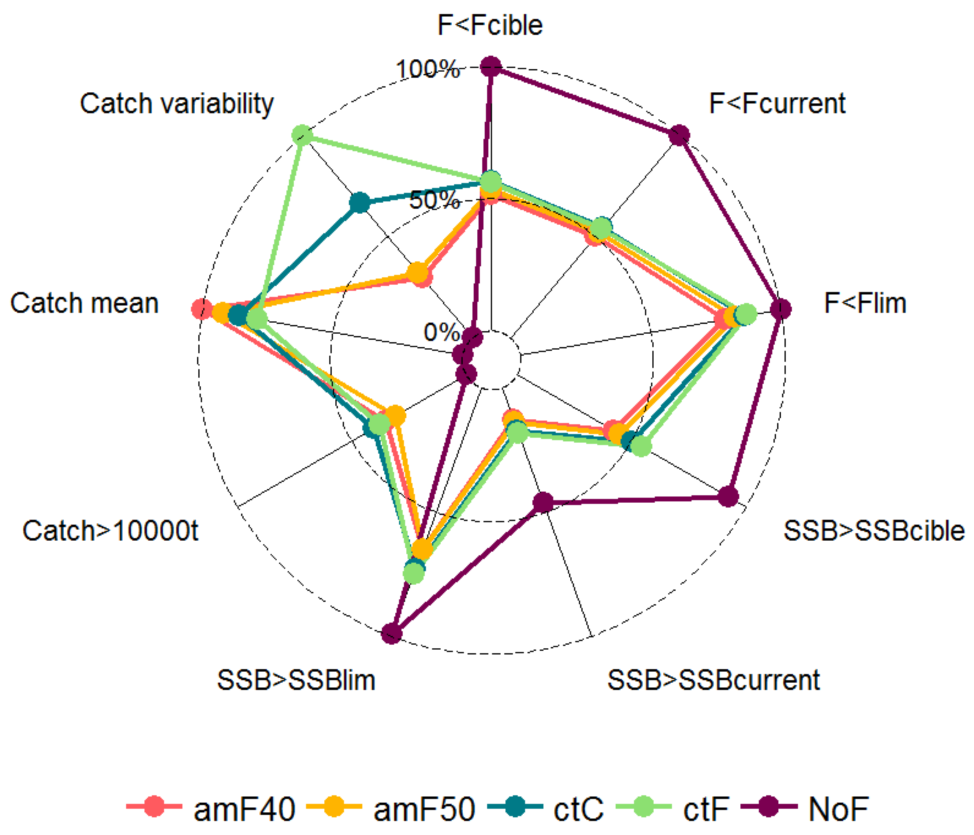
**Future HIGH herring productivity**




**THE MANAGEMENT OF THE FISHERIES DEPENDS ON THE FISH STOCK PRODUCTIVITY**

# HERRING MSE PERFORMANCE METRICS

## Future LOW herring productivity

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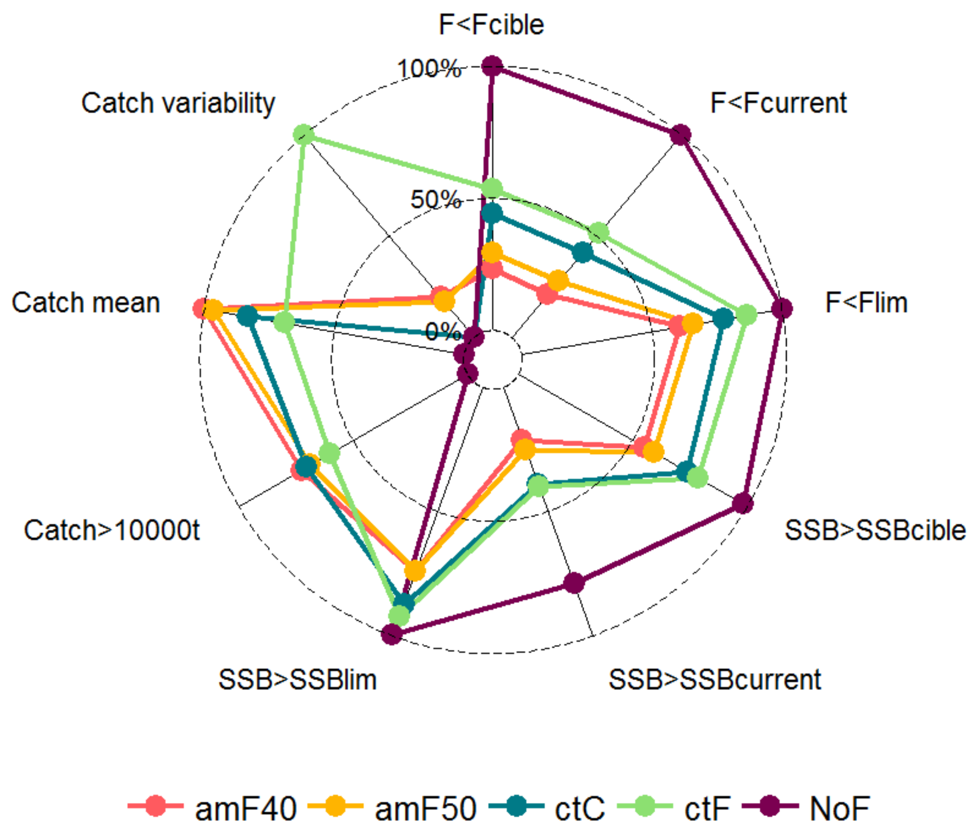

# IMPROVEMENTS

## MSE

**Including the environment**

→ Future environmental conditions lead to different stock trajectories

→ Highlight the need to take into account the different levels of productivity to inform management and reduce stock vulnerability and risks under climate change

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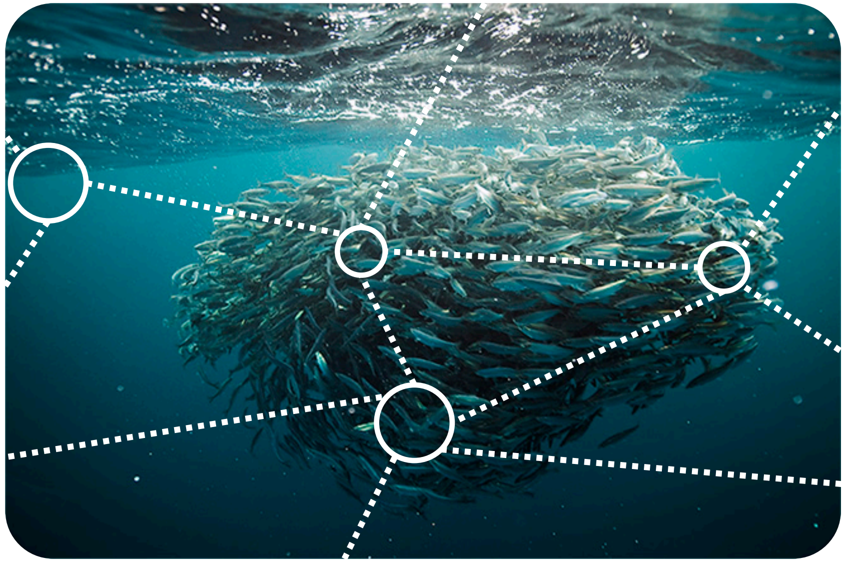
- **Future directions**
  - Objectives realistically defined with the managers and the industry
  - Test others Harvest Control Rules (moving reference points)
  - Include environmental forecasts from biophysical models

# Thank you for your attention



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