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

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ECOSYSTEM APPROACH TO FISHERIES

Centered-vision on fishery

Pair «fishermen-resource»
ECOSYSTEM APPROACH TO FISHERIES

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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

NW Atlantic
GULF OF ST. LAWRENCE HERRING STOCKS

No stock-recruitment relationship
GULF OF ST. LAWRENCE HERRING STOCKS

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

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**Abundance**

**Environmental conditions**

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Brosset et al., 2018
MSE: Framework to design and test harvest control-rules, assessment methods, and data used to set TACs
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Modelling work

Compare different Management Strategies under different environmental scenarios

How does this affect future:
- Catches?
- Biomass?

What objectives do we target?
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
State-space assessment SAM model (Nielsen and Berg, 2014)

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HERRING MSE

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Physical index 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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$$\text{Mean rec} + \beta \times \text{environmental value}$$
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
Management procedure
No Fishing

Recruitment estimate

Environmental value
- Min (cold)
- Mean
- Max (warm)
- NoEnv
Management procedure

Constant catches

Recruitment estimate

Environmental value

- Min (cold)
- Mean
- Max (warm)
- NoEnv
Management procedure
F40% with a limit at $F_{\text{max}} = 0.5$

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
HERRING MSE PERFORMANCE METRICS

Future LOW herring productivity

No F
Const Catch
F40%
F50%
ConstF

Future HIGH herring productivity
HERRING MSE PERFORMANCE METRICS

THE MANAGEMENT OF THE FISHERIES DEPENDS ON THE FISH STOCK PRODUCTIVITY

Future LOW herring productivity

No F Const Catch F40% F50% ConstF

Future HIGH herring productivity
HERRING MSE PERFORMANCE METRICS

Future **LOW** herring productivity

Future **HIGH** herring productivity
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
• 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

**MSE**

→ 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
Thank you for your attention

Considering climate change in the management policy

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