“The potential use of a Gadget model to predict stock responses to climate change in combination with Bayesian Networks: the case of the Bay of Biscay anchovy”

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Outline

- Introduction: Bay of Biscay anchovy population
- Material and methods:
  - New recruitment model
  - Single-species Gadget model for anchovy
- Some preliminary results
- Work in progress
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4. Work in progress

Bay of Biscay anchovy population

- from 48°N to 44.30°N and from 11°W to the coastlines of France and NW Spain
- corresponds biogeographically to a subtropical/boreal transition zone (OSPAR, 2000)
- ecological richness
- warming trend over the Bay of Biscay (+0.3°C per decade)
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Population dependent on recruitment (affected by environmental changes):
- NAO & EA patterns,
- upwelling index
- stratification index

Main nuclei for anchovy in the NW-Atlantic; commercial fisheries targeting on anchovy (33000t). Fishery closure in 2005, re-open in 2010 (7000 t)

Anchovy population has increased in the northern areas during the last decade
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Improving our ability to predict recruitment is a key element in fisheries management.

Robust methodology for predicting recruitment using climatic and environmental information.

Machine learning techniques: supervised classifications methods (Bayesian Networks).

Possibility to establish the uncertainty associated with a prediction in addition to the model performance estimation and balance the error through the recruitment levels.

Recent changes: Naive Bayes for Regression, aiming to get a single value for the predicted recruitment level in the continuous domain.
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-Indices (from the ICES/GLOBEC Workshop on ‘Long-term Variability in SW Europe’ held in 2007):

- North Atlantic Oscillation (NAO); East Atlantic pattern (EA); East Atlantic/Western Russia pattern (EA/WR); Scandinavia pattern (SCA); Tropical/Northern Hemisphere pattern (TNH); Polar/Eurasia pattern (POL).

These indices, covering the period 1950–2006 (from the US NOAA Climate Prediction Center)

- other (winter NAO, spring EA, global mean T of the NA, two solar indices...)

- SSB was introduced as a variable in the analysis
CLI1 is the first component from PCA of NAO, TNH, UI, SCA, EA/WR, POL and EA (Bode et al., 2006).

Predictors selection:

- CLI1 + Upwelling index + Turbulence index + wind speed

- Coincide with the information available in the literature

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\( x[n] = \text{trend}[n] + \text{periodic}[n] + \text{random}[n] \)

(Fernandes et al., 2009)
SSB not included as a predictor (limiting factor for predictions)

- SSB short time series
- Widely discussed in the literature

(Fernandes et al., 2009)
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- Globally applicable Area Disaggregated General Ecosystem Toolbox
  (www.hafro.is/gadget)

- To model marine ecosystems, including both the impact of the interactions between species and the impact of fisheries harvesting the species.

- Three parts:
  - A parametric model to simulate the ecosystem
  - Statistical functions to compare the model output to data
  - Search algorithms to optimize the model parameters
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  1. Biological model: recruitment, growth and M (No migration, no consumption)
     • Fleet: International commercial fleet and surveys (MPDH and PELGAS)

2. Likelihood files
   • Commercial landings (Id)
   • Survey indices by age

3. Optimisation: hibrid algorithm
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Modelled recruitment (Naive Bayes for Regression)
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GADGET:

- 16 parameters: 4 for the initial population and 12 for the selectivity patterns of the fleet:

- Graphs showing selectivity patterns for different PSIs.
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Fishing mortality

Spawning Stock Biomass
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Recruitment predictions (Naive Bayes for Regression)

R predictions based on semi-random values of the climatic variables
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From GADGET:
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1. Improve recruitment projections by using real data downscaled from global variables of the available climate change scenarios

2. Multidimensional recruitment models in order to work in multispecific scenarios

3. Work on the multi-species Gadget model, aiming to implement both predation (hake) and competition (sardine) relationships in our simulations

4. Link Gadget-FLR → MSE framework. Include economic analysis.
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