"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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Bay of Biscay anchovy population

- from 48ºN to 44.30ºN and from 11ºW 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 (+0.3ºC per decade)

Engraulis encrasicolus (Linnaeus, 1958)

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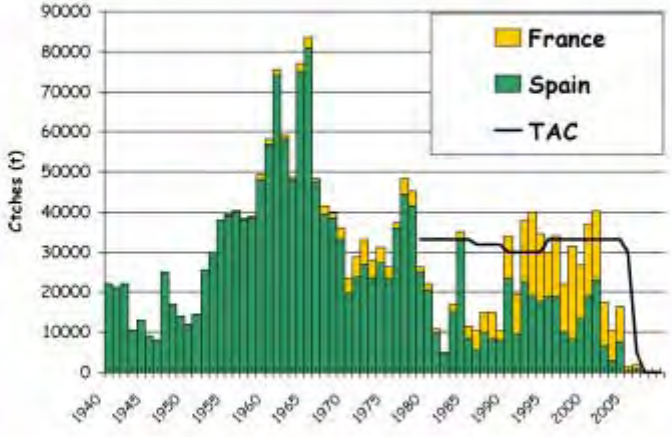
ICES

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



Population dependant on recruitment (afected by environmental changes):

- **NAO & EA patterns,**
- **upwelling index**
- **stratification index**

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.

-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 NOA, spring EA, global mean T of the NA, two solar indices...)

- **SSB** was introduced as a variable in the analysis

Coincide with the information available in the literature

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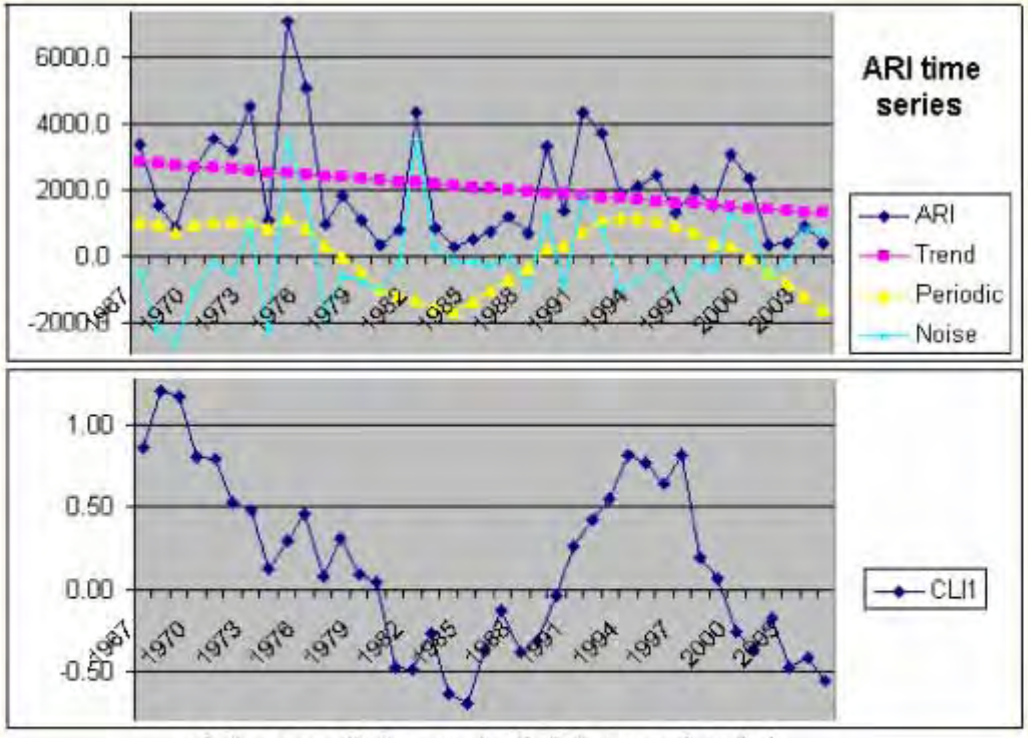
- Predictors selection:

CLI1 + Upwelling index + Turbulence index + wind spead

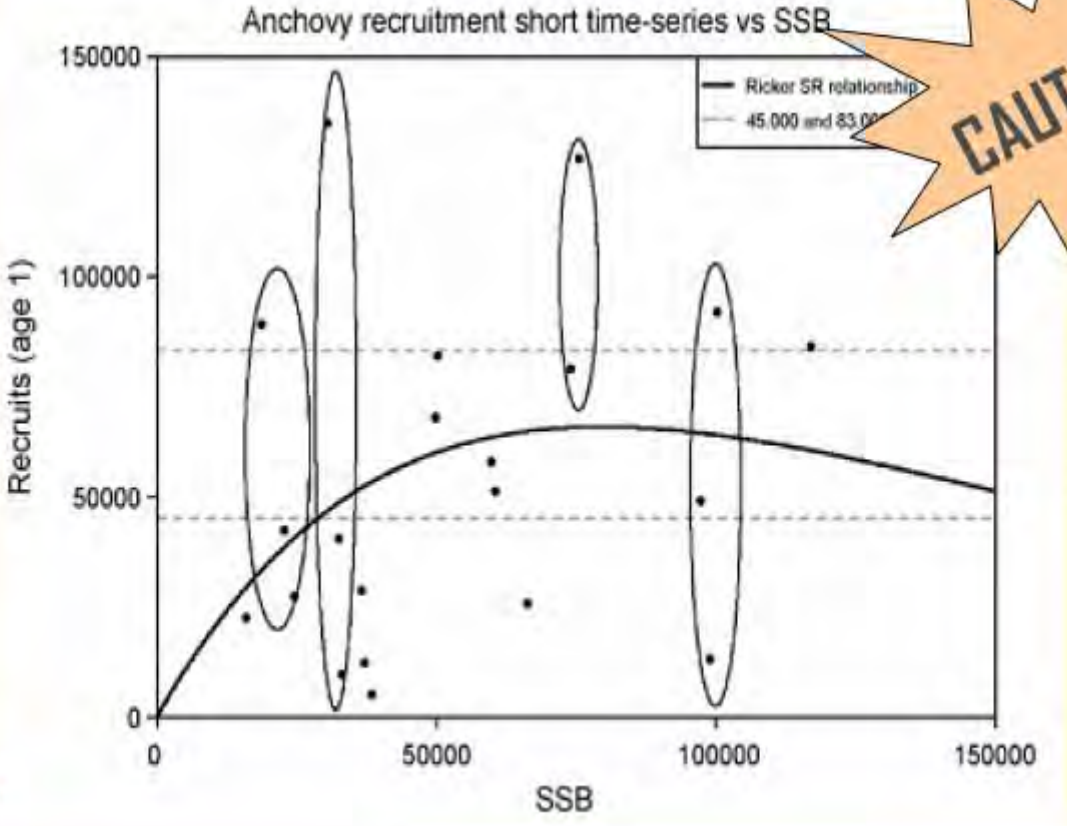


$x[n] = trend[n] + periodic[n] + random[n]$

-CLI1 is the first component from PCA of NAO, TNH, UI, SCA, EA/WR, POL and EA (Bode et al., 2006)

(Fernandes et al., 2009)

- SSB not included as a predictor (limiting factor for predictions)



CAUTION

- SSB short time series
- Widely discussed in the literature

(Fernandes et al., 2009)

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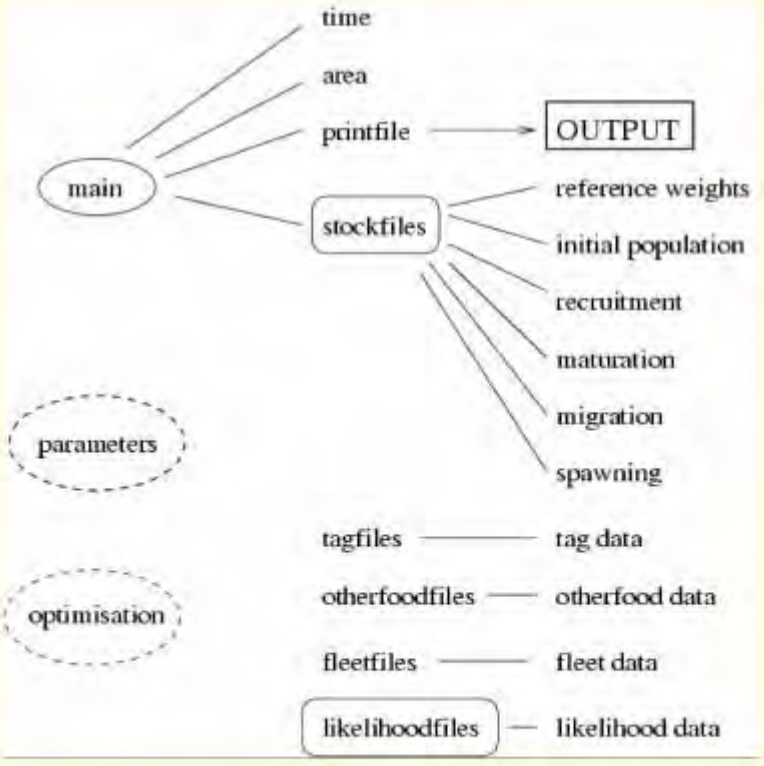
- **G**lobally applicable **A**rea **D**isaggregated **G**eneral **E**cosystem **T**oolbox (www.hafro.is/gadget)

-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



-Length-based model (1987-2008, quarterly timesteps)

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 (ld)
   - Survey indices by age
3. Optimisation: hibrid algorithm

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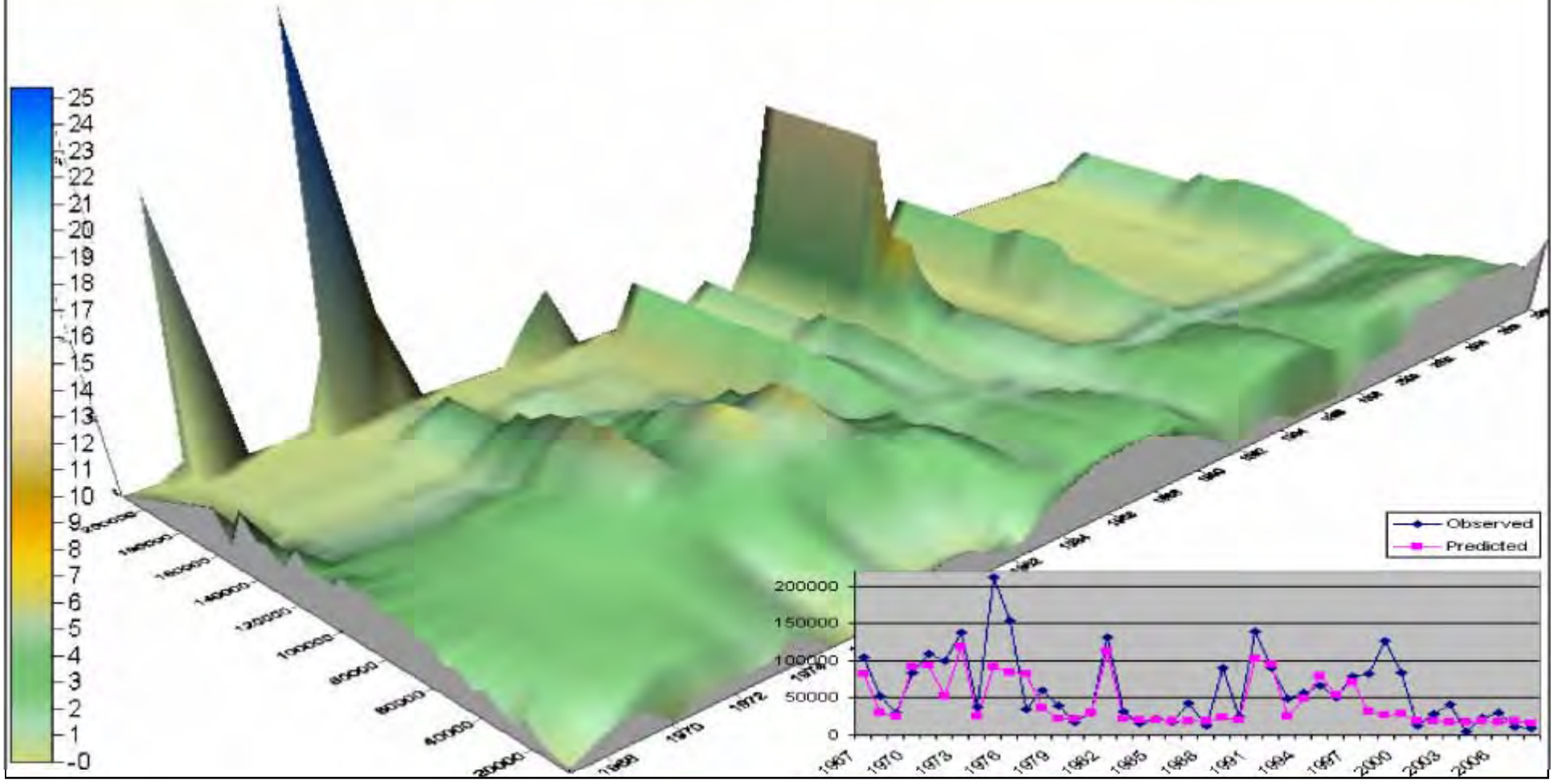
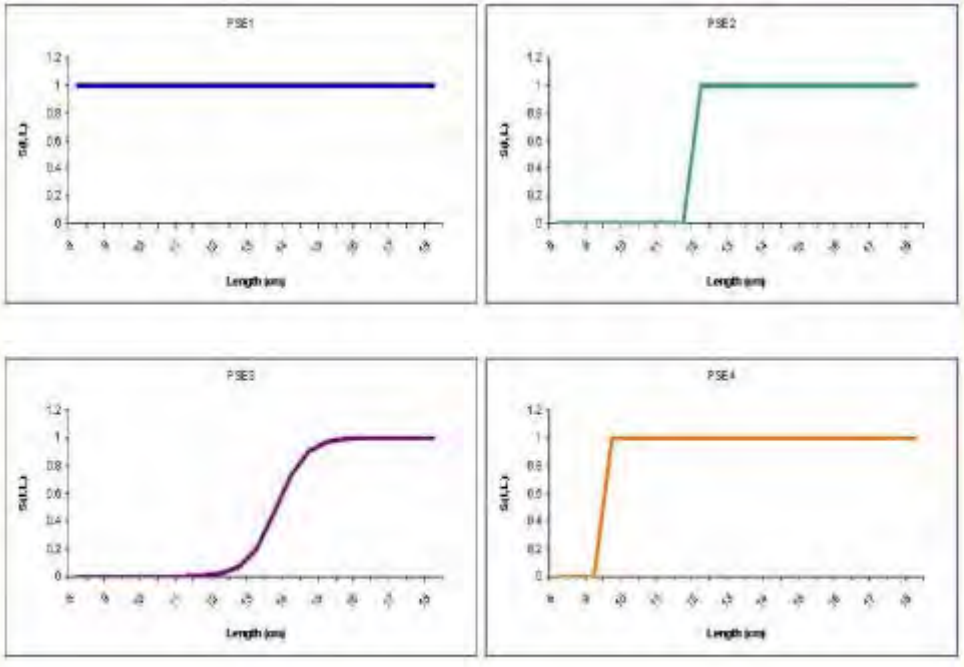
Modelled recruitment (Naive Bayes for Regression)



GADGET:

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



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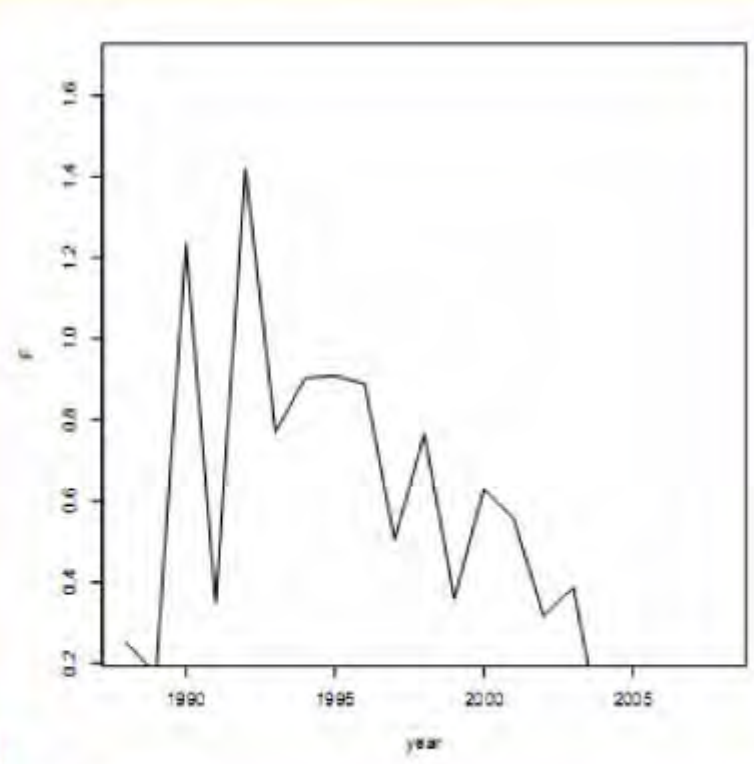
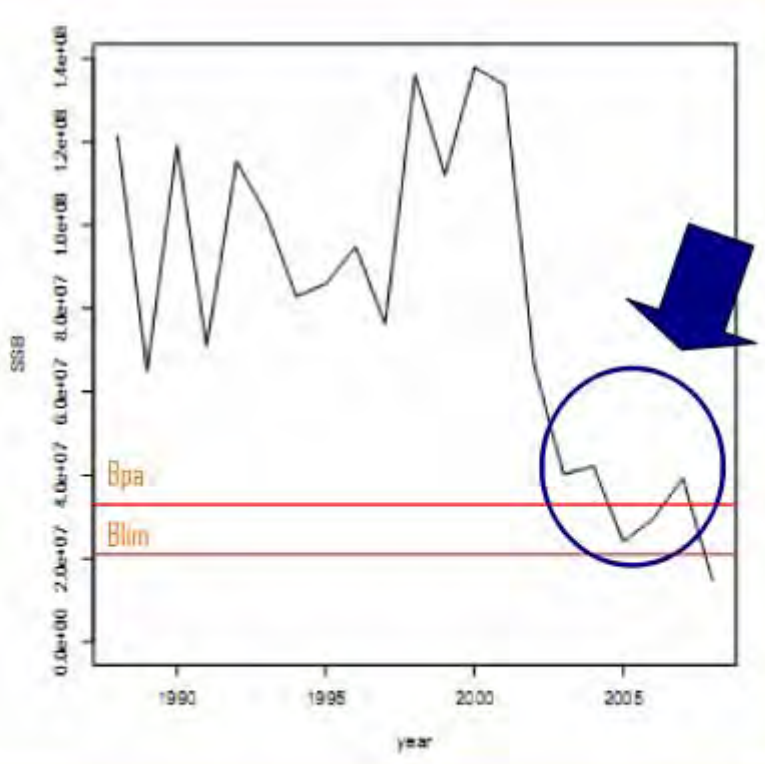
Fishing mortality

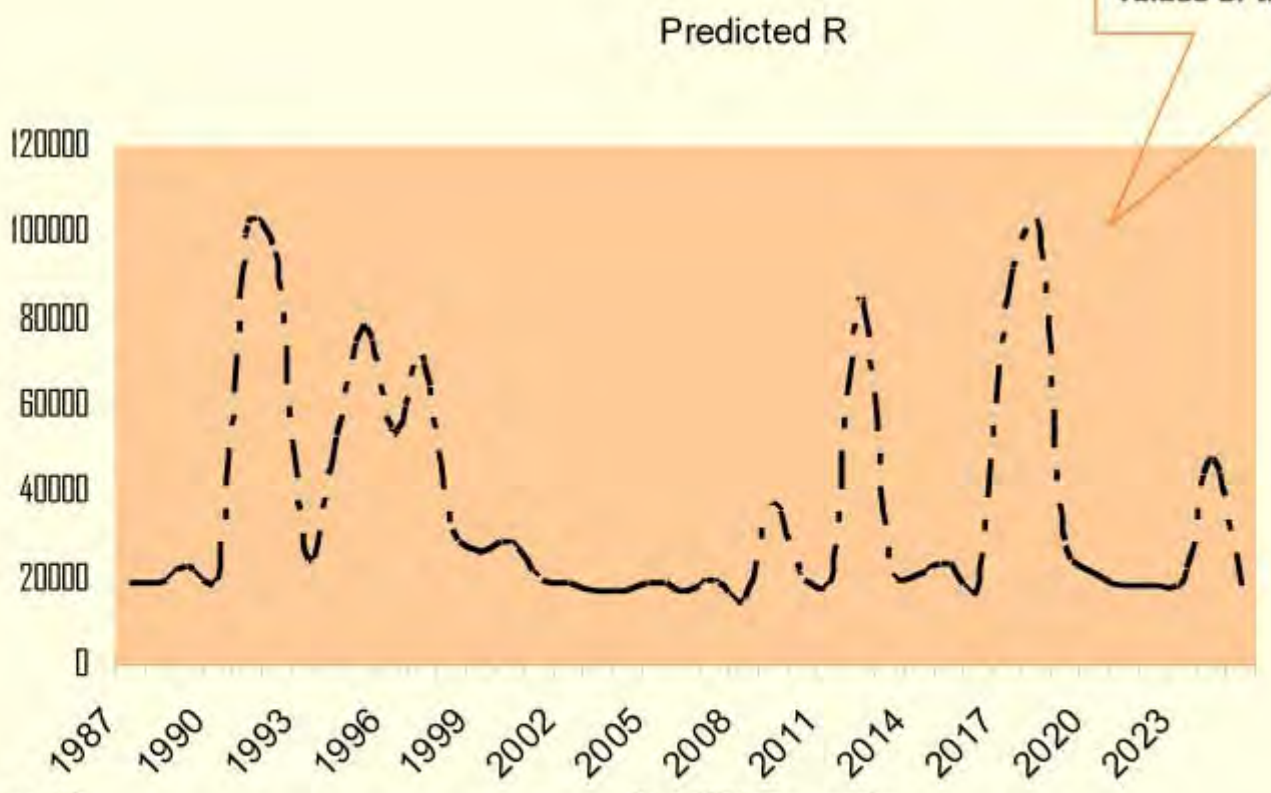


Spawning Stock Biomass



Recruitment predictions (Naive Bayes for Regression)

R predictions based on semi-random values of the climatic variables



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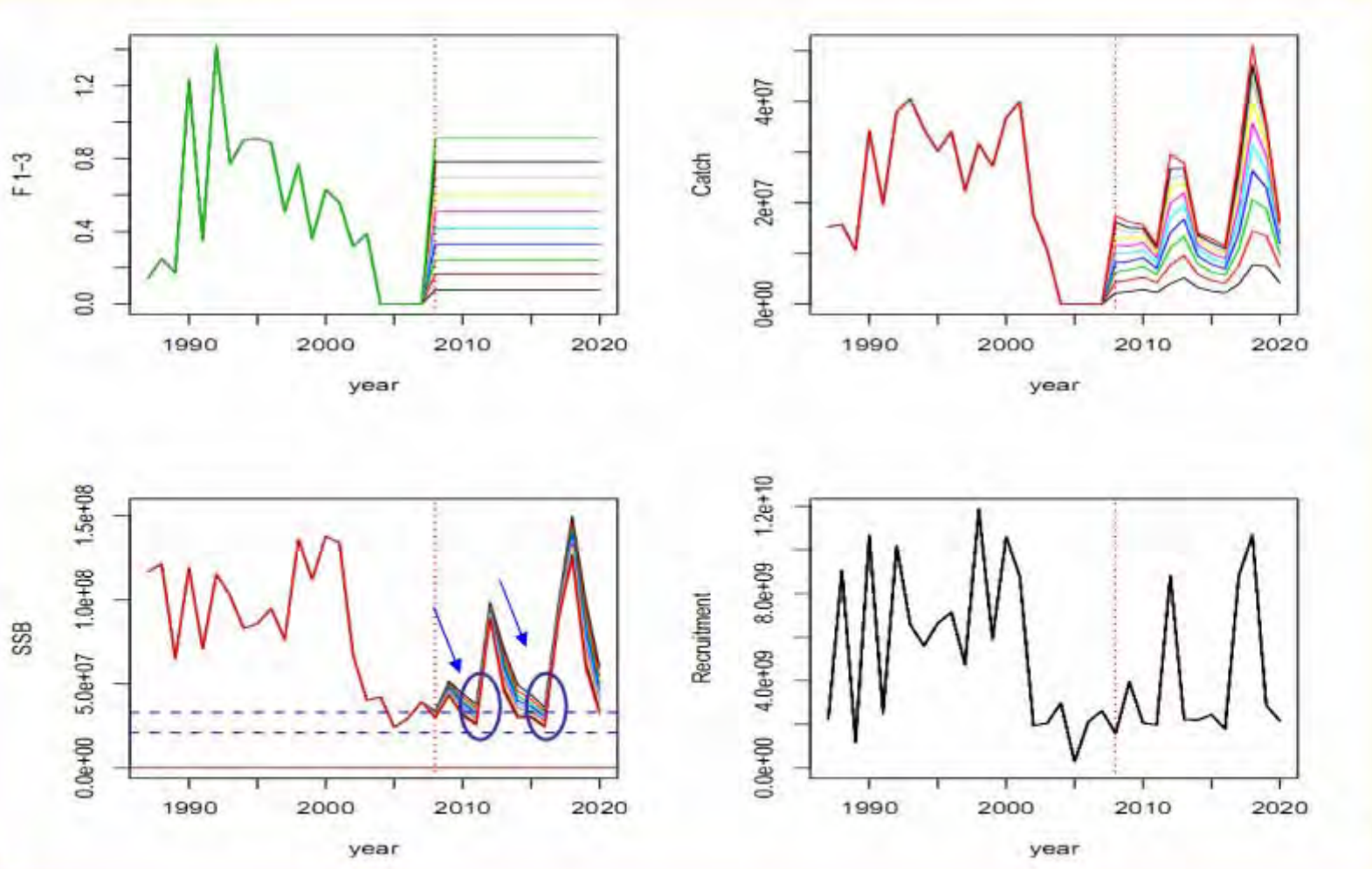
From GADGET:



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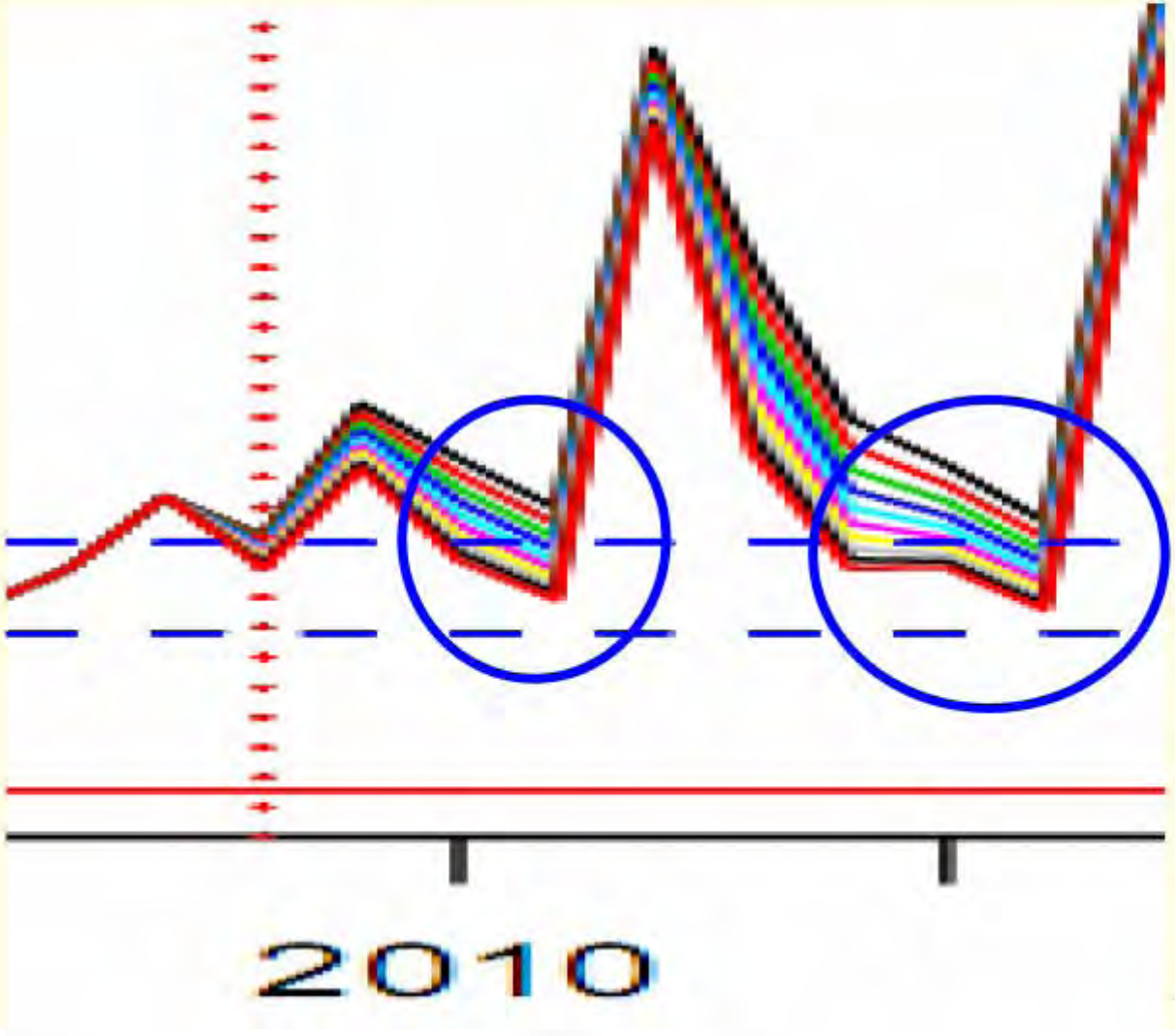

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1. Improve recruitment projections by using real data downscaled from global variables of the available climate change scenarios
2. Multidimensional recruitment models in order to work in multispecific scenarios
3. Work on the multi-species Gadget 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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