Workshop FarFish on Small pelagic and climate change in the CECAF area

Links between the environment and population dynamics model outputs: The case of Anchovy in Gulf of Cádiz and first steps with chub mackerel in Morocco.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727891.

Hello!

I am Margarita Rincón

INSTITUTO ESPAÑOL DE OCEANOGRAFÍA

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Coauthors:

Ghoufrane Derhy

Diego Macías

MARRAKECH
جامعة القاضي عياض
UNIVERSITÉ CADI AYYAD

المدرسة العليا للتكنولوجيا- الصويرة
L'ÉCOLE SUPÉRIEURE DE TECHNOLOGIE – ESSAOUIRA

ICMAN
Instituto de Ciencias Marinas de Andalucía

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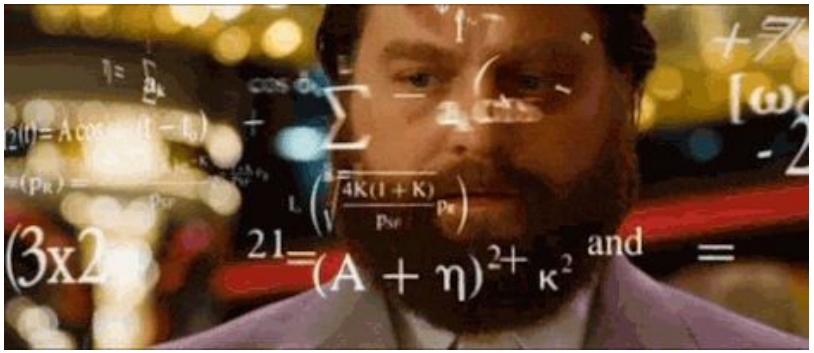
- Chub Mackerel in Morocco
  - Chub mackerel in Morrocan Atlantic coast
  - Data
  - Model implementation
  - Looking for environmental covariates
- Summary Chub mackerel

1.

A CHALLENGE FOR STOCK ASSESSMENT MODELLERS



Stock assessment models for an ecosystem-based fisheries management

Take home message

A methodology on how to use stock assessment model outputs to determine environmental drivers.

Engraulis encrasicolus

Scomber colias

Gulf of Cádiz

Morrocan Atlantic coast

WORK IN PROGRESS

2.

ANCHOVY FISHERY IN THE GULF OF CADIZ

The Gulf of Cádiz

Engraulis encrasicolus

3.646.276,35 EUR in the first quarter of 2016, is the most important fishery in the region representing 10% of the Andalucian commercial landings

Environmentally-based recruitment

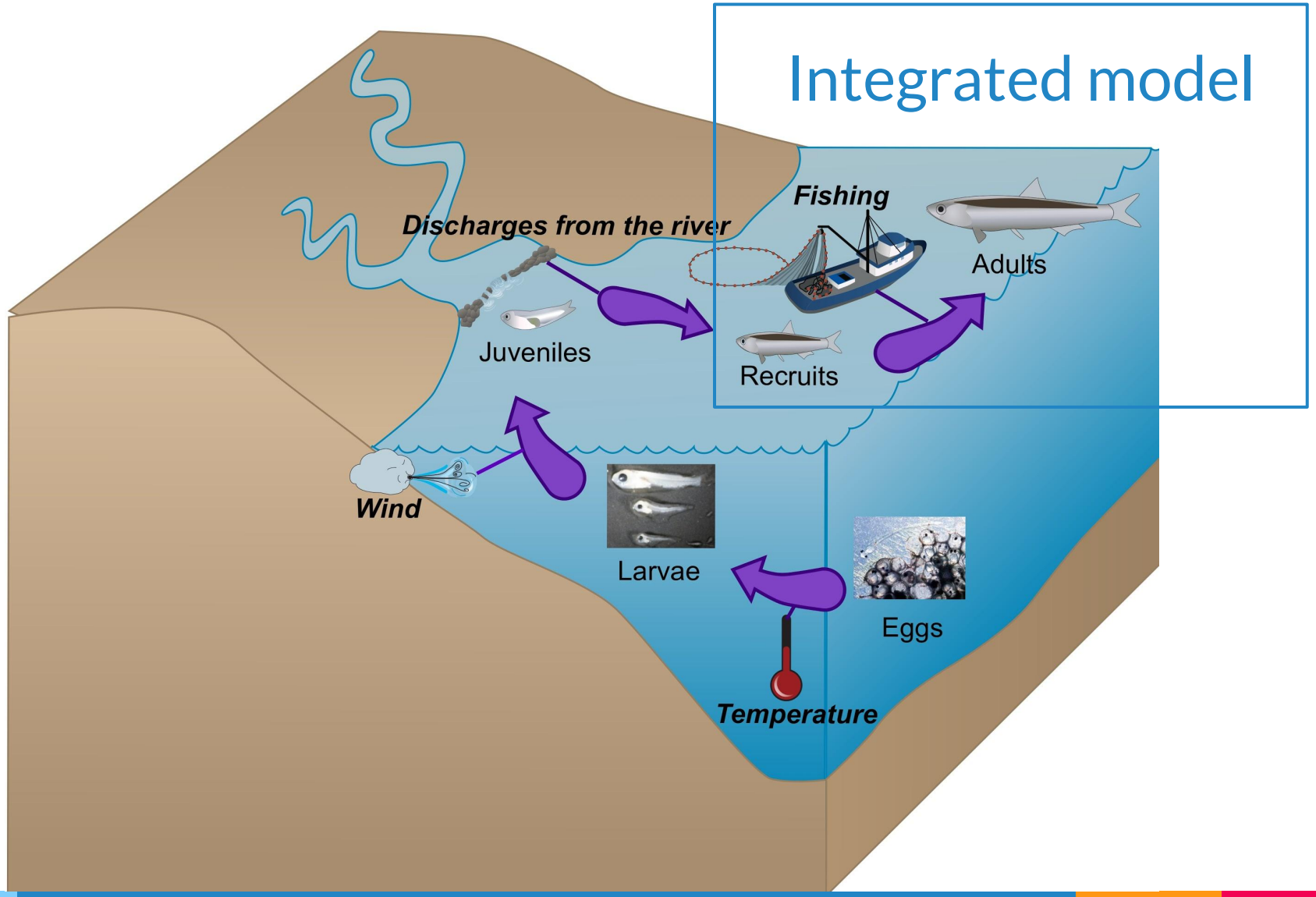
https://youtu.be/xNiTda6FQfM

Ecosystem based fisheries management EBFM

The approach

Expand an integrated model to incorporate the ecosystem approach

Model implementation



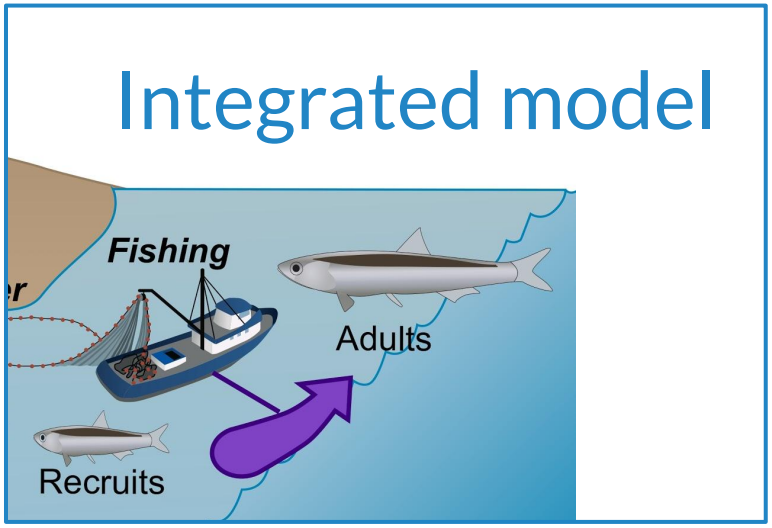
Model implementation

Integrated model

A model that includes a lot of information, i.e:

- Abundance indexes from surveys, age-length composition
- Spawner-recruit relationships
- CPUE and effort
- Direct estimates of abundance from mark-recapture or line transect methods.

GREAT ADVANTAGE: Consistency
"The inclusion of auxiliary information along with catch-age data allows for unbiased estimation" (Quinn 2003)



Model implementation

Integrated model

A model that includes a lot of information, i.e:

- Survey abundance, age-length composition,
- Spawner-recruit relationships
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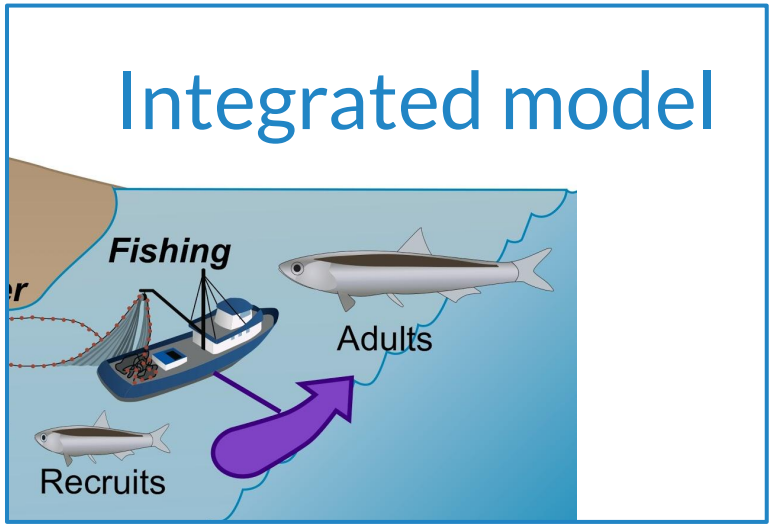
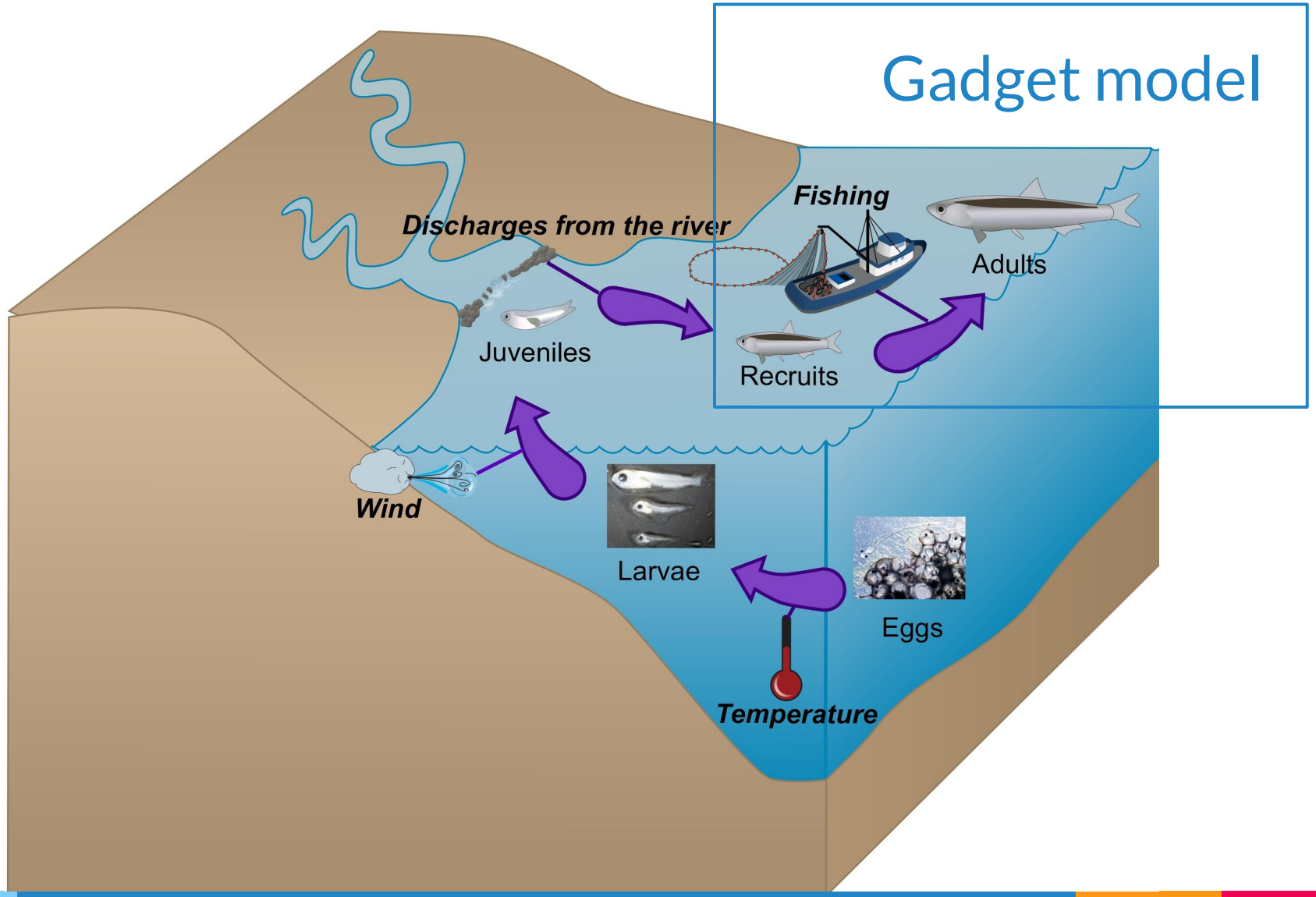


Examples:

- SS3
- Gadget
- CAGEAN
- ADAPT

Model implementation

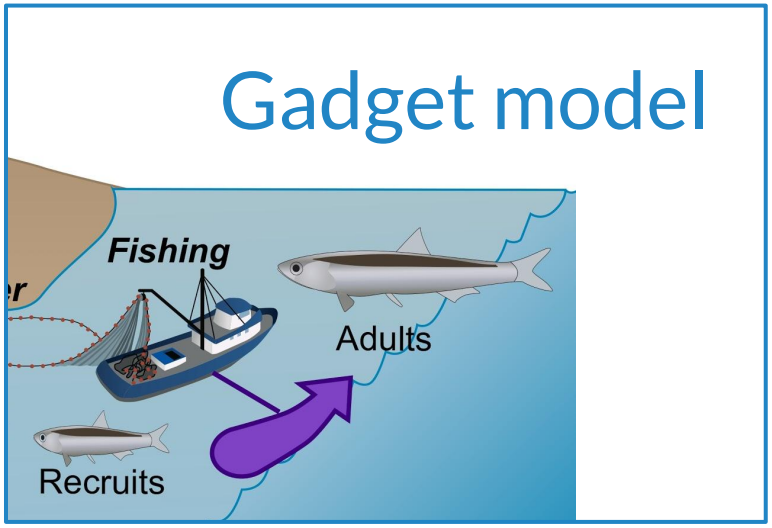


Model implementation

Gadget

A parametric, age-length-structured model. For this implementation we used:

- Landings from 1988 (Numbers, Age and length distributions)
- 3 Acoustic Surveys (Numbers, Age and length distributions)



CAVEATS:

- Very complex
- Need specialized training and lot of time

ADVANTAGES:

- It is the model used as the basis of the assessment in ICES WGHANSA
- Data input and data output automated in R (data.frames, mfdb and Rgadget packages)
- Multiarea and multispecies

Model implementation

Gadget

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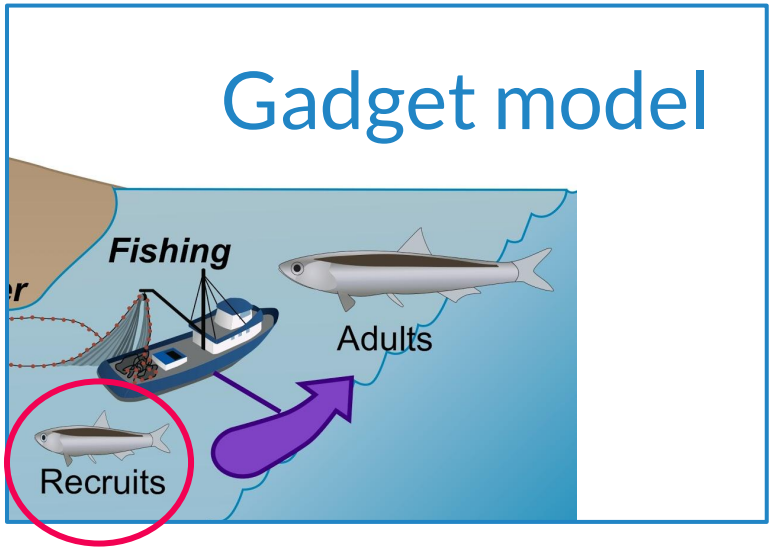
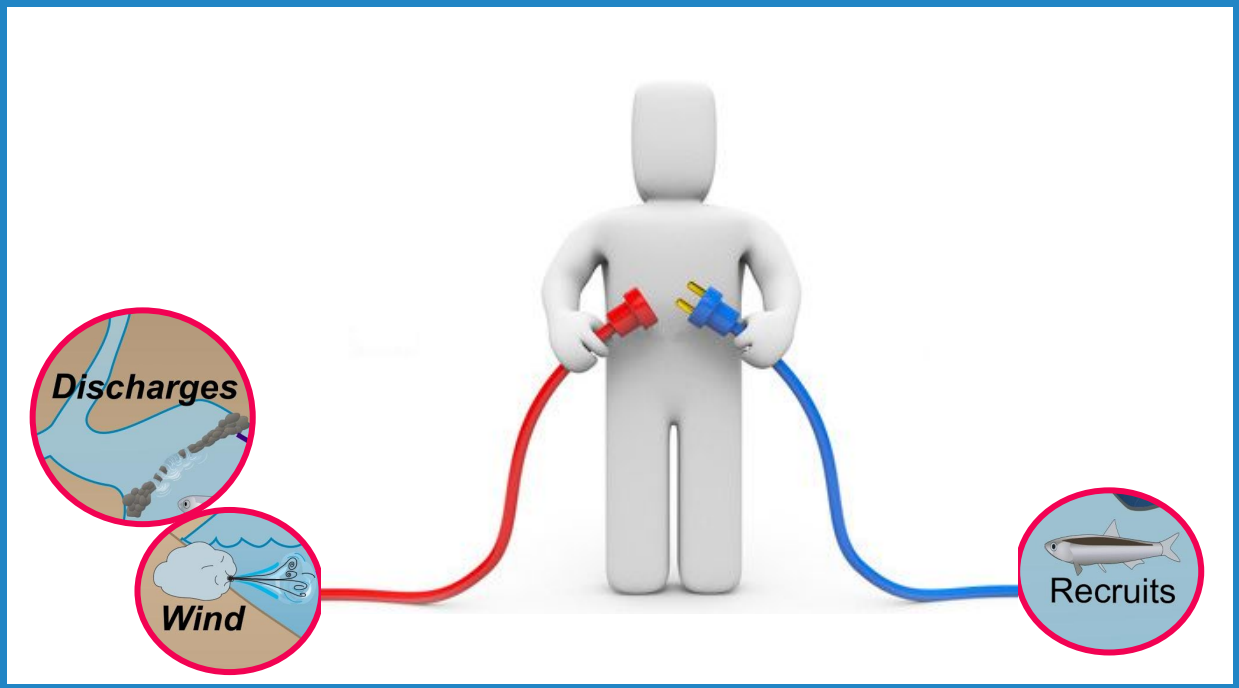
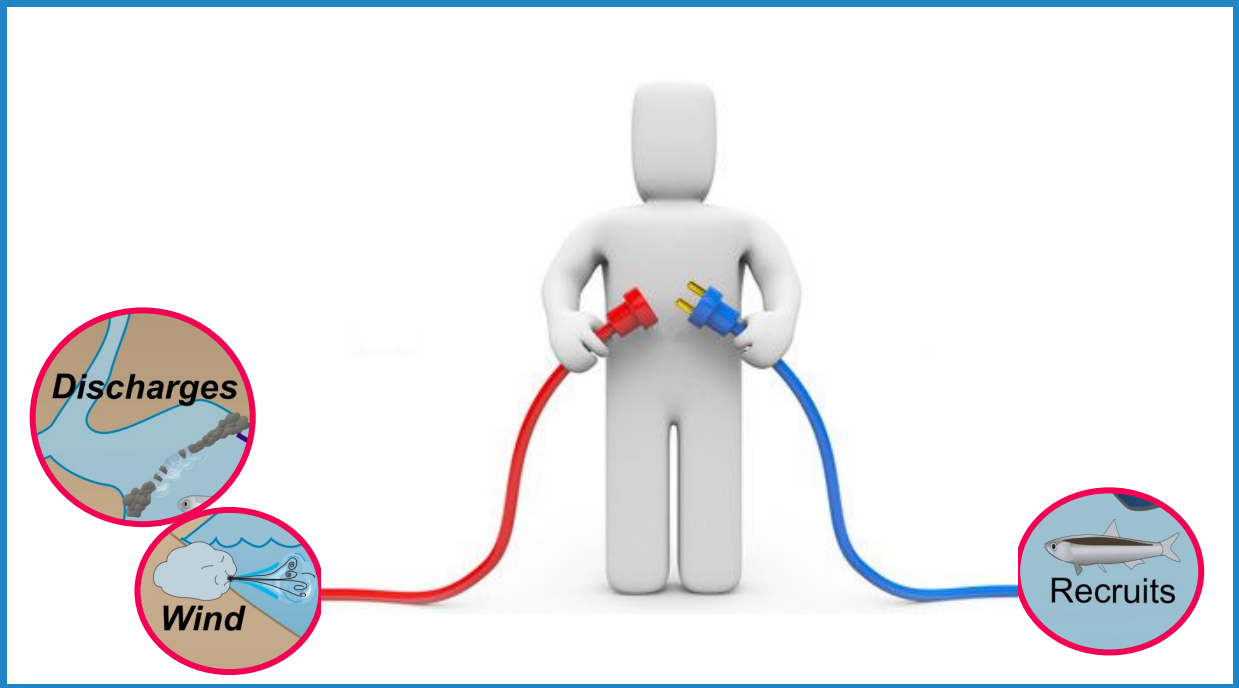


Simulation and log-likelihood optimization


Discharges
Wind
Recruits



Granger-causality

Provides a framework that uses predictability to identify causation between time-series variables, provides a mathematical relationship between population dynamics and environmental covariates

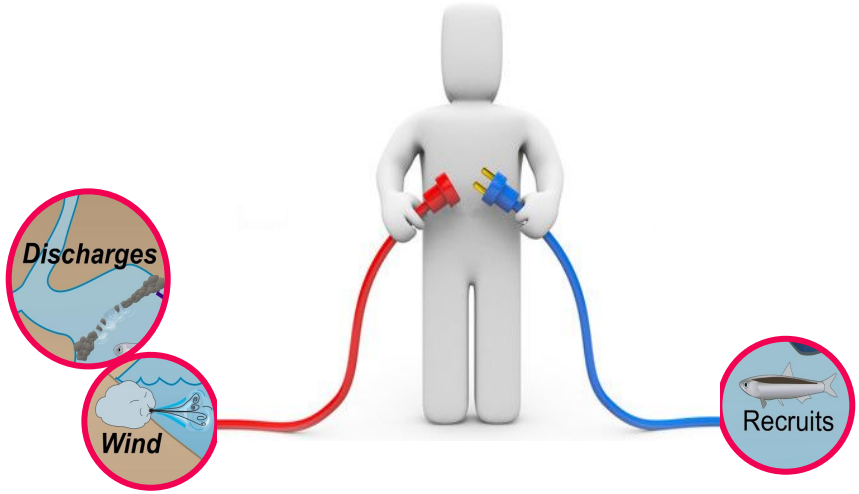
Granger-causality

Granger-causality concept says that an stationary time-series variable X is said to "Granger-cause" (Granger, 1969) the stationary time-series variable Y, if past values of X help to predict the current value of Y better than just the past values of Y do.

$$Y_t = a + \alpha_1 Y_{t-1} + \cdots + \alpha_L Y_{t-L} + \beta_1 X_{t-1} + \cdots + \beta_L X_{t-L} + \epsilon_t$$

Test

$$H_A : \beta_i \neq 0$$



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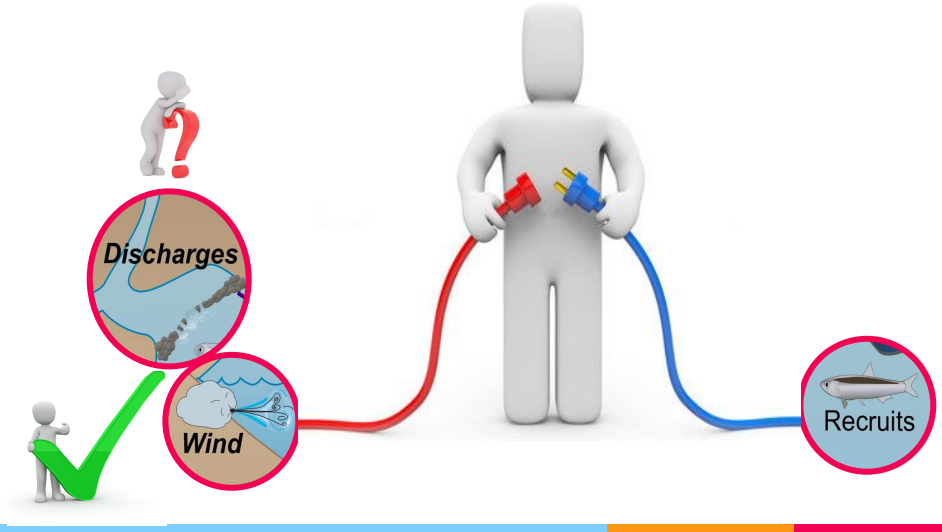
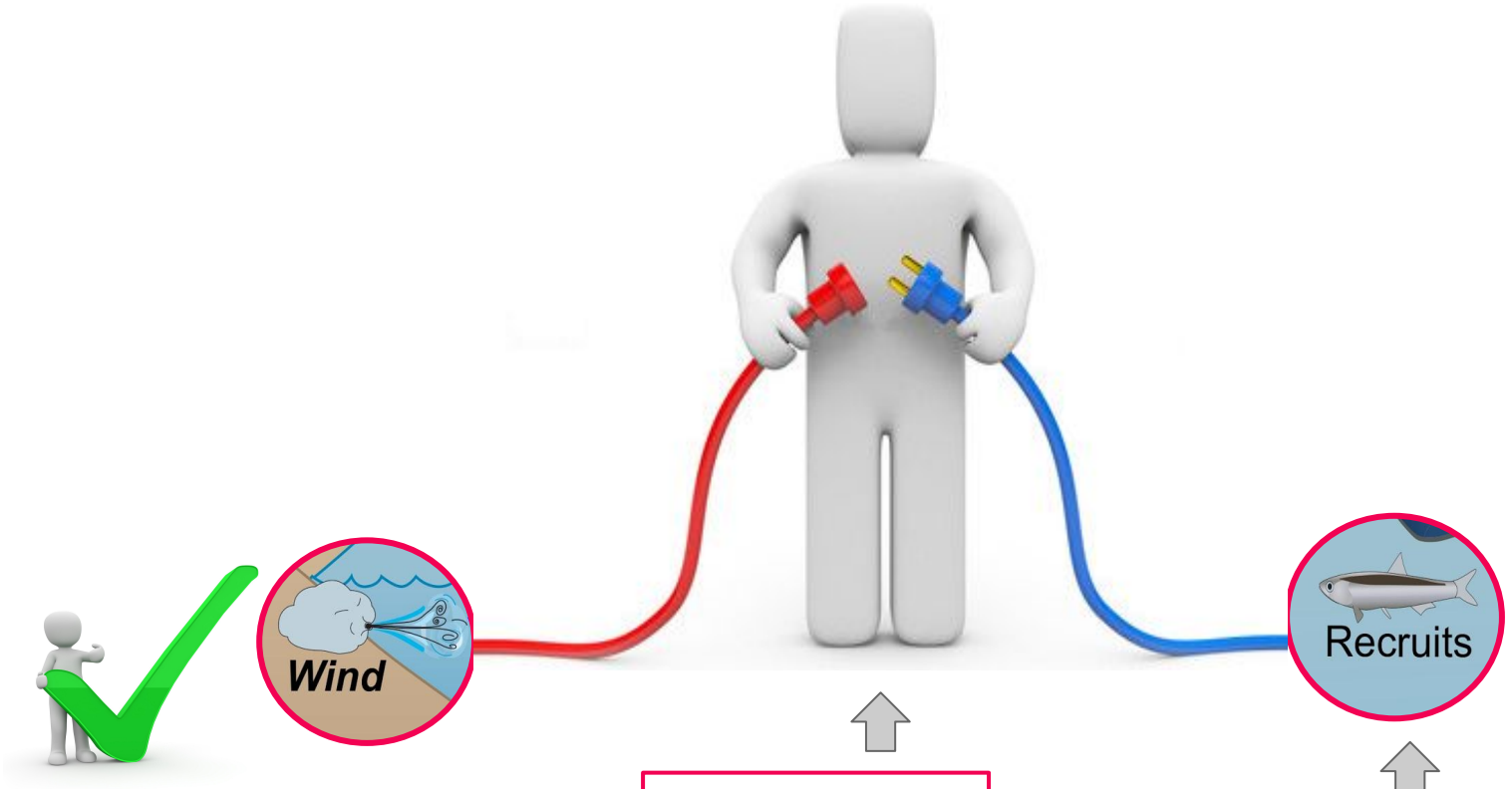
Test

$$H_A : \beta_i \neq 0$$

WARNING: A well specified model is needed: No serial autocorrelation, no roots outside the unit circle



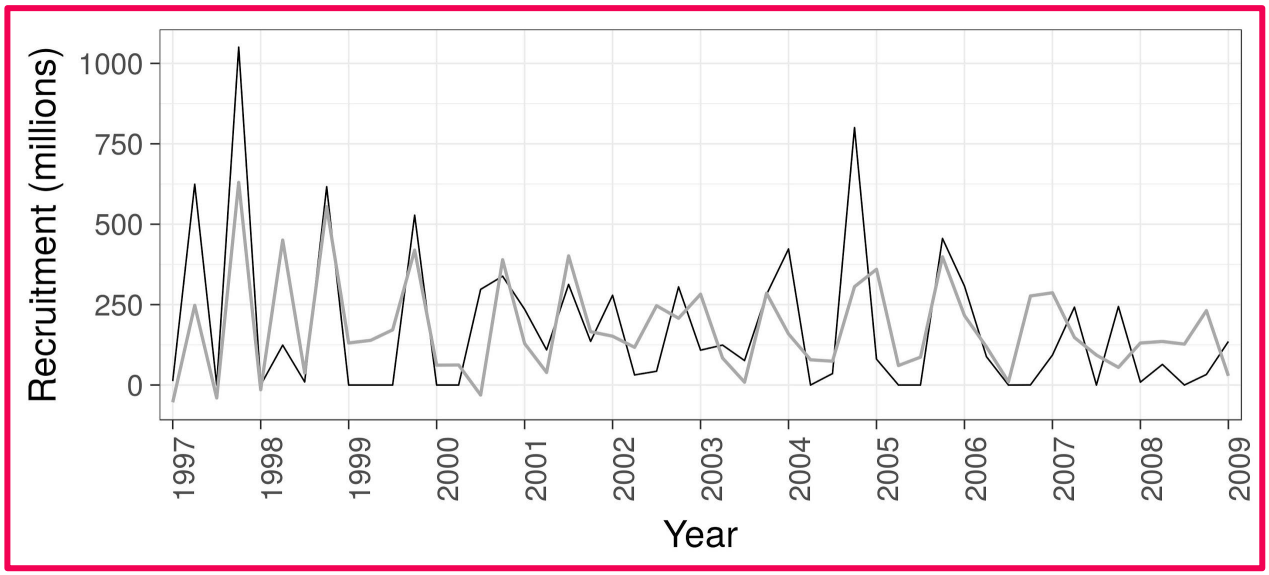


Mathematical relationship

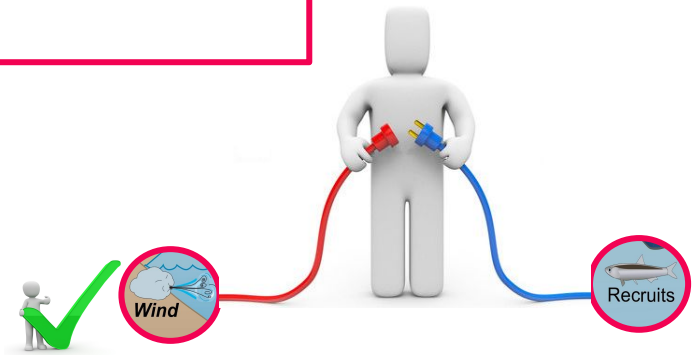
Anchovy in the Gulf of Cadiz-Gadget model output

Recruitment-environmental factor relationship

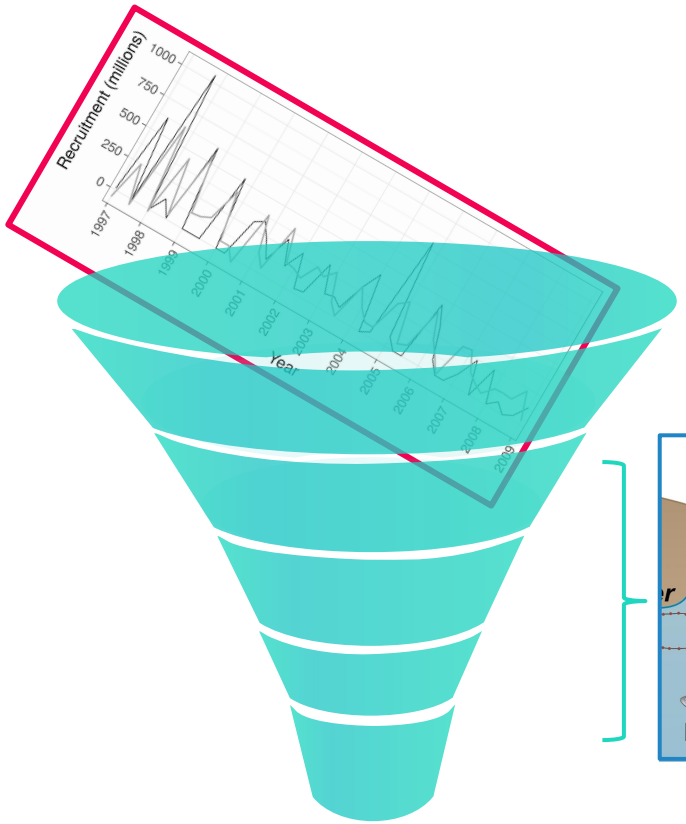
$$R_t = a + \alpha_1 R_{t-1} + \cdots + \alpha_L R_{t-4} + \beta_1 W_{t-1} + \cdots + \beta_L W_{t-4} + \epsilon_t$$

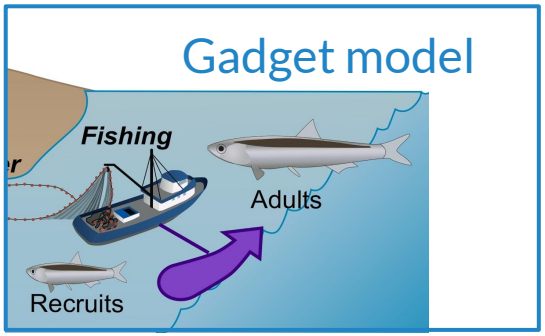


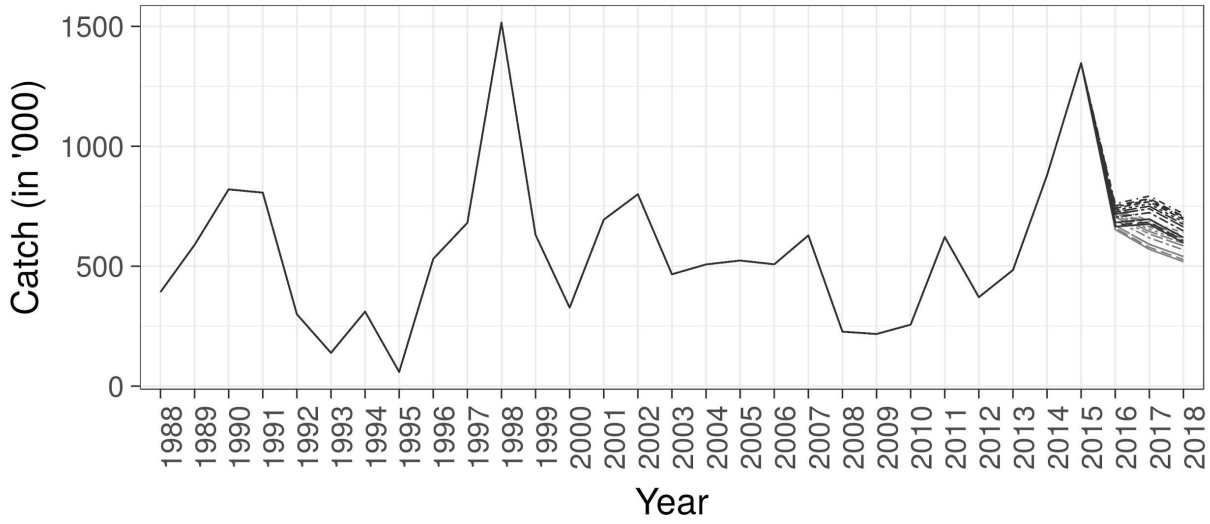
Comparison between Gadget recruitment output time series (black line) and fitted values (grey line).



Forecast







Three years forward projection with a Gadget simulation in two different wind scenarios: Good wind conditions (dark grey) and bad wind conditions (light grey).

3.
SUMMARY ANCHOVY

The process

Implement a Gadget model

Find a mathematical relationship between wind and recruitment output

$$R_t = a + \alpha_1 R_{t-1} + \cdots + \alpha_L R_{t-4} + \beta_1 W_{t-1} + \cdots + \beta_L W_{t-4} + \epsilon_t$$

Use that relationship to forecast recruitment

Fisheries Research 213 (2019) 42–55

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Granger-causality analysis of integrated-model outputs, a tool to assess external drivers in fishery

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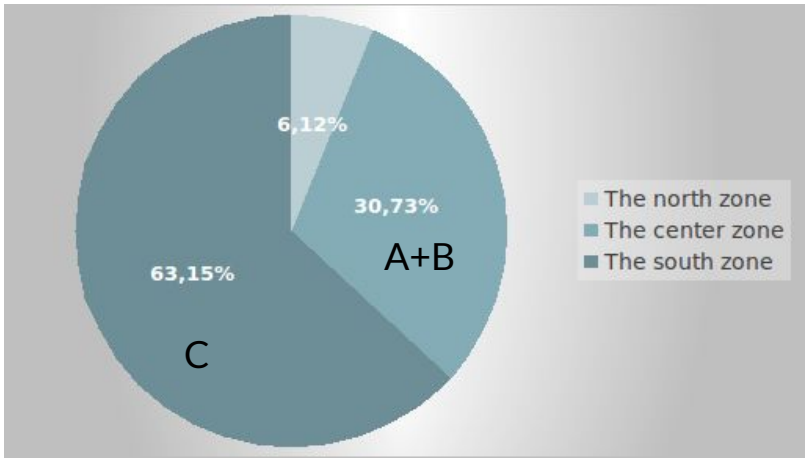
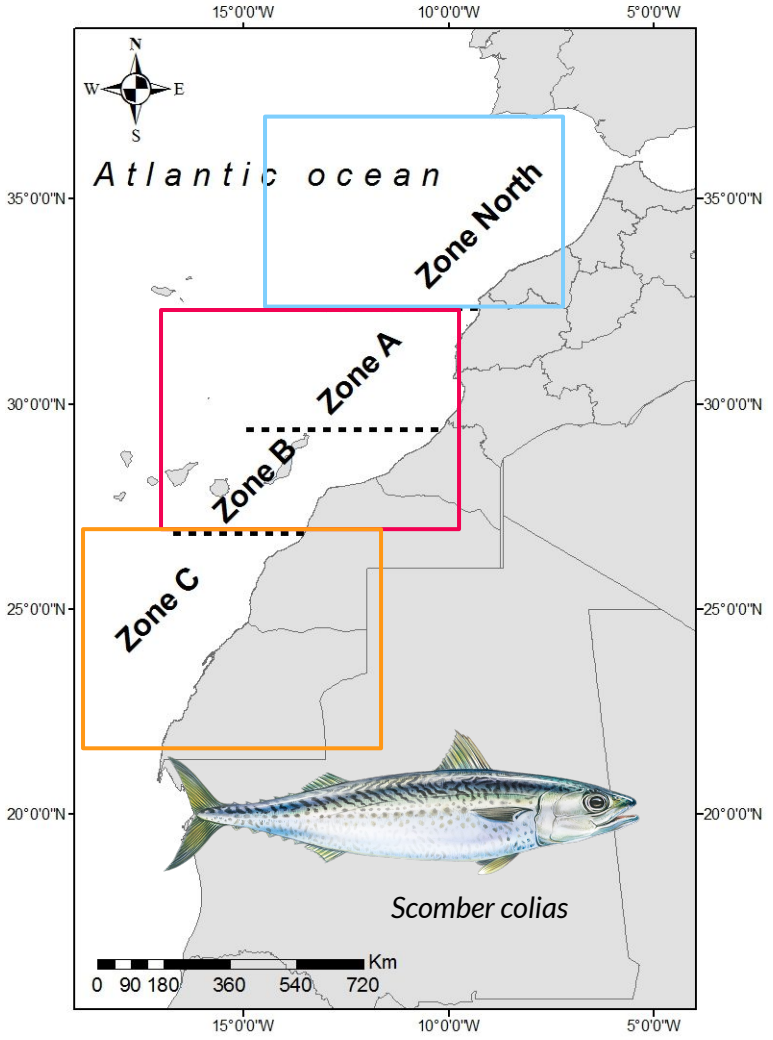
[b] Ms.C. of Marine Biology, School of Science, University of Bologna, Ravenna Campus, via S. Alberto 163, 48123 Ravenna, Italy
[c] Marine and Freshwater Research Institute, Hafrannsóknastofnun, Skulagata 4, 121 Reykjavík, Iceland
[d] Instituto Español de Oceanografía, Centro Oceanográfico de Cádiz, Puerto pesquero, Muelle de Levante s/n, Apdo. 2609, 11006 Cádiz, Spain

4.
CHUB MACKEREL IN MOROCCO

Chub mackerel in Morrocan Atlantic Coast

- One of the most important small pelagic fishery resources (17% of Morocco's total small pelagic stock) .
- Three stocks are defined along the Moroccan Atlantic coast: The north (Tangier-Cap Cantin), the center (Cape Cantin-Cape Bojador A+B) and The southern stock (Cape Bojador-Cap Blanc), but **higher catches correspond to Zone A+B+C**

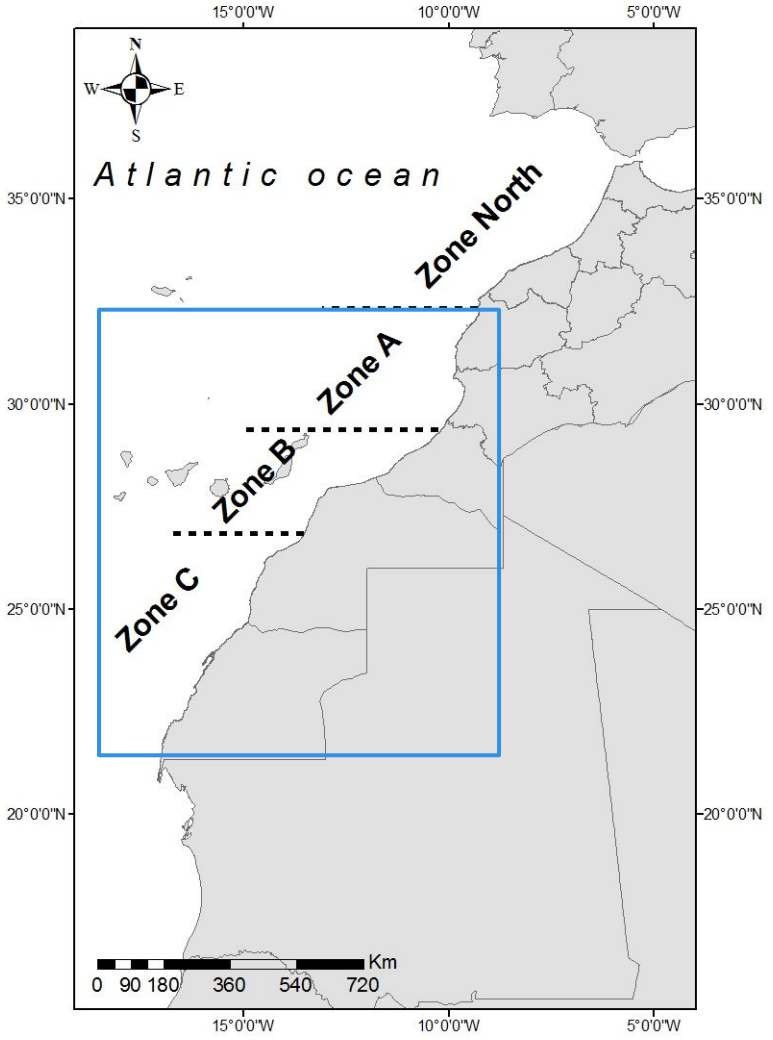




Data

Catches and three abundance indexes available for A+B+C Zone

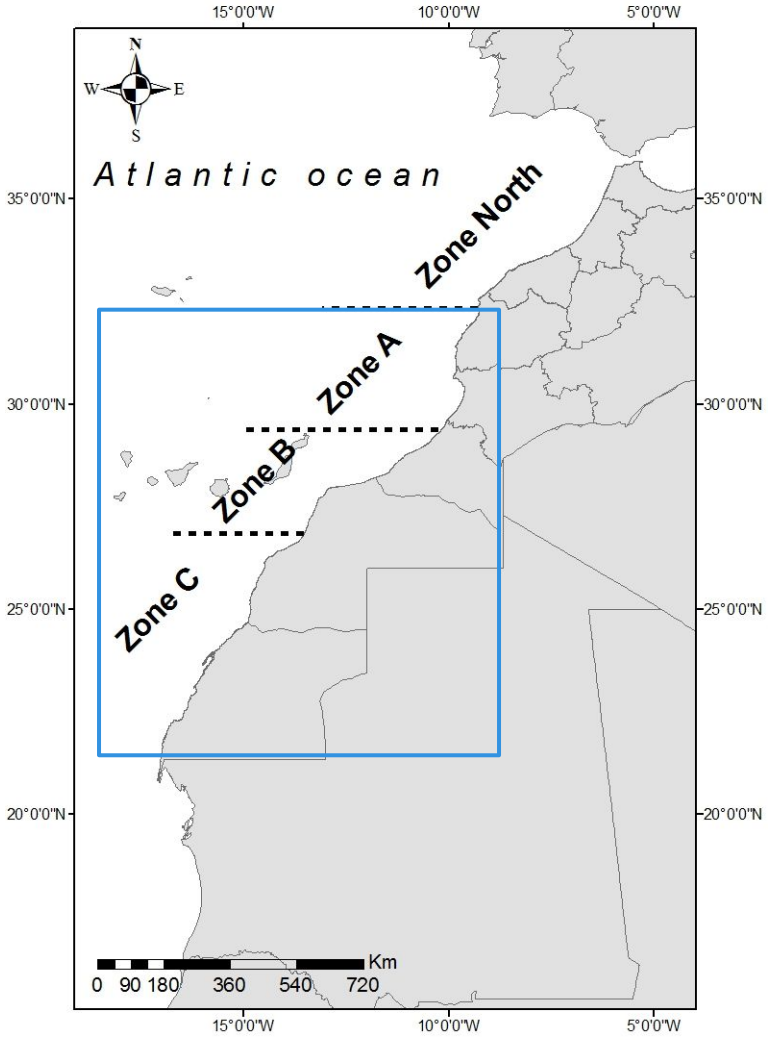
- Annual catch data from national and international fleets [1990-2018] (FAO, 2020);
- Index 1: estimated biomass from the acoustic survey by the **Amir Moulay Abdellah** vessel from 2000 to 2017 (INRH, 2017);
- Index 2: estimated biomass data from the **Nansen** survey from 1999 to 2015 (FAO, 2020);
- Index 3: estimated biomass data from 1994 to 2015. **Atlantida** acoustic survey in summer (FAO, 2020).



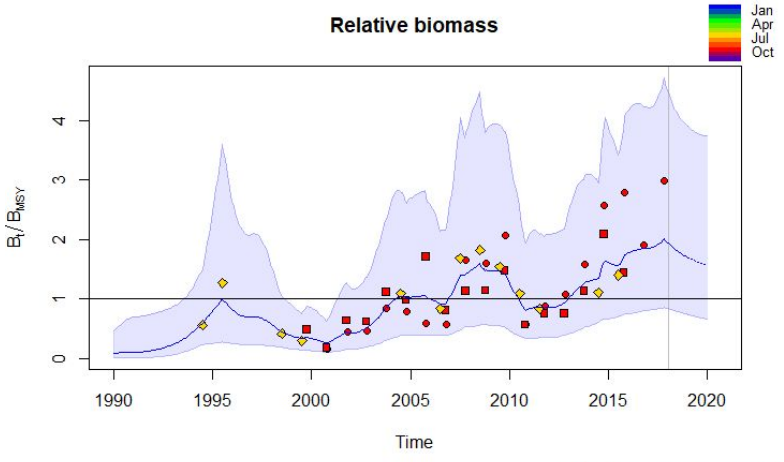
Model implementation

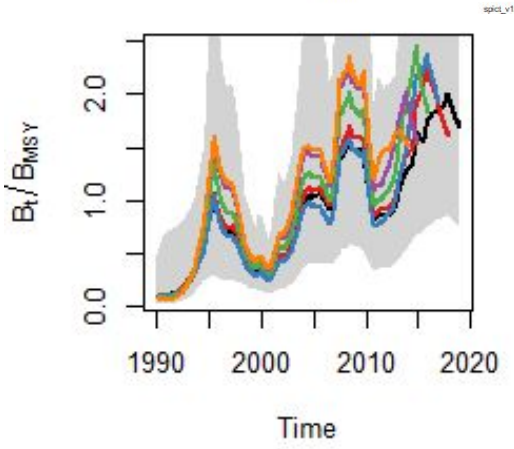
Surplus production in continuous time model (Pedersen and Berg, 2017) (SPiCT), A+B+C Zone

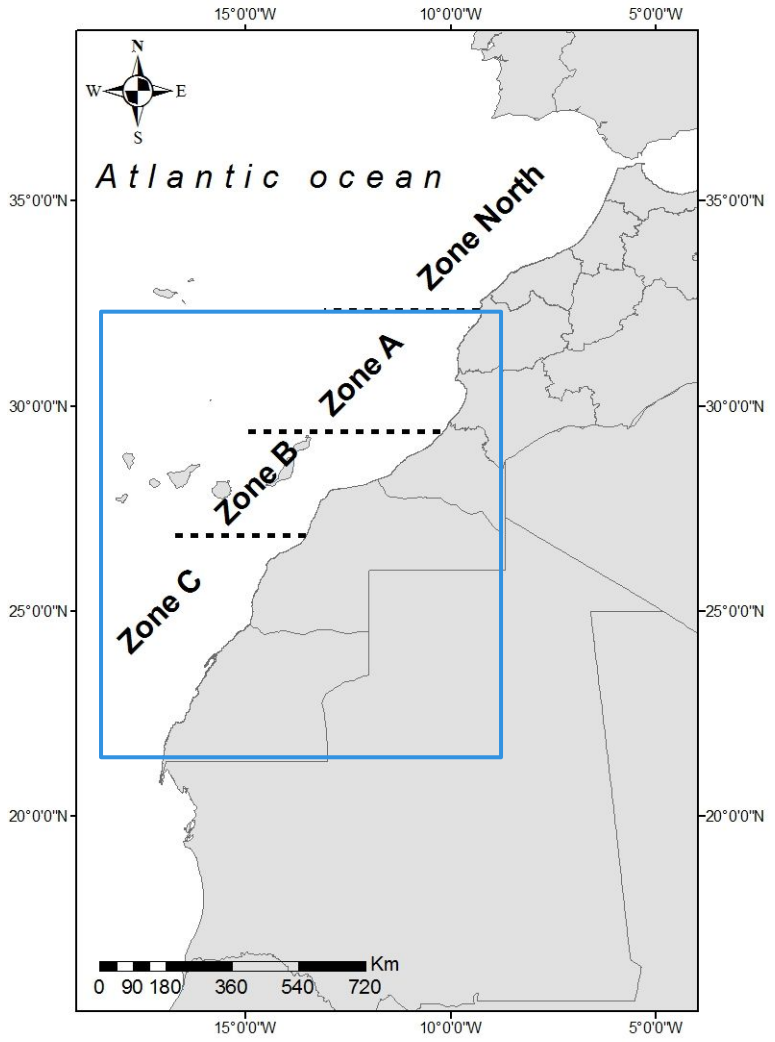
- Data input in continuous time basis (**different time steps and gaps**).
- This model can be fitted using **only abundance indices time series and catch information**.
- **Relatively easy to implement providing diagnostics on violation of assumptions and consistency.**
- Provides uncertainty estimations
- It is used for assessment of category one stocks in ICES areas



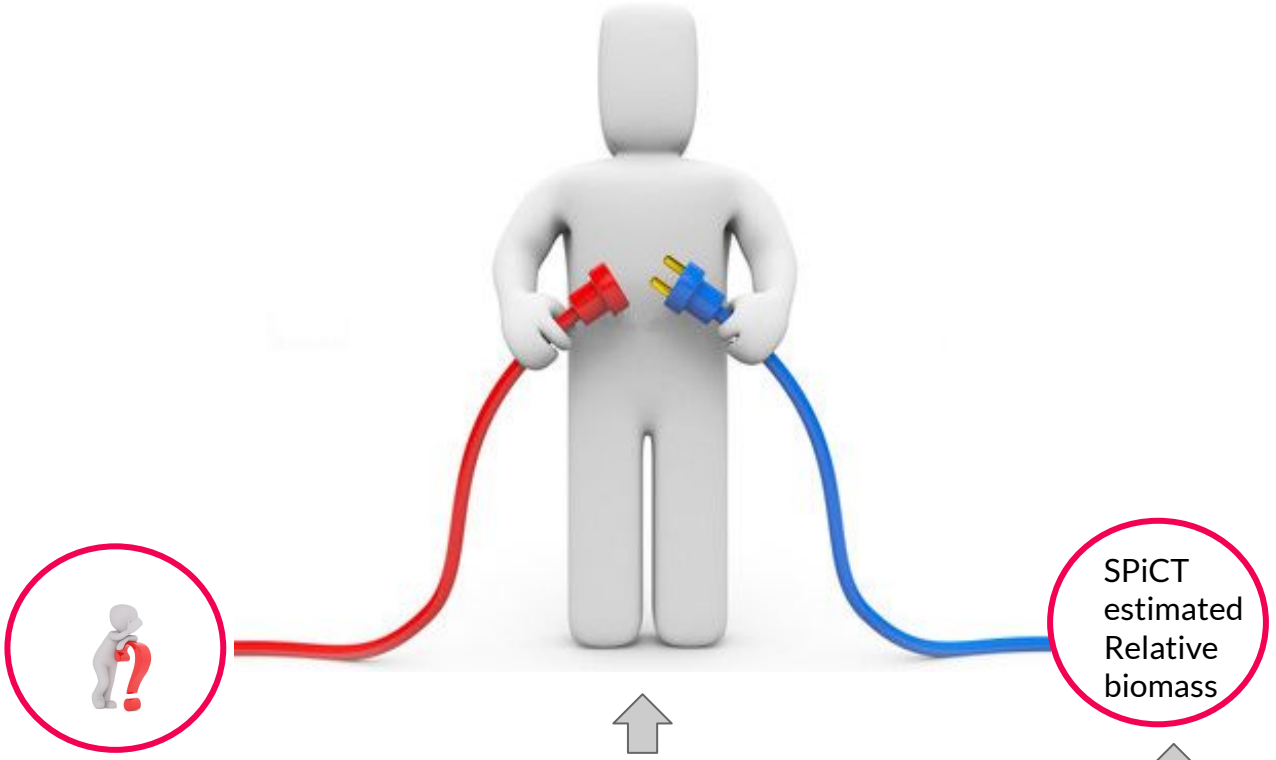
Model implementation



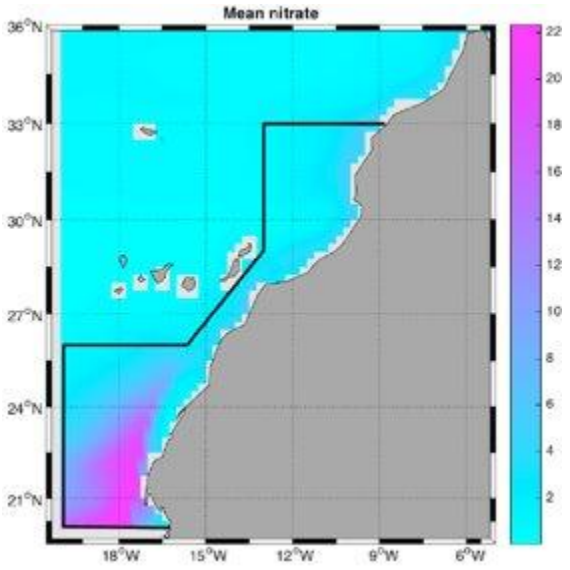




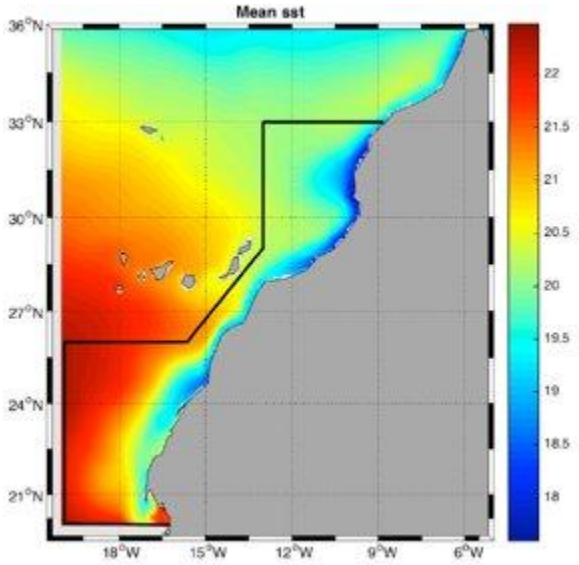
The model provides a **consistent trend** for population dynamics


SPiCT estimated Relative biomass
Mathematical relationship
Population trend model output

Looking for environmental covariates



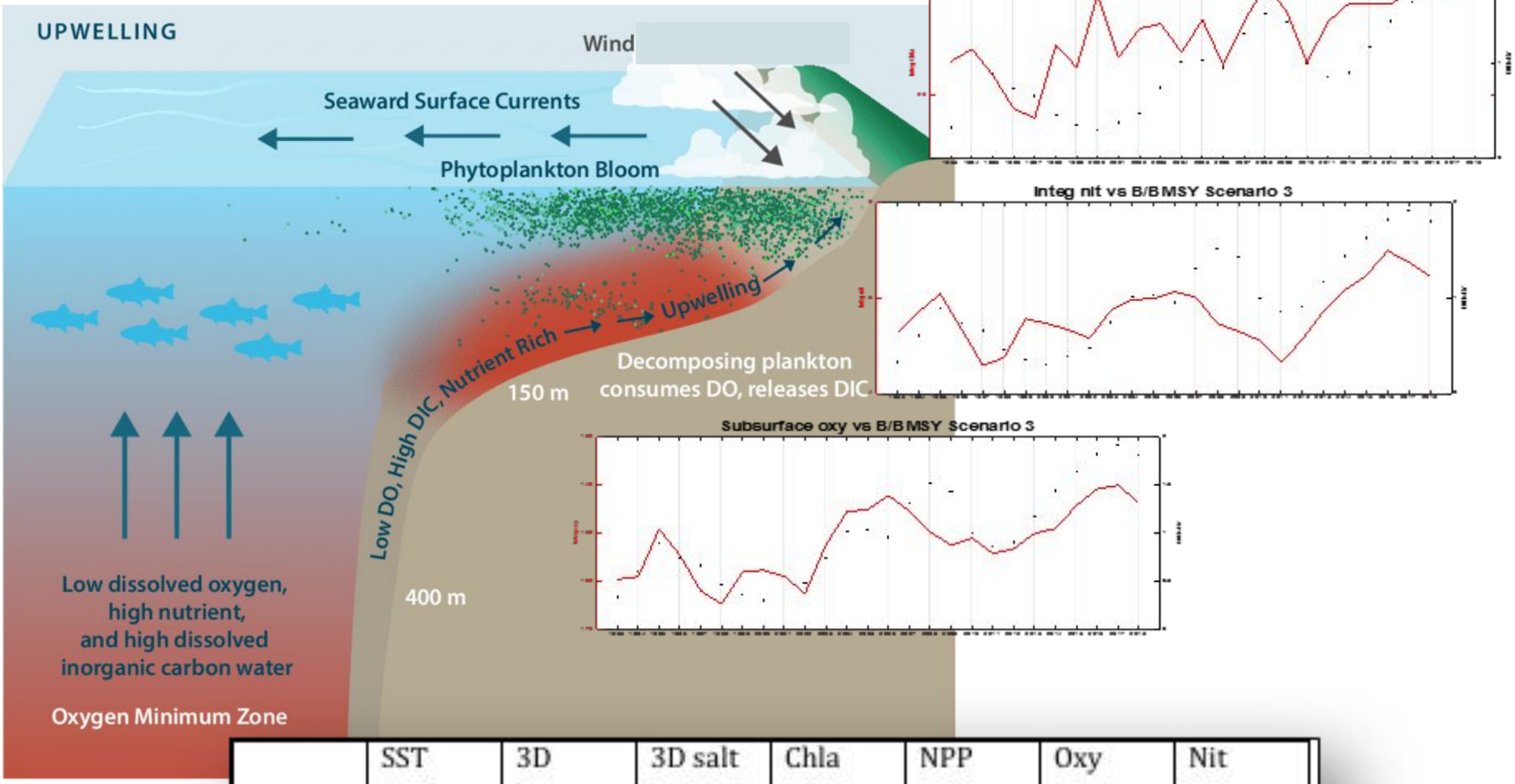
Intensive data analysis!



Copernicus Marine Service

Physical conditions:
-Product: GLOBAL_REANALYSIS_PHY_001_030
-Period: 01/1993 to 06/2019
-Spatial resolution: 0.086 degrees
-Temporal resolution: monthly means
-3D fields (surface to bottom)
-Variables:
Bottom salinity, 3D temperature, 3D salinity, 3D u velocity, 3D v velocity

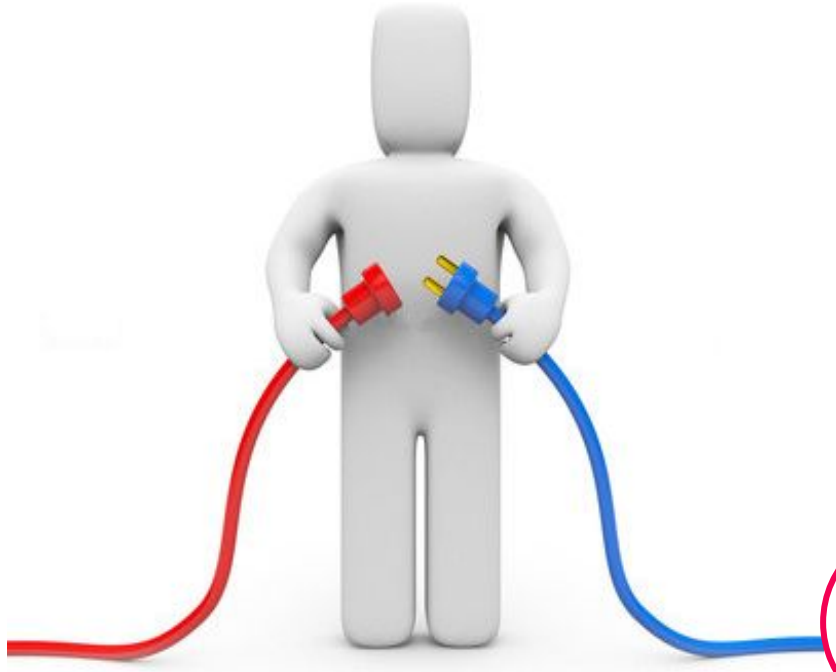
Biogeochemical conditions:
-Product: GLOBAL_REANALYSIS_BIO_001_029
-Period: 01/1993 to 06/2019
-Spatial resolution: 0.25 degrees
-Temporal resolution: monthly means
-3D fields (surface to bottom)
-Variables:
3D Chlorophyll, 3D Net Primary production, 3D Nitrate, 3D Phosphate



From Chan et al. 2019

	SST	3D temp	3D salt	Chla	NPP	Oxy	Nit
Winter	-0,00014	-0,05	**-0,49**	0,36	0,34	-0,83	0,69
Spring	-0,06	-0,08	-0,32	0,64	0,56	-0,80	0,68
Summer	0,27	0,06	-0,16	0,58	0,48	-0,65	0,56
Fall	0,31	-0,07	**-0,42**	0,64	0,44	-0,73	0,69

One step closer to finding a mathematical relationship



Upwelling related variables

SPiCT estimated Relative biomass

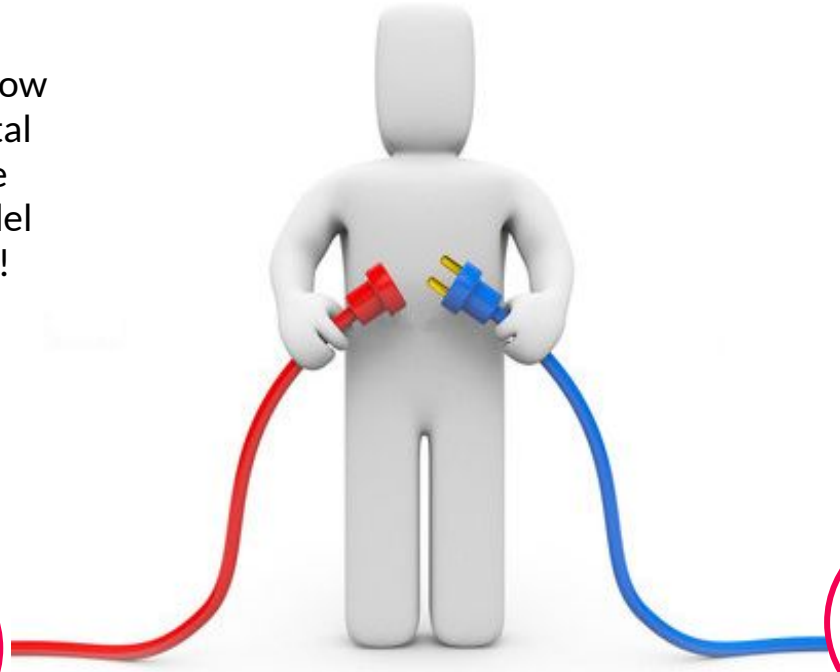
- Subsurface Oxygen
- Newt primary production
- Chlorophyll
- Nitrate

Mathematical relationship

Population trend model output

One step closer to finding a mathematical relationship

That relationship will allow to include environmental covariates to simulate scenarios in SPiCT model but also other models!



Upwelling related variables

- Subsurface Oxygen
- Newt primary production
- Chlorophyll
- Nitrate

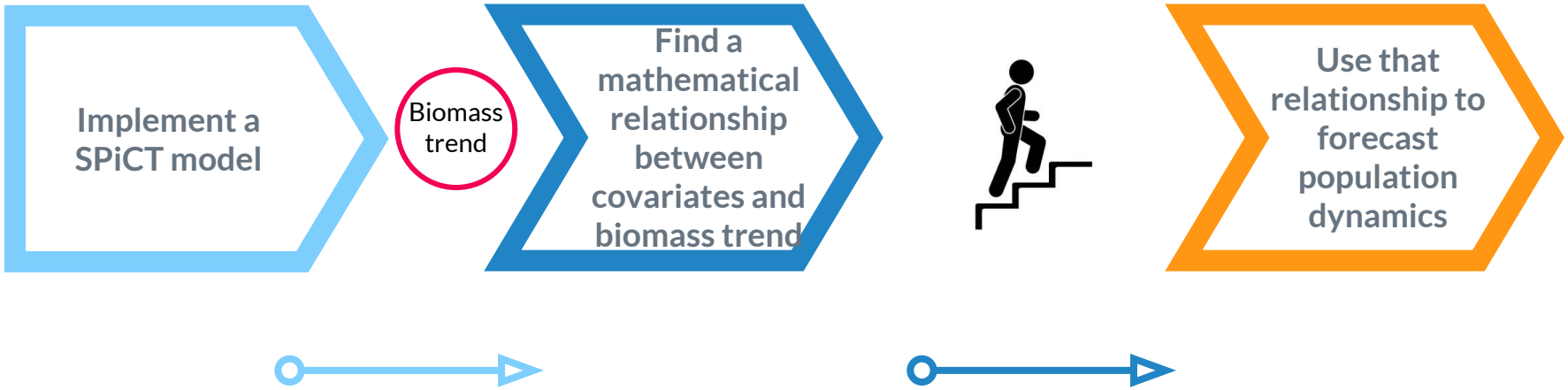
Mathematical relationship

SPiCT estimated Relative biomass

Population trend model output

5.
SUMMARY CHUB MACKEREL

The process


Implement a SPiCT model
Biomass trend
Find a mathematical relationship between covariates and biomass trend
Use that relationship to forecast population dynamics

- Are the data from this research available? If yes indicate where.

Anchovy: Supplementary material of Rincón et al. 2019 provides the code and data necessary to reproduce the article itself.

Article preprint open: https://osf.io/preprints/marxiv/zn63y/

Supplementary material:

https://github.com/mmrinconh/Rinconetal.2019_Supplementary-material-/blob/main/Reproducible.zip

Chub Mackerel:

Data input SPiCT: FAO 2020

The rest of the data will be available when the work is finished and published (open access)

- What additional data (or analysis) would benefit this research?

  Samples of age composition of catches, length composition of catches

  Samples of age composition of surveys, length composition of surveys

  Age-length keys for catches and surveys
- What are the implications of your findings for the CECAF area?

To provide an idea of different scenarios under different climate scenarios, for the SPiCT model and also to other stock assessment models

- What would suggests as next steps to advance knowledge on this topic?

Continue exploring mathematical relationships, implement more complicated models and more data demanding

Thanks!

Any questions?

You can find me at:

@Margarita_RH

https://www.youtube.com/c/MargaritaRincónHidalgo

margarita.rincon@ieo.es