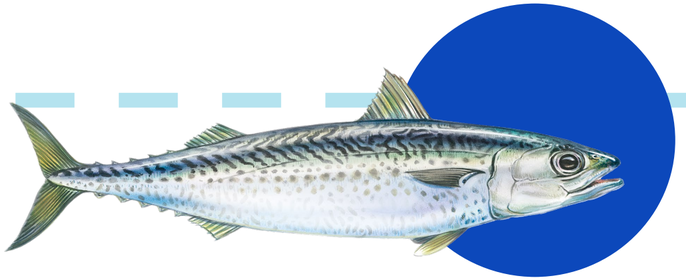
Assessing external environmental drivers for the Moroccan Chub Mackerel (Scomber colias) population dynamics

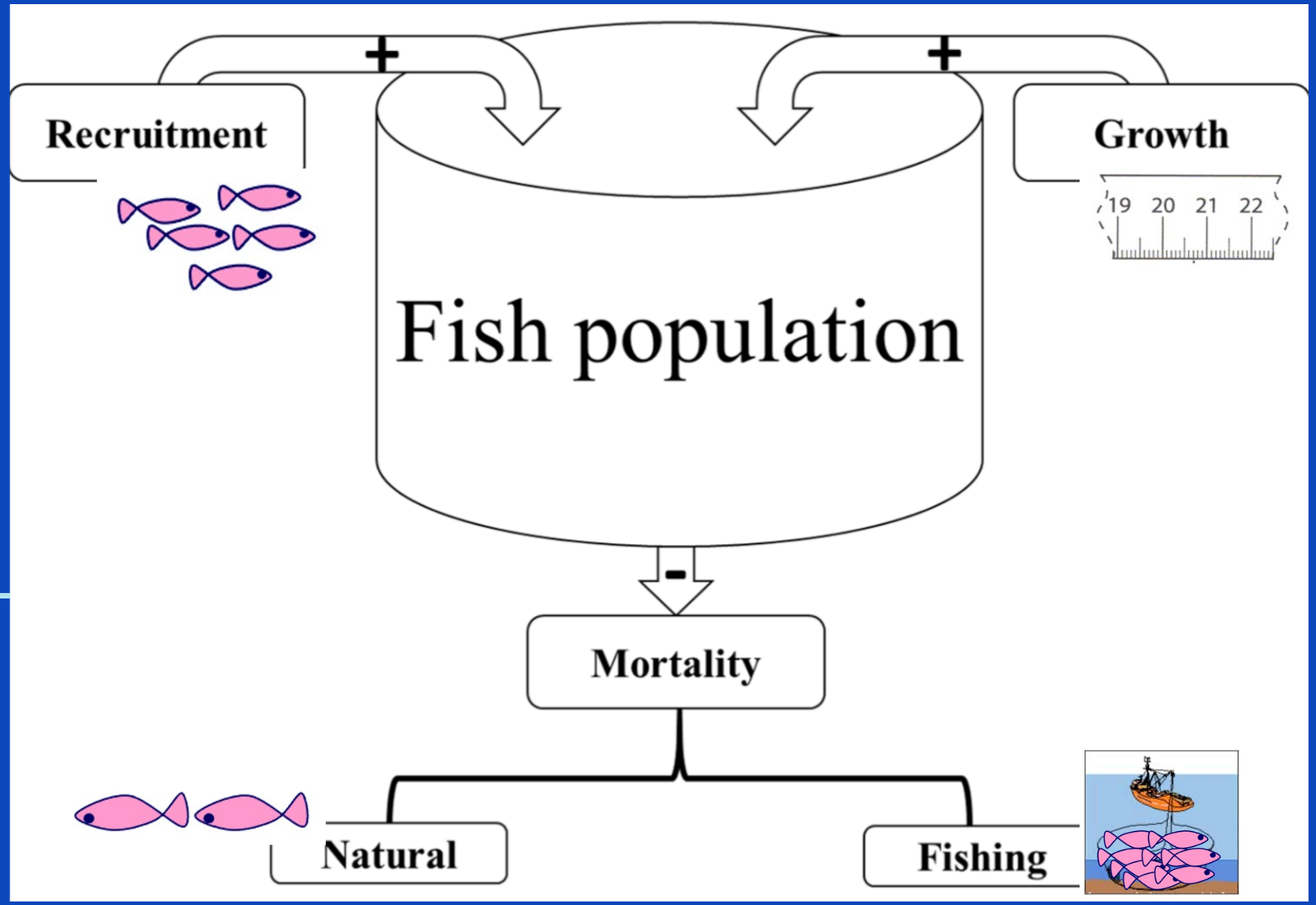
Ghoufrane Derhy, Diego Macías , Karima Khalil , Khalid Elkalay, Margarita María Rincón



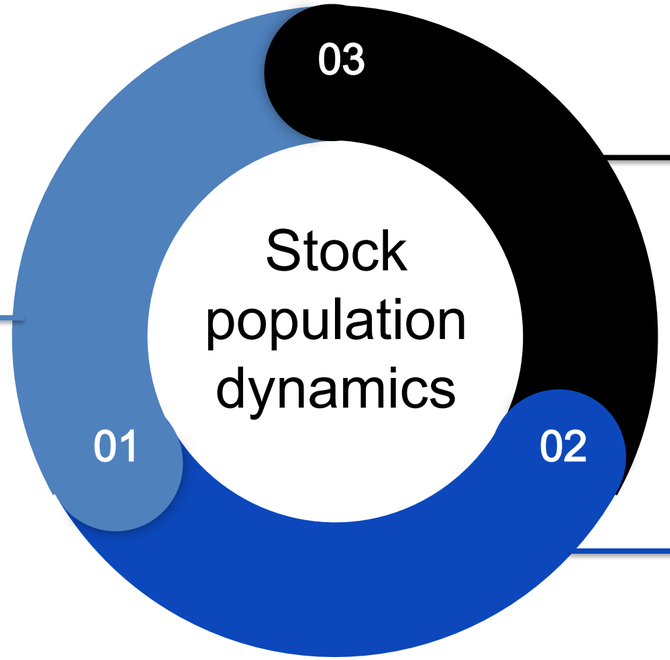
Stock population dynamics

Changes in stock population dynamics may be caused by a combination of natural and fishing effects or other factors.

$$B_{t+1}=B_t+R+G-M-C$$



Estimating population dynamics trends ?



Life history

e.g.,average mortality rate, individual growth rate, maximum length or mass, and timing of maturity…

Fishery monitoring

Fishery catches, standardized fishing effort…

Resources surveys

Fish abundance surveys, age and size stock composition…

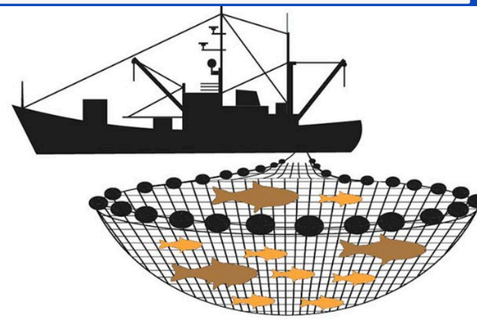
One keyword is missing, which is the environment.

Changing in environmental conditions

May violates the key assumptions of traditional stock assessment models

- Change in primary productivity
- Change in fish growth
- Change in fish distributions
- Newly opened fisheries

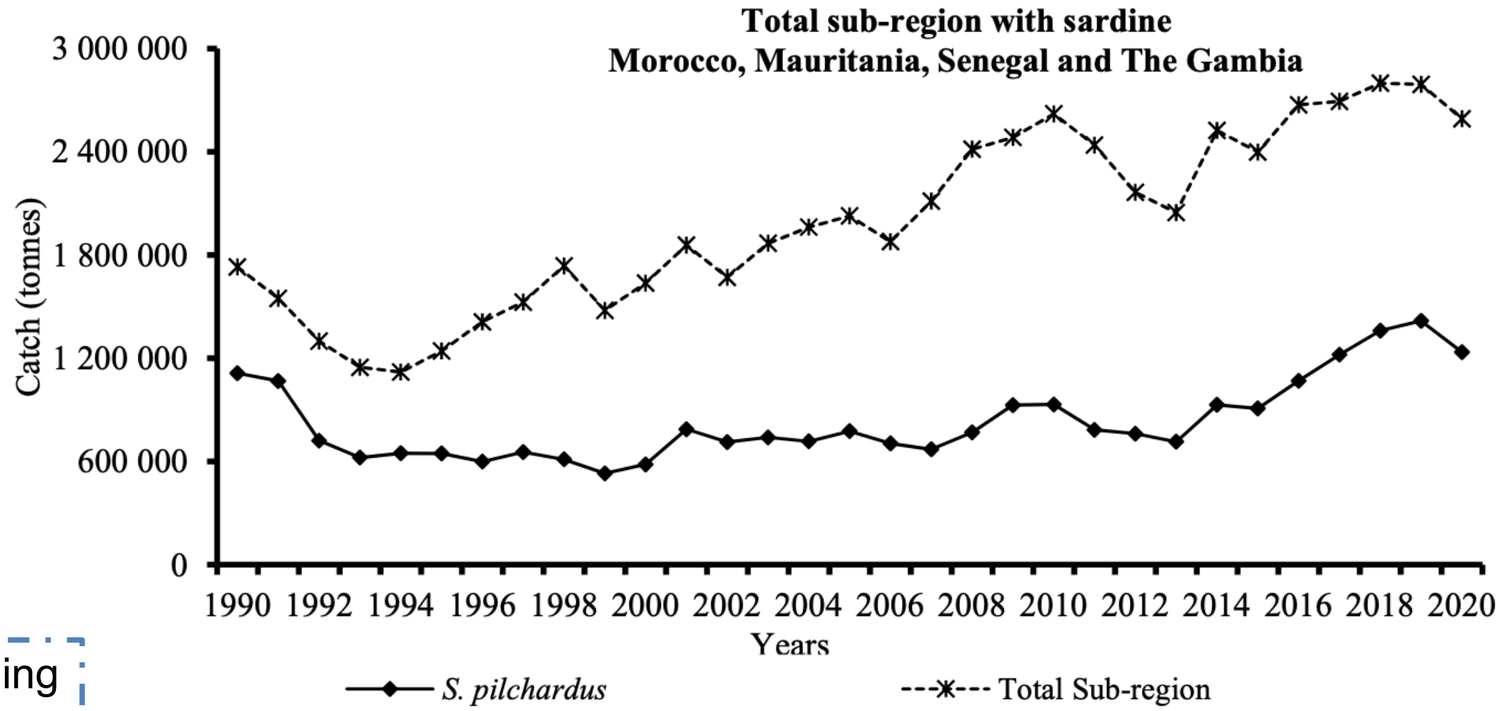
- Changing fishery yields
- More fishers



Small pelagic stocks in CECAF areas

- Small pelagic fish are highly dynamic fish populations, influenced by complex processes;
- Their dynamic and complex life-cycles often cover wide ocean areas, which is why many small pelagic fish stocks are shared between different coastal states;
- Understanding the factors triggering the observed changes in small pelagic stocks entails research and deeper analyses.

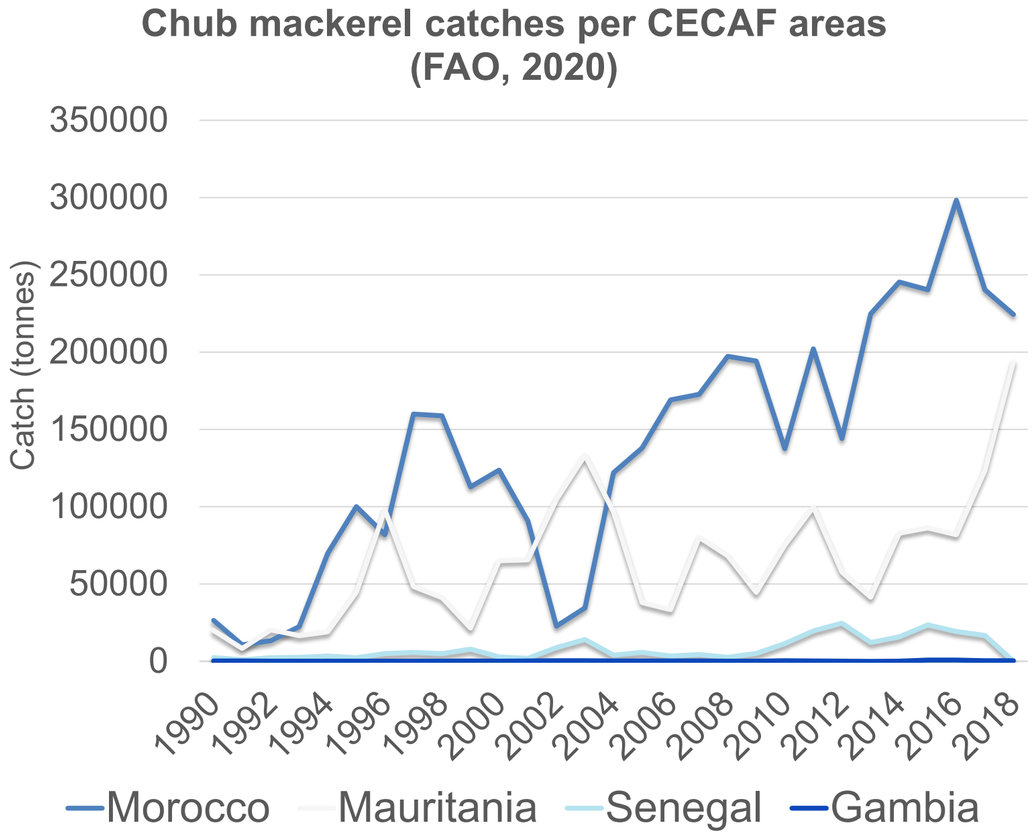
Improve oceanographic modeling for understanding fisheries biology and population dynamics.

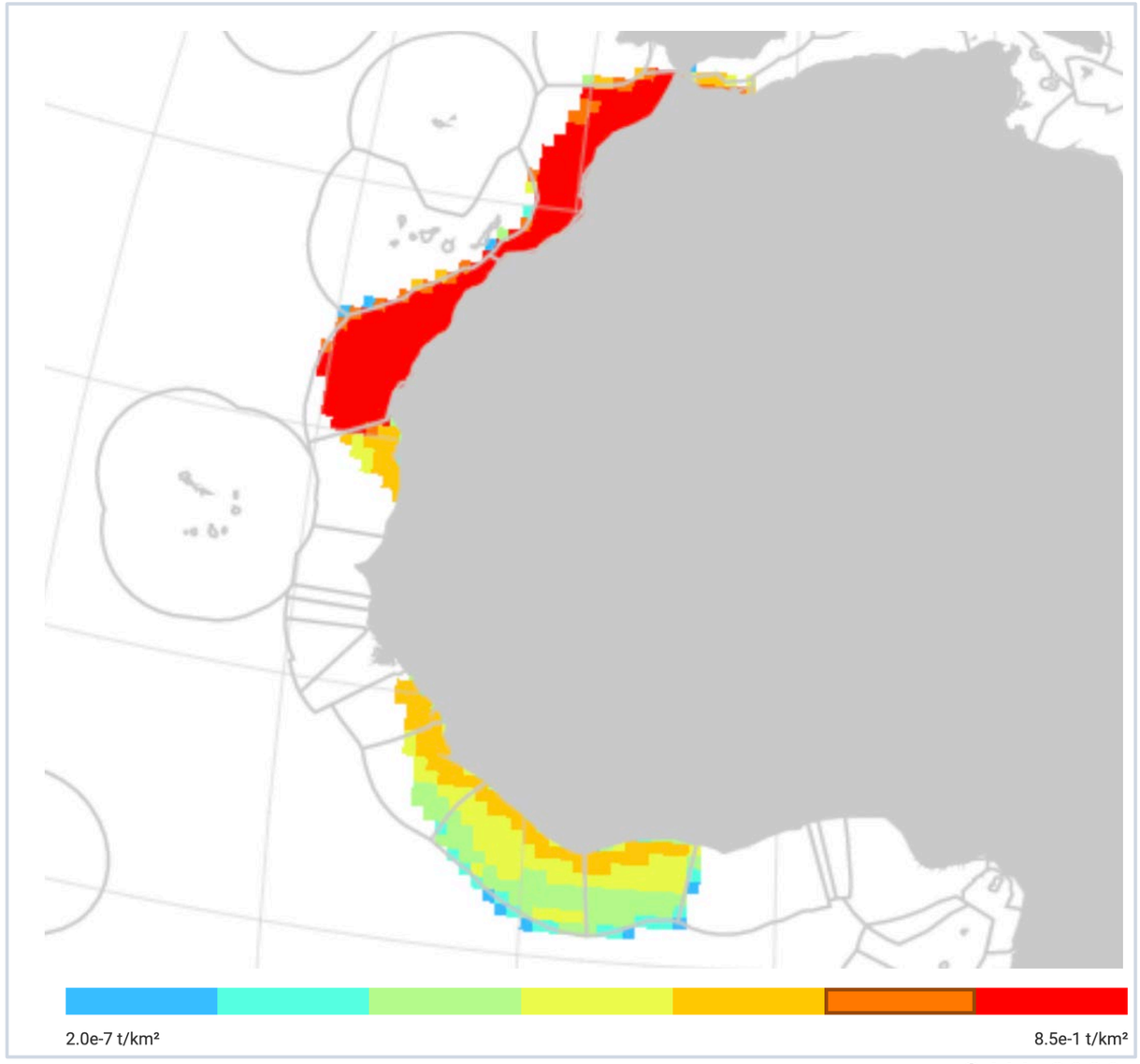


Total small pelagic species and sardine catches in the subregion by year with and without Sardine catches (FAO, 20021)

Chub mackerel population dynamics

Environmental impacts on recruitment tend to be significant drivers of population variability for small pelagic species such as Chub mackerel (*Scomber colias*).

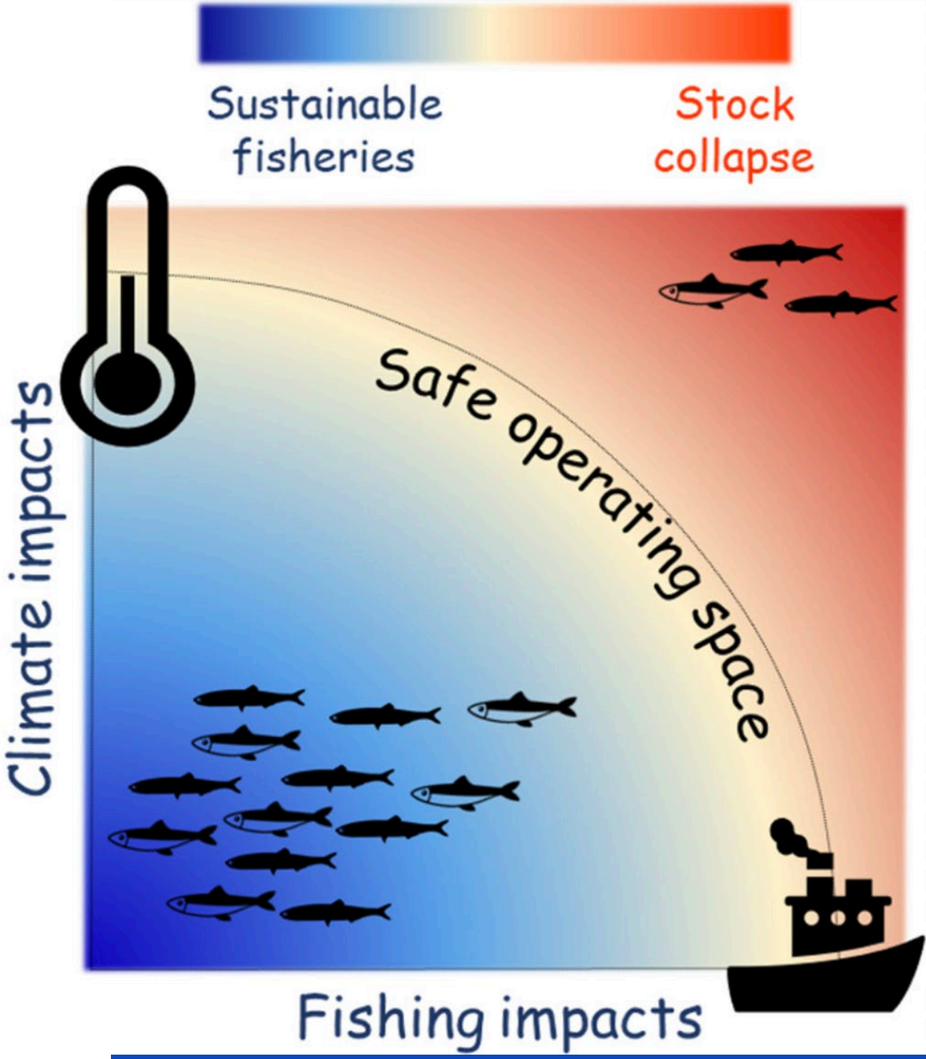




SAU, 2020

However, fishing can affect natural dynamics

A population's response to its environment may in fact
changed by the impacts of fishing so the processes are
interrelated



Methodology

Adopted approach

- **Collecting all available data**
  - Fisheries and surveys data
- **Estimating chub mackerel population trend**
  - Using a stock assessment model (SPiCT model)
- **Correlation analysis between stock abundance trend and environmental covariates**
  - Define the environmental factors affecting the stock abundance
- **Develop an integrated stock assessment mode**
  - Including the impact of environmental variables

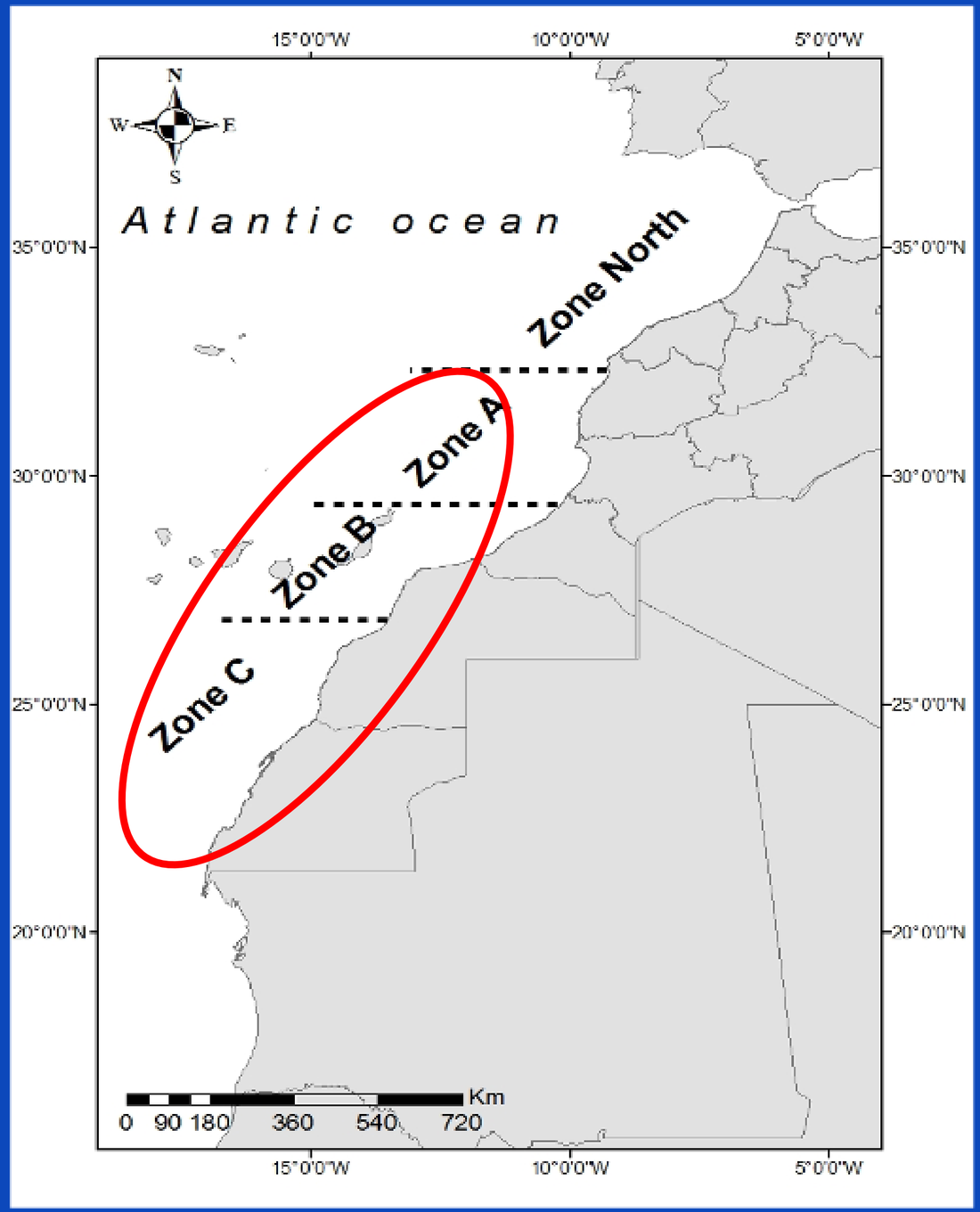
Chub Mackerel stock

Center and south of Moroccan Atlantic coast

17%

Of Morocco’s total small pelagic stock

High level of organic production (1997.419 mgCm-2day-1)



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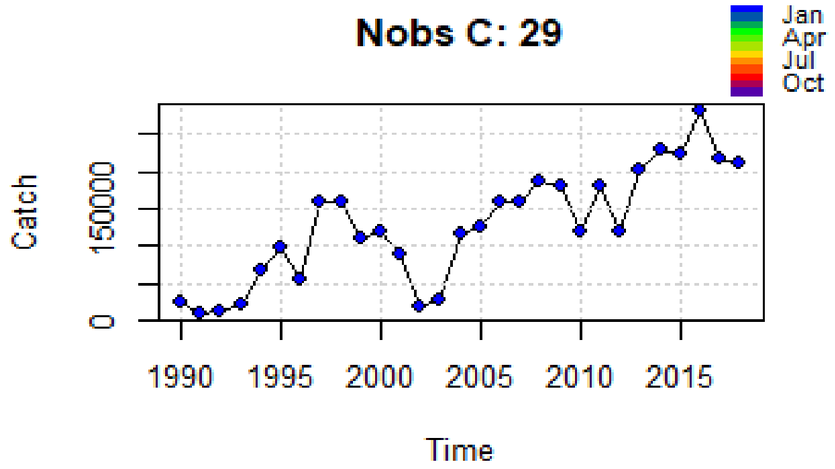
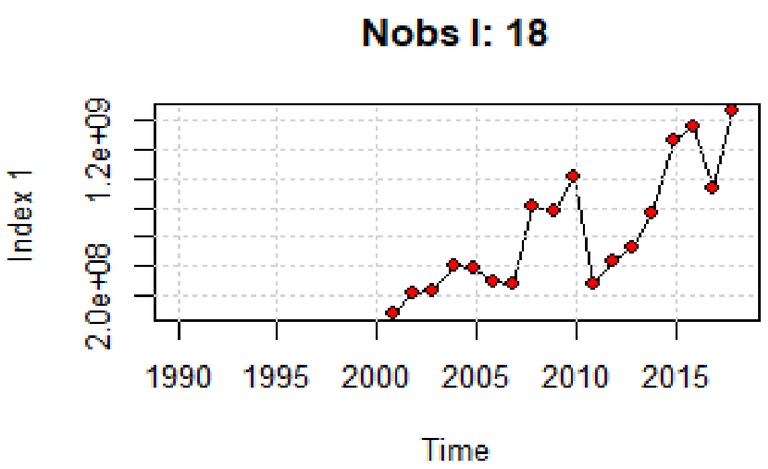
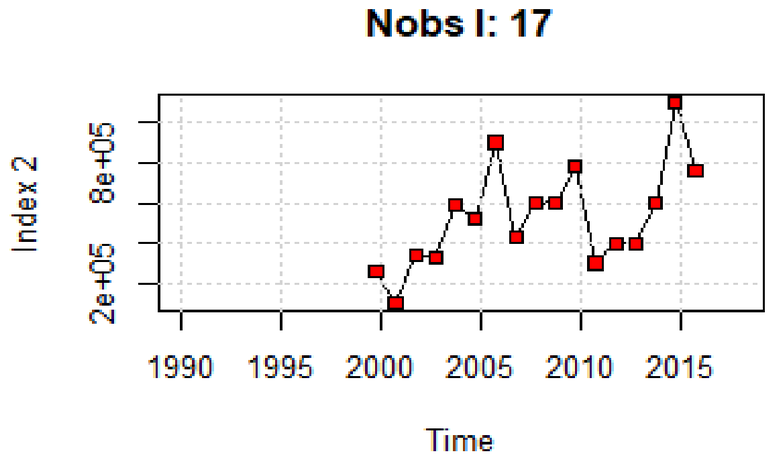
Collecting all available data

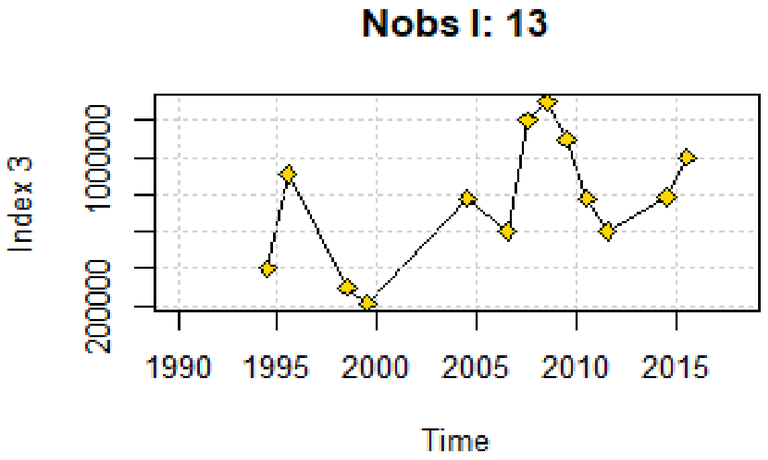
Fisheries and surveys data

- Catches data (1990-2018) [FAO, 2020]
- Abundance index data (3 indices from Amir Moulay Abdellah survey, Nansen survey and Atlantida acoustic survey)









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Estimating chub mackerel population trend

Using a stock assessment model -**Surplus Production model in iContinuous Time (SPiCT)-**

- State space model, incorporating dynamics of fisheries and biomass;

- Two statistical parts:

The process equations

Biomass: $dB_t = rB_t\left(1-\left[\frac{B_t}{K}\right]^{n-1}\right)dt - FtBtdt + \sigma_B B_t dW_t$

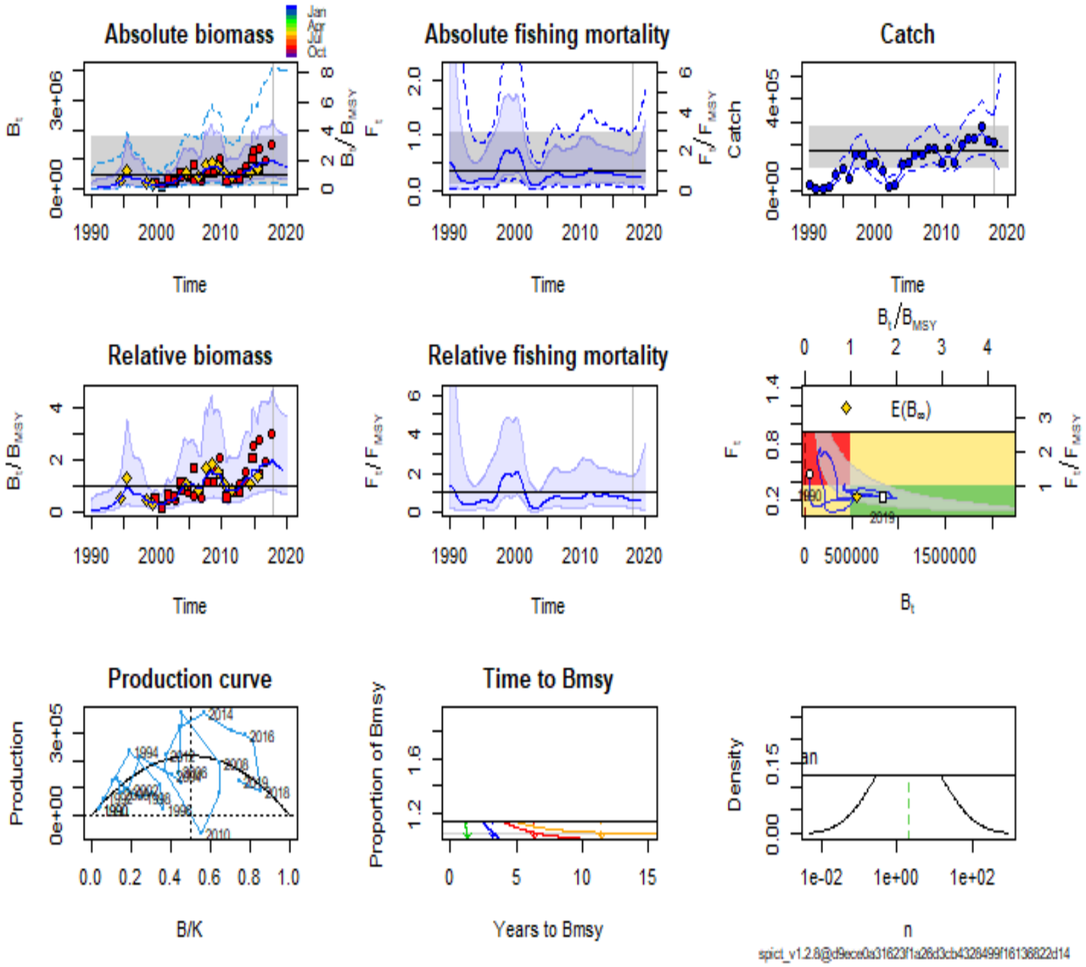
Fishing: dlog(F_t)=f(t,σ_F c)

The observation equations

Catch: $log(C_t) = log\left(\int_t^{t+\Delta} F_s B_s ds\right) + \epsilon_t, \quad \epsilon_t \sim N(0, [\beta\sigma_F]^2)$

Index: log(I_t)=log(qB_t)+e_t, e_t~N(0,[ασ_B]^2)

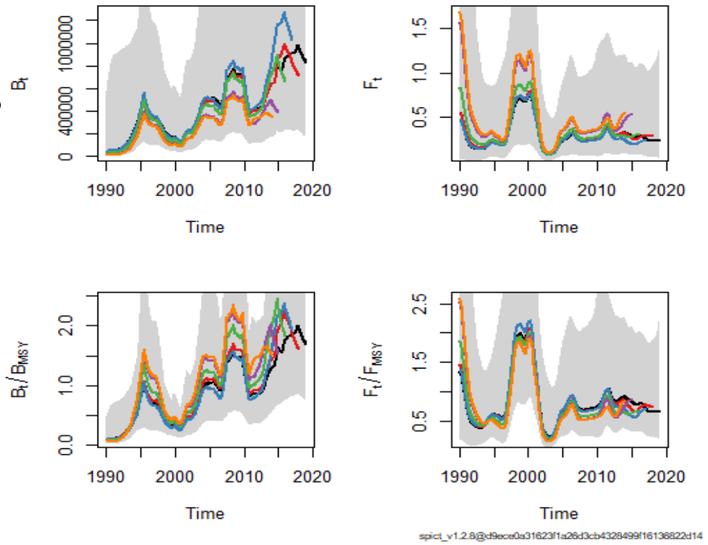
- **Model outputs**



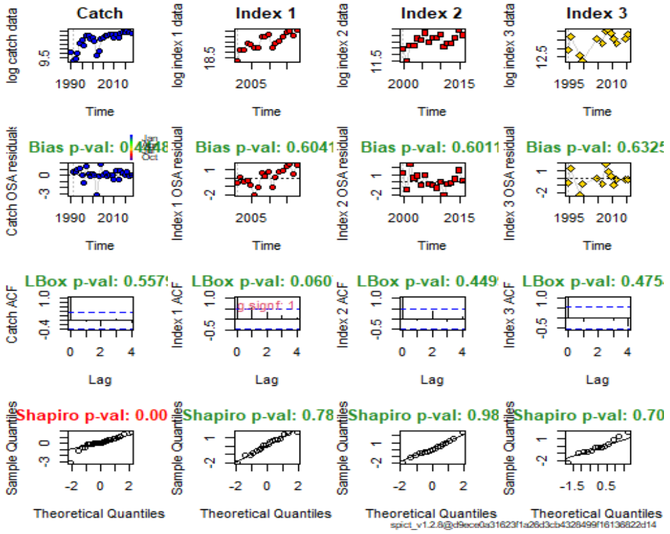
Estimating chub mackerel population trend

Using a stock assessment model -**Surplus Production model in iContinuous Time (SPiCT)**-

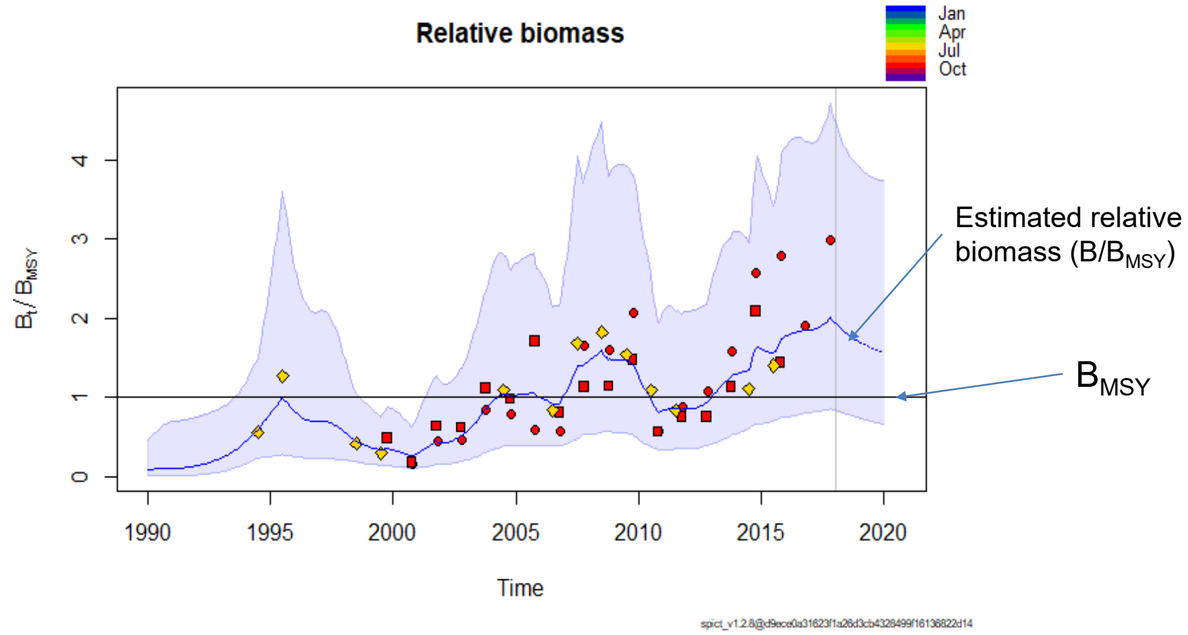
- **Retrospective analysis**



- **Model diagnostic**



Estimated relative biomass (B_t/B_{MSY})



- The relative biomass (B/BMSY) trend used to explore the relationship between the estimated chub mackerel stock abundance and different external environmental drivers

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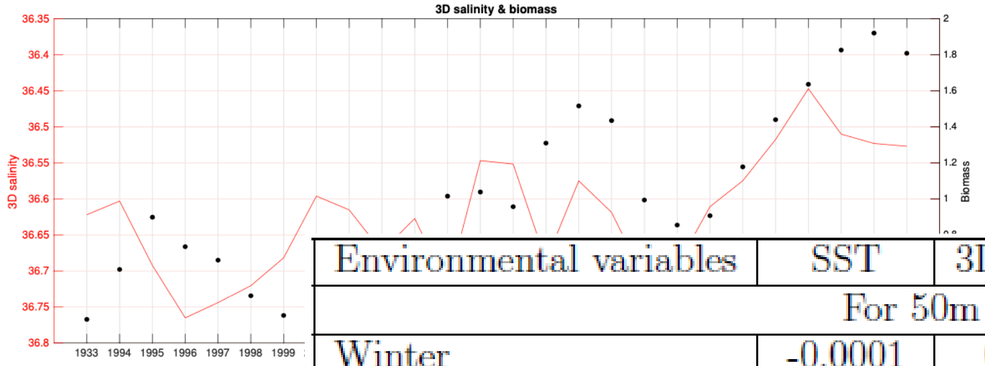
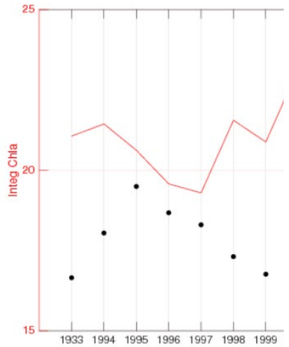
Correlation analysis between stock abundance trend and environmental covariate

Define the environmental factors affecting the stock abundance

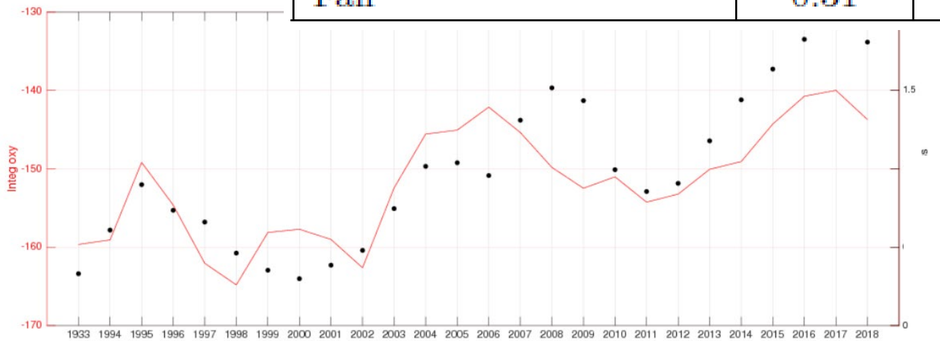
Salinity



Chlorophyll mg/m3

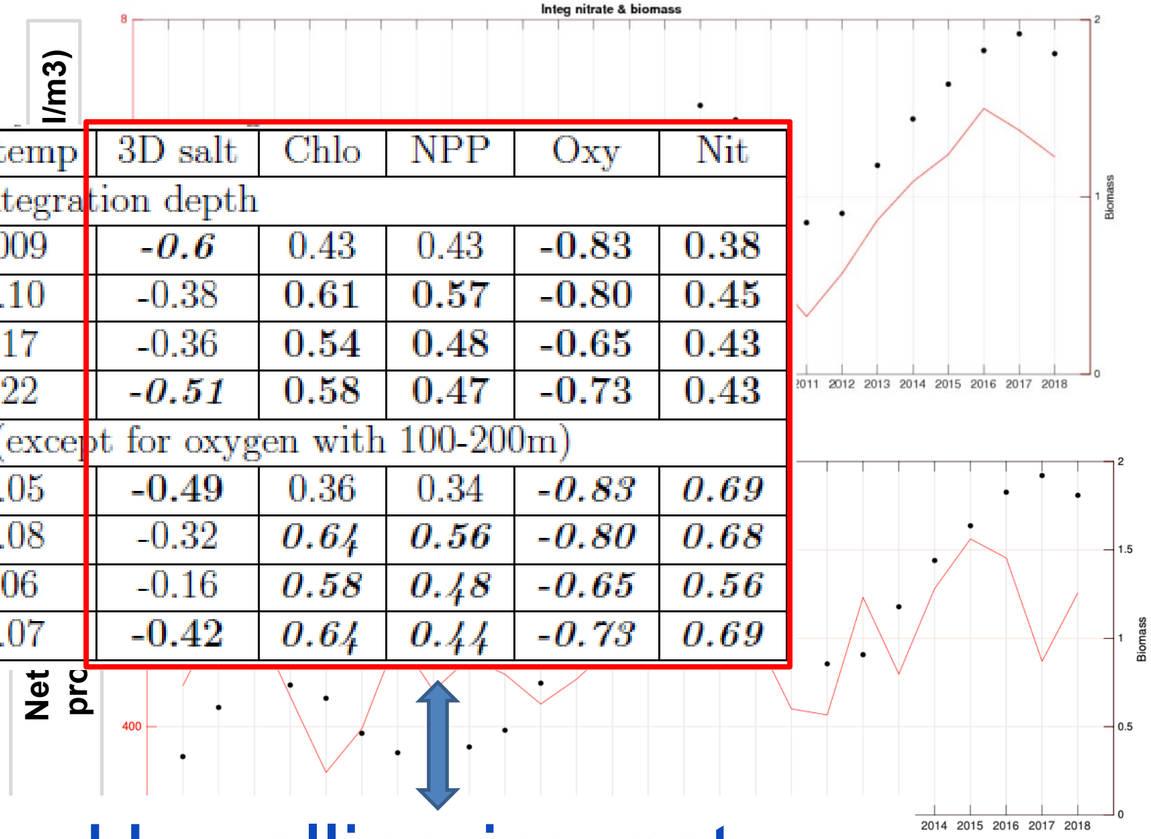


Oxygen (nmol/m3)



Environmental variables	SST	3D temp	3D salt	Chlo	NPP	Oxy	Nit
For 50m integration depth							
Winter	-0.0001	0.009	***-0.6***	0.43	0.43	**-0.83**	**0.38**
Spring	-0.05	-0.10	-0.38	**0.61**	**0.57**	**-0.80**	**0.45**
Summer	0.26	0.17	-0.36	**0.54**	**0.48**	**-0.65**	**0.43**
Fall	0.31	0.22	***-0.51***	**0.58**	**0.47**	**-0.73**	**0.43**
For 150m integrartion depth (except for oxygen with 100-200m)							
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***

Net prc

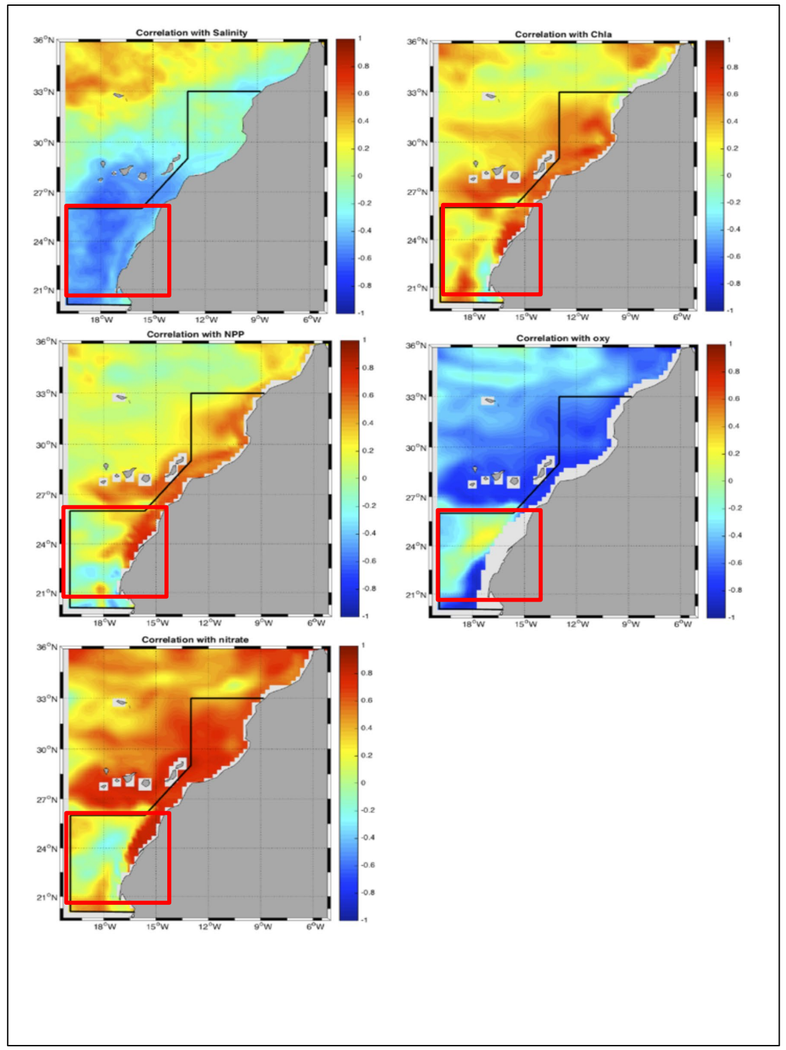


Upwelling impact

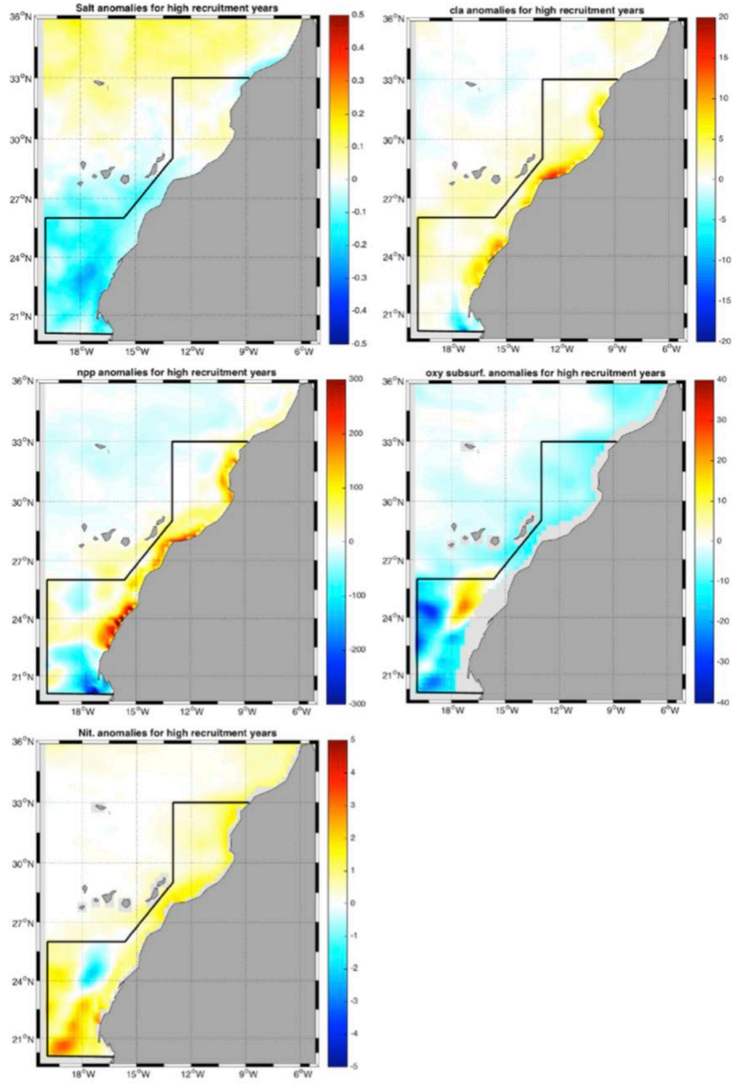
Correlation analysis between stock abundance trend and environmental covariate

Define the environmental factors affecting the stock abundance

- **Spatially explicit analysis for the correlation between B/*BMSY* and the selected environmental variables**



- **Anomalies for the different environmental variables in years of high B/*BMSY***



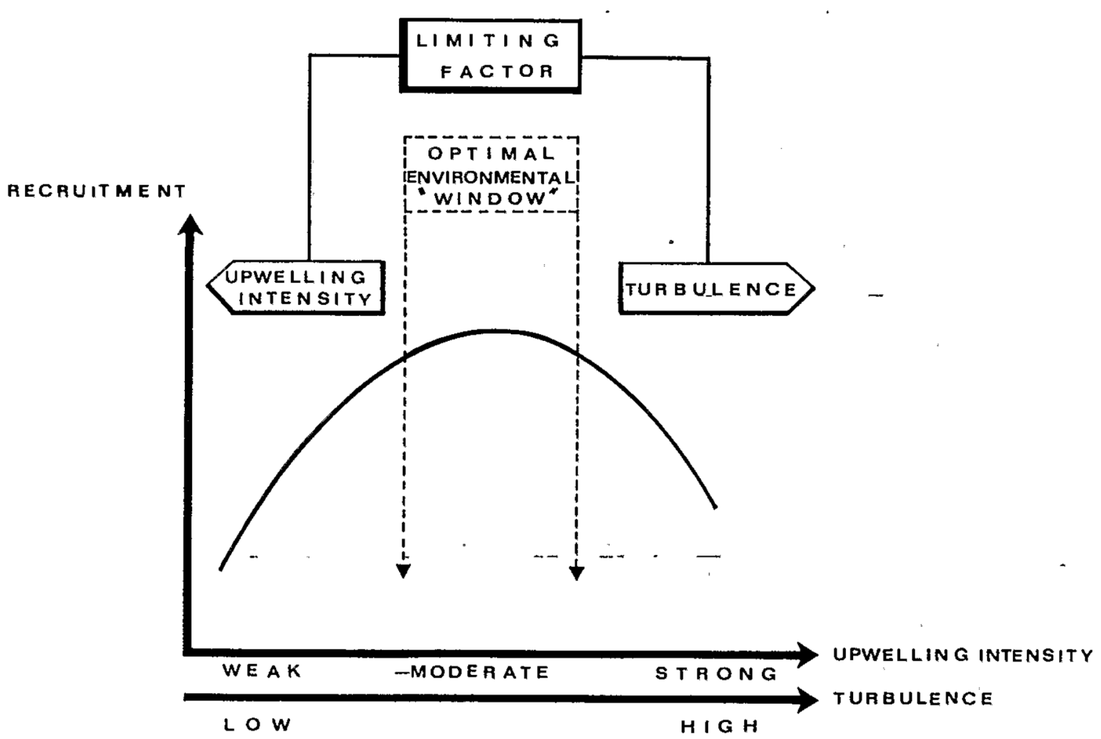
Conclusions

- Maximum R values for are located in the southern zone
- Strong upwelling intensity in the south → Accompanied with important catches (INRH, 2019; FAO, 2020)

High biomass of recruited individuals

- In our case, the turbulence is the only limiting factor for recruitment
- Adome shaped relationship between environmental factors and adult biomass

non-linear equation



Thanks!

Any questions?

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