Effect of the environment on the biomass of small pelagic fish: Case of Senegal

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Workshop FARFISH on Small pelagic and climate change in the CECAF Area
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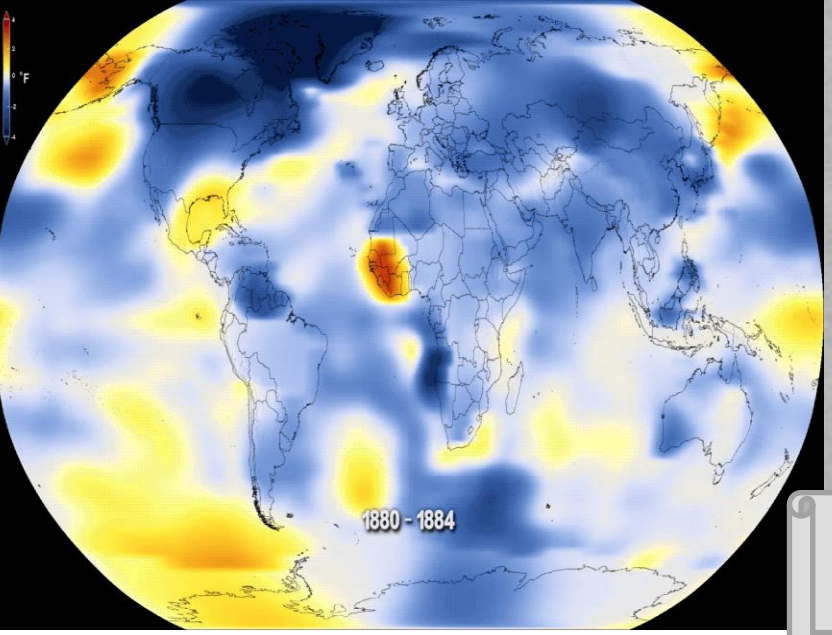


Cury et Roy (1989); Baldé *et al* (2019)
"Optimal environmental window".

Œufs

Larves

Juvéniles

Hjort (1914)
"Critical period".

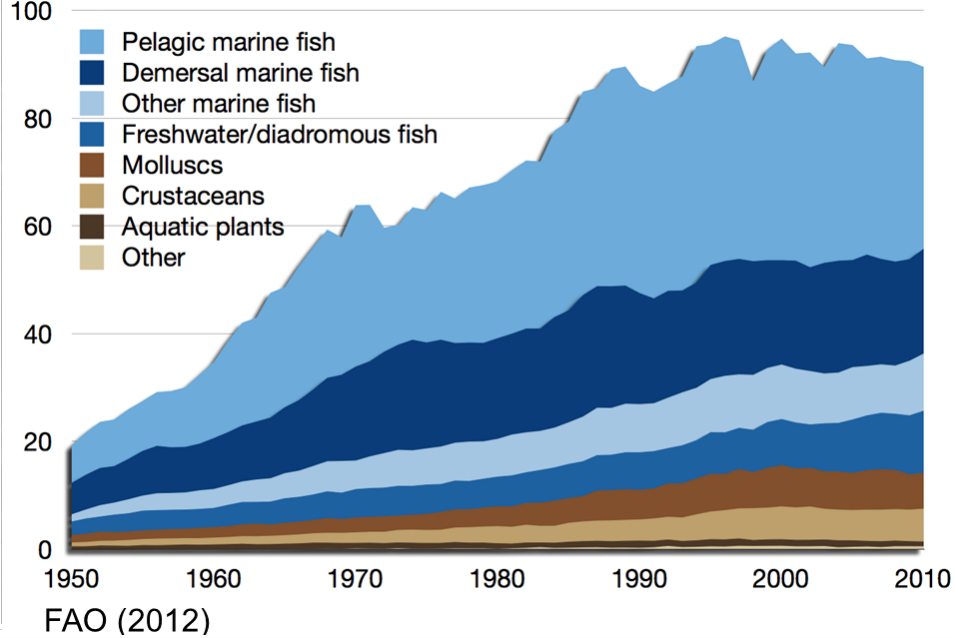
Armstrong *et al*. (2013)
"Plasticity of small pelagics

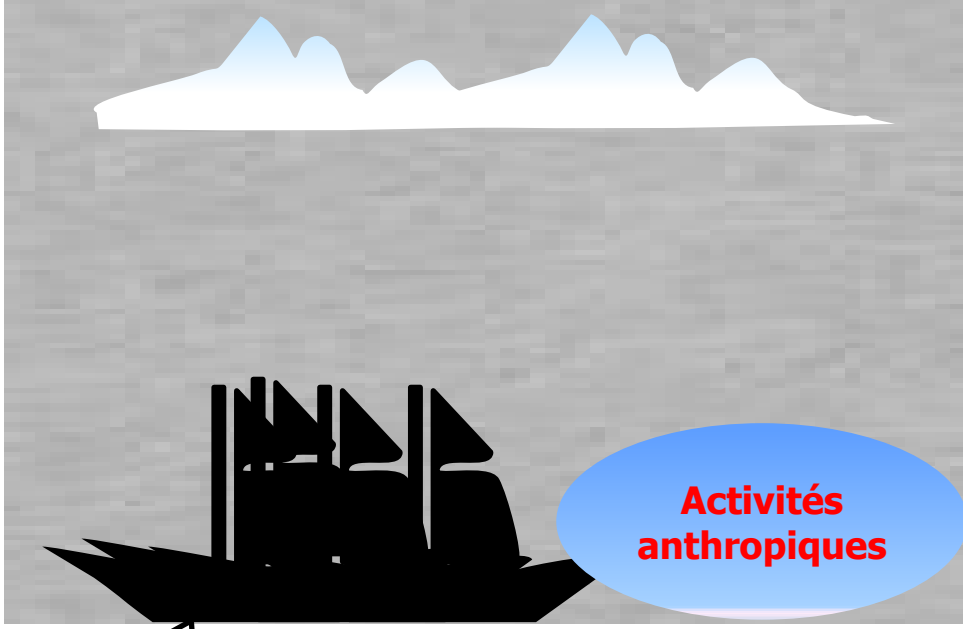
Diankha *et al*. (2018)
"Successful recruitment

Paramètres environnementaux

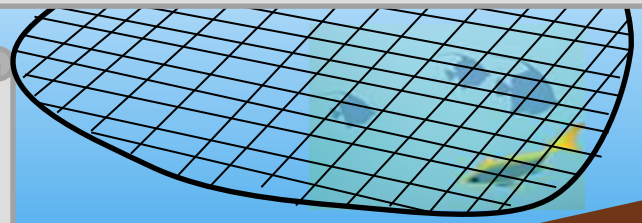
Adultes

Bakun (1996)
"Triad"





Froese *et al*. (2004, 2008, 2015, 2016, 2018)
« Pression de la pêche sur la croissance »



Thiaw *et al*. (2017) (Sénégal)
« Abondance des sardinelles »

Hiyama *et al*. (1995) (Japon)
« Croissance de *Sardinops melanostictus* »

Voulgaridou and Stergiou (2003) (Grèce)
« Croissance de *Sardina pilchardus* »

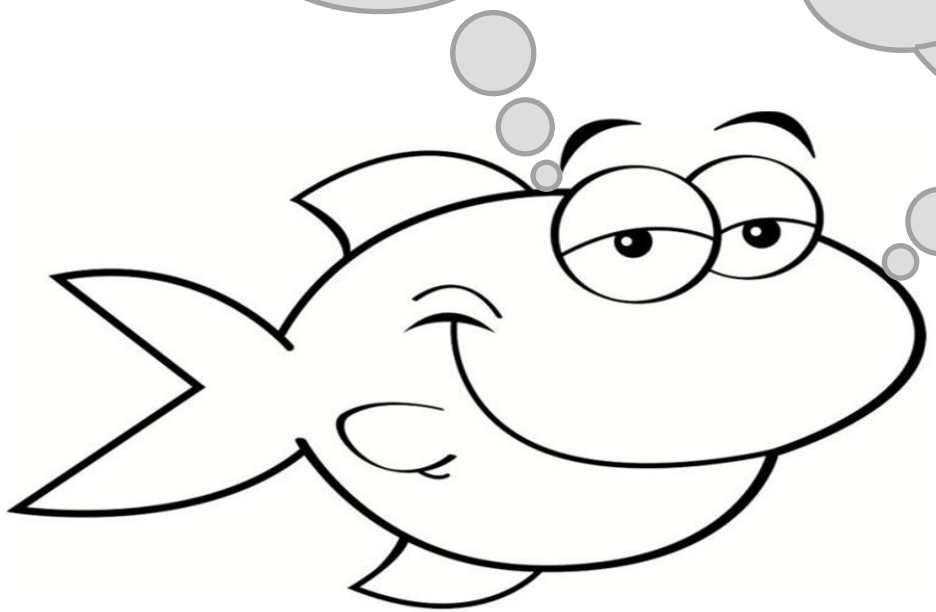
Importance of Small Pelagics in Senegal

- The small pelagic fishery contributes about 70% of the total tonnage of catches landed by pirogues (e.g. Ndiaye and Kébé 2017);
- Main resource for traditional processing activities;
- Source of protein (e.g. Ba et al. 2017);
- Artisanal fisheries provide employment (e.g. Greenpeace 2012).

Improving understanding of the impact of the environment on small pelagic fish in Senegal

Goal 1: Effect of the environment on the stock-recruitment model

Goal 2: Exploring the susceptibility of the model to interdependence of SSB and recruitment success



Environment, biology, ecology and exploitation

- **Species with tropical affinities**

Sardinella maderensis
Yaboy tass

Sardinella aurita
Yabóy mërëg

Ethmalosa fimbriata
Cobo

- **Species with temperate affinities**

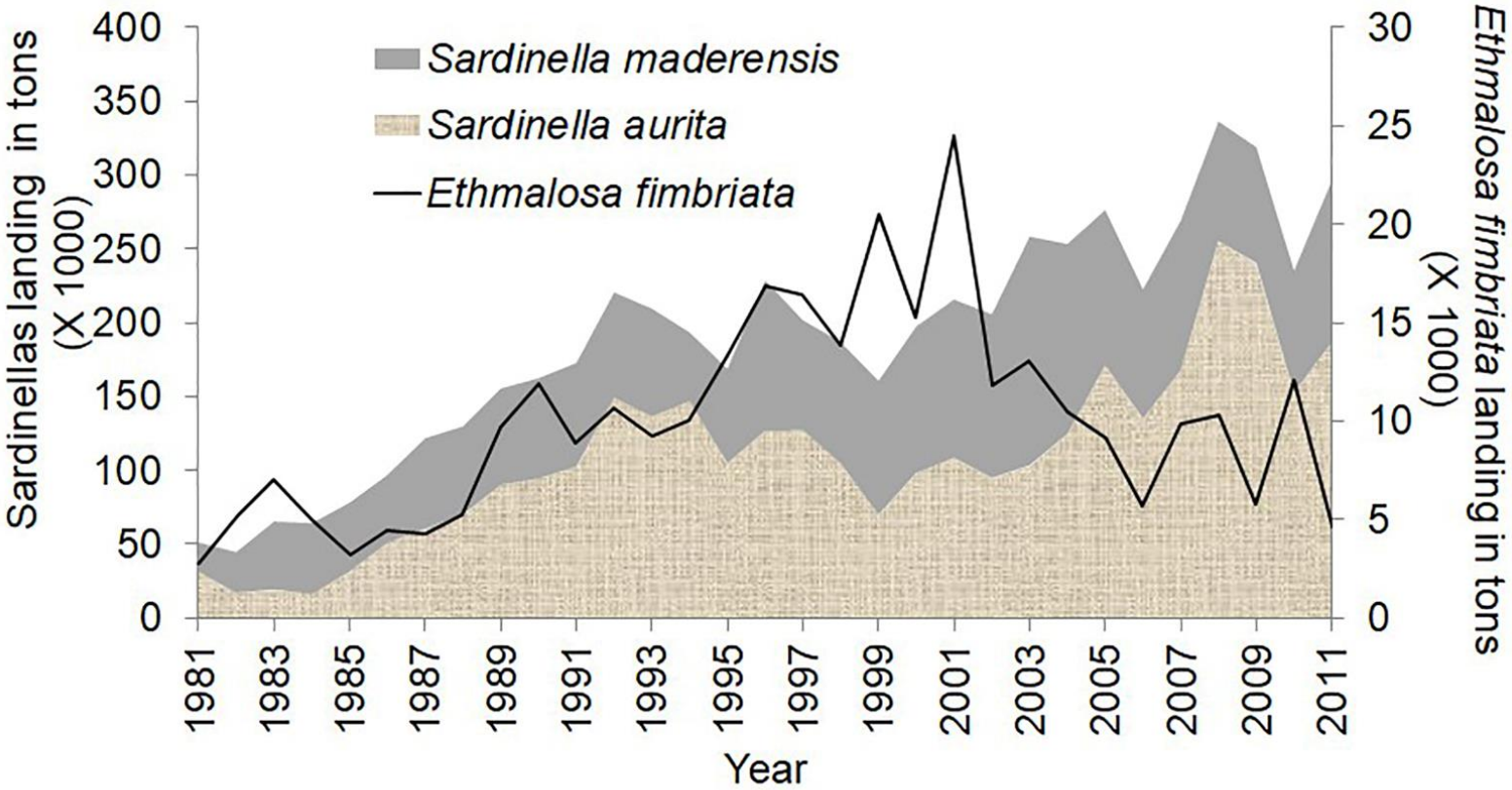
Pomatomus saltator
Ngott

Scomber colias
Ouo

Mugil capurrii
Deem

Trachurus trecae
Dyay

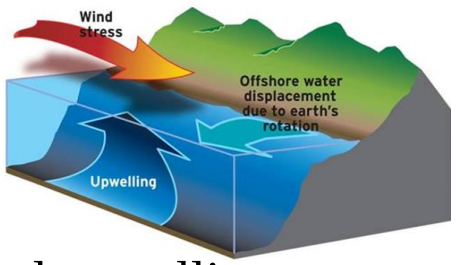
Environment, biology, ecology and exploitation



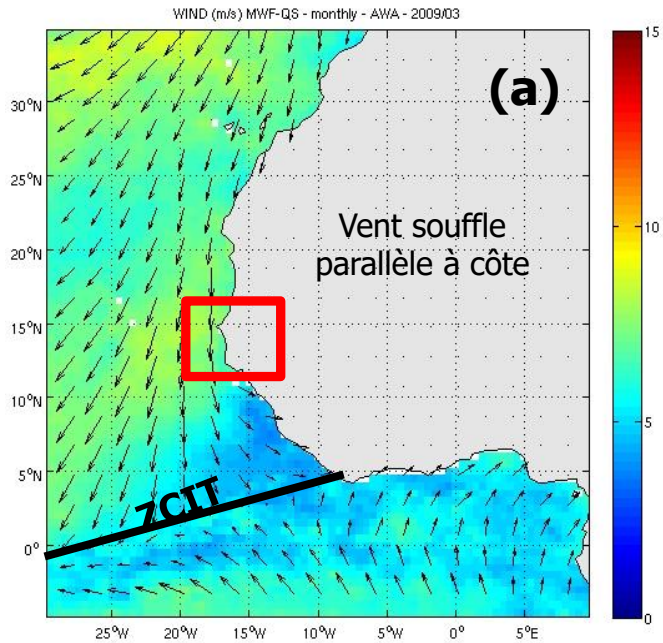
Landing of sardinella species [*Sardinella aurita* (beige fill) *S. maderensis* (grey fill) and *Ethmalosa fimbriata* (back line)] of the artisanal fishery of Senegal (1981 to 2011). *Ethmalosa* fimbriata is on a separate scale (second y-axis) than the Sardinella species. Data obtained from the Centre de Recherches Océanographiques de Dakar-Thiaroye (CRODT).

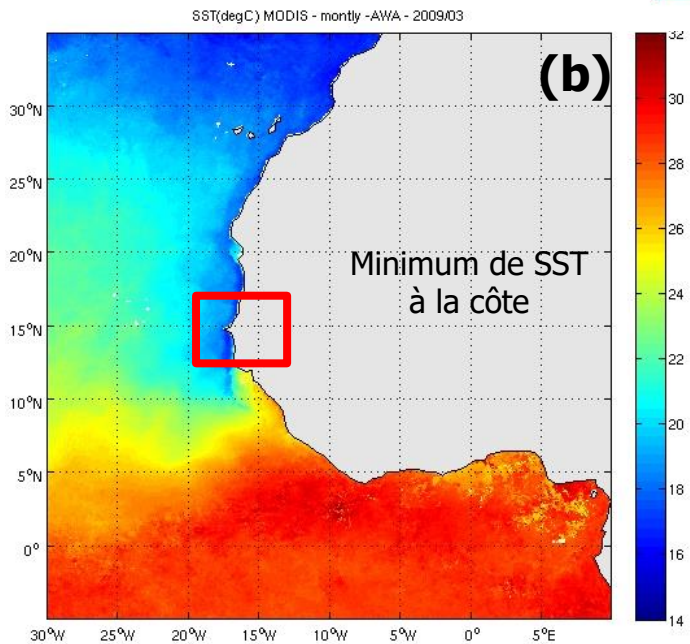
Environment

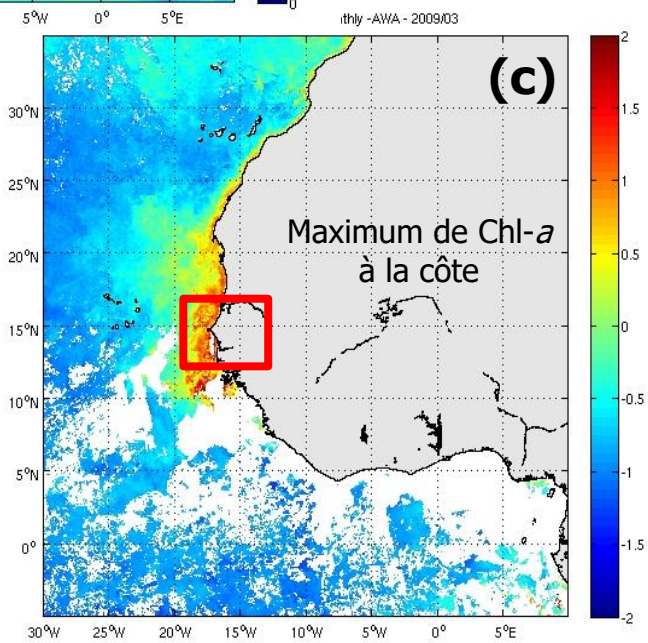
Senegalese coastal upwelling in the North Atlantic Ocean

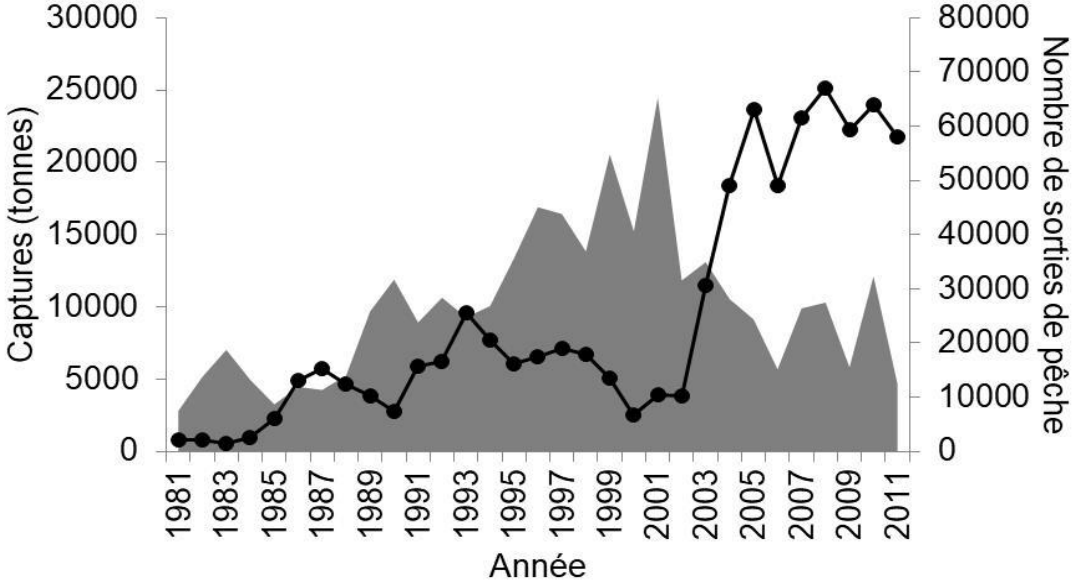


Seasonal upwelling









Tendance à l'augmentation des captures et de l'effort de pêche entre **1985-2001** et **2005-2011** (Baldé et al. 2018)

Méthodes
Analyse des populations virtuelles

SSB at each age and at each species

$$SSB = Mp * W * N$$

Equation de survie

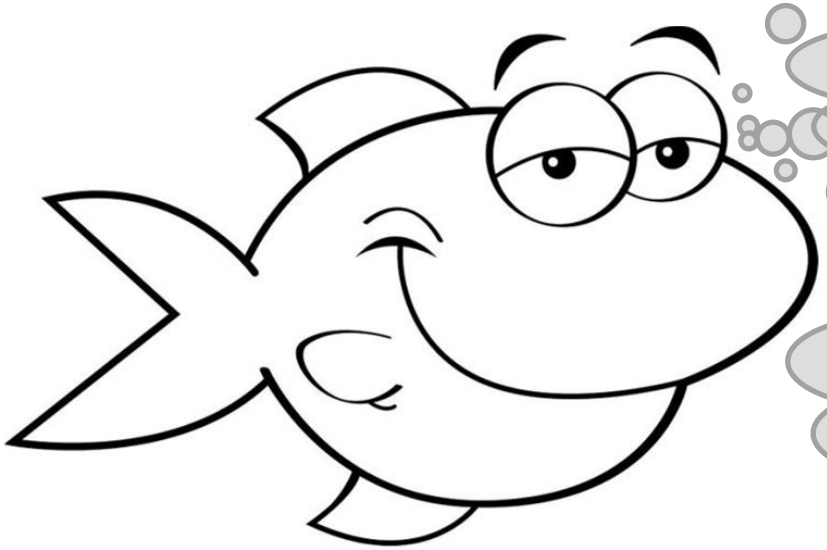
$$N_{t+1,i+1} = N_{t,i} \times e^{-(F_{t,i}+M)}$$

Approximation de l'équation de survie

$$N_{t,i} = N_{t+1,i+1} \times e^{-M_{t,i}} + C_{t,i} \times e^{-\frac{M_{t,i}}{2}}$$

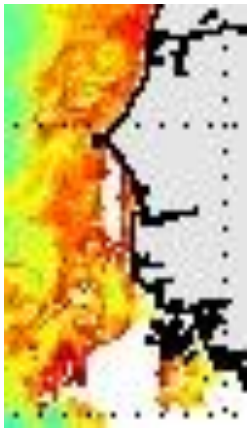
Spawning stock biomass per recruit (SSB / R)

$$SSB/R = \sum SSB/N$$



(Pope 1972; Gascuel 1994, 2009)

Matériels



Impact of environmental fluctuations on the SSB of Ethmalosa fimbriata

Ethmalosa fimbriata

Growth parameters (Baldé et al. (2018)

Catches (1995-2013)

Environmental data (1995-2011)

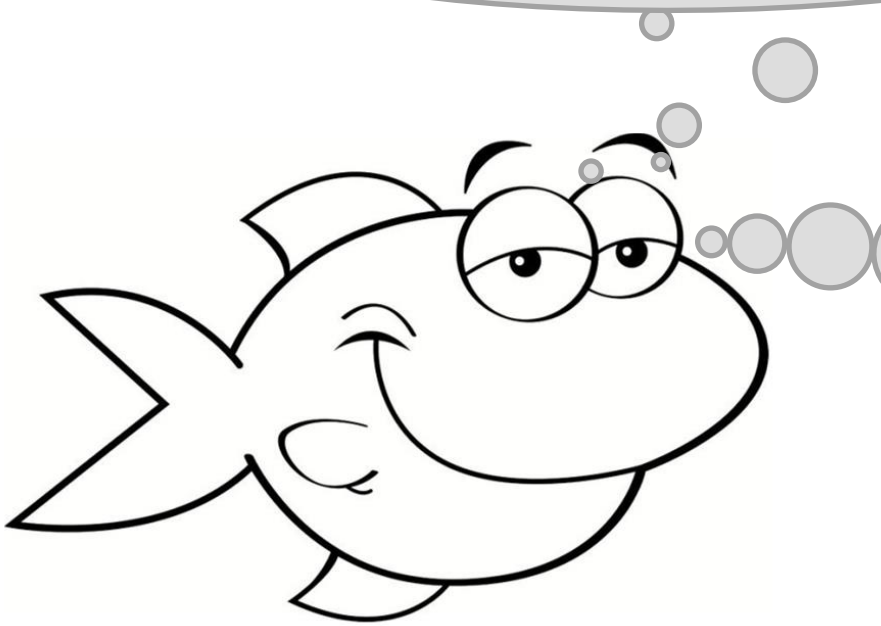
Méthodes estimation d'indicateurs

Taux d'exploitation

$$E = \frac{F}{Z}$$

Rendement par recrue

$$Y/R = \frac{F/M}{1+F/M}\,(1 - L_C/L_\infty)^{M/K}\left(1 - \frac{3(1-L_C/L_\infty)}{1+\frac{1}{M/K(1+F/M)}} + \frac{3(1-L_C/L_\infty)}{1+\frac{2}{M/K(1+F/M)}} - \frac{(1-L_C/L_\infty)^3}{1+\frac{3}{M/K(1+F/M)}}\right)$$



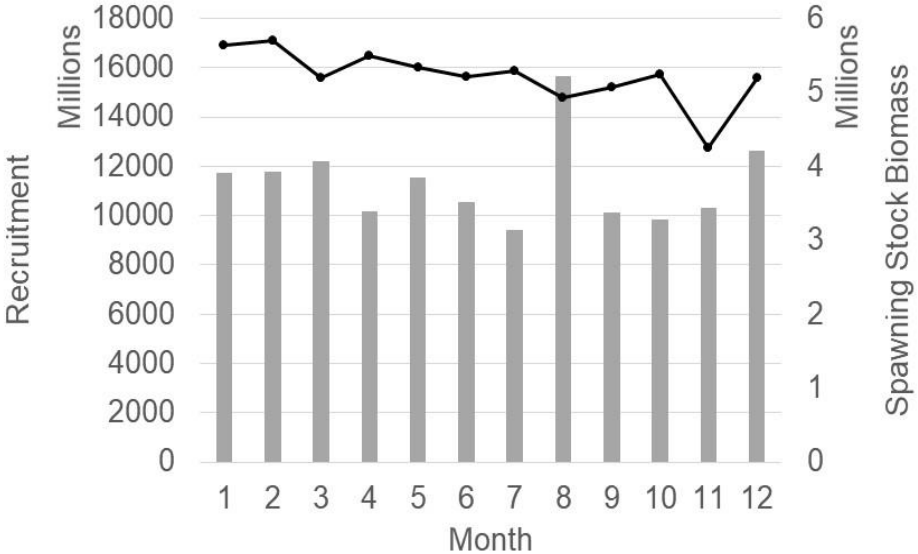
Biomasse par recrue

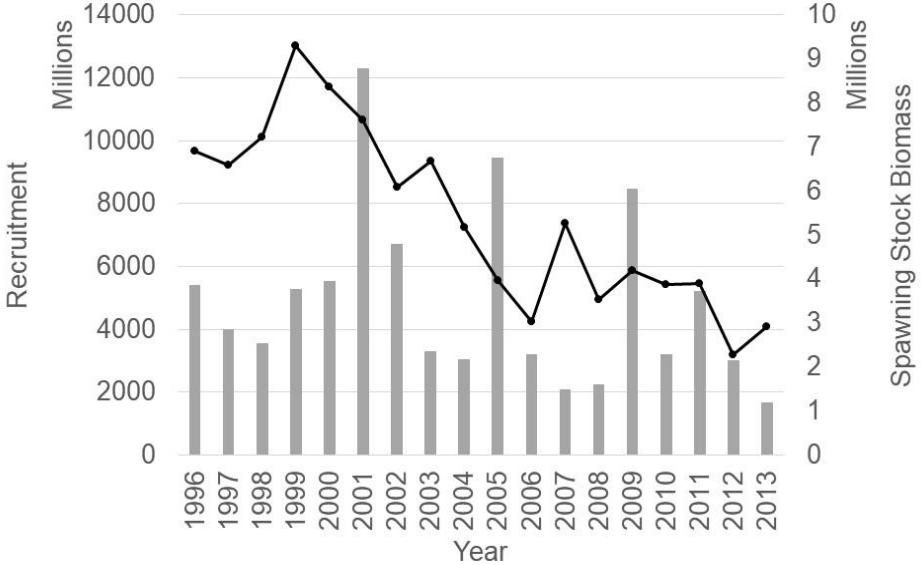
$$B/R = e^{[-M(t_c-t_r)]}W_\infty \sum_{n=0}^{3} \frac{U_n e^{-nK(t_c-t_0)}}{Z+nK}$$

(Beverton et Holt 1957, 1966)

Uncertainties

- Stock-recruitment relationship;
- Natural mortality;
- Growth;
- Selectivity;
- Capturability;
- Spatial distribution.

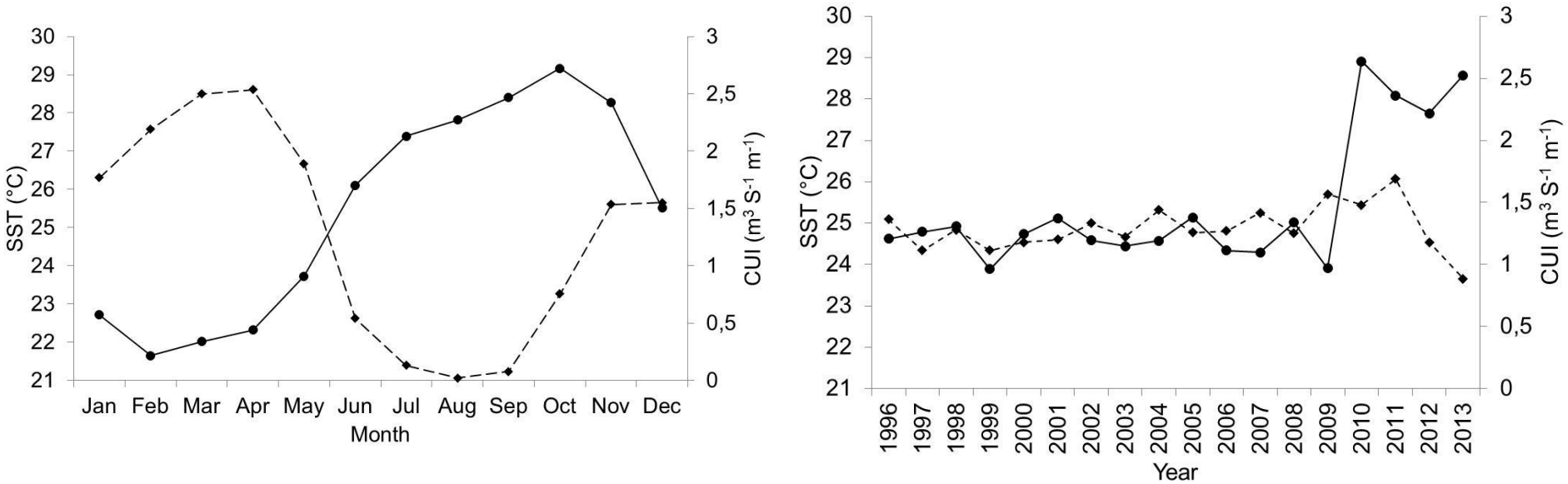




Monthly and annual recruitment and SSB (1996-2013)

Environmental parameters

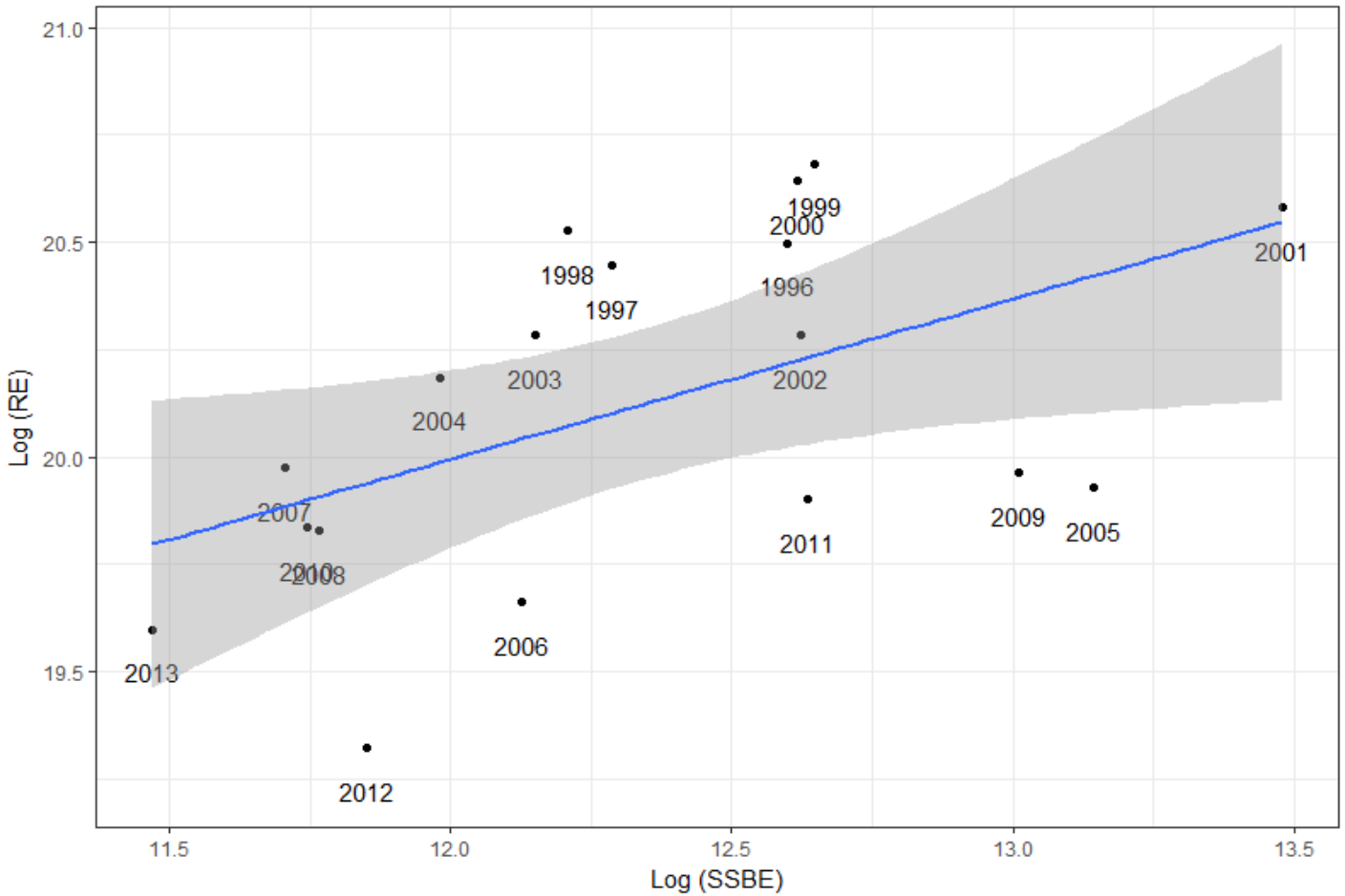
Results



Normalized seasonal components of environmental change in southern Senegal from 1996 to 2013: (a) monthly and (b) annual data. Sea surface temperature at the coast (SST: solid line with diamond), Chlorophyll-a (Chl-a: dotted line with circles), and Coastal Upwelling Index (CUI: dotted line with asterisk).

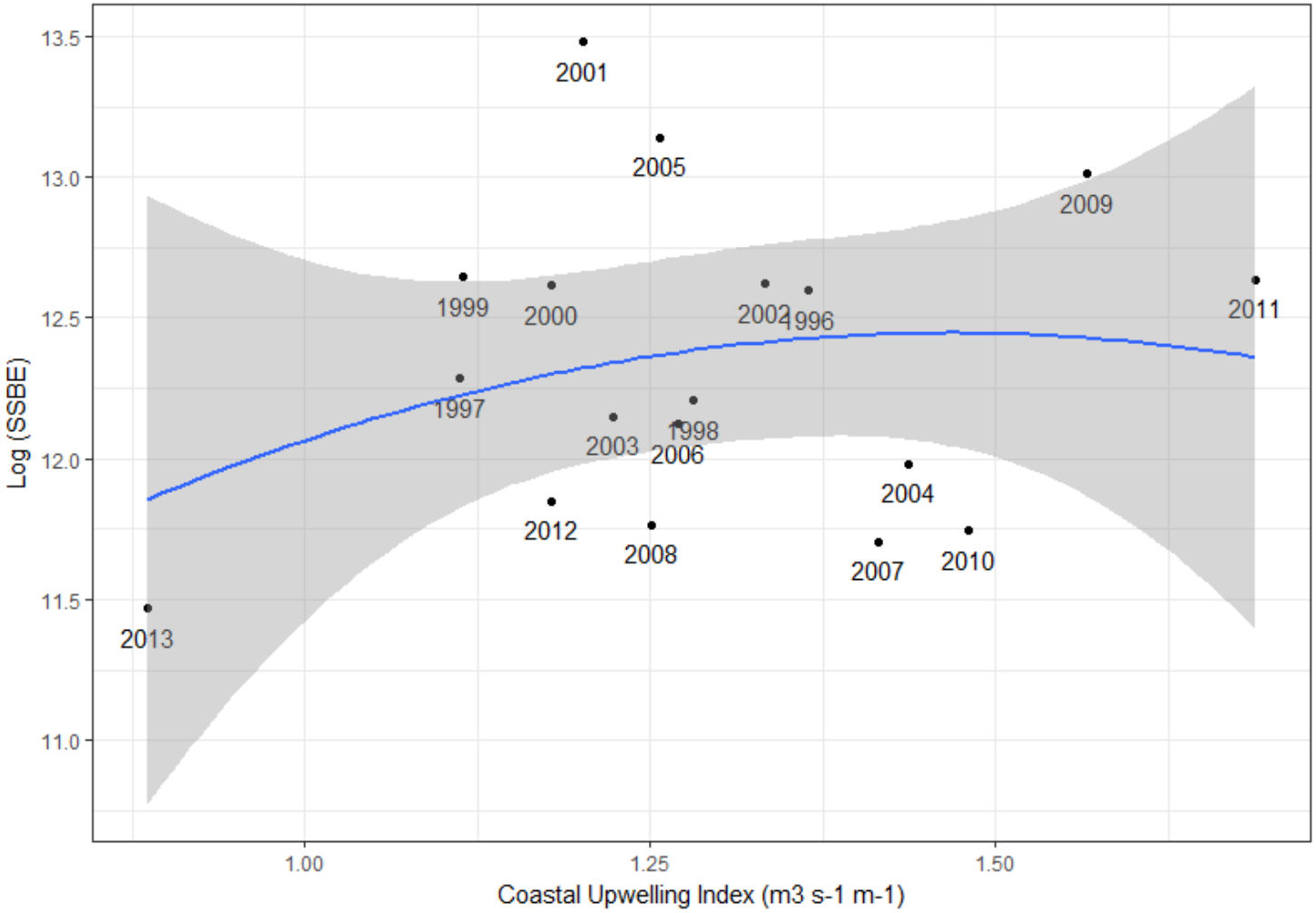
Potential effects of environment on bonga shad spawning stock biomass composition

Results



Relationship between recruitment and SSB

Recruitment– Spawning Stock Biomass relationship



Relationship between SSB and CUI

Conclusions

SSB is the highest; link to **optimum environmental window**;

SSB will be affected by the **effects of climate change**

Small pelagics adapt to annual and seasonal **environmental fluctuations**

Perspectives

- Promote sub-regional collaboration and support the gradual establishment of an important knowledge base, particularly on the fishery for small pelagic fish such as bonga, which is very little known;
- Study and monitoring in situ of the spawning (in batch) to the hatching of bonga larvae;
- The influence of the environment (biotic and abiotic) on the development of the different larval stages;
- Genetic study to rule on the controversies of stock identification and metapopulation of bonga in the sub-region;
- Encourage the introduction of complementary analyses in the stock assessment and environment effect procedures in the sub-region.

THANKS


GOVERNMENT CONTROL
ELIMINATE CARS, PLANES, BOATS
NO CHEESEBURGERS
GLOBAL CLIMATE CHANGE
REDUCE CO2
SPEND TRILLIONS
REDISTRIBUTION of WEALTH
GLOBAL COOLING
NEW "ICE AGE"
GLOBAL WARMING
WEATHER
SULFUR DIOXIDE
CUT POPULATION GROWTH
ELIMINATE AIR CONDITIONING
Plant MORE TREES
SEA LEVEL RISING 20 FEET
Greta Thunberg Is Best
#Envirolize
#Climate Change and Plastic Pollution Action Group