Intense warming causes a spatial shift of small pelagic fish: early warning for food security in North-West Africa

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Importance of Small Pelagics in North West Africa (NWA)

- NWA → **Pelagic resources** are one of the most **abundant** in the word. High productivity → attributed to costal **upwelling** (permanent/saisonal)

- Small pelagic fish are a major component in the region **for food security** (Ba et al. 2017).

Small pelagic resources in North West Africa

Tropical species…….

Round sardinella

Sardinella aurita/ Sardinelle ronde

Flat sardinella

Sardinella maderensis/ Sardinelle plate

Cunene horse mackerel

Trachurus trecae
Chinchard noir

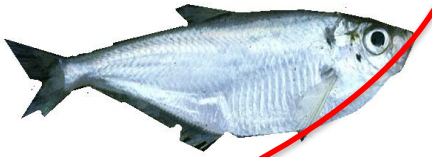
False scad

Decapterus rhonchus
Chinchard jaune

bonga shad

Ethmalosa fimbriata
Bonga

West African Ilisha



Ilisha africana
Alose rasoir

Temperate species ……..

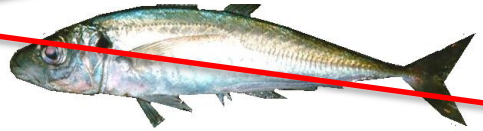
Sardine

Sardina pilchardus
Sardine

Chub mackerel

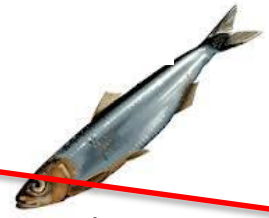
Scomber colias
Maquereau

Atlantic horse mackerel



Trachurus trachurus
Chinchard commun

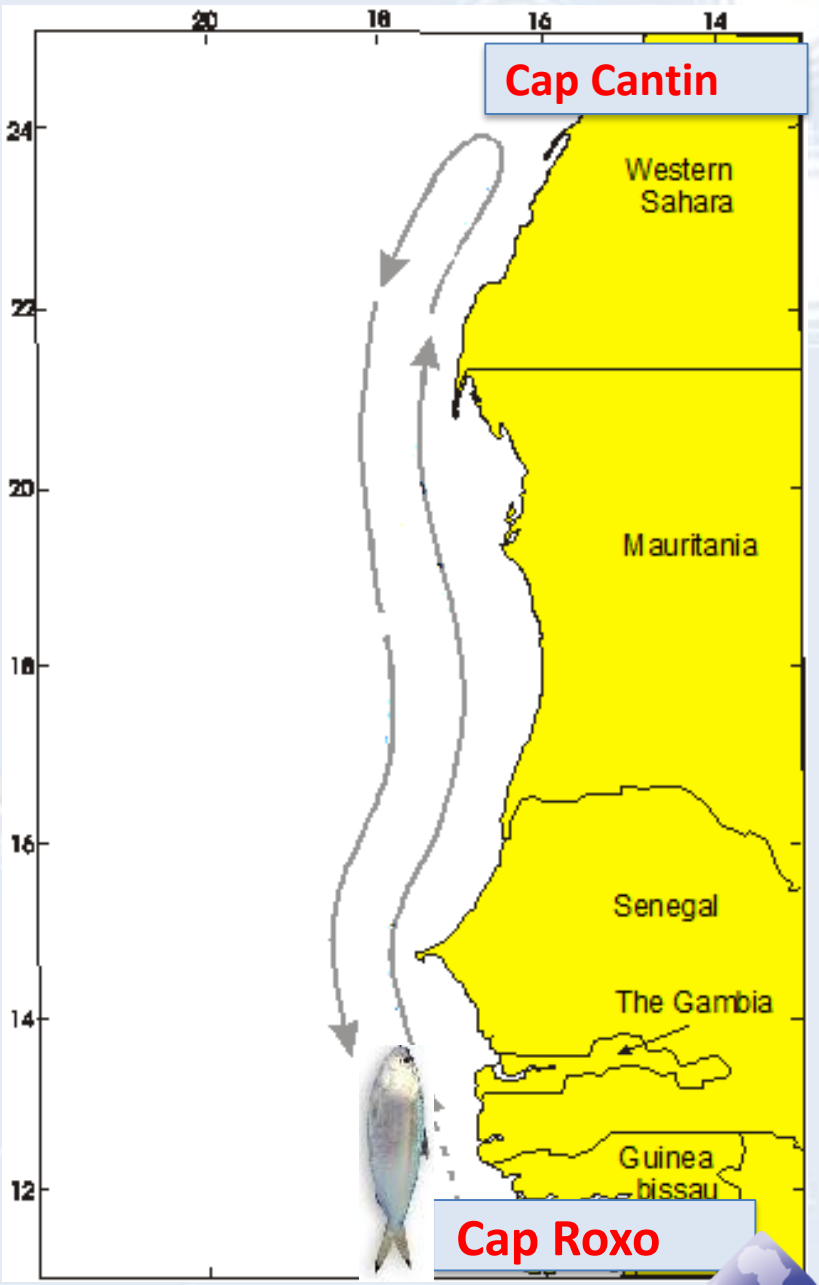
Anchovy



Engraulis encrasicolus
Anchois

Shared resources…

Among several different countries of (CCLME) between Cap Roxo (Senegal) and Cap Cantin (Morocco)



Objectifs/ Problématique

- *What changes occured in the spatio temporal distribution of small pelagics during the last thirty years?*

- *What may be the driving factors behind these changes in their dynamics?*

Data used / Données utilisées dans l'étude

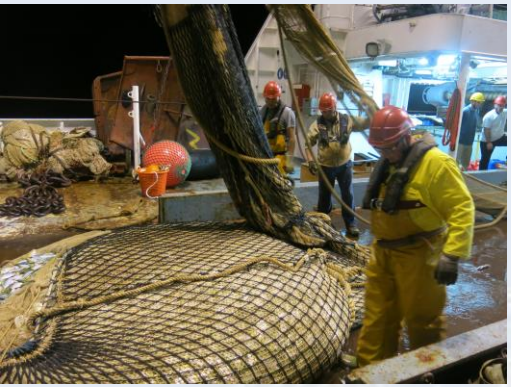
Fridtjof Nansen Database
(Acoust surveys since 1995)

→ **consistent** sampling protocol

Acoustic: 170 000 km
Biologic: 2 263 chaluts

Acoustic data

→ Biomasses of both sardinella (in NASC)



Fishing data

→ 8 species of interest en NWA

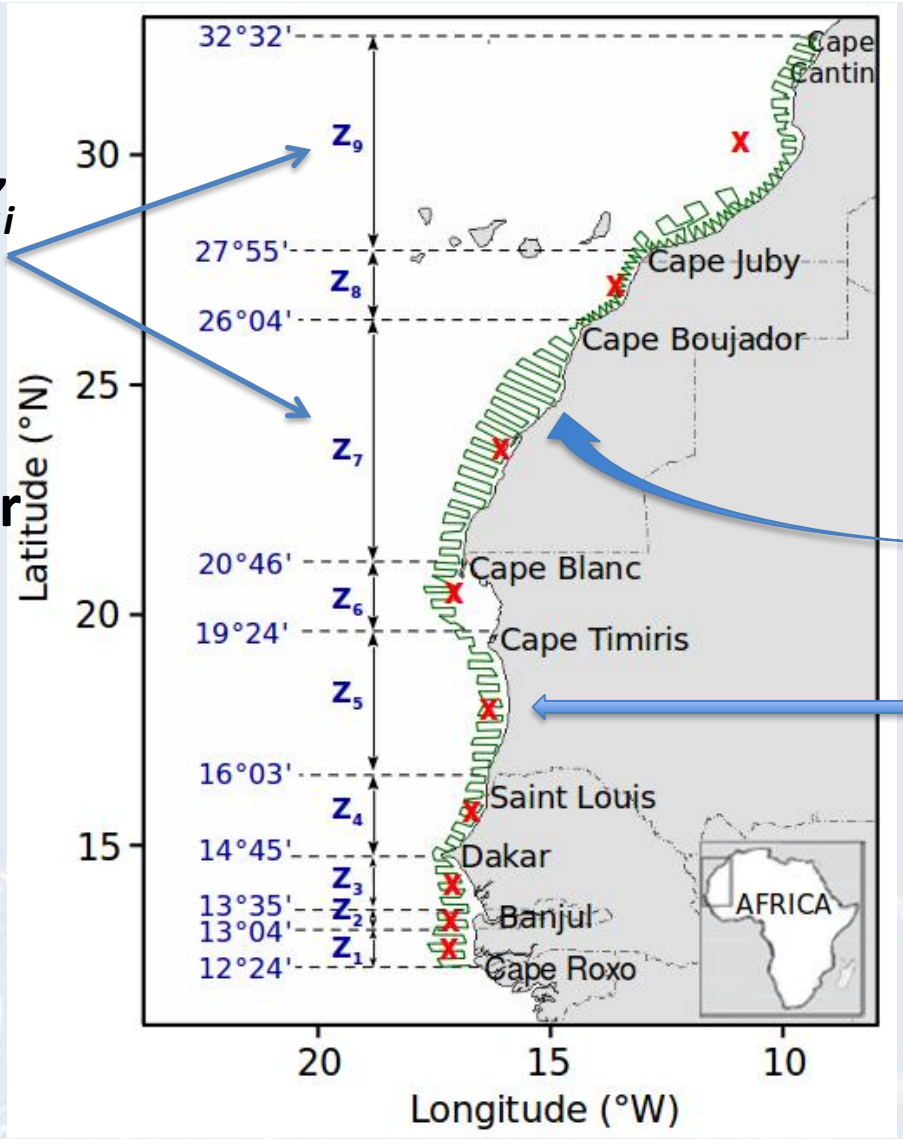
Satellites

→ Méridian wind, Chlorophylle *a* , SST
1982 to 2015

for each Zone Z_i

A biomass

Estimated /year



DFN Acoustic transects …

Z_i Position (latitude, longitude)

(Sarré, 2017)

Traitements effectués :

❖ ***Barycentre of biomasses***

Le barycentre des biomasses

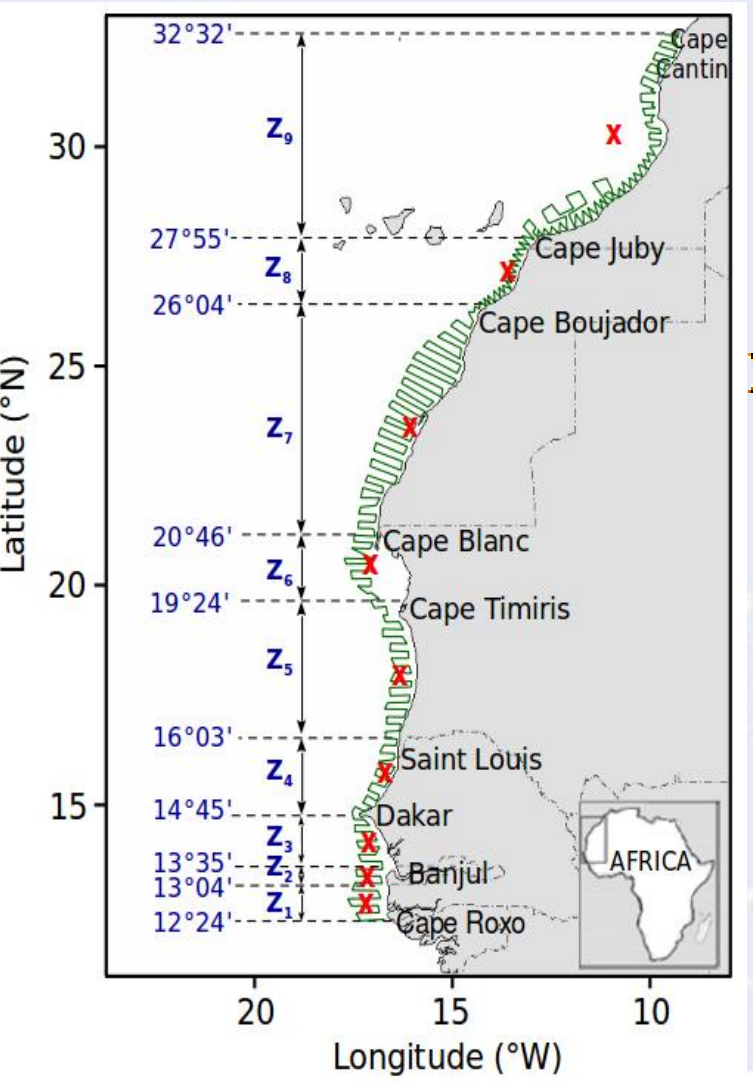
❖ ***Northernmost limit of presence***

La présence extrême nord

Analyses annuelles

biomasses barycentre computation

The barycentre indicates the mean location of the surveyed population (Woillez et al,2009)



The coordinates of the barycentre "C_a" fit the equation:

$$\sum_{i=1}^{n} Bai\overrightarrow{CaAi} = Ba1\overrightarrow{CaA1} + Ba2\overrightarrow{CaA2} + \cdots + Ban\overrightarrow{CaAn} = \vec{0} \quad (1)$$

latitude "*Xa*" and **longitude** "*Ya*" of "*Ca*" are:

$$Xa = \frac{\sum_{i=1}^{n} Bai * Xai}{\sum_{i=1}^{n} Bai} \Big/ Ya = \frac{\sum_{i=1}^{n} Bai * Yai}{\sum_{i=1}^{n} Bai} \quad (2)$$

environnemental data

3 key environmental parameters are followed to address our issue:

Trois paramètres environnementaux clés, dont la couverture est synoptique pour aborder notre problématique :

- *Equatorial wind* /Le vent méridional
- *Chlorophyll*-a /*Chlorophyll*-a,Primary production
- Sea surface temperature / *SST*

Environnemental data

All > > from **satellite remote-sensing** products available from ***US NOAA* database**

Toutes > > *de la base de données satellitaire **US NOAA.***

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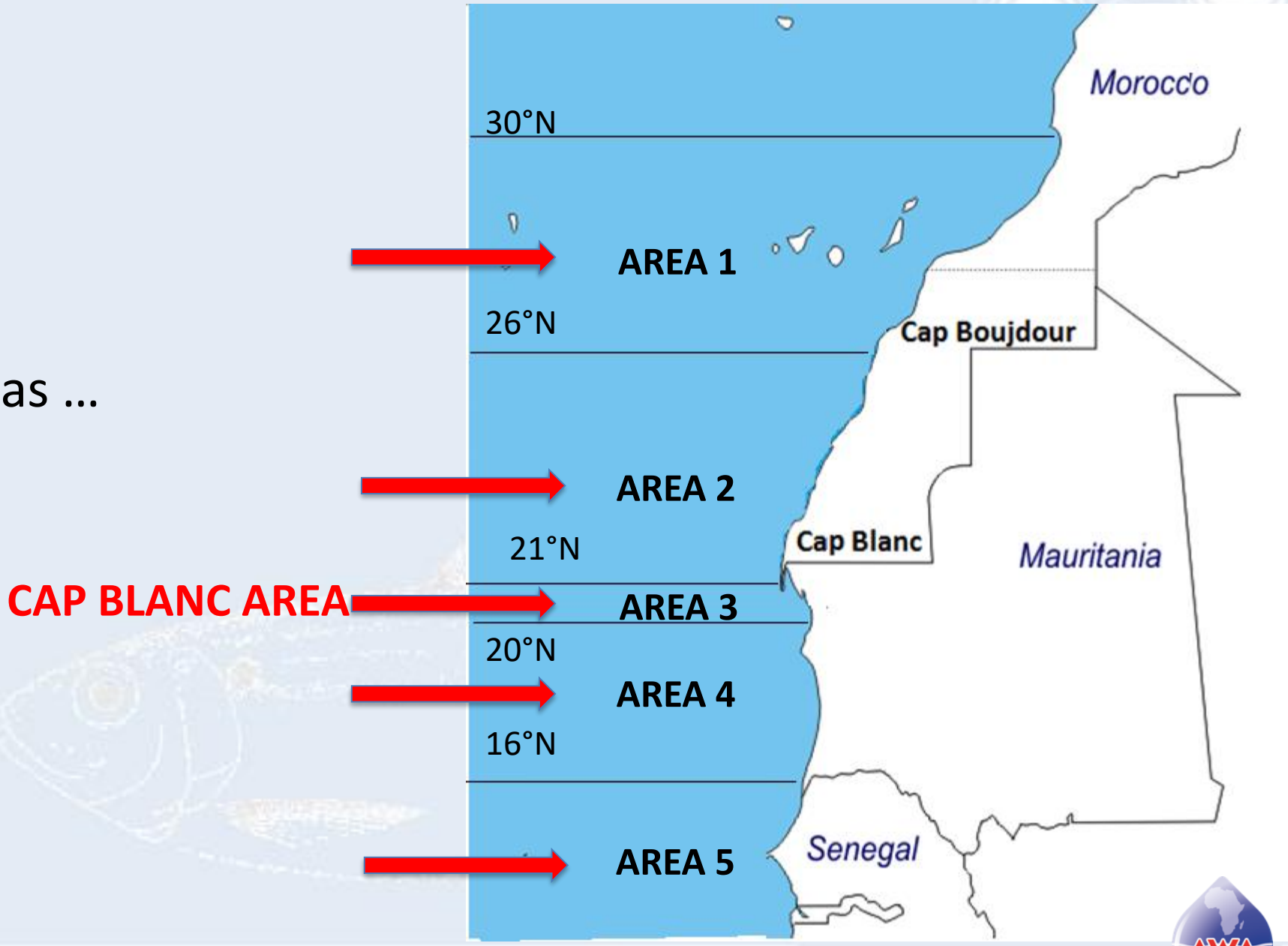
- **SST data ->** from the daily day-time series of the **pathfinder AVHRR** dataset version 5.2 from 1982 to 2012 at **4 km resolution**((Casey, Brandon, Cornillon, & Evans, 2010) and from **MODIS** (Moderate Resolution Imaging Spectro-radiometer) data for (2012-2015).

- **Meridian wind data->** from the daily **CCMP** (Cross-Calibrated **Multi-Platform**) wind product V2.0 at **0.25-degree spatial resolution**, from 1988 through May 2016

- **Chlorophyll-*a* data ->** collected from the **AQUA-MODIS** sel amsnsor (Moderate Resolution Imaging Spectroradiometer) from 2003 to 2012.

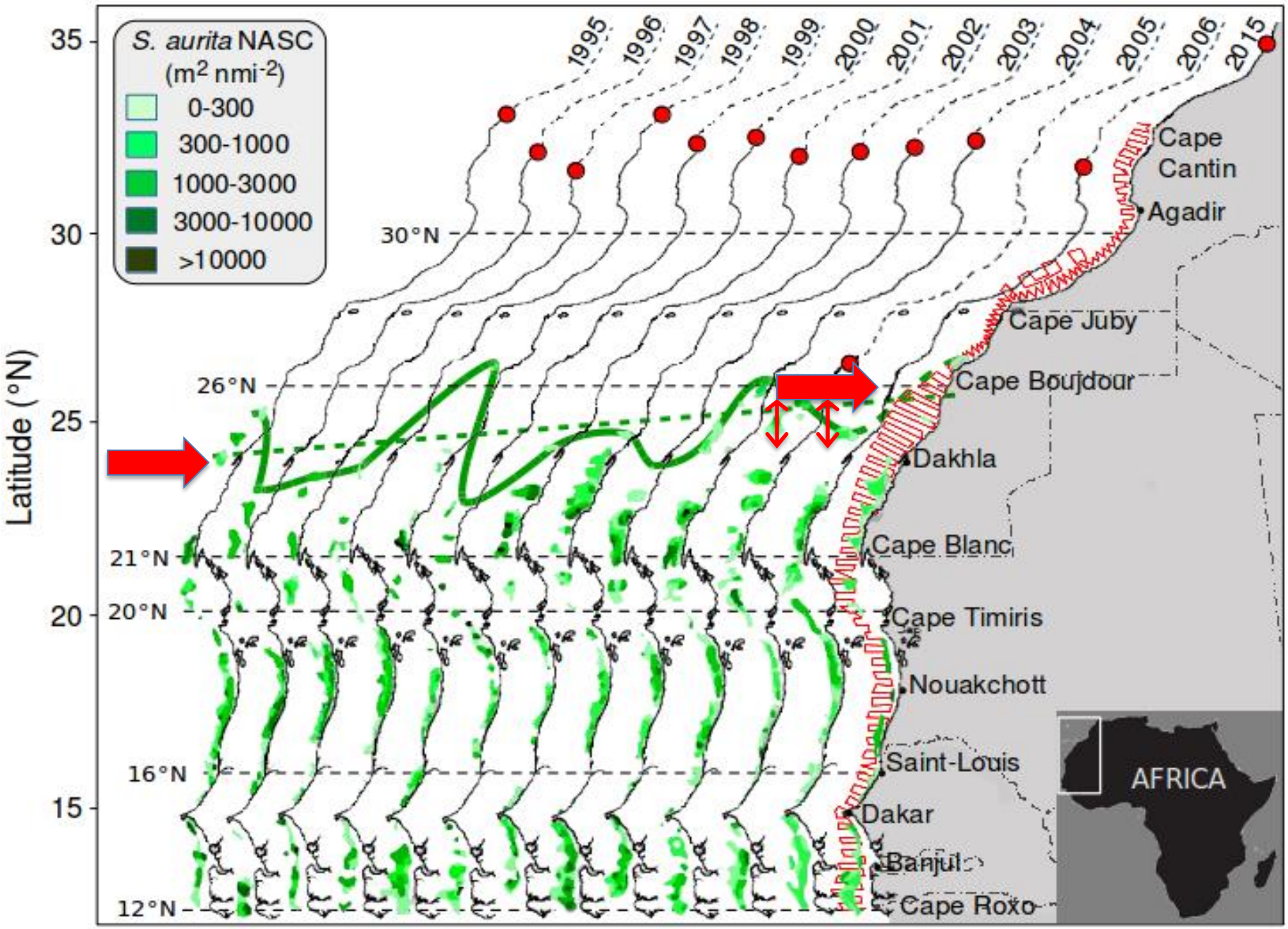
Area of study of the environnemental parameters

5 areas …



Résults

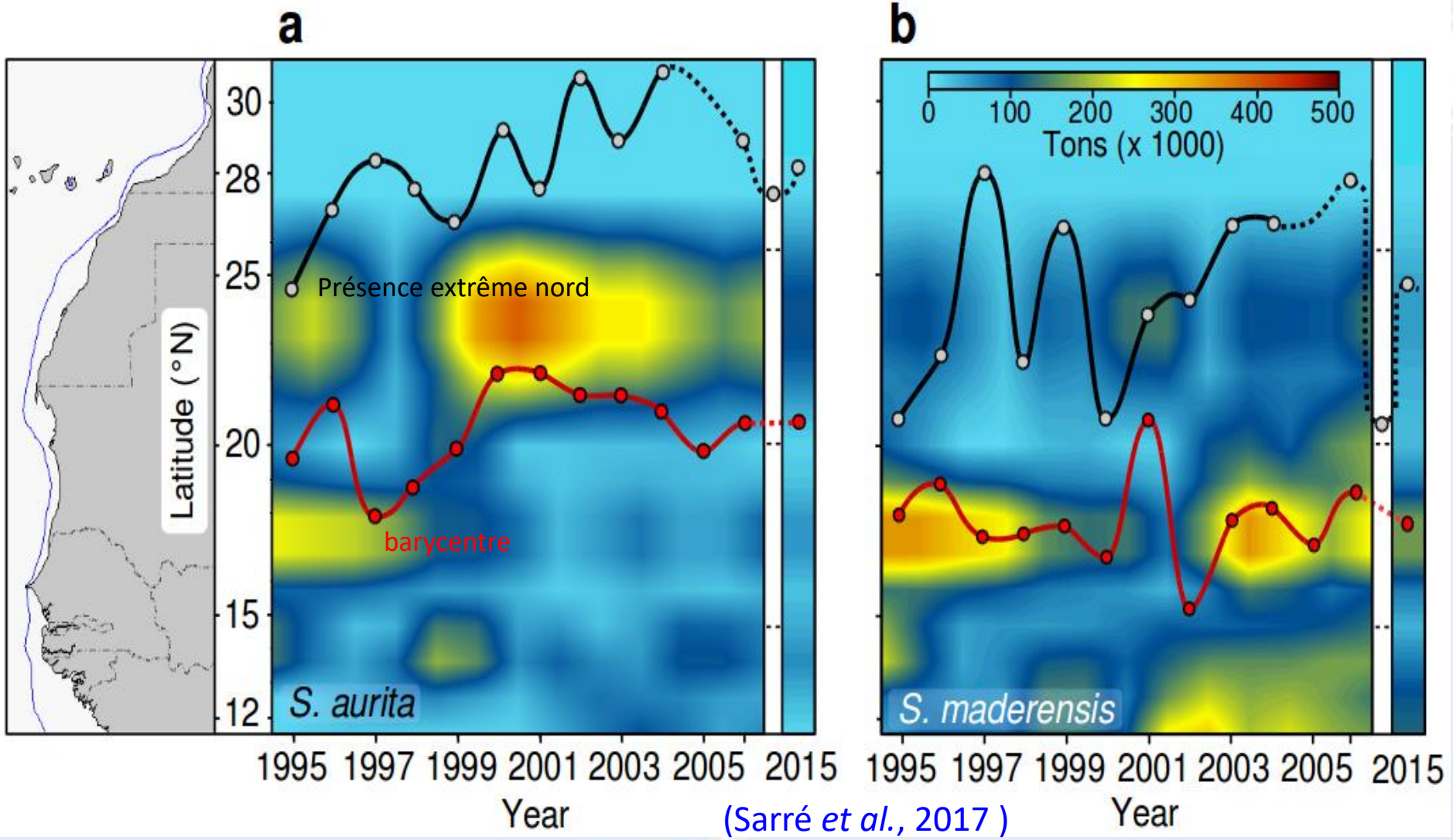
Sarré *et al.*, 2017



Results

The barycentre of the biomasses and latitudinal extreme presence

Hovmoller Diagrams of the observed changes

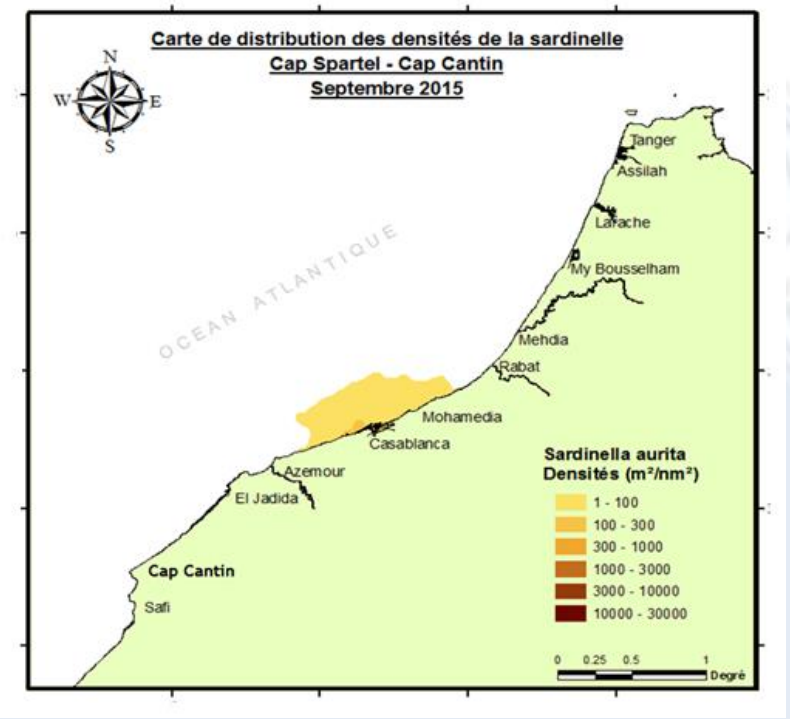


(Sarré *et al.*, 2017)

Résults

From 2015 Moroccan vessel ***assessment***

This finding supports the Moroccan acoustic survey of 2015.

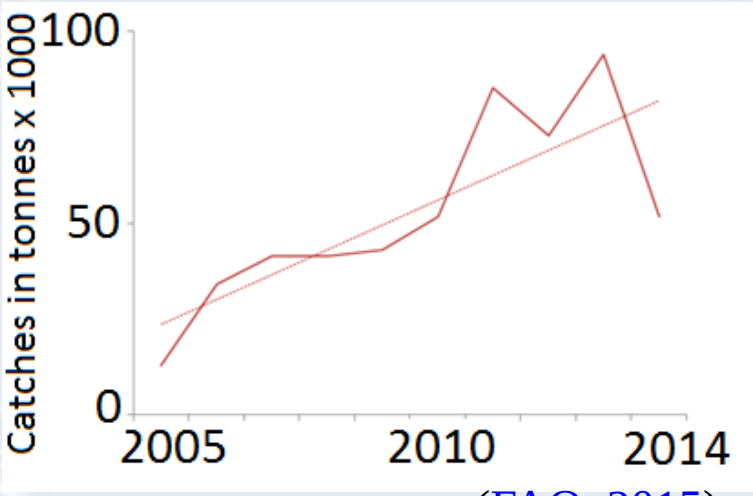


(Salahedine El Ayoubi, 2015)

And also

From Russian and UE fleets catches in Morocco

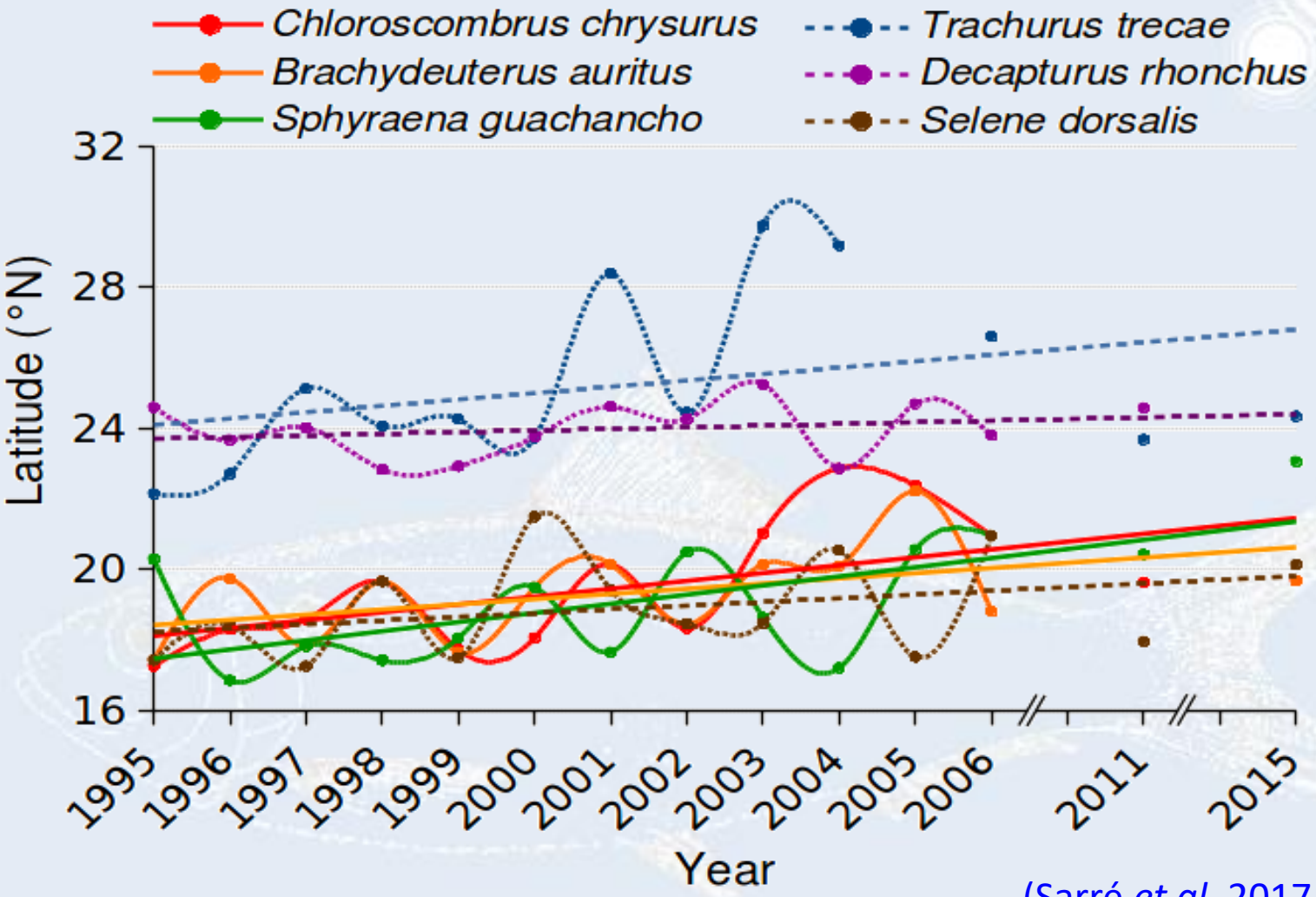
by industrial trawlers from the Russian Federation, and the EU. ***The catch data show an clear increase since 2005***



(FAO, 2015)

Like S. aurita, other small pelagic fish species showed northward trends in their distribution

Comme *S.aurita*, d'autres espèces ont montré les mêmes signes :



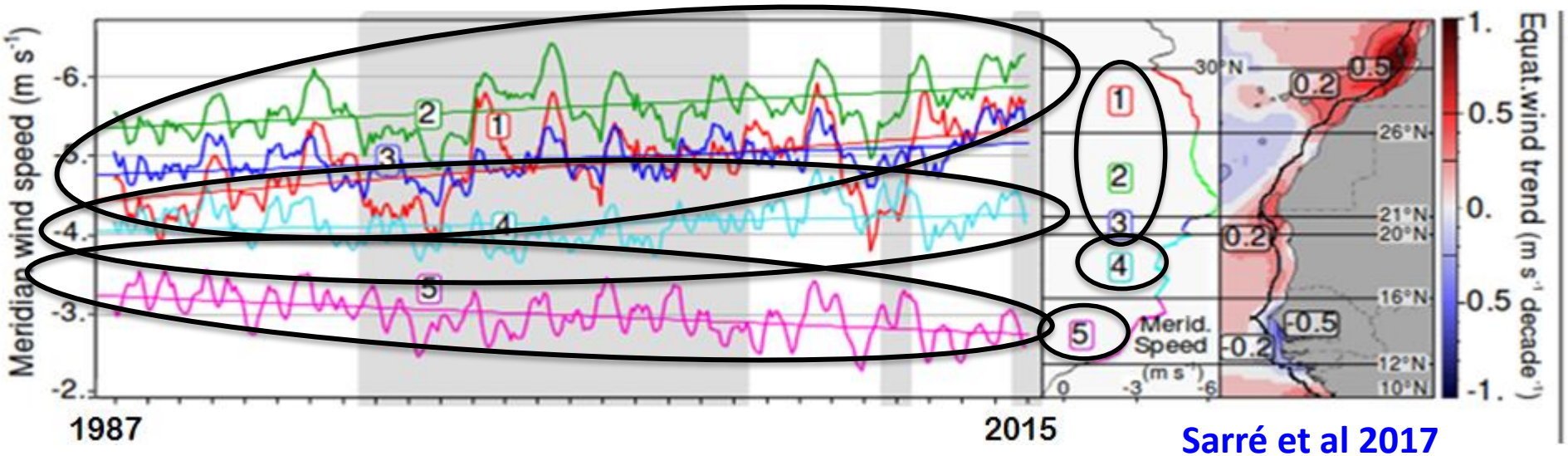
(Sarré *et al.* 2017)

Significance of trends

Spearman and Boostrap Tests on the **northernmost limit of presence**

Year	S_aur	S_mad	T_tre	D_rho	B_aur	C_chr	S_dor	S_gua
1995	24.60	24.50	22.15	24.60	17.43	17.27	17.43	20.30
1996	27.17	22.48	22.72	23.68	19.75	18.30	18.43	16.87
1997	28.40	28.02	25.13	24.02	17.83	18.58	17.27	17.83
1998	27.35	22.02	24.07	22.83	19.67	19.67	19.67	17.43
1999	26.42	26.42	24.27	22.93	17.67	17.73	17.50	18.07
2000	29.03	20.83	23.73	23.77	19.50	18.07	21.50	19.50
2001	27.73	23.83	28.40	24.62	20.15	20.15	19.42	17.67
2002	31.23	24.27	24.45	24.27	18.47	18.33	18.47	20.50
2003	29.03	26.63	29.75	25.25	20.15	21.03	18.48	18.65
2004	30.10	25.73	29.18	22.87	20.10	22.87	20.55	17.22
2005	-	25.08	-	24.70	22.23	22.38	17.53	20.57
2006	28.77	27.95	26.60	23.80	18.81	20.97	20.97	20.97
2011	27.38	21.72	23.69	24.59	20.43	19.64	17.96	20.43
2015	28.16	24.72	24.35	25.72	19.68	19.68	20.14	23.07
r	*0.51*	0.12	0.46	0.42	0.55	0.66	0.43	0.62
***p*-value**	***0.07***	0.69	0.11	0.14	**0.04**	**0.01**	0.12	**0.02**

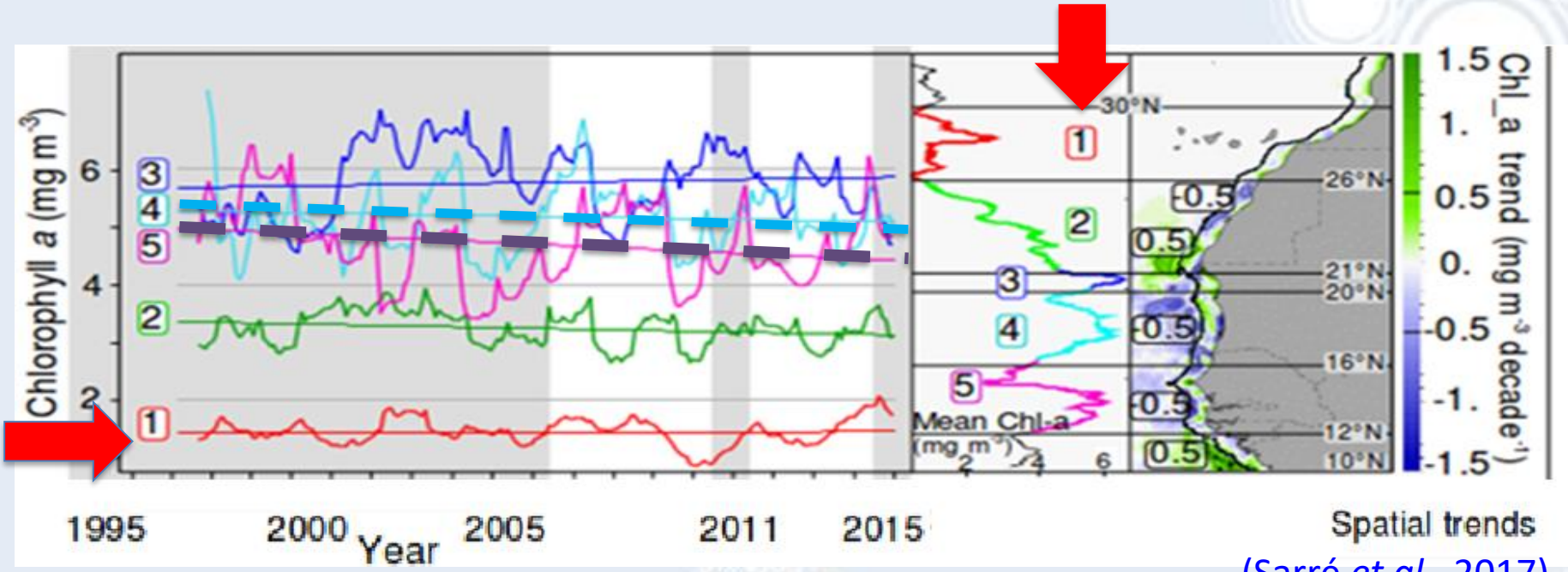
Results --- Meridian component of the sea surface wind



Sarré et al 2017

(Sarré *et al.*, 2017)

Primary production

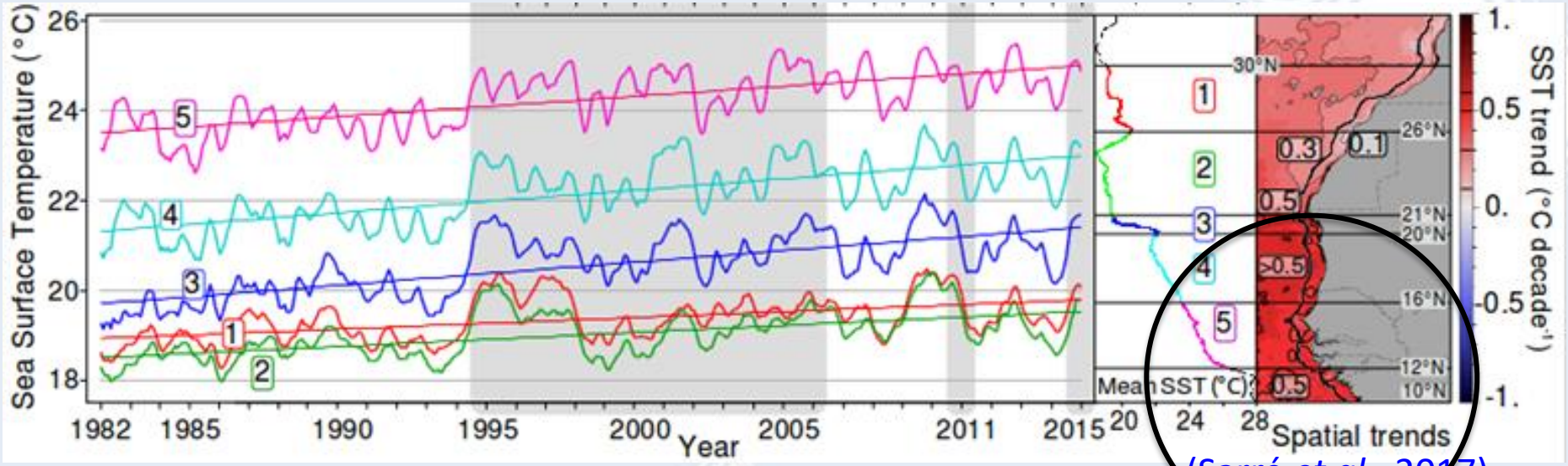


(Sarré *et al.*, 2017)

Slight decrease (not significant) in Senegal and Mauritania

Contrast in area 1 (26–30 °N)

Sea surface température (SST)



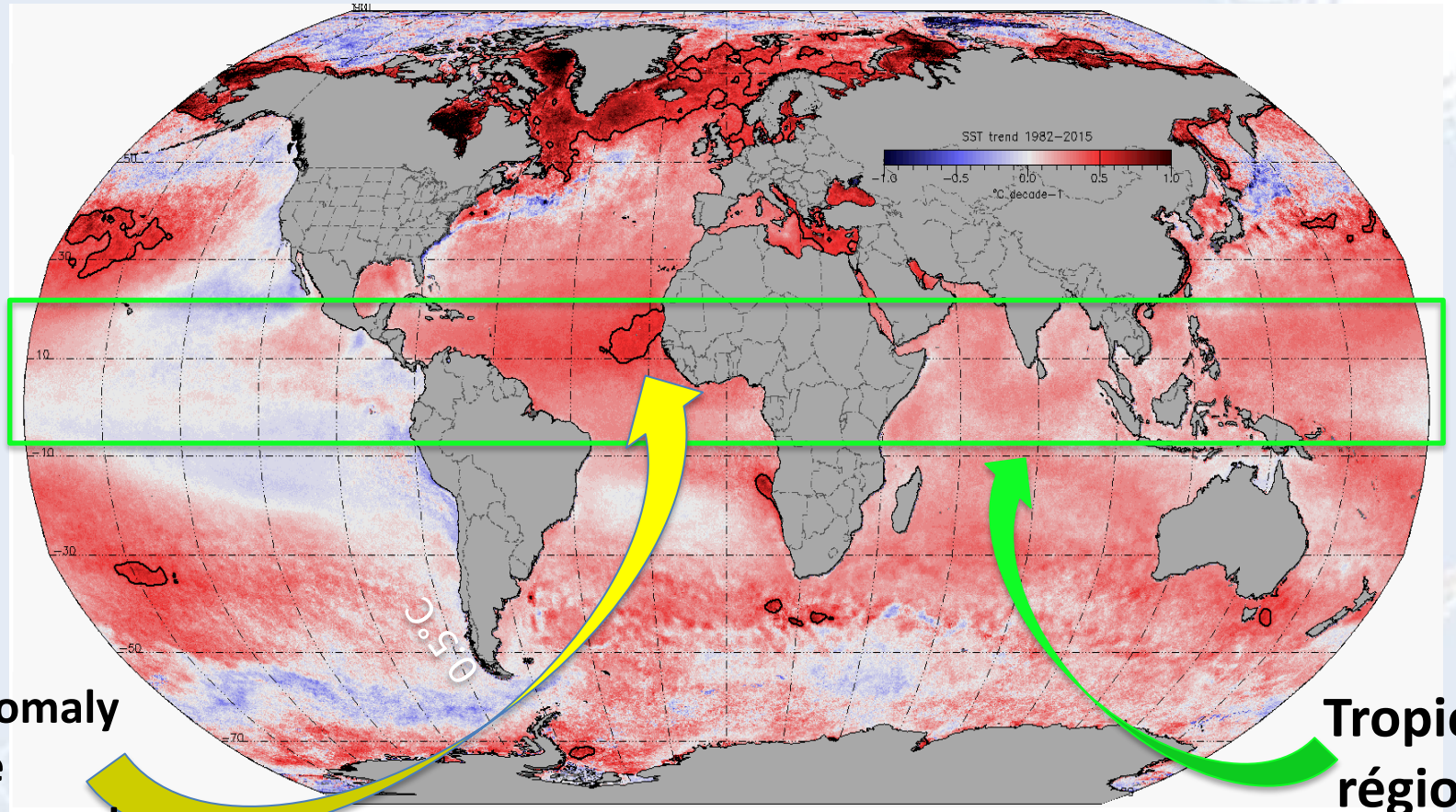
(Sarré *et al.*, 2017)

• SST displays a regular and homogeneous **intense warming** trend **throughout the whole region**

• especially **south of Cape Blanc** (areas 3 to 5) with cumulative increases of between 0.5 °C and 1.5 °C in the past 34 years

Temperature anomaly SST in NWA region/ période 1982-2015

At global level…

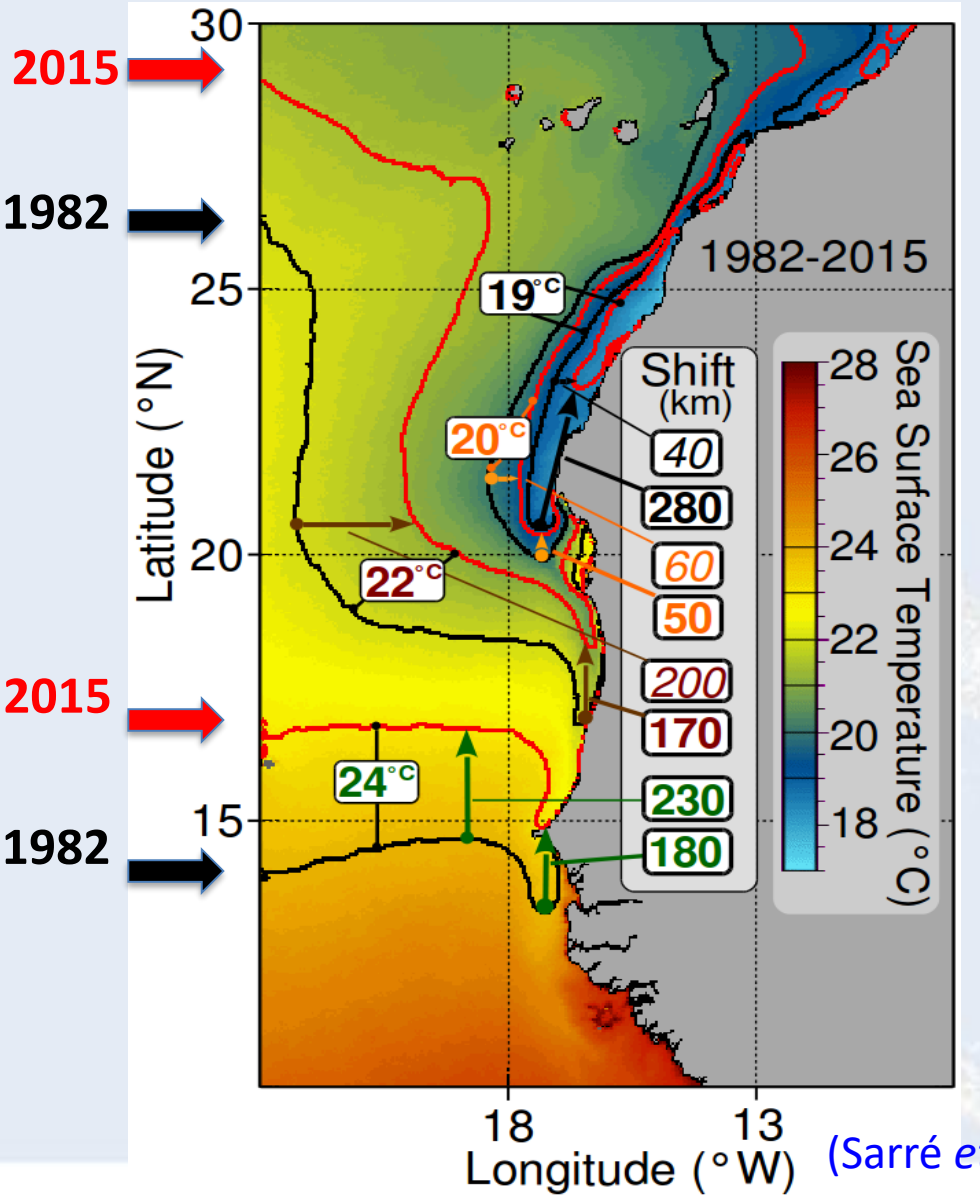


0.5°C anomaly / decade iso-contoured

Tropical régions

Anomalies de températures SST au niveau mondial sur la période 1982-2015 (1982-2011: AVHRR, 2012-2015: MODIS) avec la valeur 0.5°C décennie

Sea surface Temperature (SST)



(Sarré *et al.*, 2017)

- **The increase in SST was evaluated in terms of northward displacement of isotherms** by comparing the last 17-year period (1999-2015) with the previous one (1982-1998).

- 24 °C Isotherm (Dakar)

Observed displacement: 230 km

Results

Displacement **key small pelagic species** from1995 to2015 // Displacement of **isotherms**

a)

Species	Mean latitudinal North limit (°N) 1995	2015	Shift distance (in km)
Sardinella aurita	26,77	29,17	267
Sphyraena guachancho	17,24	20,61	375
Trachurus trecae	23,59	26,61	335
Chloroscombrus chrysurus	17,75	20,73	332
Brachydeuterus auritus	18,28	19,94	184
Selene dorsalis	17,98	19,93	217
Decapterus rhonchus	23,72	24,14	48
Sardinella maderensis	24,10	24,95	94

b)

Isotherm (°C) / Period	19	20	21	22	23	24
1982-1998	20.5	20.0	18.5	16.9	15.0	13.3
1999-2015	23.0	20.5	19.9	18.4	17.5	14.9
Shift 1982-2015	280	50	150	170	170	180
Shift 1995-2015	>200	30	-	50	20	40

Note: the distances that migratory pelagic fish have moved were of the **same order of magnitude** as those observed for the isotherms in the region (150–300 km) since 1995.

Conclusions

		Pearson r	p-value
WIND	Area 1	**0.54**	**0.003**
	Area 2	**0.48**	**0.010**
	Area 3	0.41	0.030
	Area 4	0.21	0.280
	Area 5	**-0.53**	**0.004**
CHL_a	Area 1	0.07	0.779
	Area 2	-0.18	0.476
	Area 3	0.01	0.978
	Area 4	-0.24	0.340
	Area 5	-0.18	0.484
SST	Area 1	**0.56**	**6.00E-04**
	Area 2	**0.61**	**1.18E-04**
	Area 3	**0.74**	**4.91E-07**
	Area 4	**0.73**	**8.03E-07**
	Area 5	**0.77**	**7.47E-08**

Effet de la température

- ***It is likely that SST is the most significant environmental parameter explaining the movements of S. aurita****, even though combination of physical and ecological factors contribute to this phenomenon*

.

- *The observed variation in meridian wind cannot explain the gradual northward shift of the S. aurita population.*

Conclusions

- **The observed northwards shifts of the *S. aurita* stock** as well several tropical pelagic species **may significantly** affect **(decrease) their abundance in the Southern part of the system**, *i.e.*, South of Cape Blanc

- The specific shift of ***S. aurita*** has to be underlined as it **constitutes a key source of proteins for the regional populations**

Consequently, any shift in the distribution of this stock might induce significant social instability

Early warning 

Thank you for your attention