



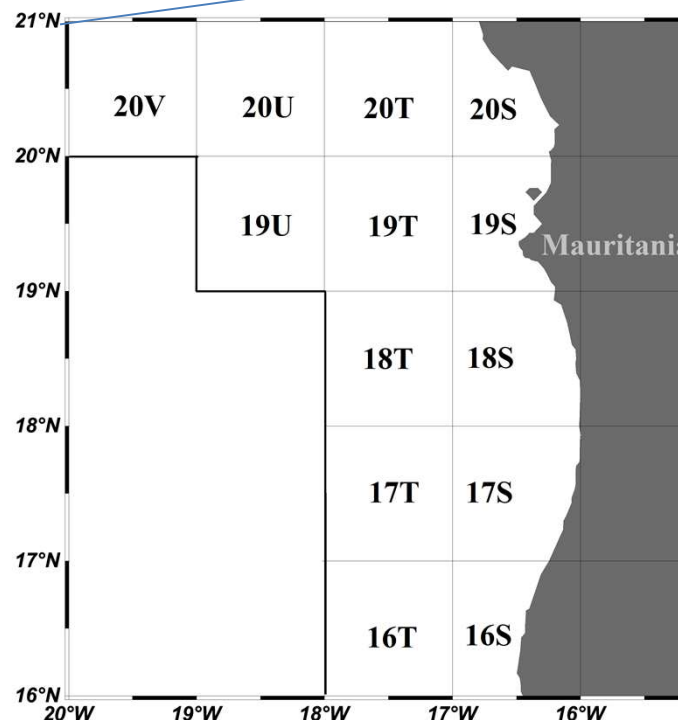
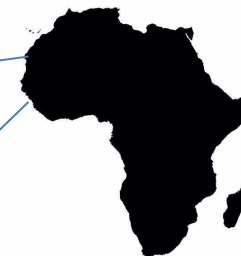
Relationships between environmental factors and abundance of *Sardina pilchardus* and sardinella spp off the Mauritanian coast using generalized additive model (GAM)

BACHA Mahmoud¹, JEYID Ahmed^{1,2}, VANTREPOTTE vincent¹, DESSAILLY David¹, AMARA Rachid¹

1. Laboratoire d'Océanologie et de Géosciences, UMR 8187 CNRS, Université du Littoral Côte d'Opale, 32 Avenue Foch, 62930 Wimereux, France 2

2. Institut Mauritanien de Recherches Océanographiques et des Pêches (IMROP), BP 22, Nouadhibou, Mauritania





➔ Sardine and Sardinella play an **important role in NW Africa fisheries and marine ecosystems.**

➔ Significant **gaps in the knowledge about their population dynamic** off the Mauritanian coast,

➔ The present study aimed to **describe the spatio-temporal patterns of abundance and distribution** of these two species.

➔ We specifically investigated the **environmental influences** and identified the underlying processes influencing sardine and sardinella spp abundance and delineated their **optimum habitat in the Mauritanian coast.**

Fish and environmental data

- ▶ Monthly CPUE (catch-per-unit-effort) : Sardine and sardinella spp (1998 – 2011):

$$CPUE = \frac{\sum Catch}{\sum Fishing\ days}$$

- ▶ Monthly averaged SST data for 1998-2011 were obtained from ESA Sea Surface Climate Change Initiative (CCI)

- ▶ Monthly Chlorophyll-a was obtained from ESA Ocean Colour CCI project.

- ▶ Wind vector dataset was derived from the Cross-Calibrated Multi-Platform (CCMP)

- ▶ Wind mixing index ($m^3.s^{-3}$), which is the mean value of the cube of the wind speed.

- ▶ The upwelling index (UI) $UI^W = -\sin\left(\varphi - \frac{\pi}{2}\right)Q_x + \cos\left(\varphi - \frac{\pi}{2}\right)Q_y$

Generalized additive model fitting procedures

Spatio-temporal model

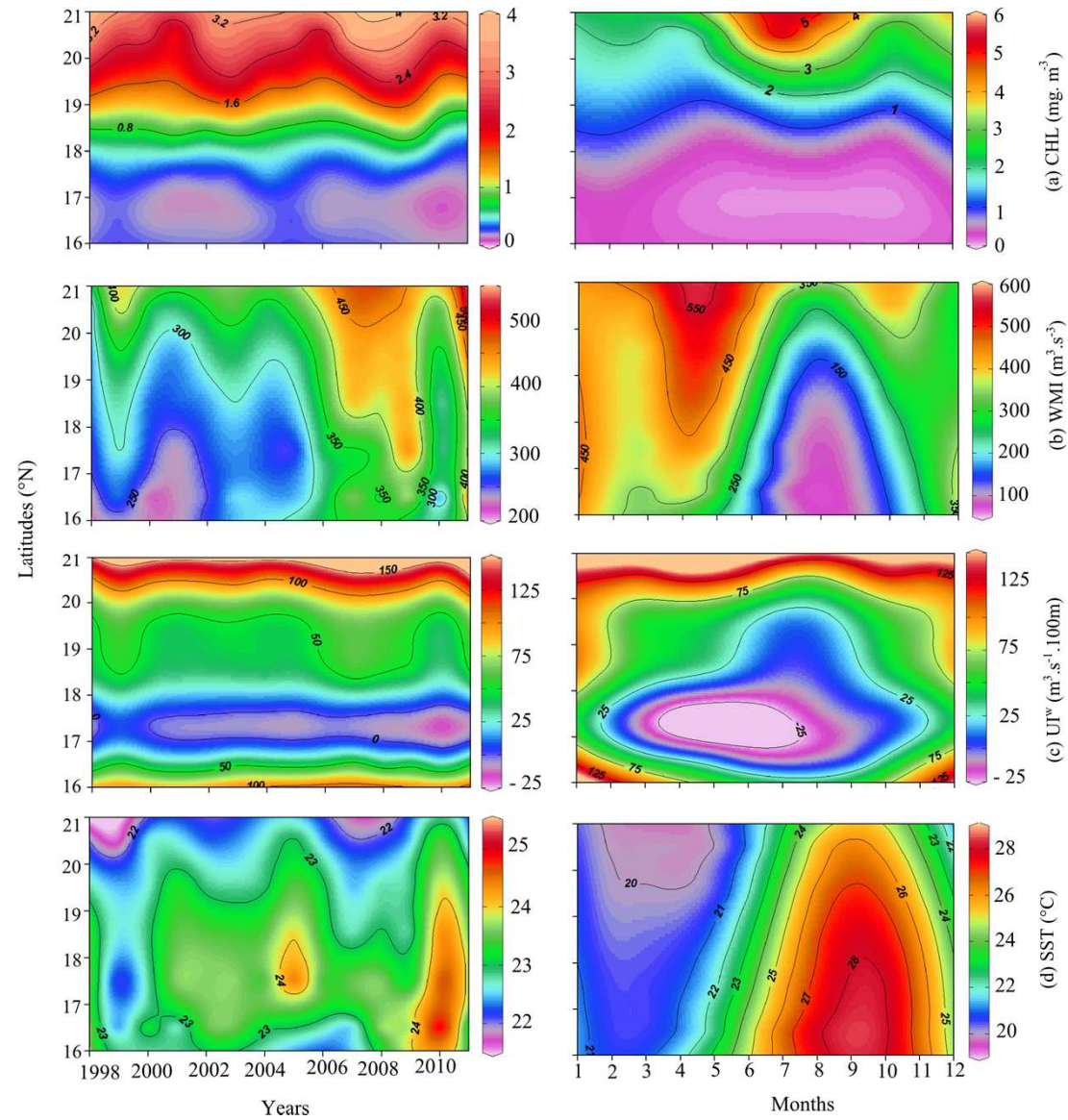
$\log(CPUE + 1) = \text{Year} + \text{Month} + s(\text{Year}, \text{Latitude}) + s(\text{Month}, \text{Latitude}).$

Oceanographic model

$\log(CPUE + 1) = \text{Year} + s(\text{SST}) + s(UI^W) + s(\text{CHL}) + s(\text{WMI}).$

Environmental conditions along the Mauritanian coast

Variations latitudinales

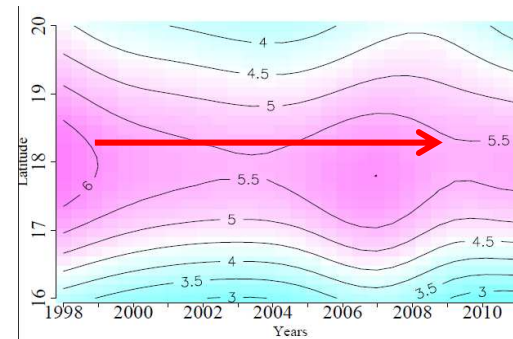
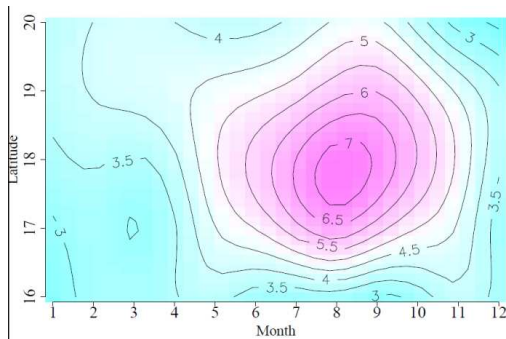


Variations interannuelles

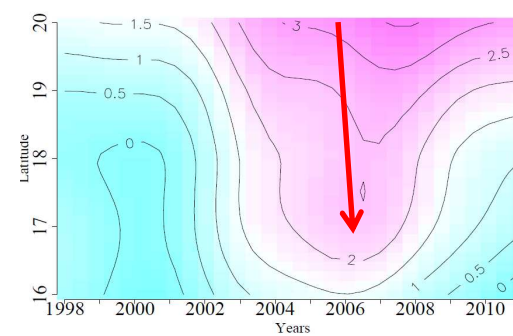
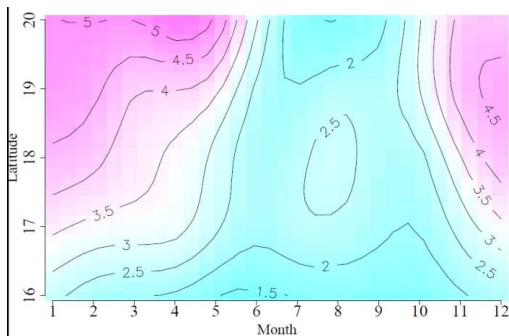
Forte saisonnalité

Interactions between spatial locations (latitude) and months and years for sardinella spp (a, b) and *Sardina pilchardus* (c, b). The number labels on contour lines denote (log cpue+1).

Model	Resid. Df	Resid.Dev	Deviance	P(>Chi)	Dev. expl (%)	AIC	GCV
Spatio-temporal model (<i>Sardinella</i> spp)							
Null model	799.00	2463.9	-	-	-	3174.426	3,08
Year	798.00	2458.4	5.45	0.0461	0,22	3174.199	3,08
Month	797.00	2392.2	66.23	6.38e-10	2,91	3154.579	3,01
s (Year, latitude)	778.98	2005.7	386.44	2.2e-16	18,6	3049.662	2,64
s (Month, latitude)	760.60	1318.6	687.12	2.2e-16	46,5	2750.880	1,82

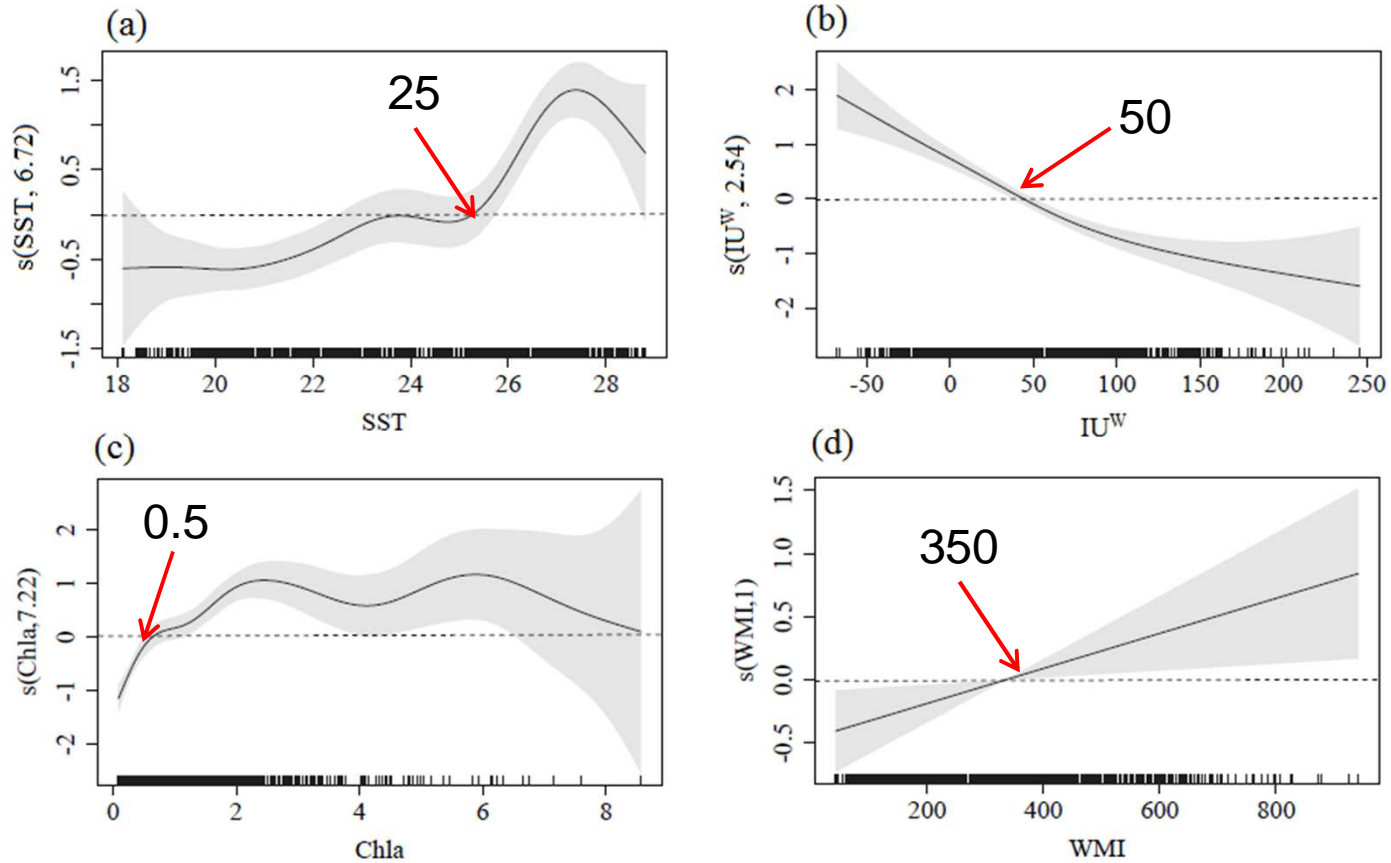


Model	Resid. Df	Resid.Dev	Deviance	P(>Chi)	Dev. expl (%)	AIC	GCV
Spatio-temporal model (<i>Sardina pilchardus</i>)							
Null model	619.00	1998.59	-	-	-	2489.179	3,23
Year	618.00	1889.99	108.59	2.2e-16	5,43	2456.542	3,06
Month	617.00	1854.25	35.75	2.02e-07	7,22	2446.703	3,01
s (Year, latitude)	607.46	1338.38	515.87	2.2e-16	33	2263.646	2,24
s (Month, latitude)	580.22	767.93	570.45	2.2e-16	61,6	1973.707	1,42



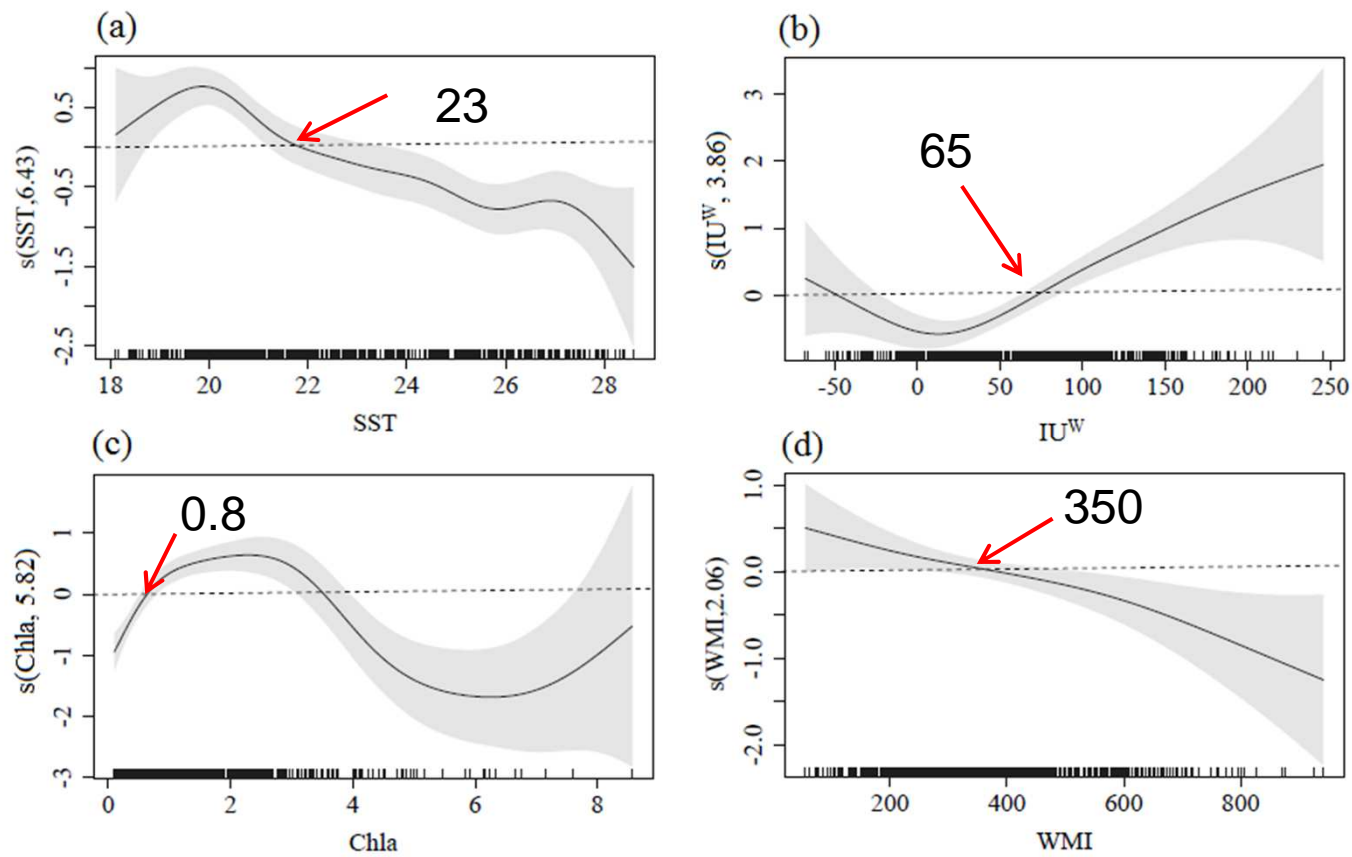
Oceanographic model	Resid. Df	Resid.Dev	Deviance	P(>Chi)	Dev. expl (%)	AIC	GCV
Sardinella spp							
Null model	799.00	2463.9	-	-	-	3174.199	3.08
Year	798.00	2458.4	5.45	0.1198	0.22	3174.426	3.08
s(SST)	791.00	2097.6	360.81	2.2e-16	14.9	3061.447	2.68
s(Chla)	783.82	1965.8	131.84	3.70e-10	20.2	3023.876	2.56
s(UI)	781.15	1769.4	196.35	2.2e-16	28.2	2945.040	2.32
s(WMI)	780.53	1759.2	10.19	0.0166	28.6	2941.658	2.31

(A)



Oceanographic model	Resid. Df	Resid.Dev	Deviance	P(>Chi)	Dev. expl (%)	AIC	GCV
Sardina pilchardus							
Null model	619.00	1998.6	-	-	-	2489.179	3.23
Year	618.00	1890.0	108.59	9.37e-14	5.43	2456.542	3.07
s(UI)	613.48	1568.0	321.96	2.2e-16	21.5	2349.785	2.58
s(SST)	608.34	1407.8	160.24	4.22e-16	29.6	2293.247	2.36
s(Chla)	602.38	1196.0	211.77	2.2e-16	40.2	2204.098	2.04
s(WMI)	599.84	1173.8	22.22	0.006268	41.3	2197.536	2.02

(B)



CONCLUSION

- ▶ Both species displayed **considerable variations in their spatial distribution based on their habitat preferences**; their **distribution is affected by seasonal and inter-annual changes in oceanographic conditions**
- ▶ The oceanographic model revealed that a high proportion of catch variability for the two species could be explained by environmental variables.
- ▶ For *S. pilchardus* , the **Upwelling intensity** accounted for a large part of the variation in abundance, followed by chlorophyll a and SST.
- ▶ For sardinellas, **SST**, upwelling index and chlorophyll a contributed substantially to the total deviance of the model.
- ▶ **Low interannual variations in sardinella** catch among latitudes and a **gradual southward extension for *S. pilchardus* between 2002 to 2009**. This latter latitudinal movement appears to be associated with oceanographic conditions mainly upwelling activity.