FIP/MSC meeting for the certification of Moroccan sardine fisheries

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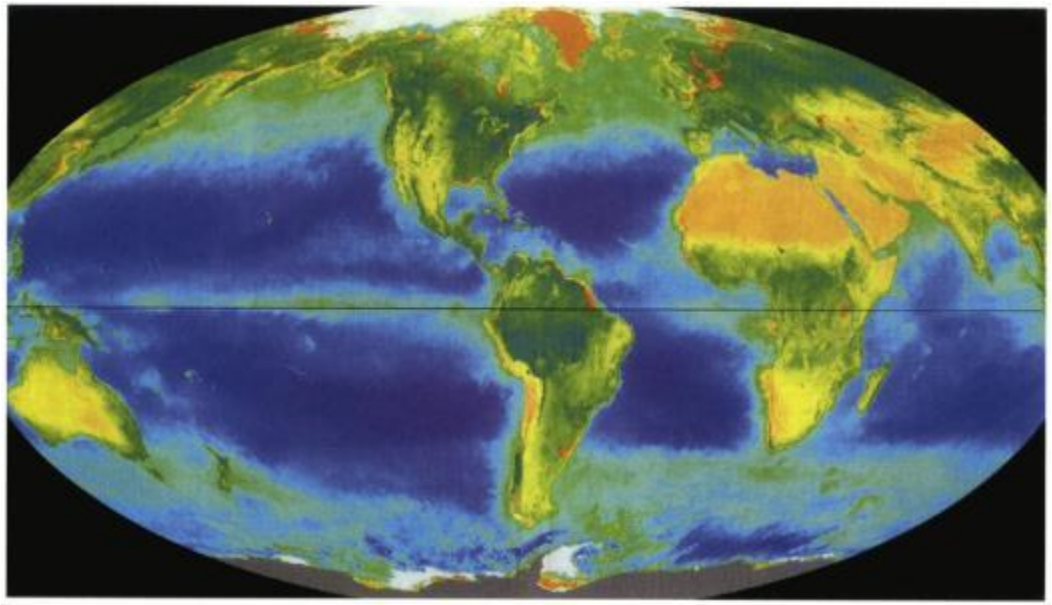
Part I : The ecosystem

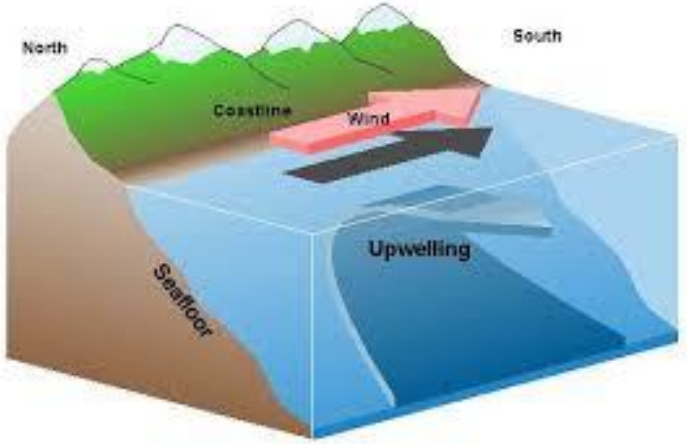
Part II : Empirical approach to evaluate the sardine status and its impact on other fish communities

Part III : Morocco's fisheries scientific monitoring and management system

Part IV : Focus on the model Ecopath with Ecosim (EwE)

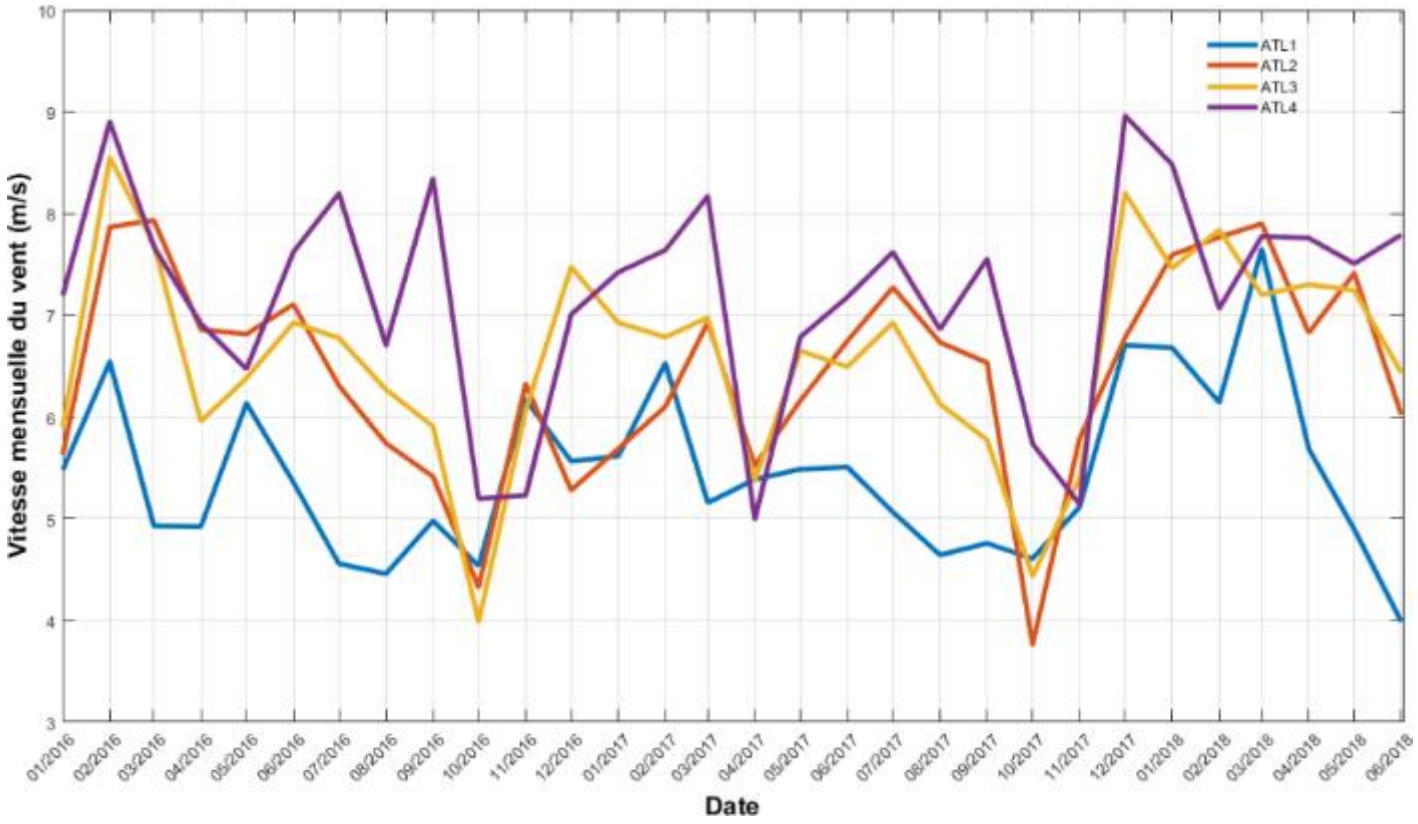
The ecosystem



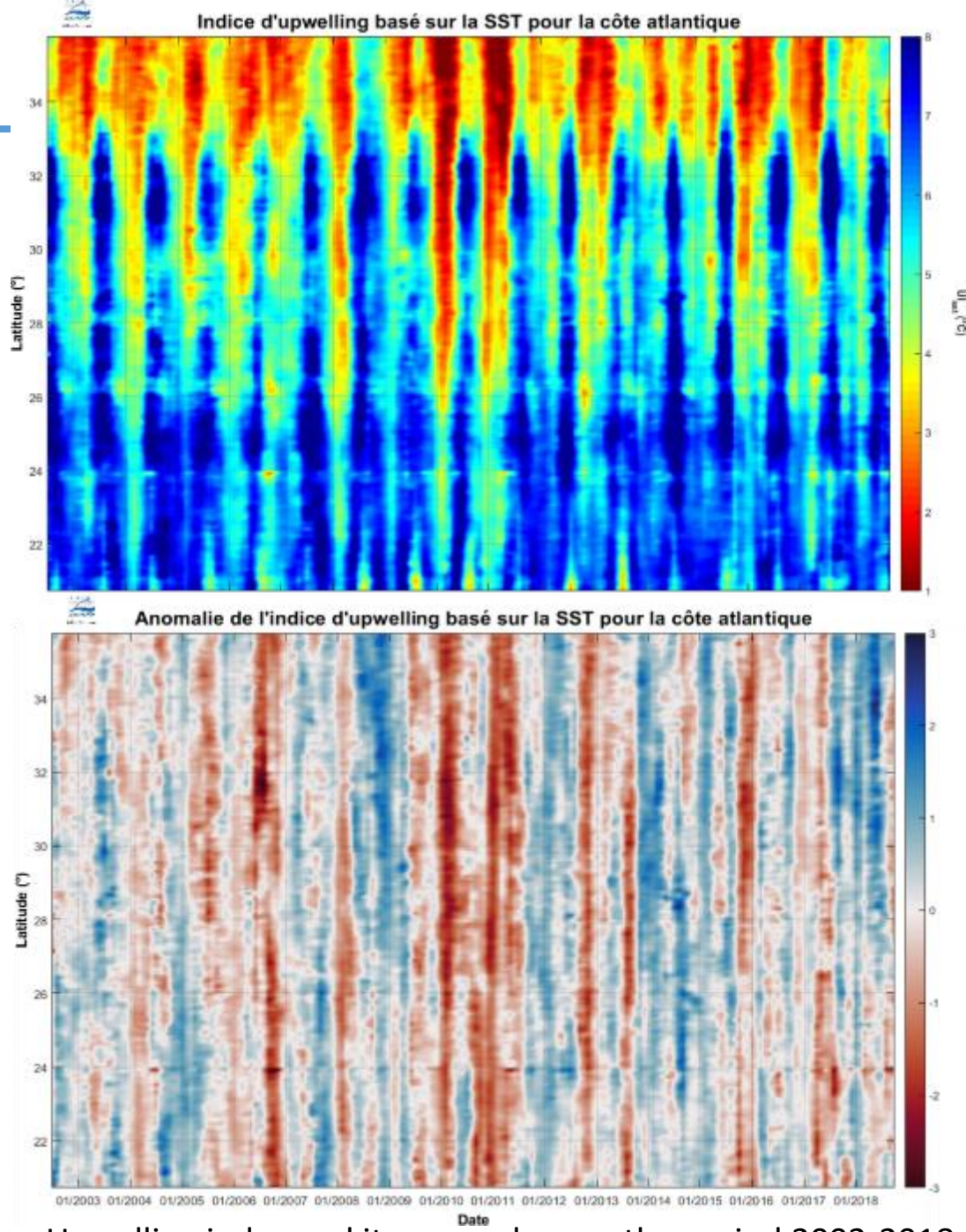


- **CCLME is the third ecosystem in the world in terms of primary productivity**
- **CCLME ensures one of the most important fisheries productions among the large ecosystem of Africa, with 2 to 3 millions annualy**
- **More than 80% the catchs are small pelagics**
- **The ecosystem productivity is driven by hydroclimatic activity, including upwelling, and biogeochemical processes occurring at different spatio-temporal scales**

Monitoring of the oceanographic conditions and Upwelling activity



Mensual average of wind speed



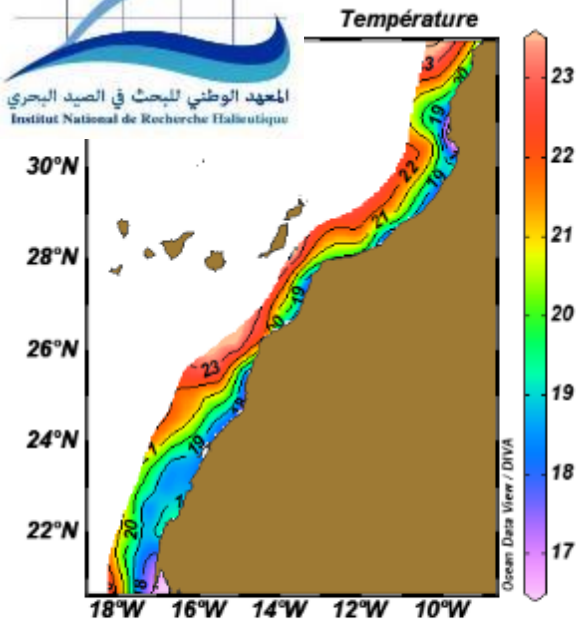
Upwelling index and its anomaly over the period 2002-2018

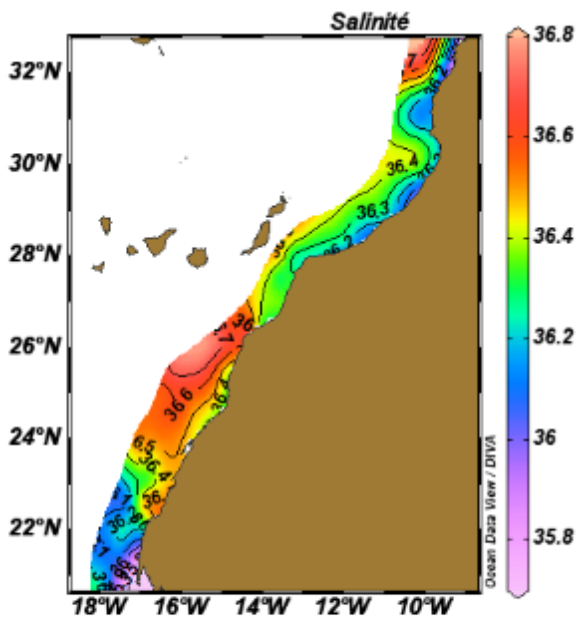
Source INRH/DO/Cellule Télédétection Spatiale

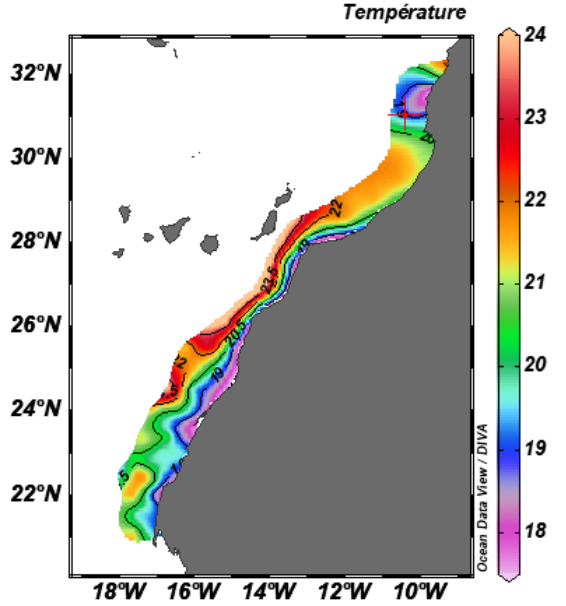
Monitoring of the oceanographic conditions

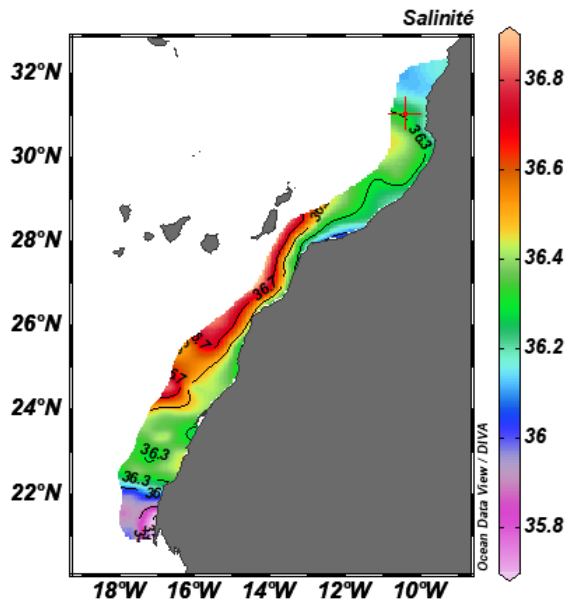
2018

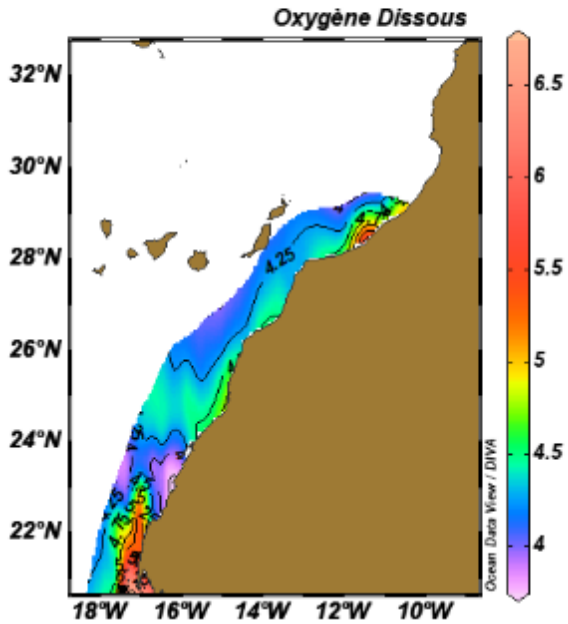
2017

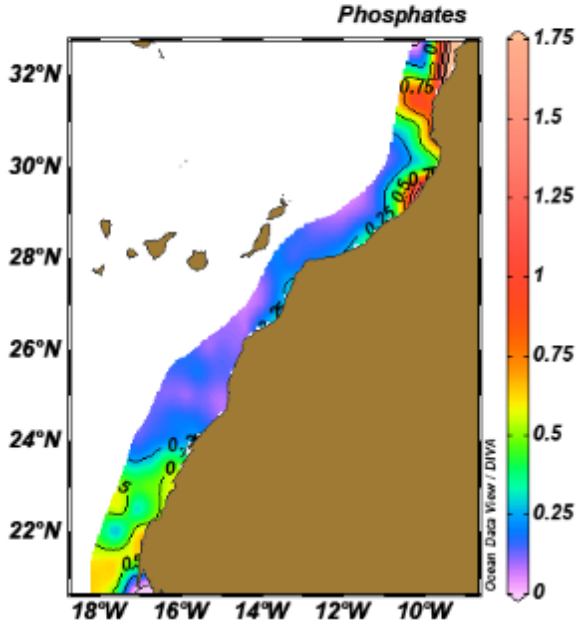


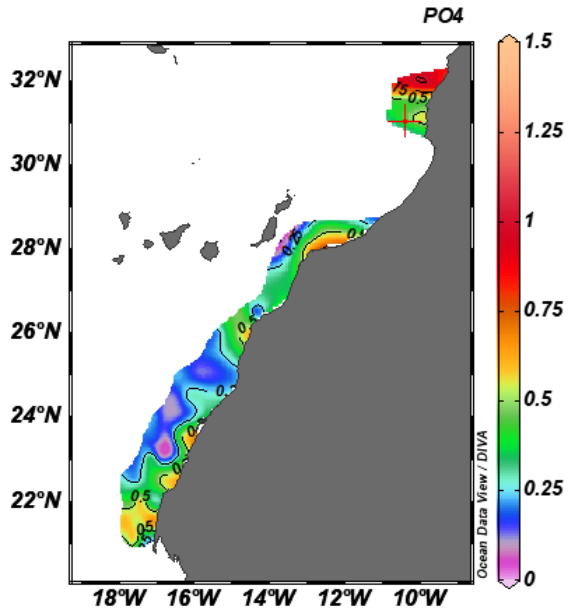


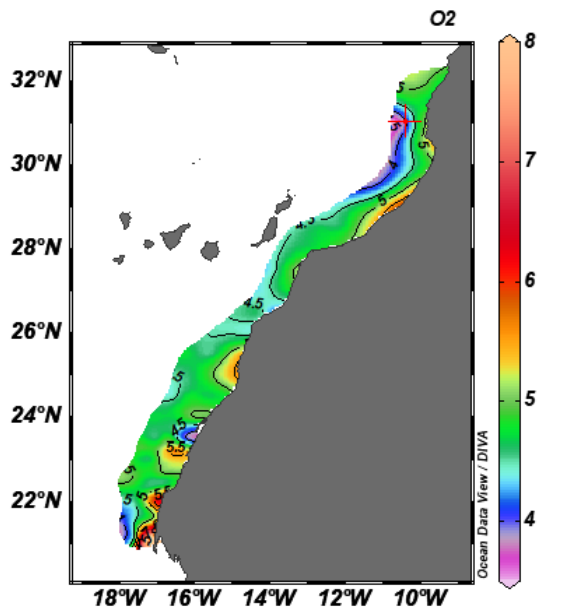








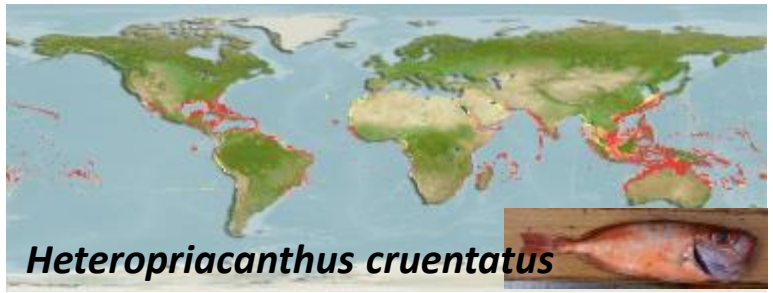




Temperature, Salinity, Oxygen and Phosphate Distributions (Oct-Nov 2017&2018) (Source INRH/DO)

Variability of the ecosystem

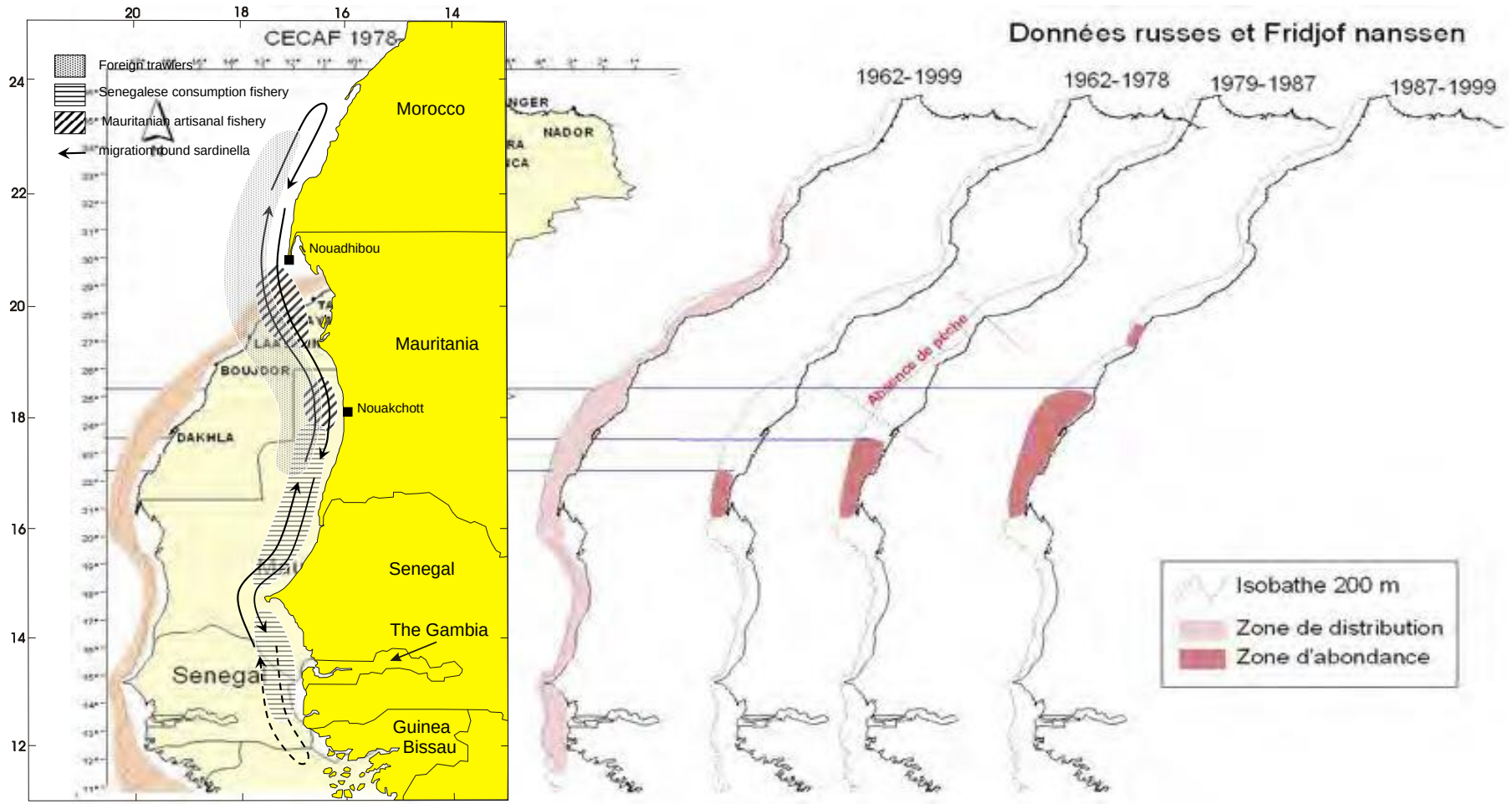
Changes occur at the level of the ecosystem (instability, temporal variability, non-stationarity) through visiting migrating fish (tuna, swordfish, tropical species, etc.), which induces reactions within the food web and relations between them. communities



Cartes

Variability of the ecosystem

Sardinella movement according to the mouvement of the thermal front



La sardinelle (Sardinella aurita)

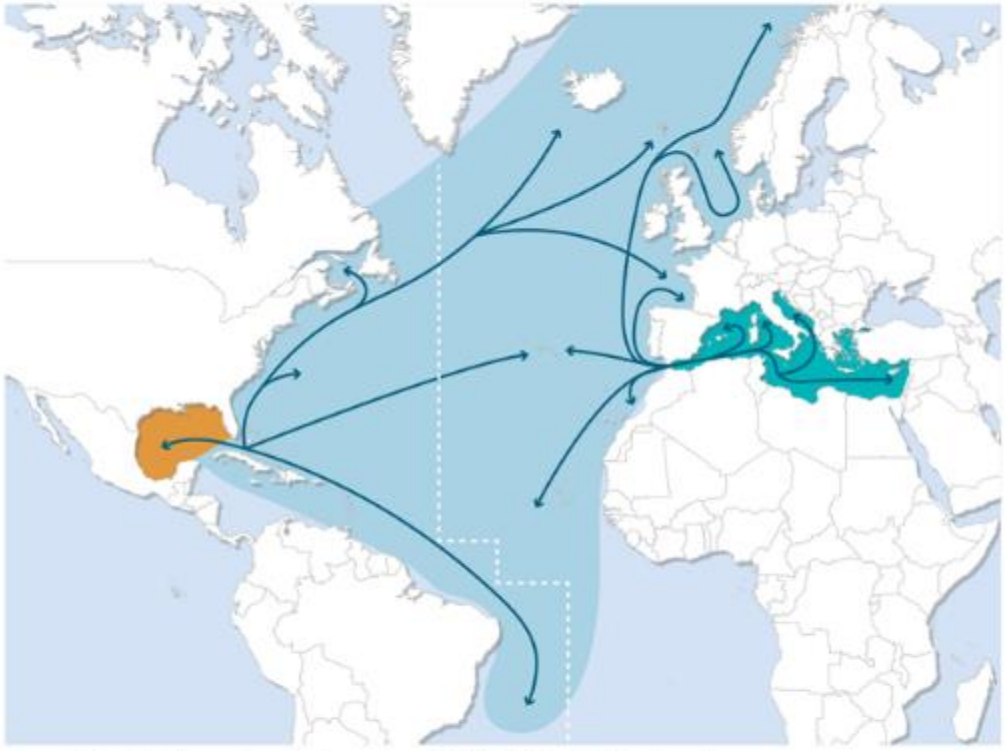
Variability of the ecosystem

Higher regulary visitors like tuna

Figure 1

At Least 2 Populations of Atlantic Bluefin Tuna: Highly Migratory and Highly Mixed

Western and eastern bluefin mix to feed but separate to breed



Two populations of bluefin—western and eastern—crisscross the Atlantic to feed and return home to spawn.

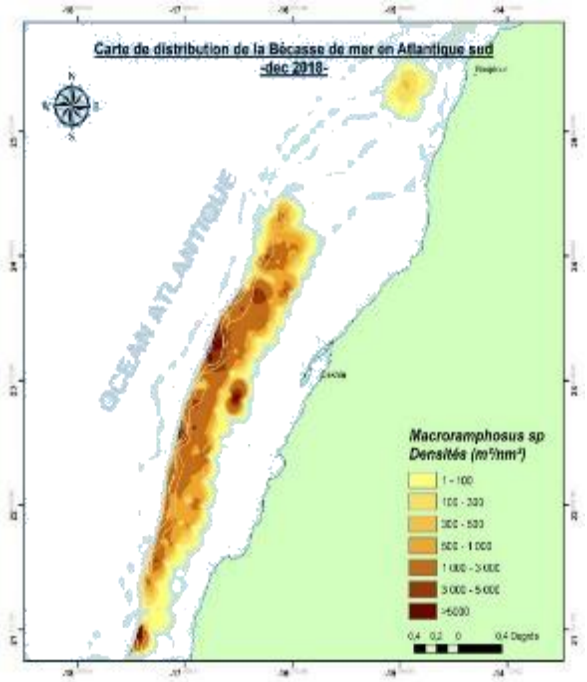
Atlantic bluefin historic range
Main western spawning area
Main eastern spawning area
East-west management boundary
Migration routes

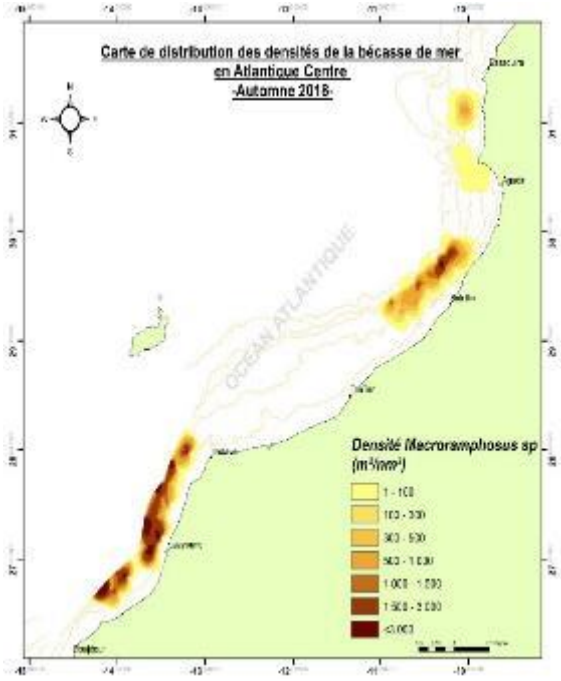
Source: Jean-Marc Fromentin and Joseph E. Powers, "Atlantic Bluefin Tuna: Population Dynamics, Ecology, Fisheries and Management," *Fish and Fisheries* 6 (2005): 281-306

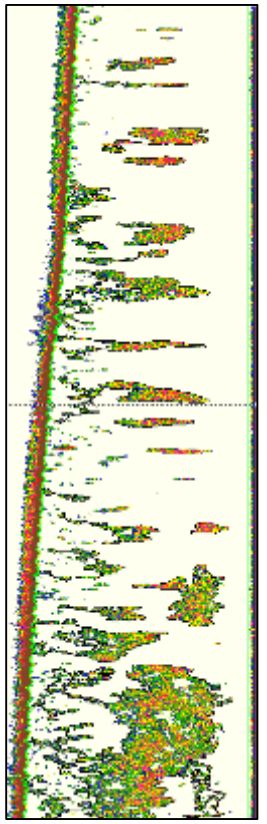
Migratory scheme of tuna, the extent of which depends on the state of the stock.
Currently, an improvement in the abundance and return of tunas in areas historically frequented by this specie (p.ex Northern waters and Black sea)

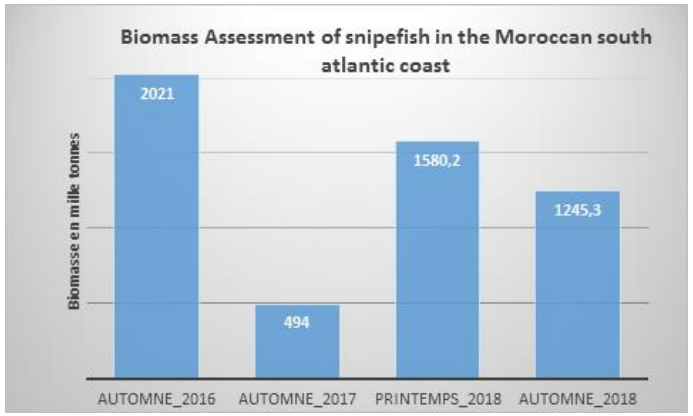
Variability of the ecosystem

Snipefish as an example





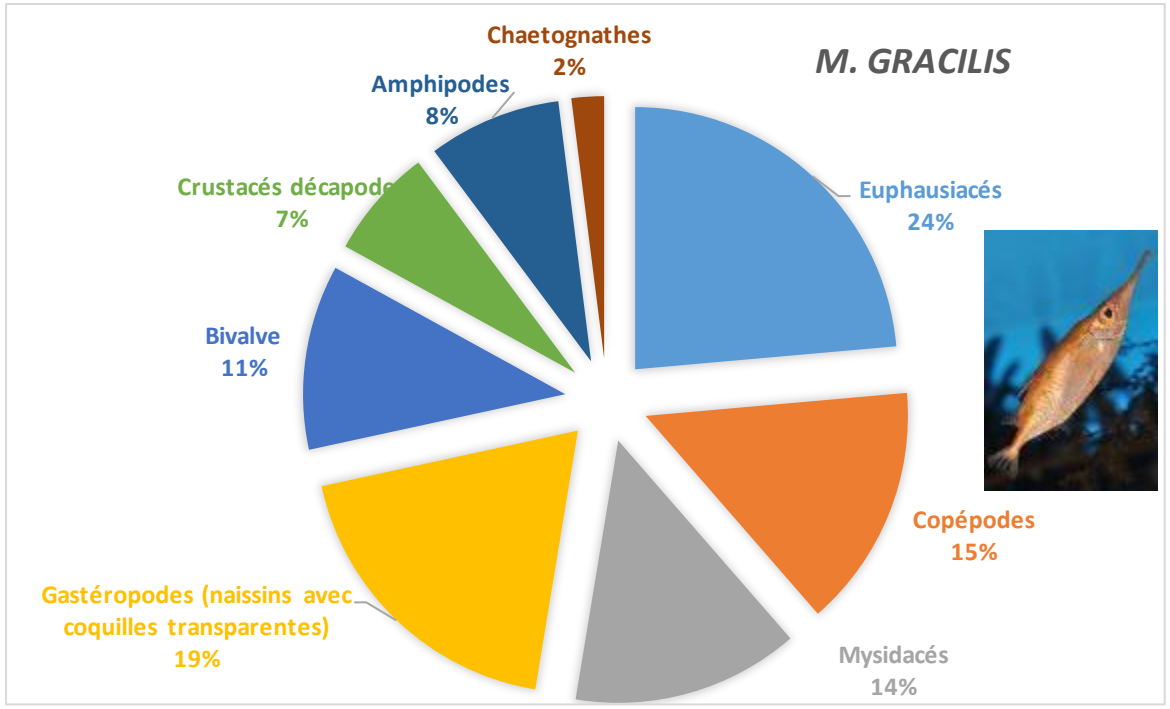


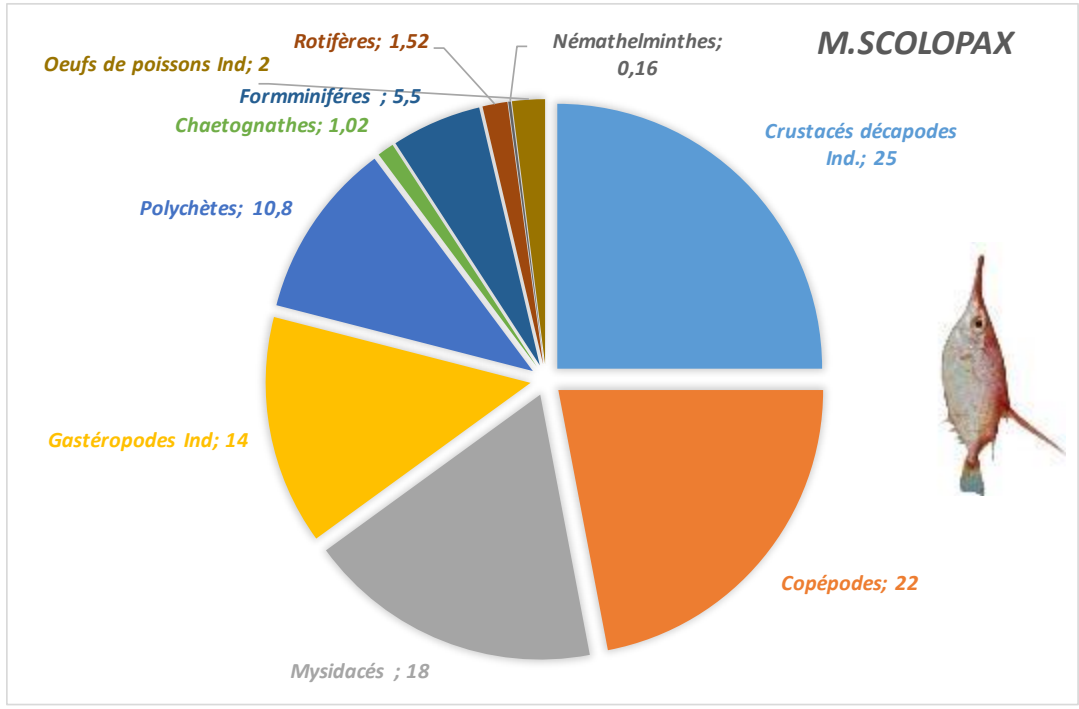


Année	printemps	automne
2010	3%	0%
2011	0%	0%
2012	4%	6%
2013	-	3%
2014	-	3%
2015	5%	1%
2016	19%	20%
2017	-	13%
2018	19,5%	15%

Variability of the ecosystem

Snipefish as an example

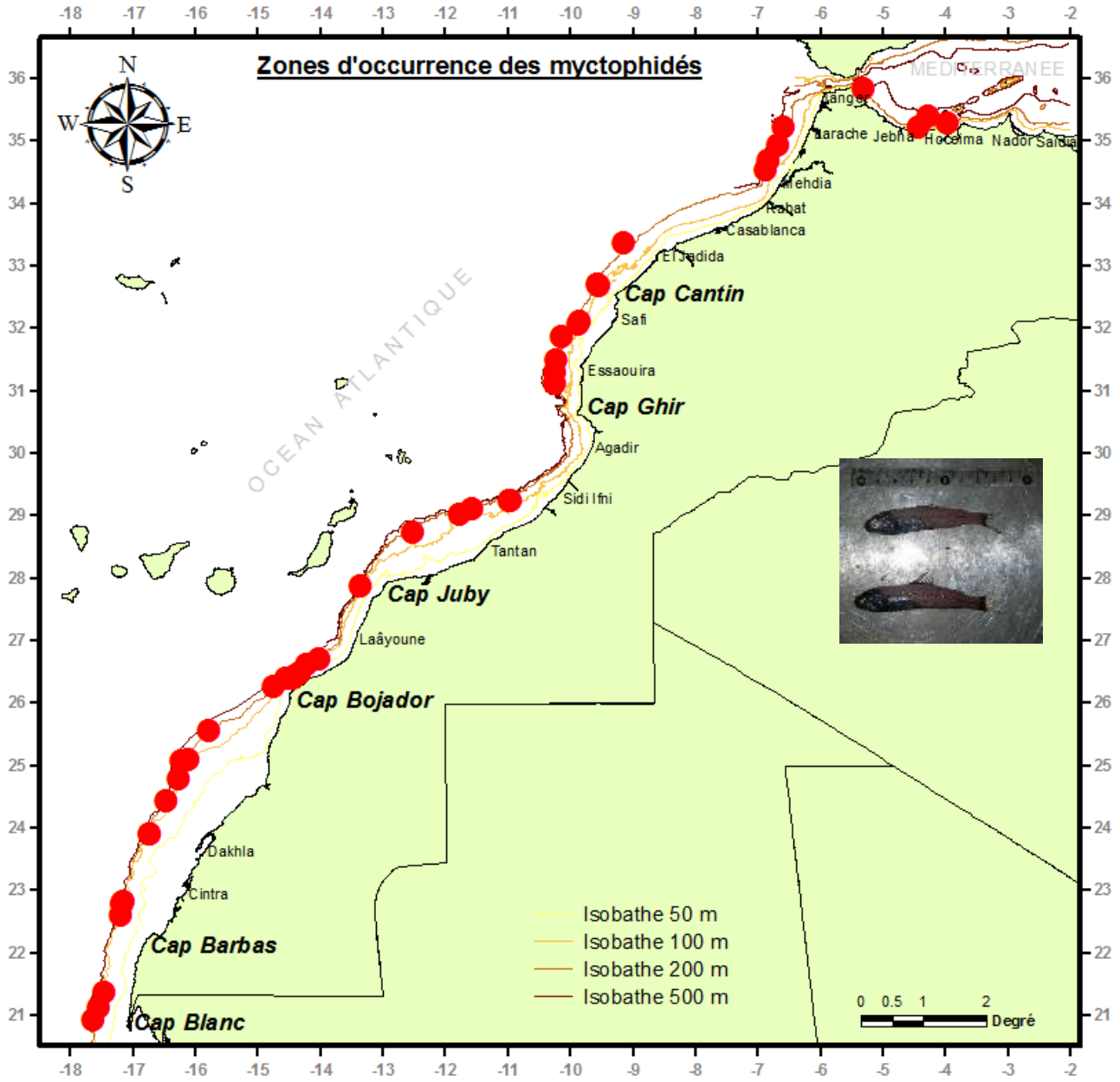




Recent diet analysis shows a very few consumption of egg and larvae of fish (2% of *M.scolopax feed).*
These species seems to be planktonophage.

Ecosystem

Biodiversity : Mesopelgic fish

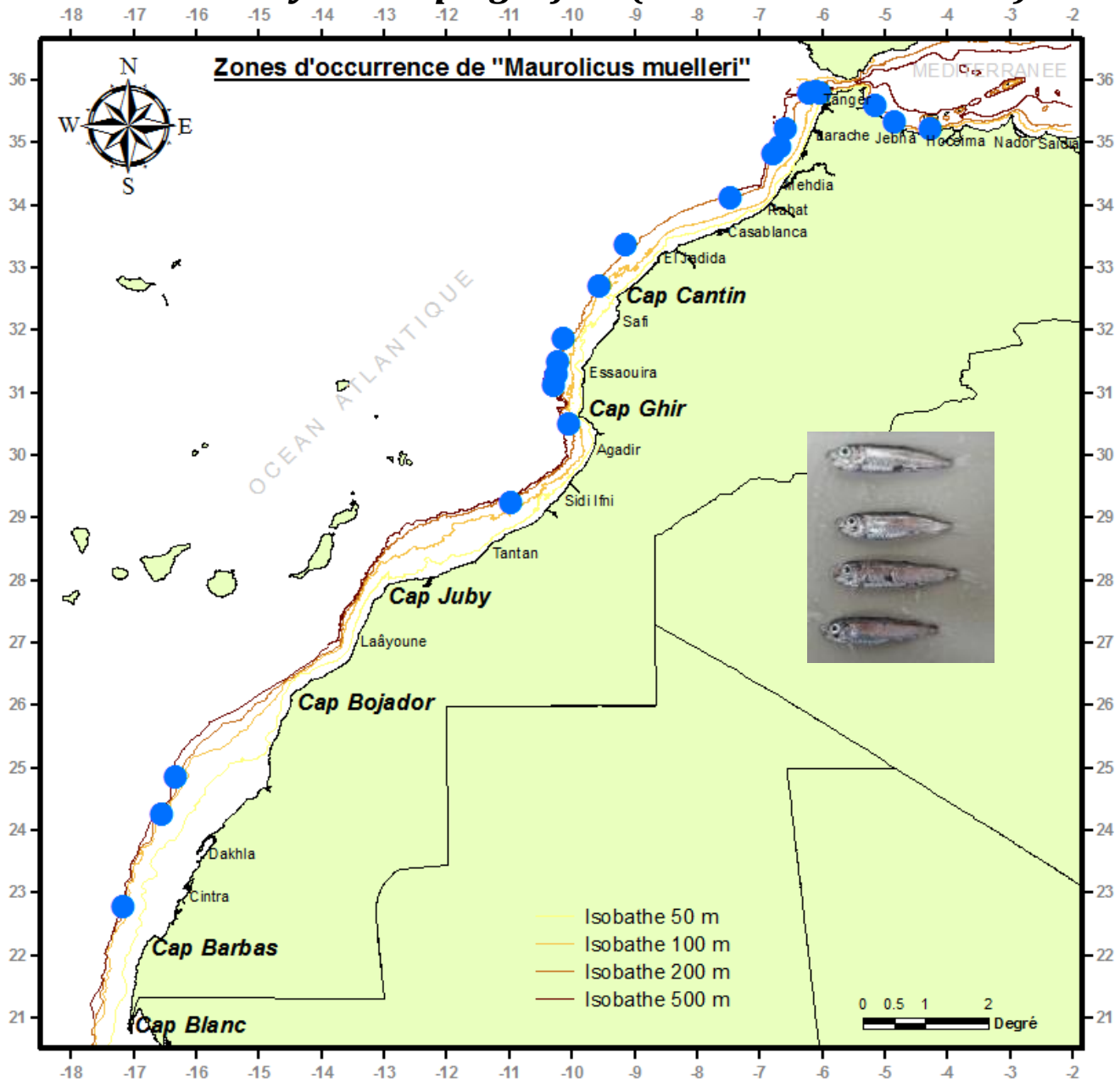


Ecosystem

Biodiversity : Mesopelgic fish (Maurolicus muelleri)

* Biomass of these species is important and therefore it can affect the balance of the ecosystem.

* Dynamic and behavior Should be considered in ecosystem modelling.



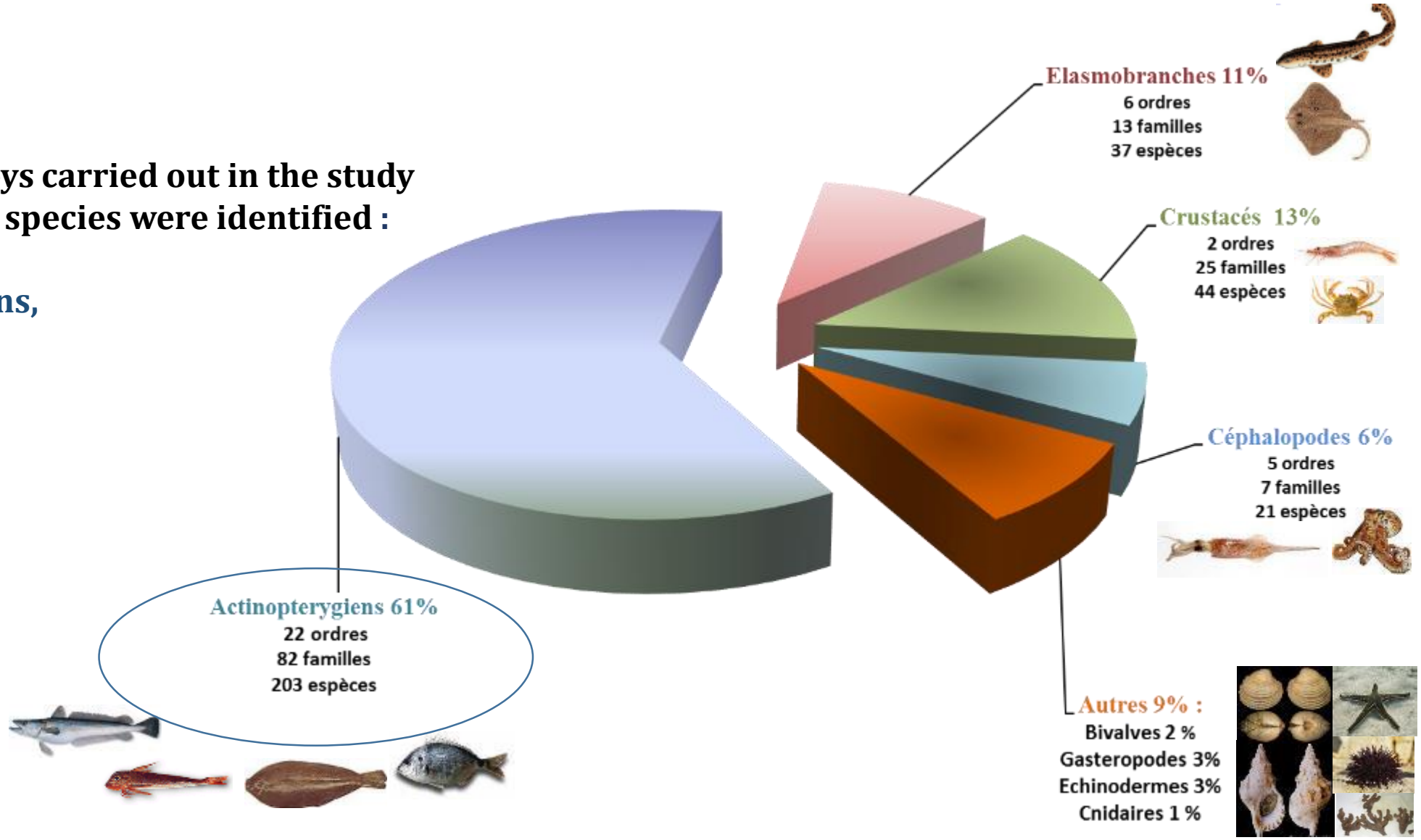
Ecosytem diversity

Biodiversity

Marine biodiversity of the Moroccan North Atlantic coast (Cape Spartel-Sidi Ifni)

According to the surveys carried out in the study area (1981-2010) 334 species were identified :

- **203 Actinopterygians,**
- **44 Crustaceans,**
- **37 Elasmobranchs,**
- **21 Cephalopod,**
- **10 Gastropod,**
- **9 Echinoderms,**
- **6 Bivalves**
- **4 Cnidarians**



Ecosystem diversity

Biodiversity

Composition of the continental shelf communities of the area between Cape Bojador (26 ° N) and Cape Blanc (21 ° N)

Surveys conducted in the study area between 1986 and 2001 identified 217 different species:

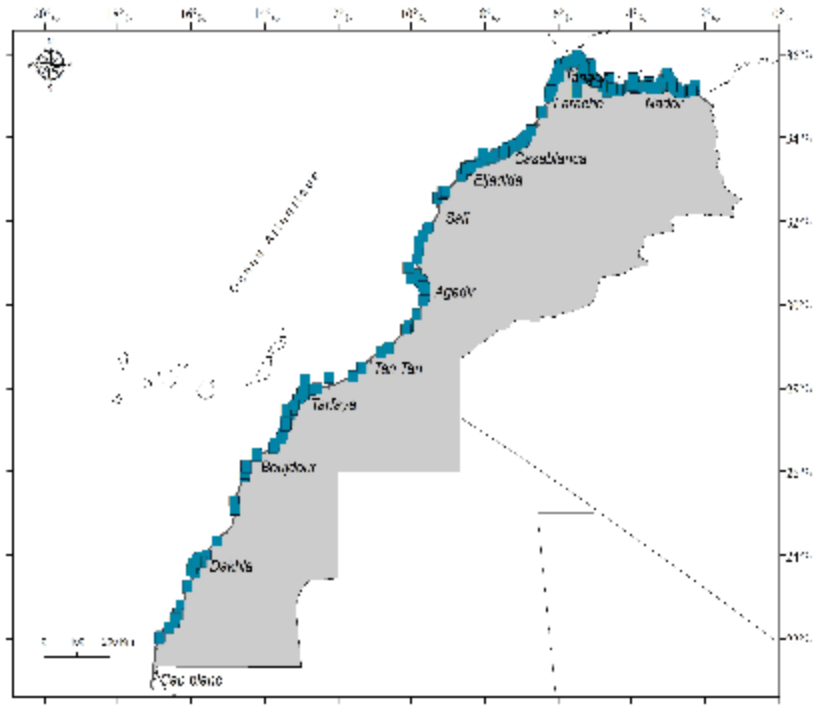
Classe	Ordre	Famille	Espèces
Actinopterygiens	16	54	154
Cephalopodes	4	5	16
Chondrichthyes	5	12	27
Malacotraca (Crustacea)	2	11	14
Gastropoda	4	4	5
Holothuroidea	-	-	ND
Ascidiacea	-	-	ND
Sauropsida (Reptilia)	1	1	1
Total	32	87	217

Ecosystem diversity

Cetaceans

- 26 cetacean species inventoried on the Moroccan coasts (Masski and DE Stephanis 2015);
- 7 The most abundant species: blue and white dolphins, common dolphins, bottlenose dolphins, fin whales, Sei whales, sperm whales and pilot whales.
- Fin whales, Sei whales and sperm whales are found in Moroccan waters from birth and at different stages of their life cycle.

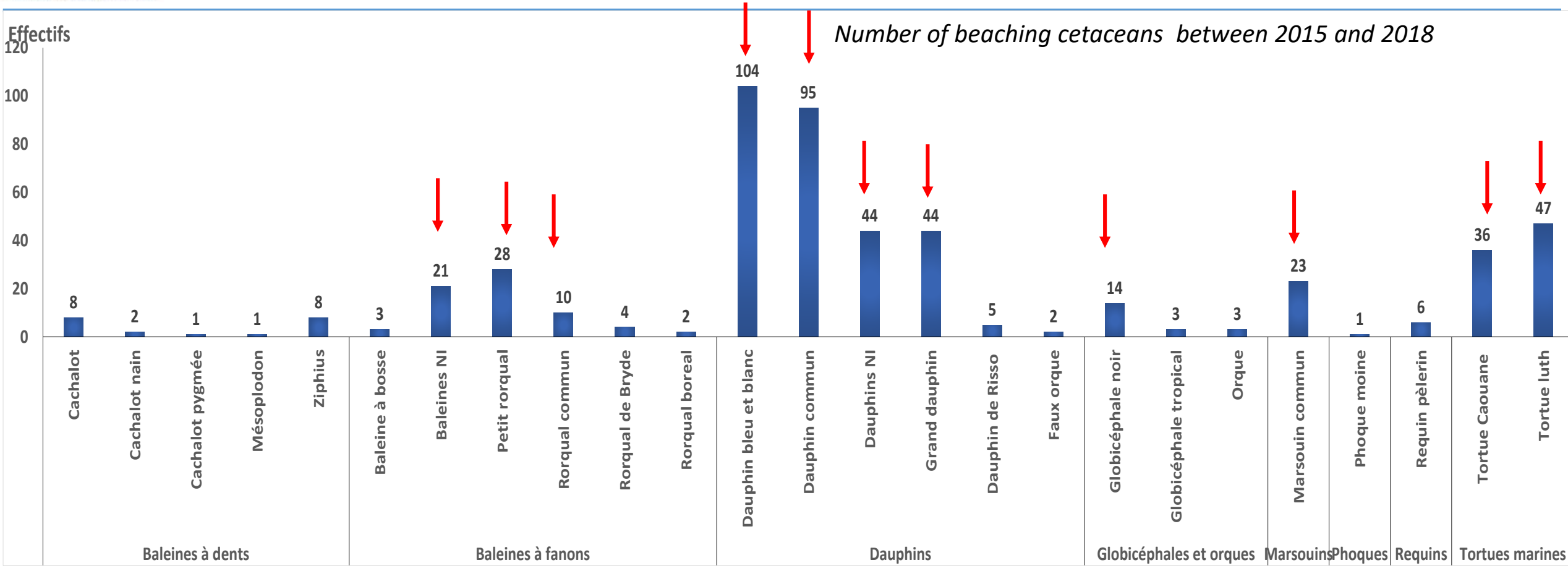
Spatial distribution of beaching between 2015 and 2018



Ecosystem diversity

Cetaceans

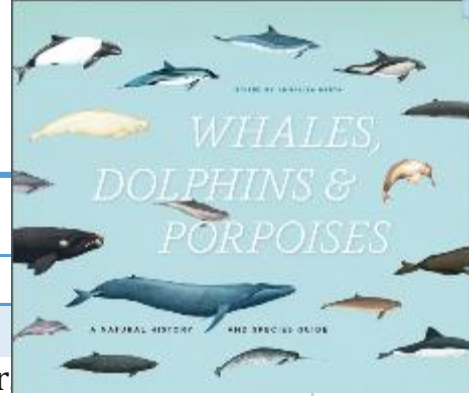
Number of beaching cetaceans between 2015 and 2018



Sperm whale
Sperm whale
Pygmy Sperm whale
Mesoplodon
Ziphius
Humpback whale
Whale ni
Minke whale
Fin whale
Bryde's whale
Boreal whale
blue and white dolphins
Common dolphins
Dolphins ni
Bottlenose
Risso dolphin
False orca
Black pilot whale
Black pilot whale
Orcas
Harbor porpoise
Monk seal
PBasking Shark
Cuckold turtle
Leatherback Turtle

Ecosystem diversity

Cetaceans



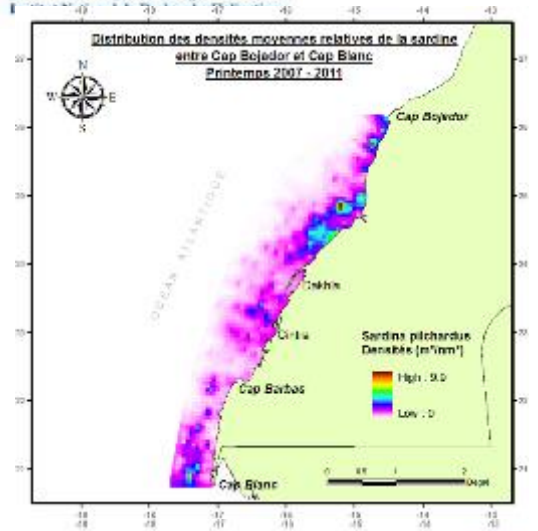
Beaching cetaceans preys

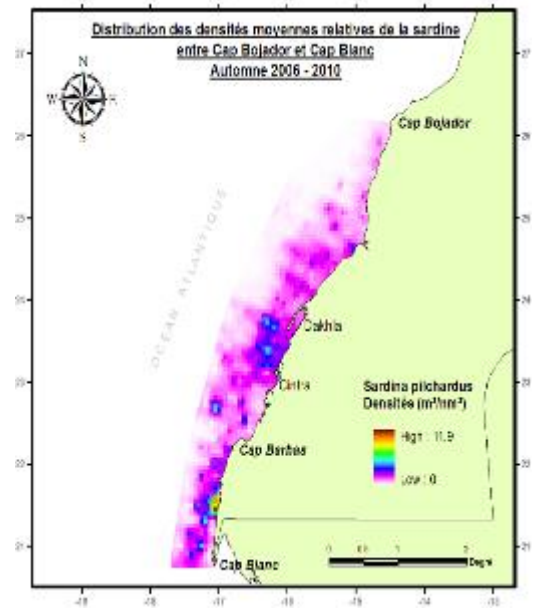
Species	Food items	Autors
Minke whale	Krill	(Kawamura 1994)
White dolphin	Small fish, juvenile squid, shrimps	Berta, Annalisa, author Whales, dolphins, and porpoises : a natural history and species guide / Annalisa Berta.
Common dolphin	**Small schooling fish (sardines, anchovies, hake) and squid**	**Berta, Annalisa, author.**
Harbor porpoise	A wide array of smaller fish and occasionally squid	Berta, Annalisa, author.
Minke whale	Small fish, squid, and krill	Berta, Annalisa, author.
Black pilot whale	Primarily squid as well as fish and other cephalopods	Berta, Annalisa, author.
Risso Dolphin	Squid (mainly), octopus, cuttlefish, anchovies, and krill	Berta, Annalisa, author.
White dolphin	Herring, mackerel, cod, smelt, squid, sand lance, shrimp, and hake	Berta, Annalisa, author.
Bottlenose	**A wide variety of schooling, and non-schooling fish; invertebrates such as shrimp, octopus, and squid**	**Berta, Annalisa, author.**
Orcas	Mainly fish, marine mammals, or both, depending on ecotype	Berta, Annalisa, author.
False orcas	Fish (including large species such as tuna) and squid	Berta, Annalisa, author.
Pygmy Sperm whale	Copepod crustaceans and occasional krill	Berta, Annalisa, author.
Boreal whale	**Copepods, other invertebrates, small fish**	**Berta, Annalisa, author.**
Bryde's whale	**Schooling fish, krill, and plankton**	**Berta, Annalisa, author.**
Fin whale	**Krill and other planktonic crustaceans, schooling fish**	**Berta, Annalisa, author.**
Fin whale	**Krill and other planktonic crustaceans, schooling fish**	**Berta, Annalisa, author.**
Sperme whale	Cephalopods and fish	Berta, Annalisa, author.
Mesoplodon	Squid and small deepwater fish	Berta, Annalisa, author.
Ziphius	Mainly deep-water oceanic squid, also some fish and shrimp	Berta, Annalisa, author.

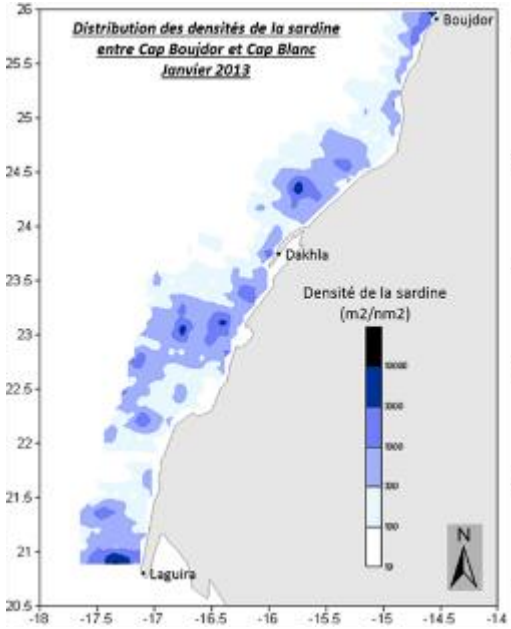
Empirical approach to evaluate the sardine status and its impact on other fish communities

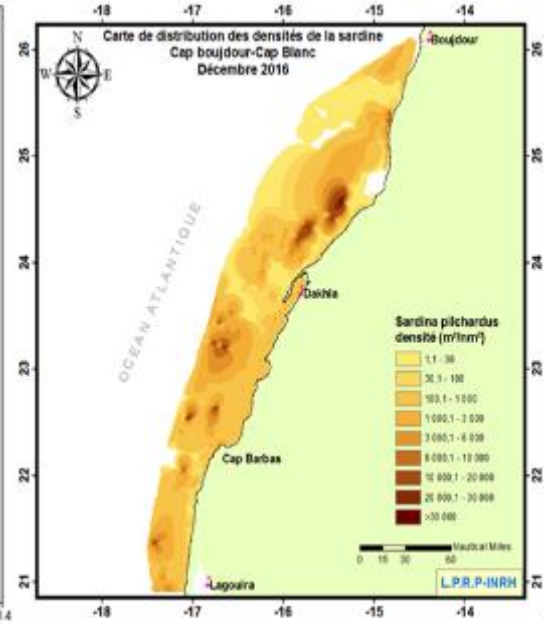
Mapping of small pelagics distribution
South sardine

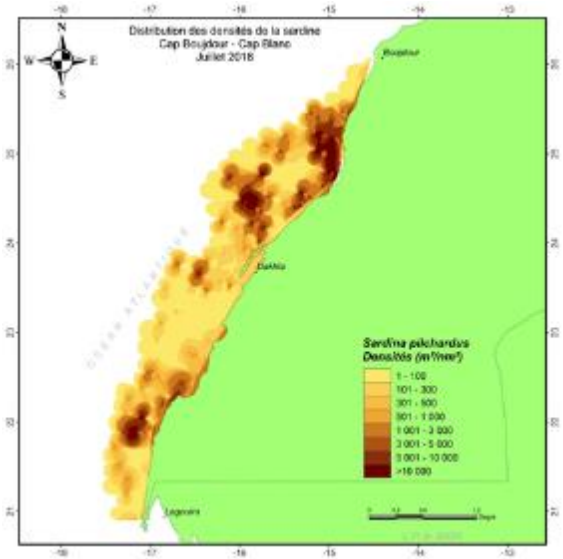
No major changes in the specie distribution over the time

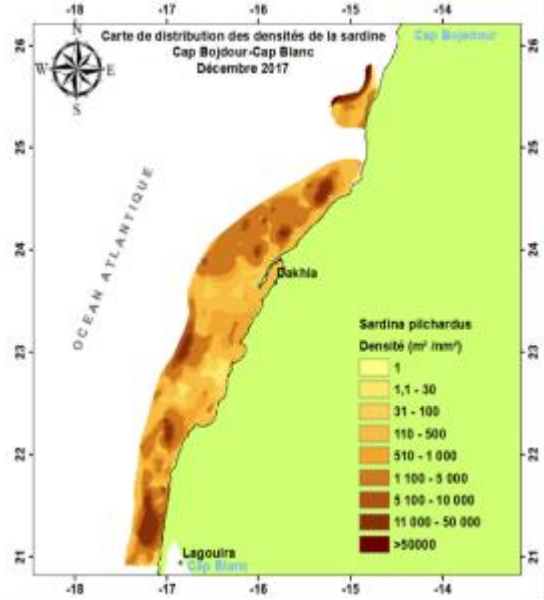




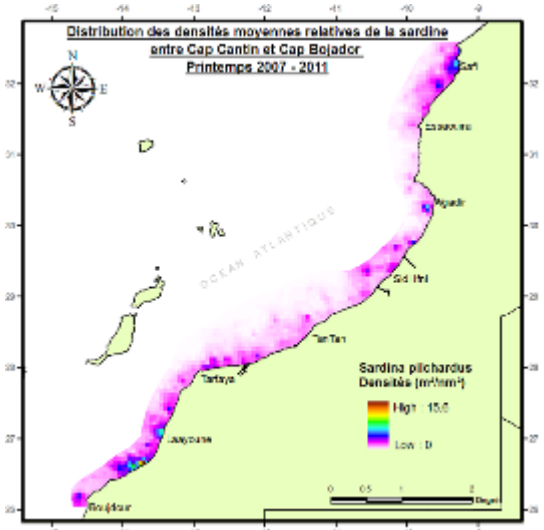


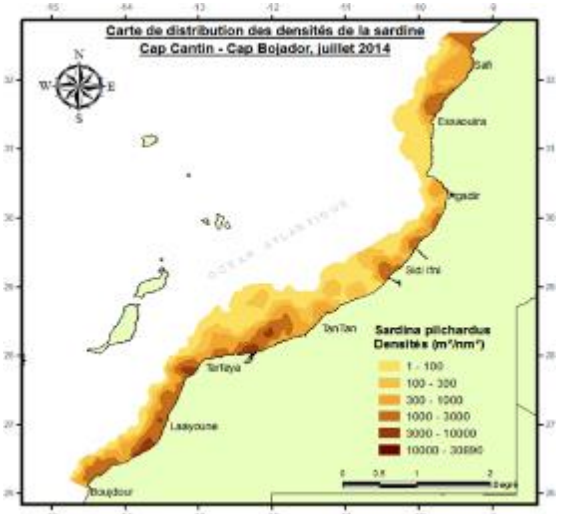


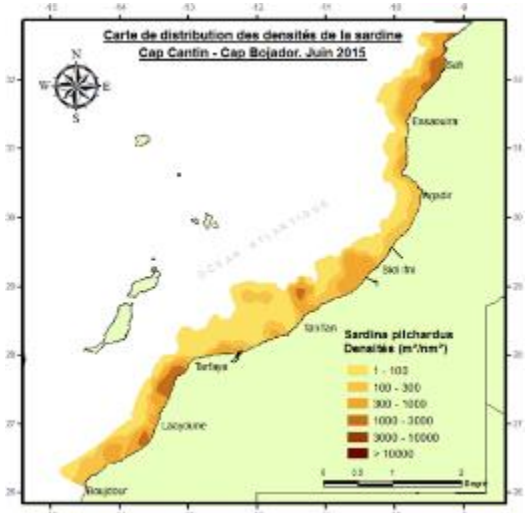


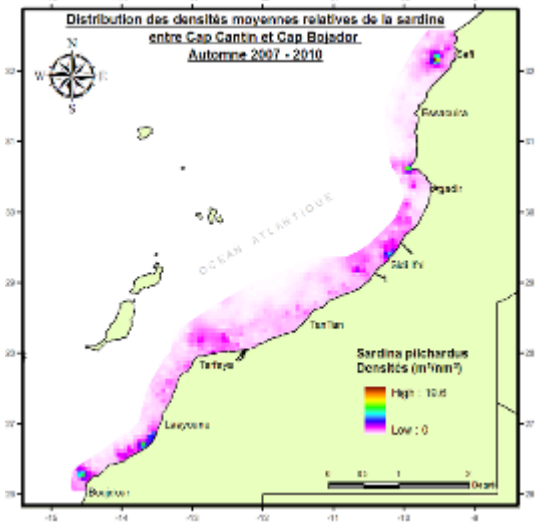


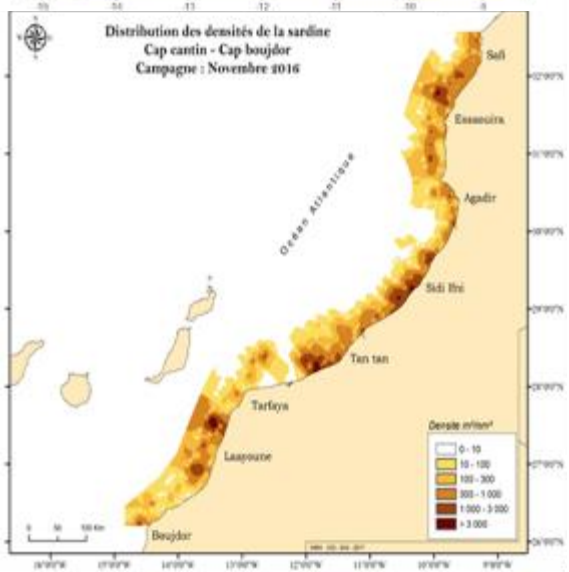
Mapping of small pelagics distribution
Central Sardine

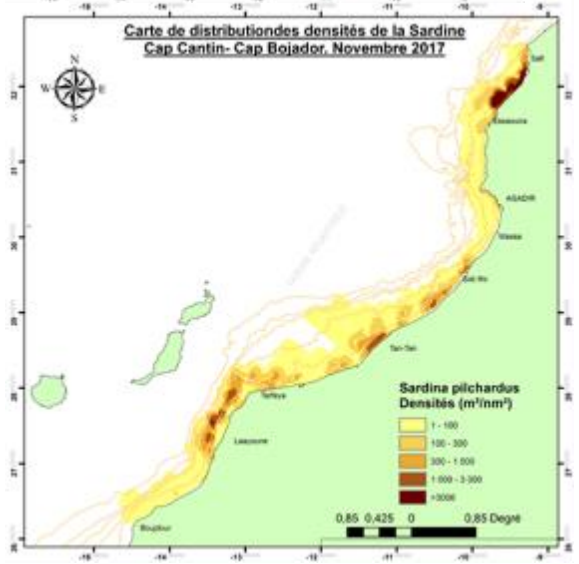


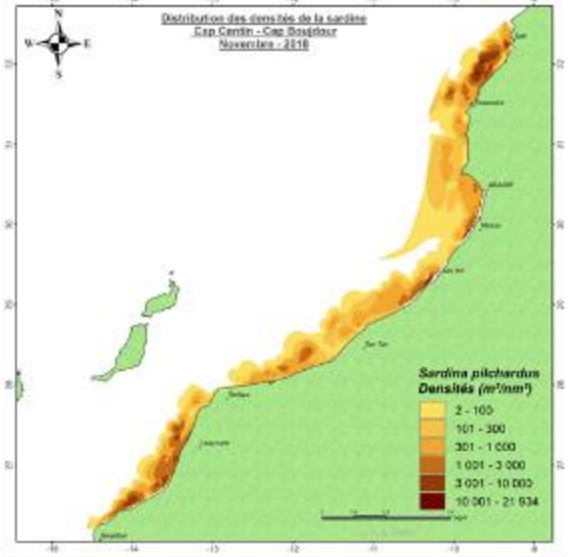








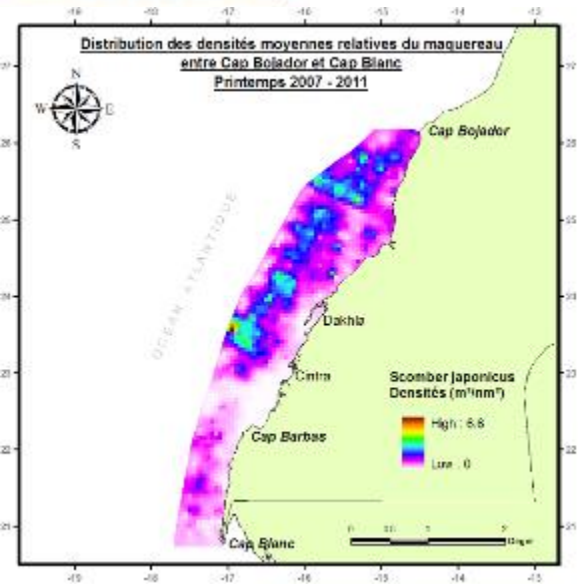


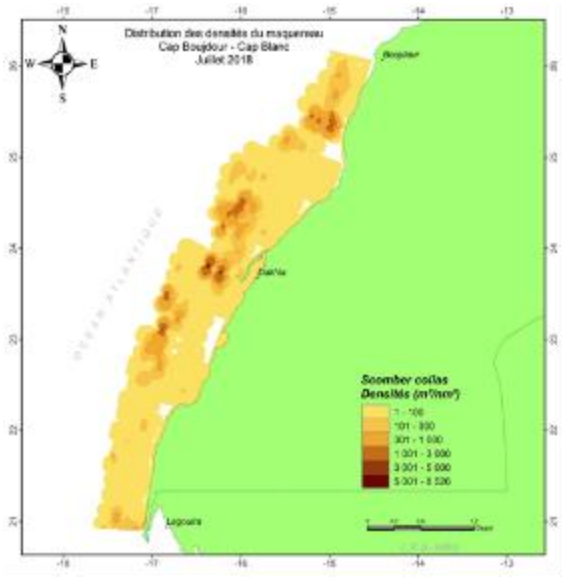


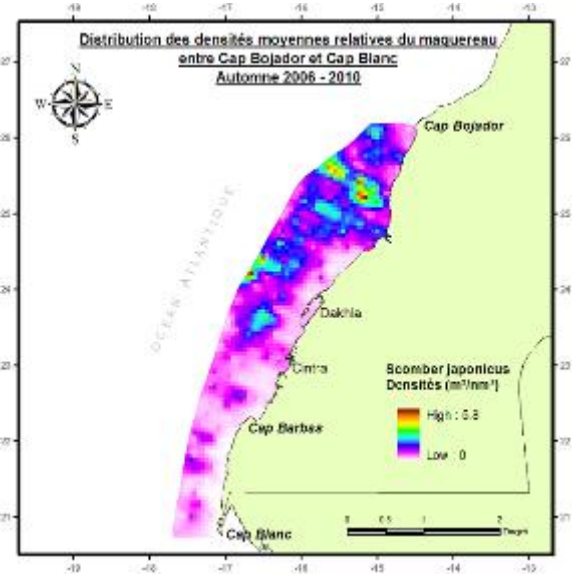
Same occuped areas
by the specie

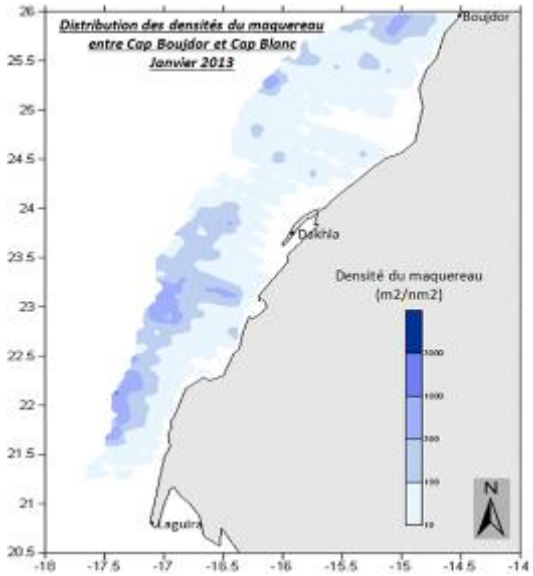
Mapping of small pelagics distribution Chub mackerel South area

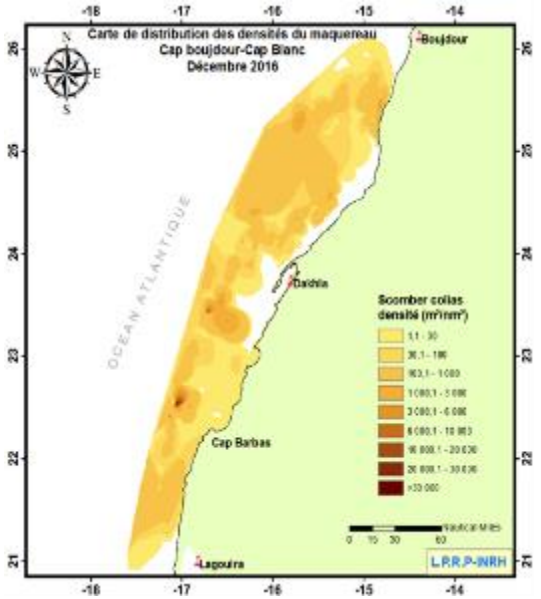
Generally, no big changes

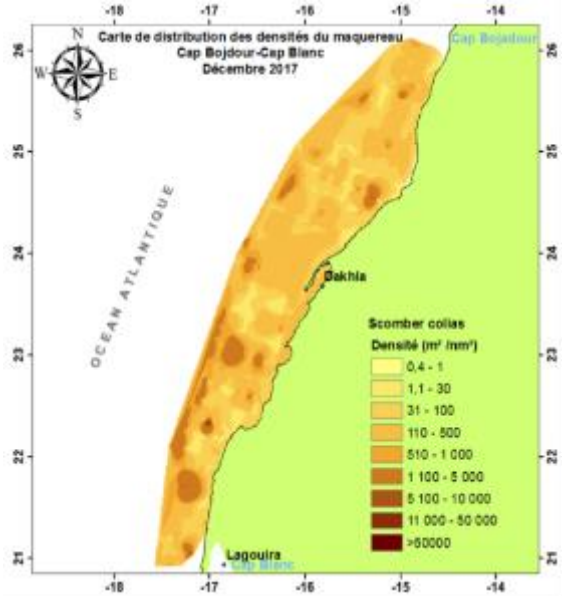




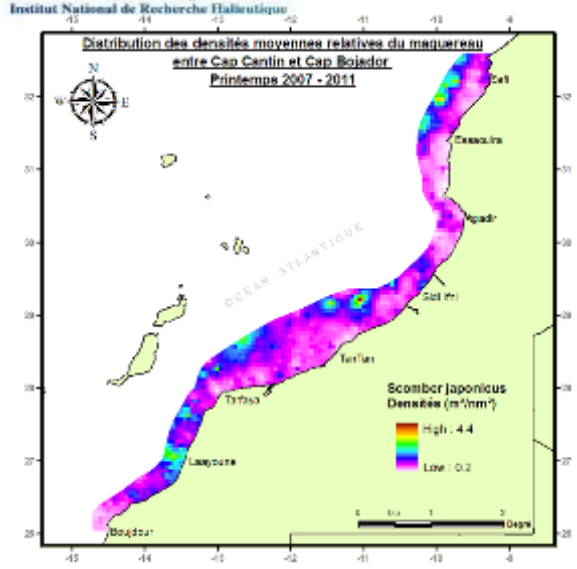


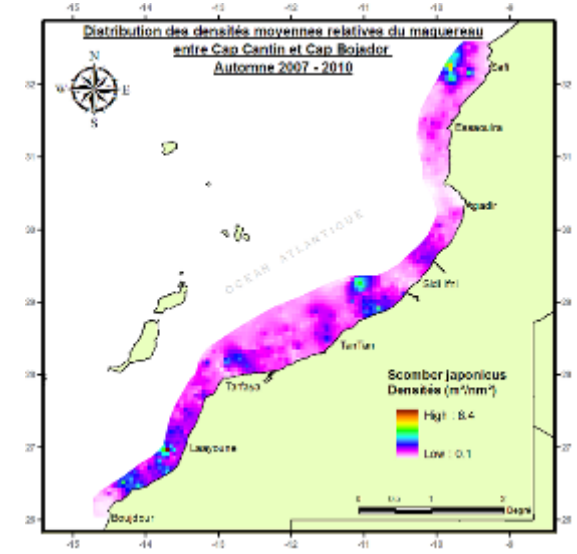


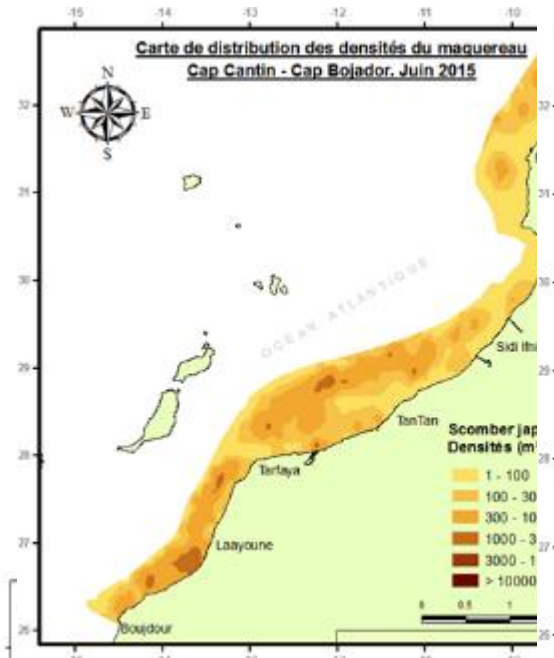


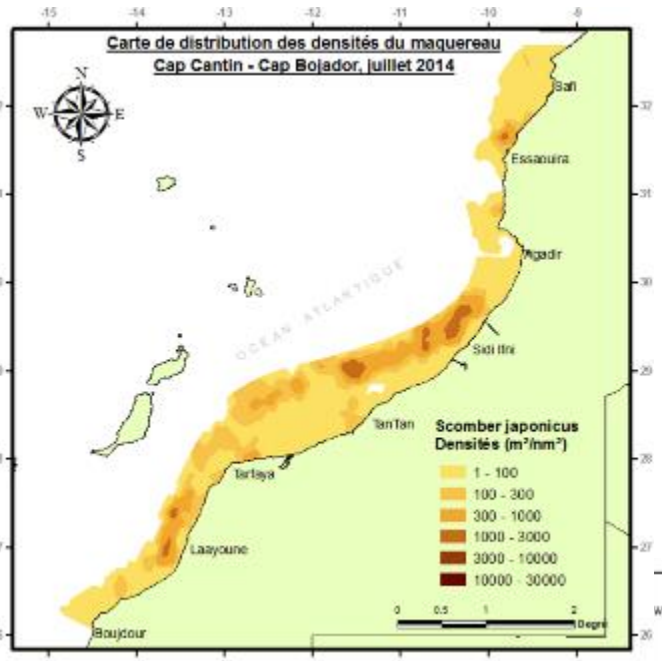


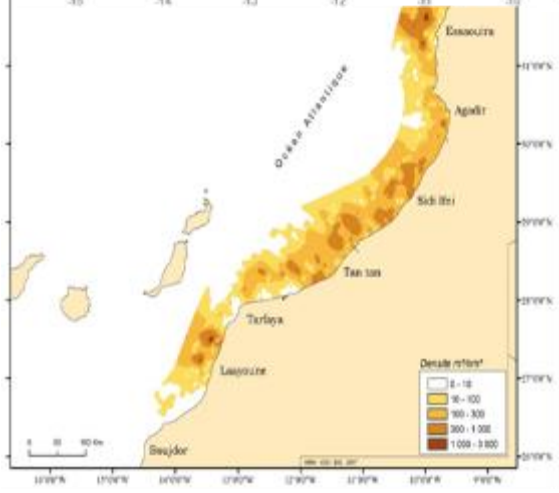
Mapping of small pelagics distribution Chub mackerel Central area

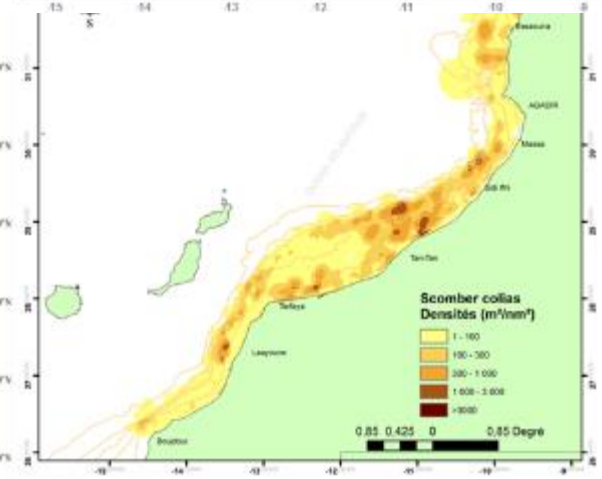


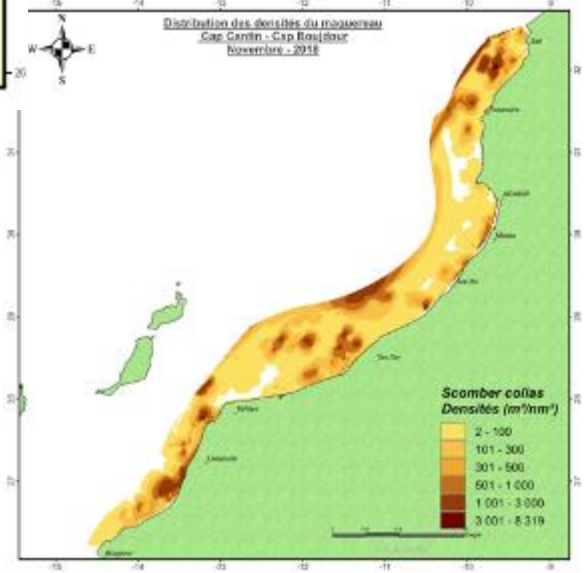








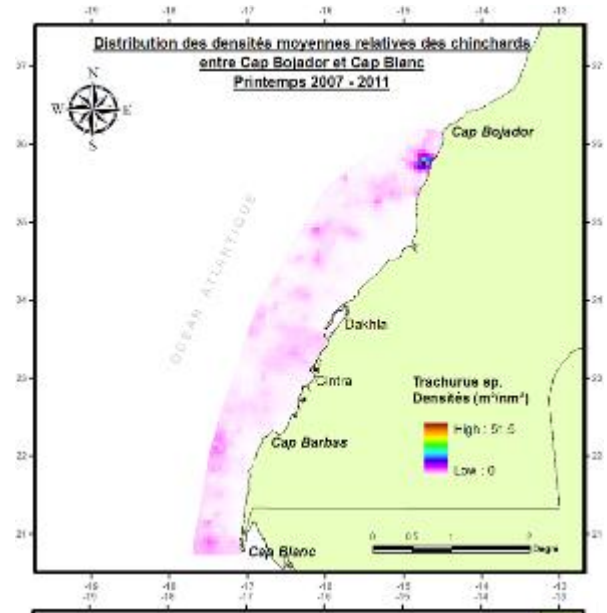


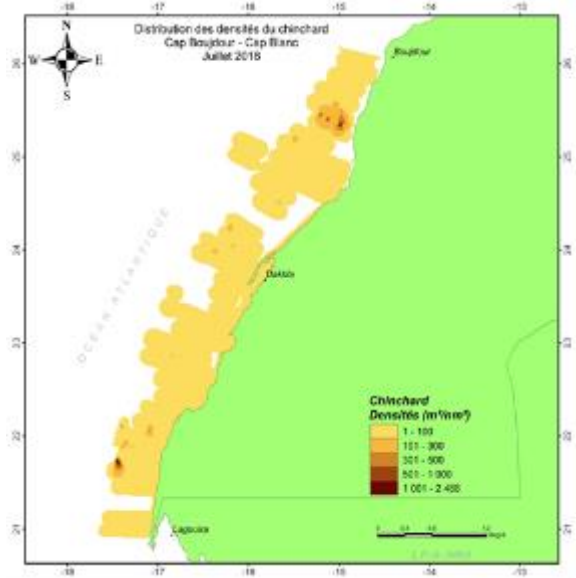


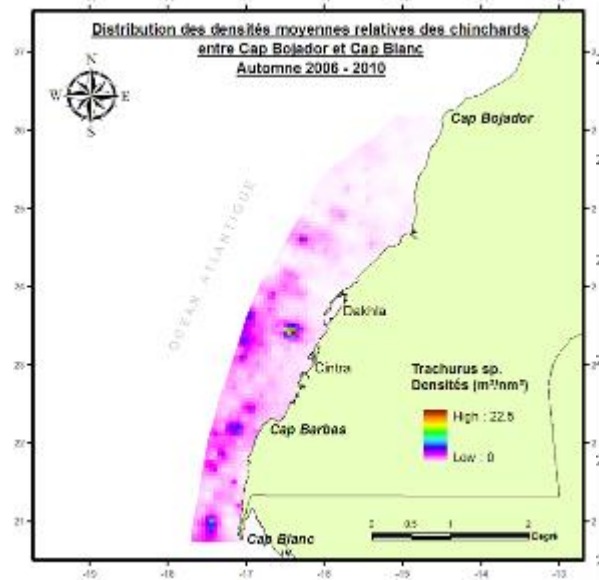
Same occuped areas by the specie

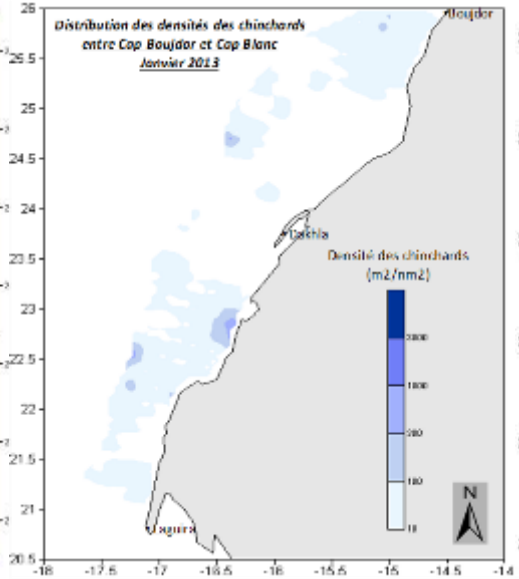
Mapping of small pelagics distribution Horse mackerels South area

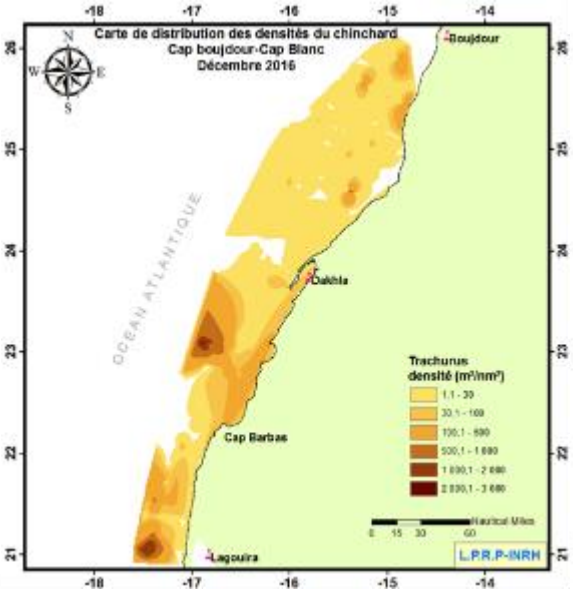
Generally, no big changes

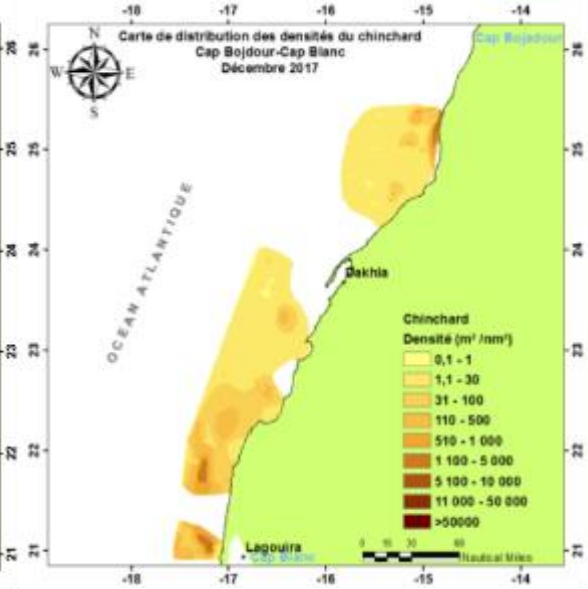




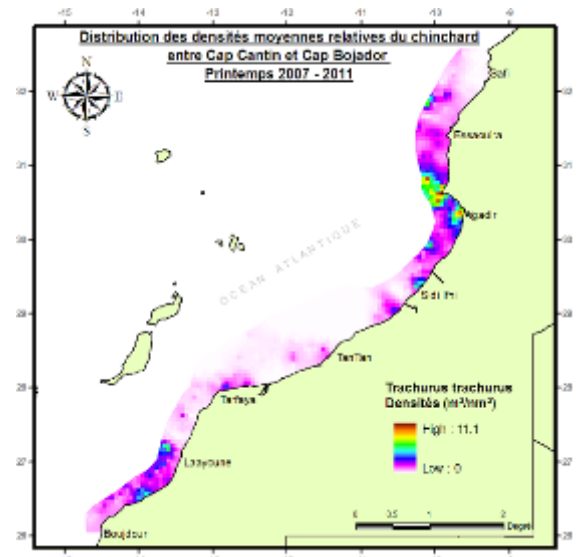


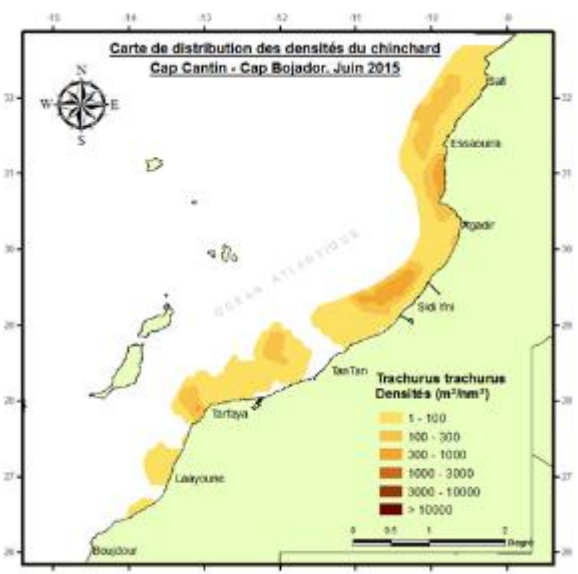


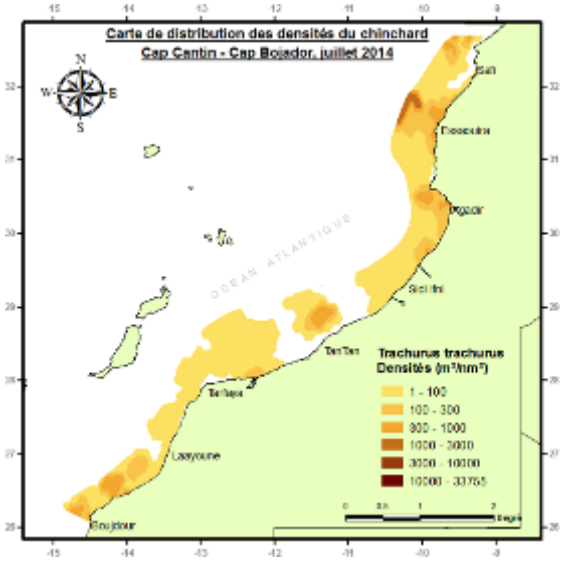


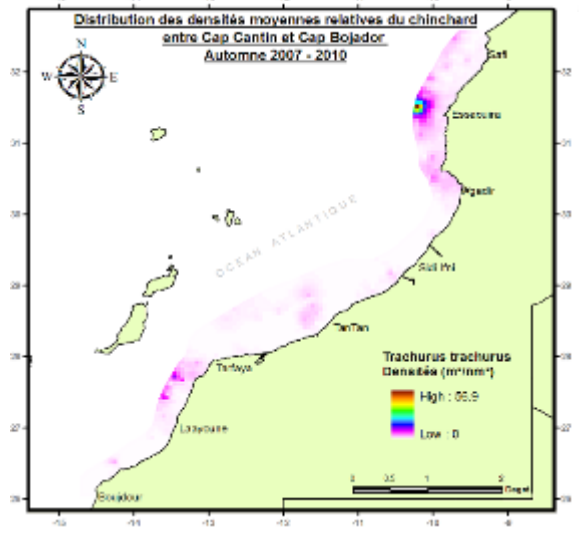


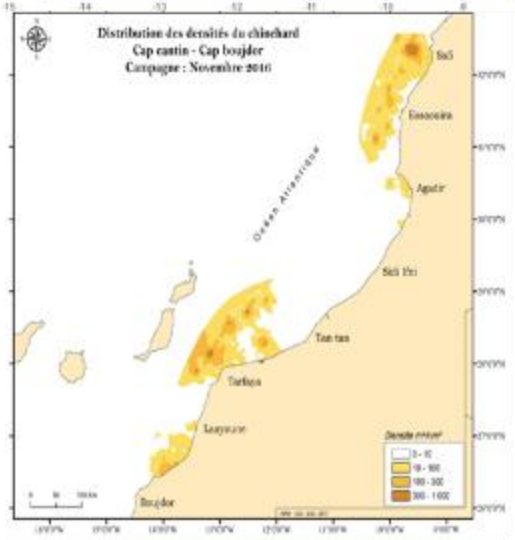
Mapping of small pelagics distribution Horse mackerels North area

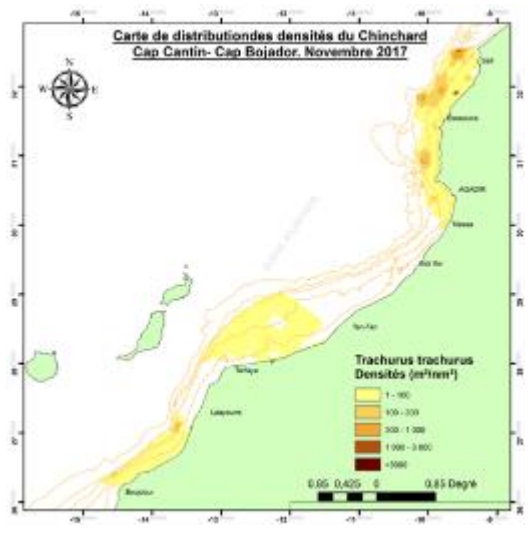


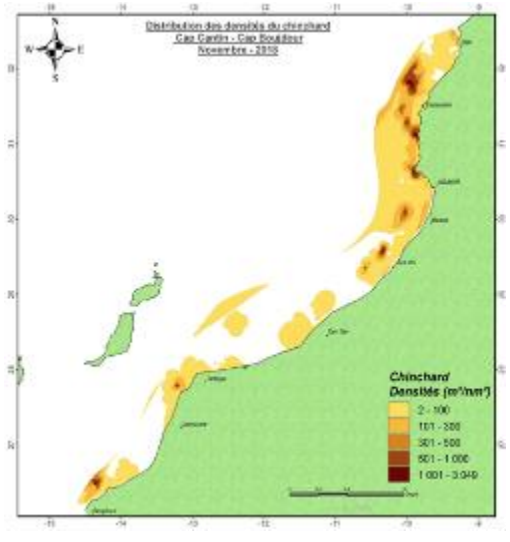








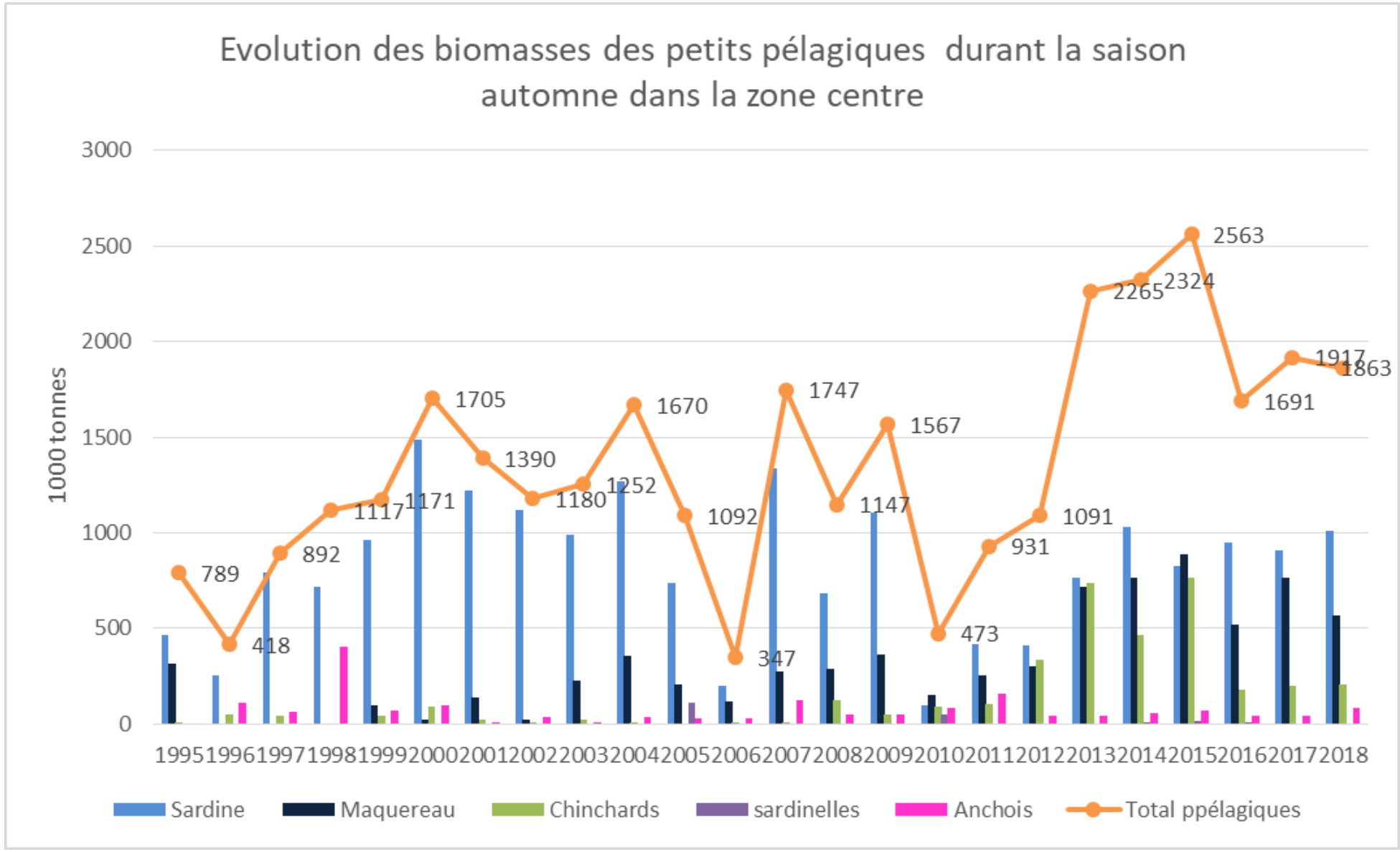




Same occuped areas by the specie

Proposition : Empirical approach

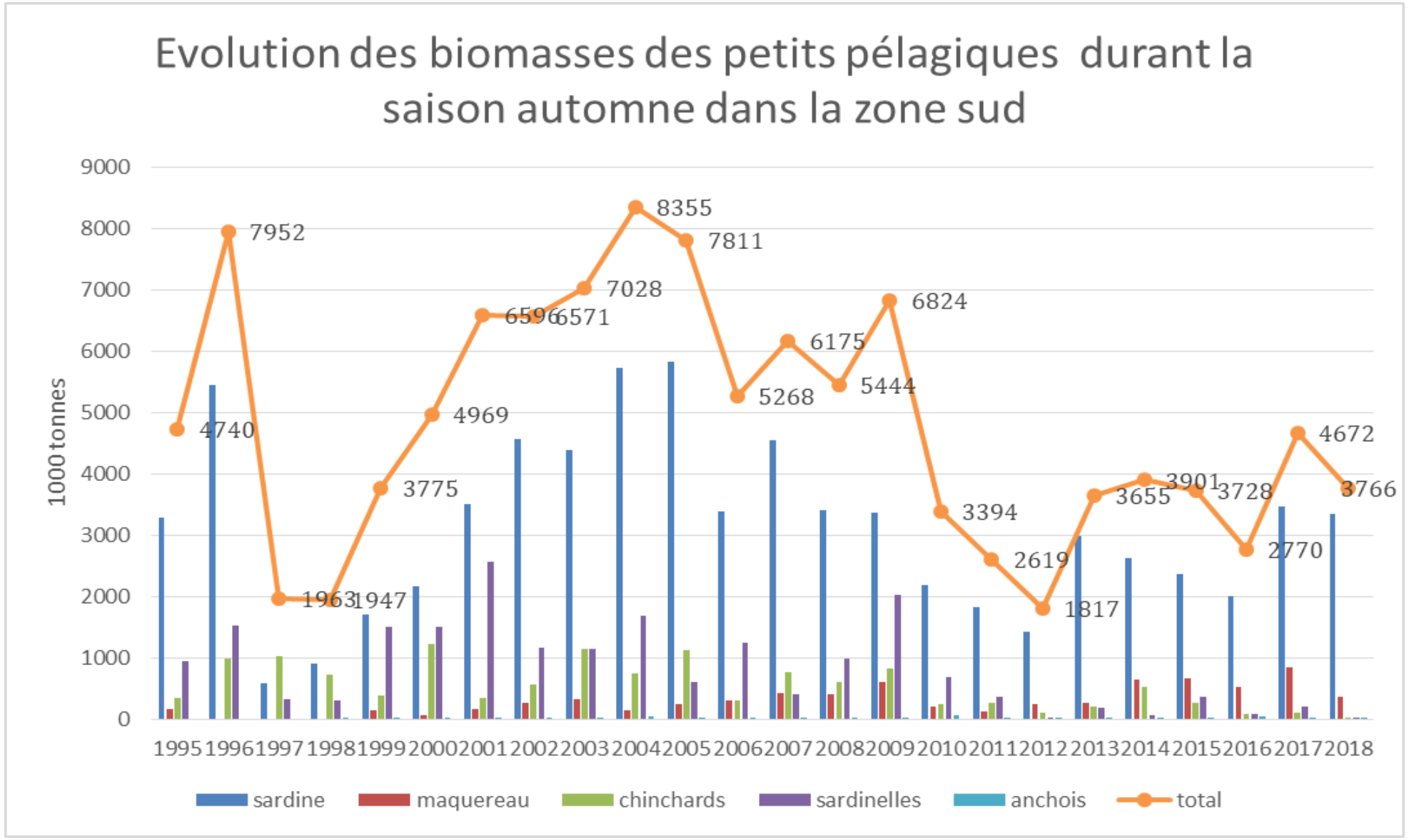
Evolution of small pelagic biomass : Center Zone



Recovring of the stocks maintly sardine in the last years

Proposition : Empirical approach

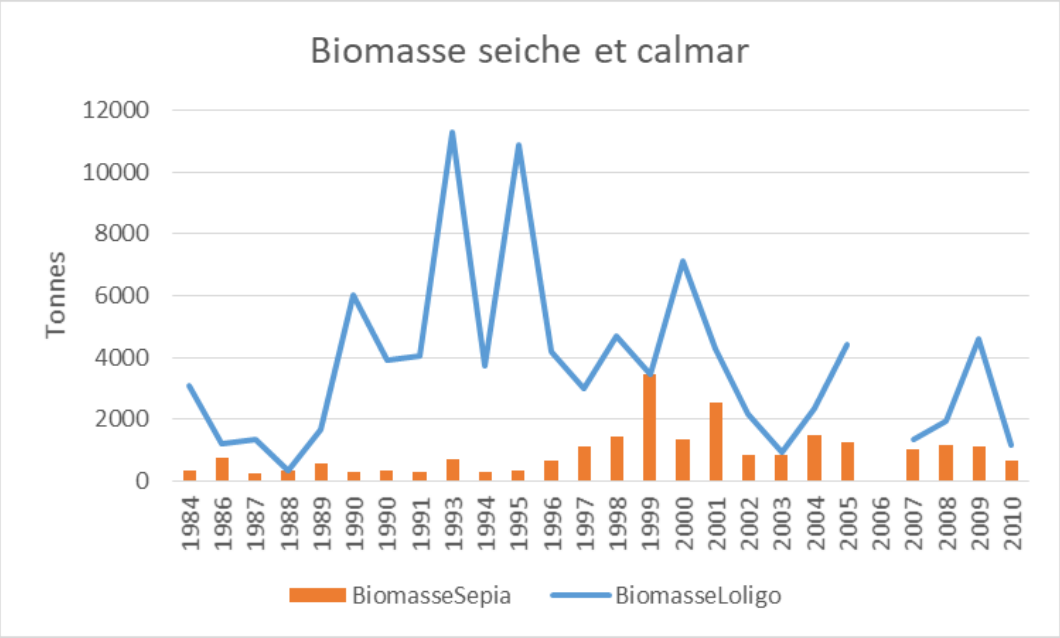
Evolution of small pelagic biomass : South Zone

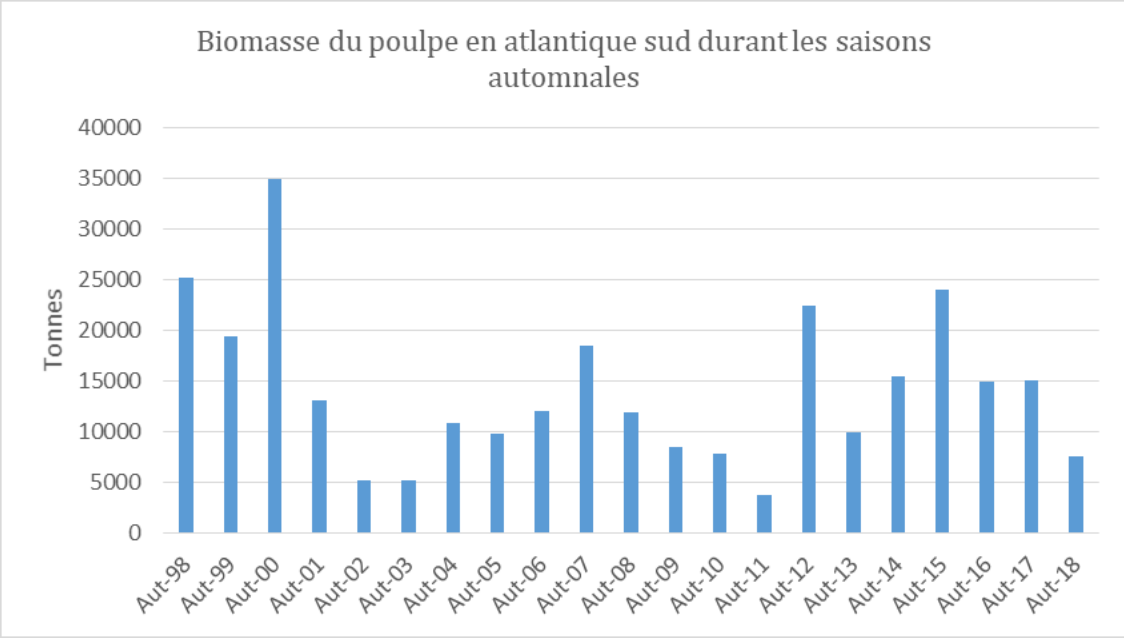


Relatively stable situation of sardine

Proposition : Empirical approach

Other demersal species : Cephalopods

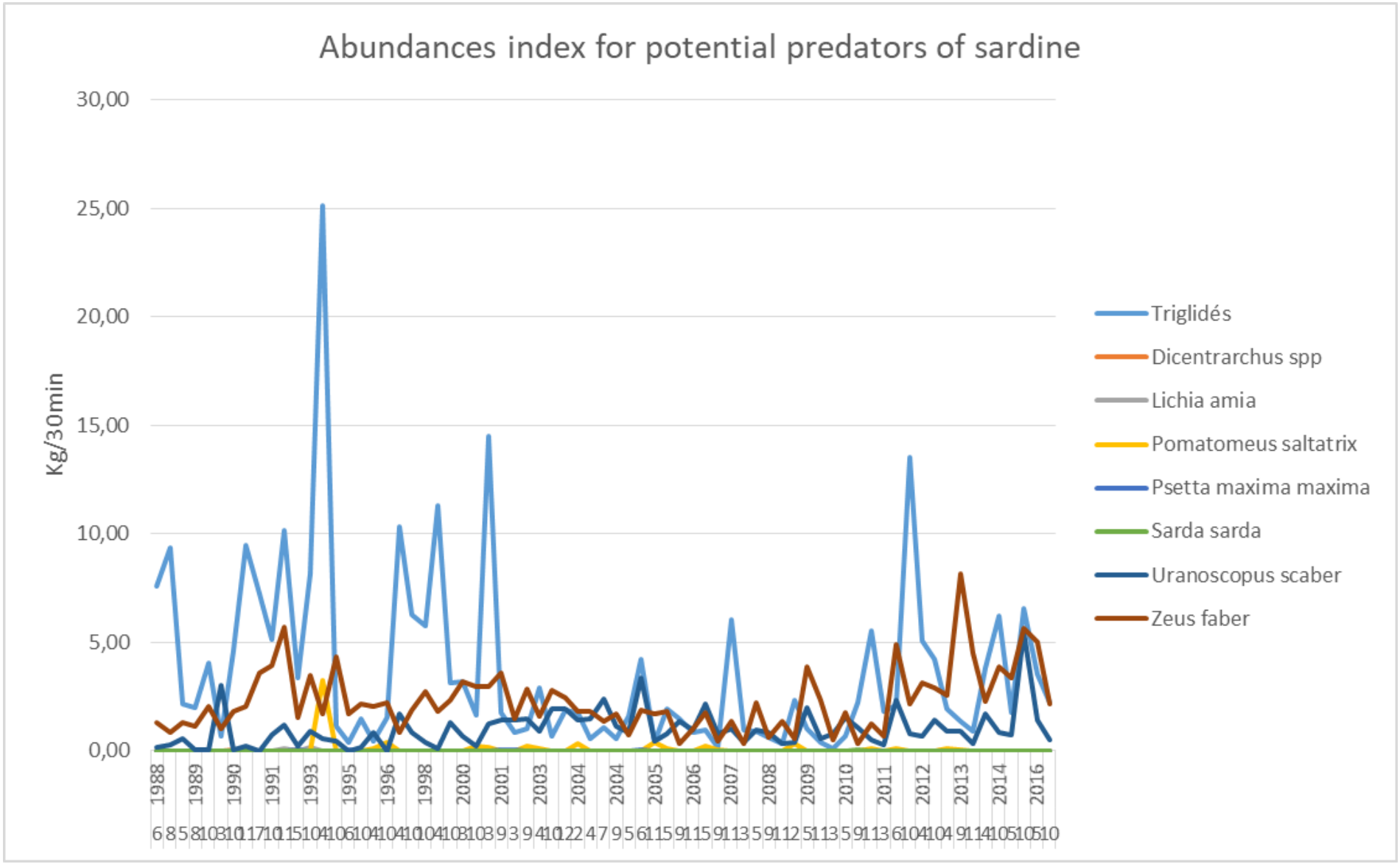




Biomass fluctuate mainly according to the recruitment dynamic :
Octopus and loligo are short lived species

Proposition : Empirical approach

Other demersal species : Abundances index from demersal surveys

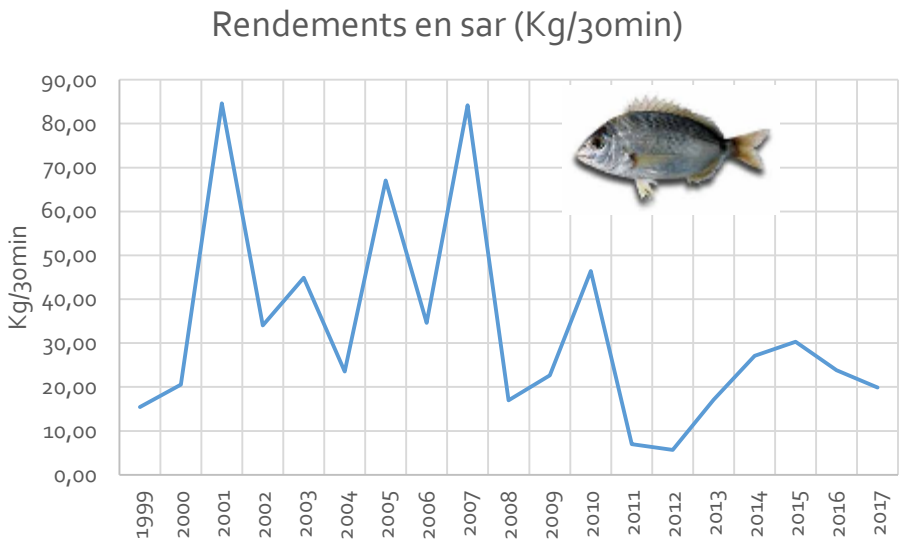


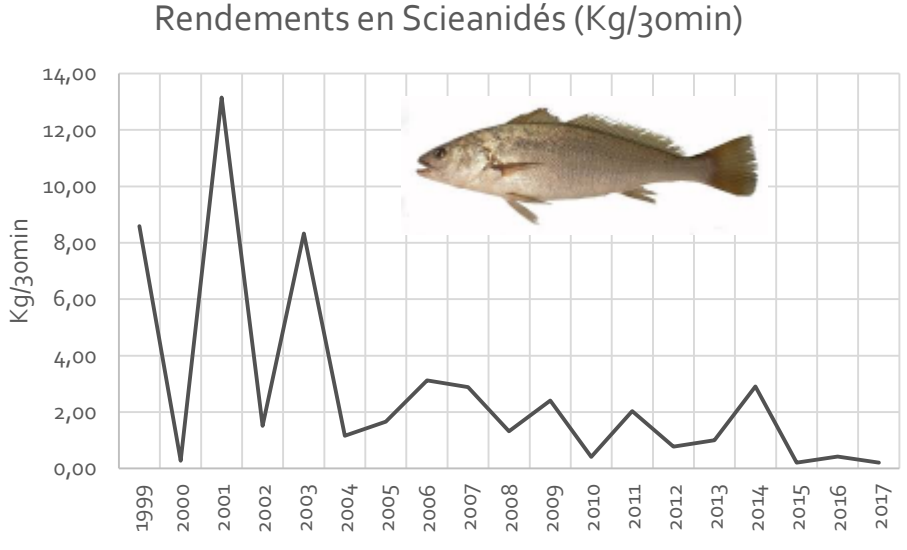
Abundances index for potential predators of sardine fluctuates without big changes in abundances trend

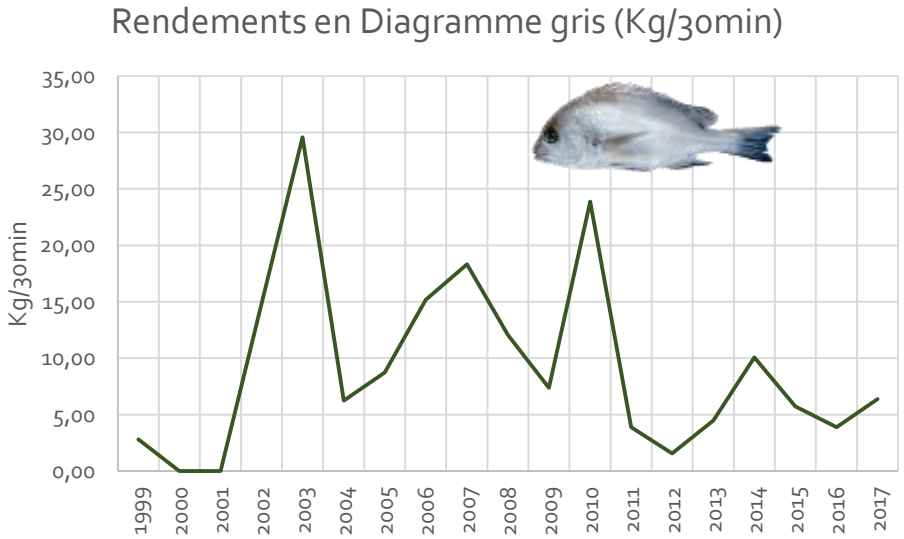
Proposition : Empirical approach

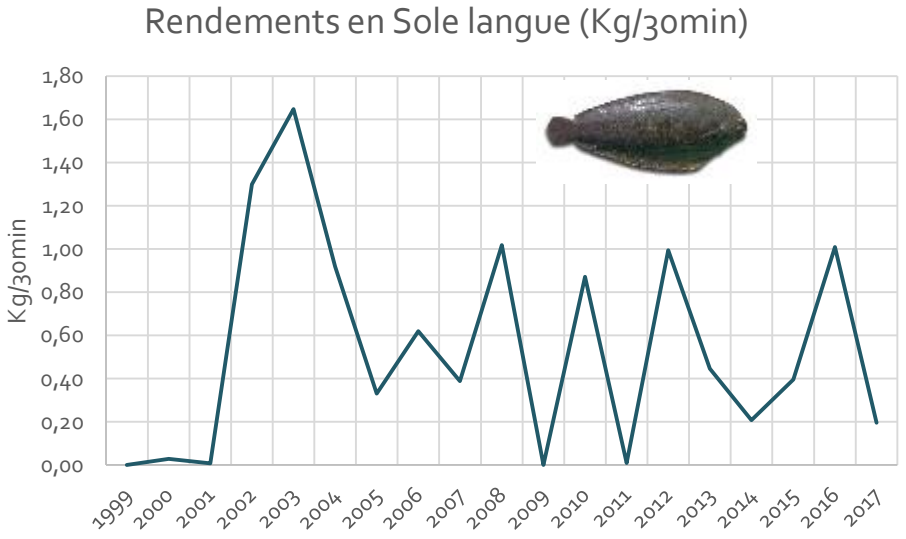
Other demersal species : Bonyfish

Evolution of the abundances index from the scientific surveys



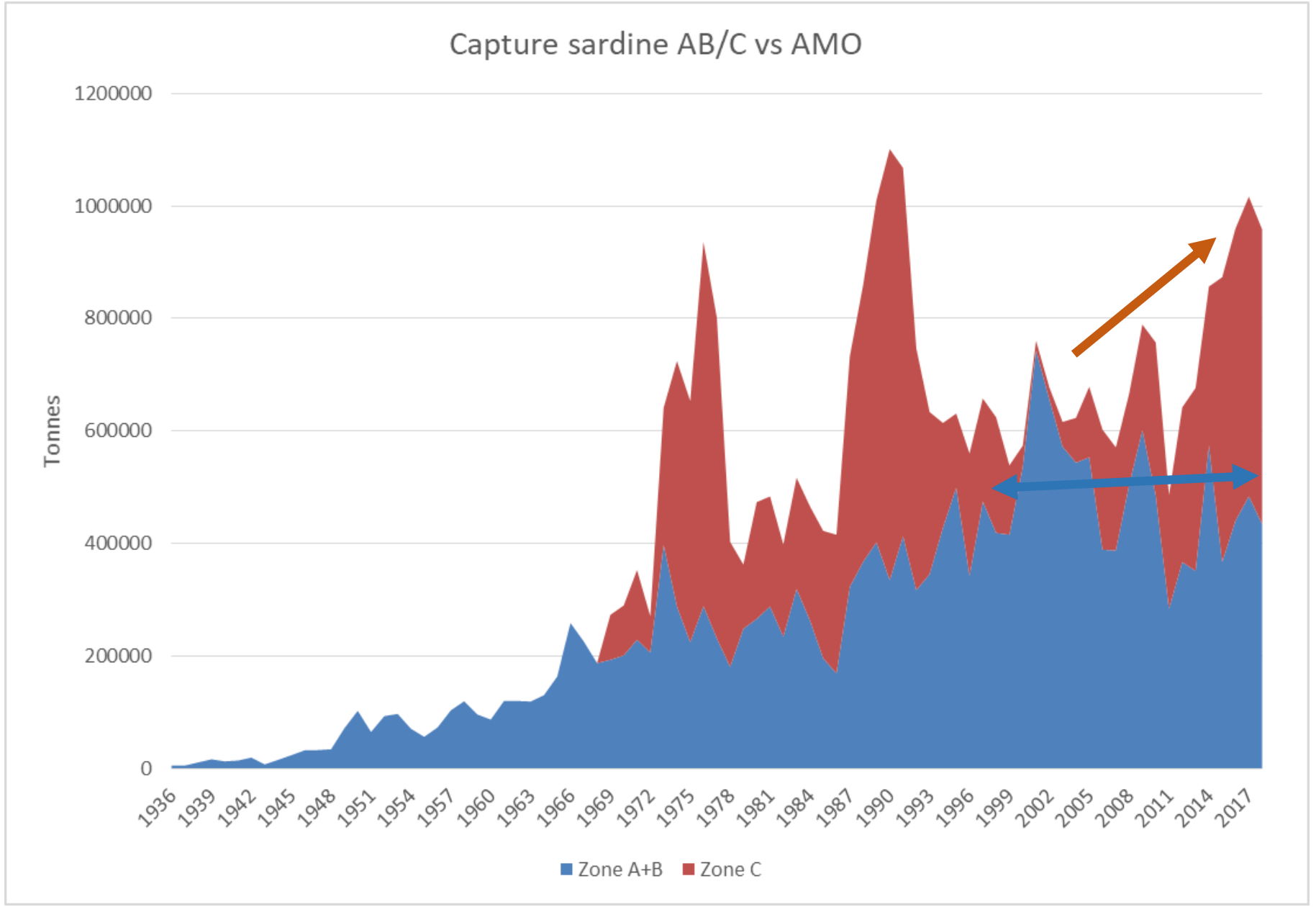






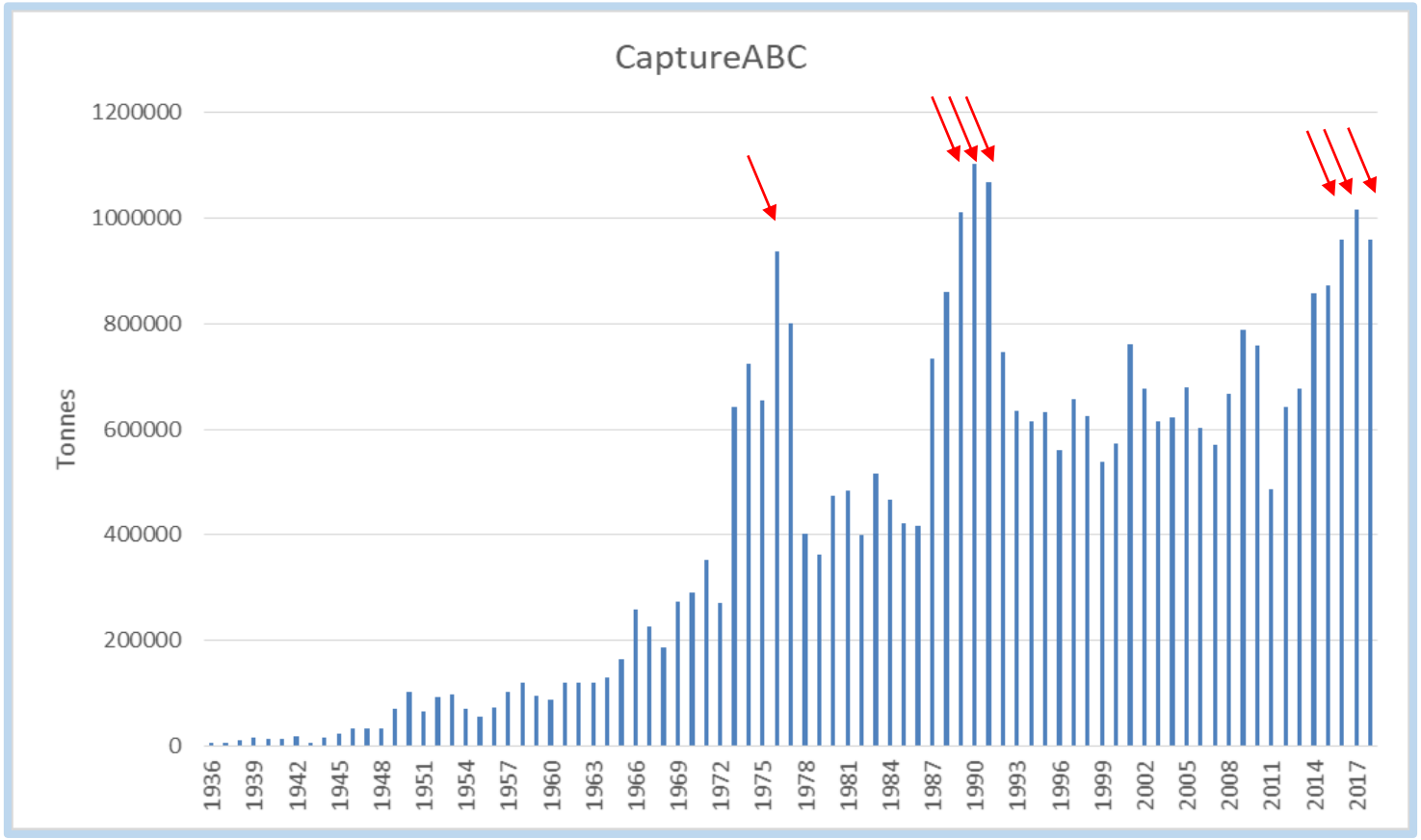
Different trends according to the species. But, abundances index fluctuate

Proposition : Empirical approach



Catchs of sardine fluctuate but remain in icrease in the south area and stable in the central area

Proposition : Empirical approach

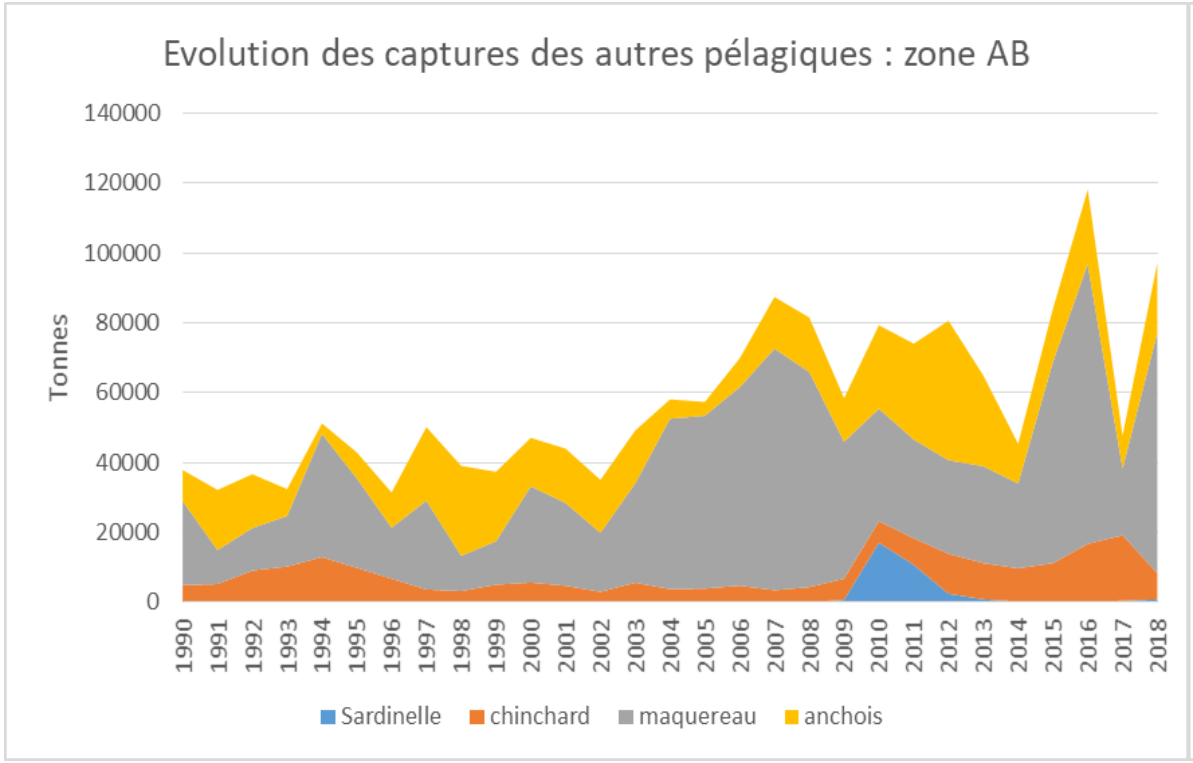


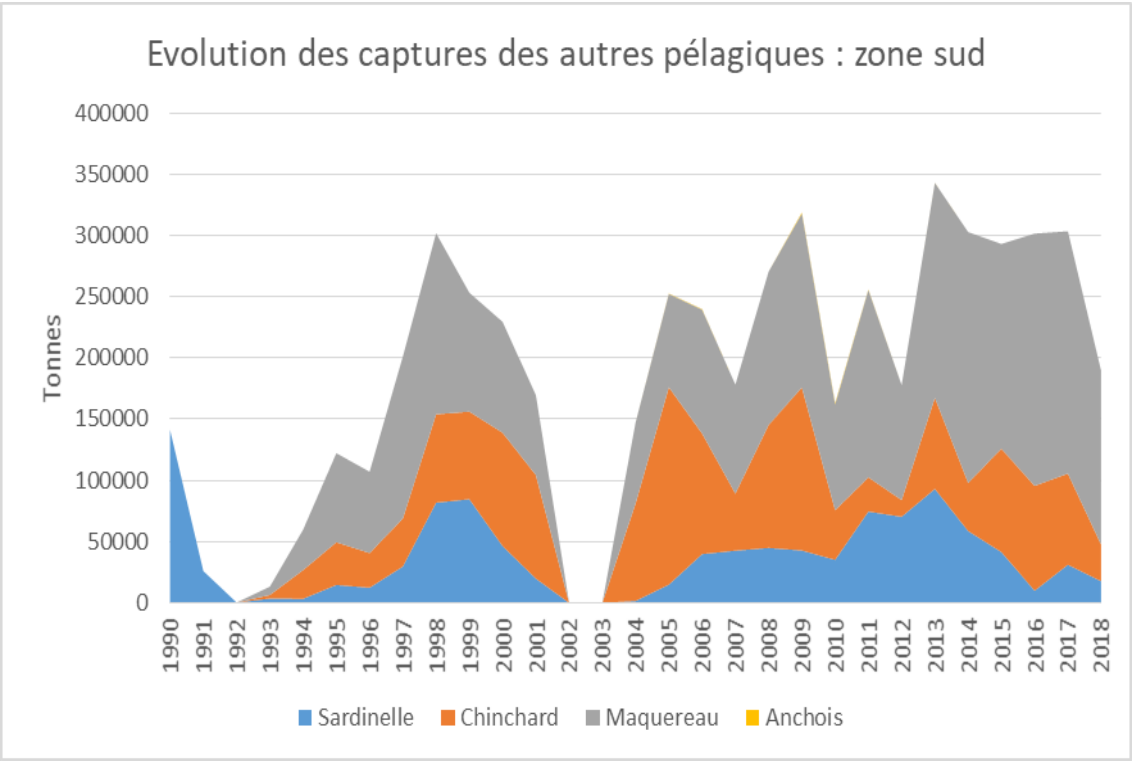
Sardine catches reached record levels (+1 million tons) in the past, fluctuated before being able to regain these record levels recently : Sardine resilience faced to fishing.

It should be noted that the effort is controlled by: **Investment freeze since 1992 / Fishing quotas / Catch limit by boat/ Catch limit by trip/ Spatial and temporal closures**

Proposition : Empirical approach

Other small pelagic species

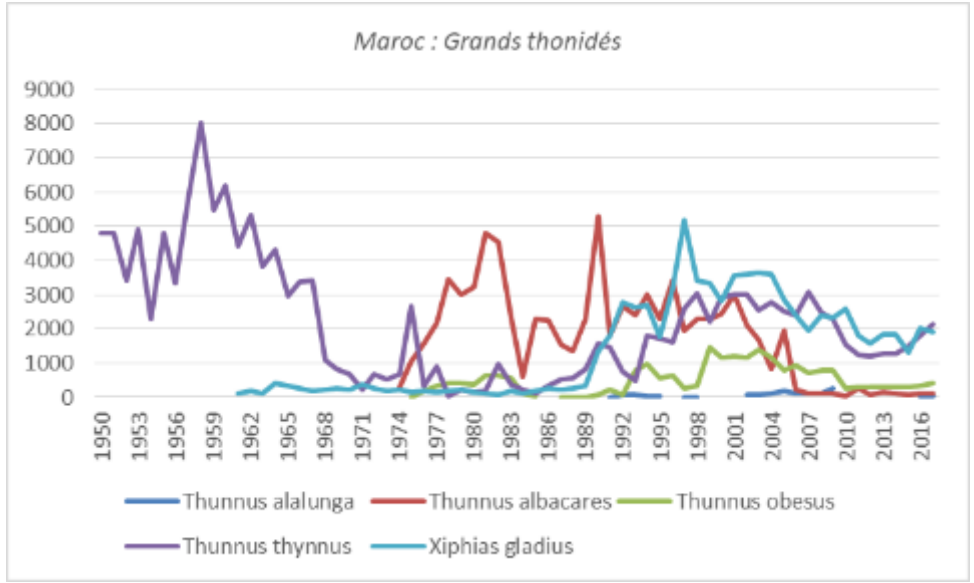


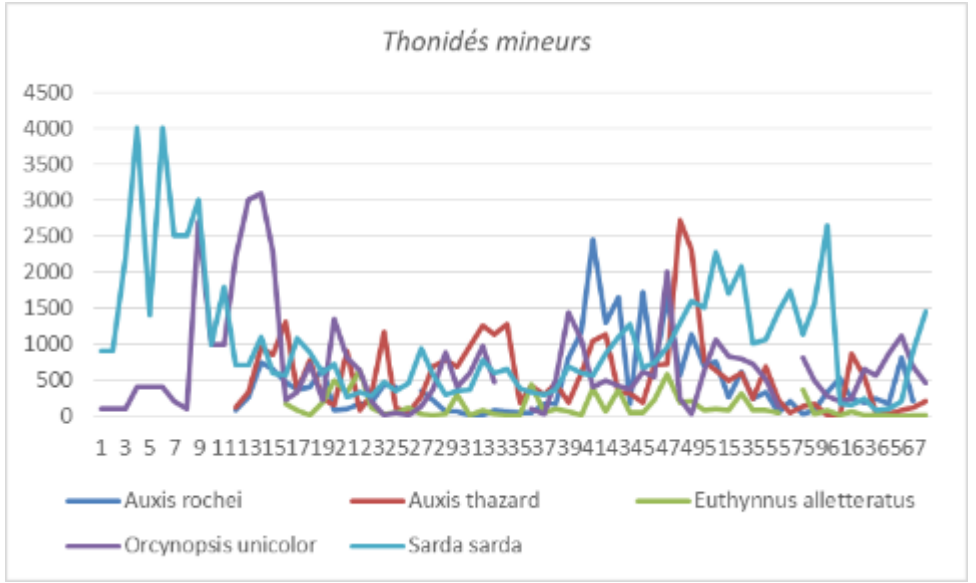


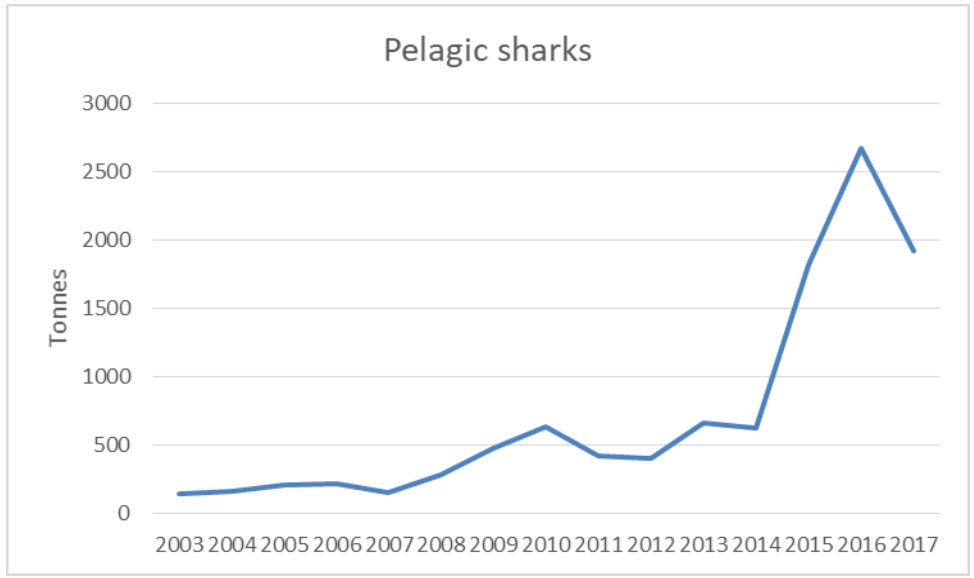
Catches fluctuate but remain more or less stable in recent years in the two areas

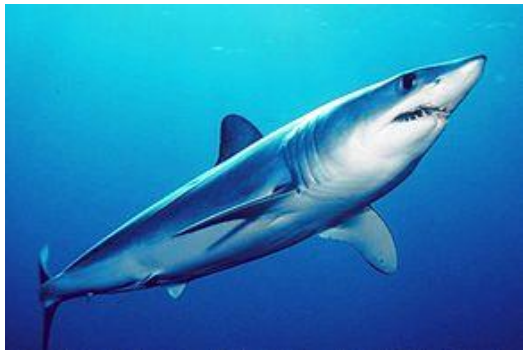
Proposition : Empirical approach

Evolution of catches of the main potentially predatory species of sardine







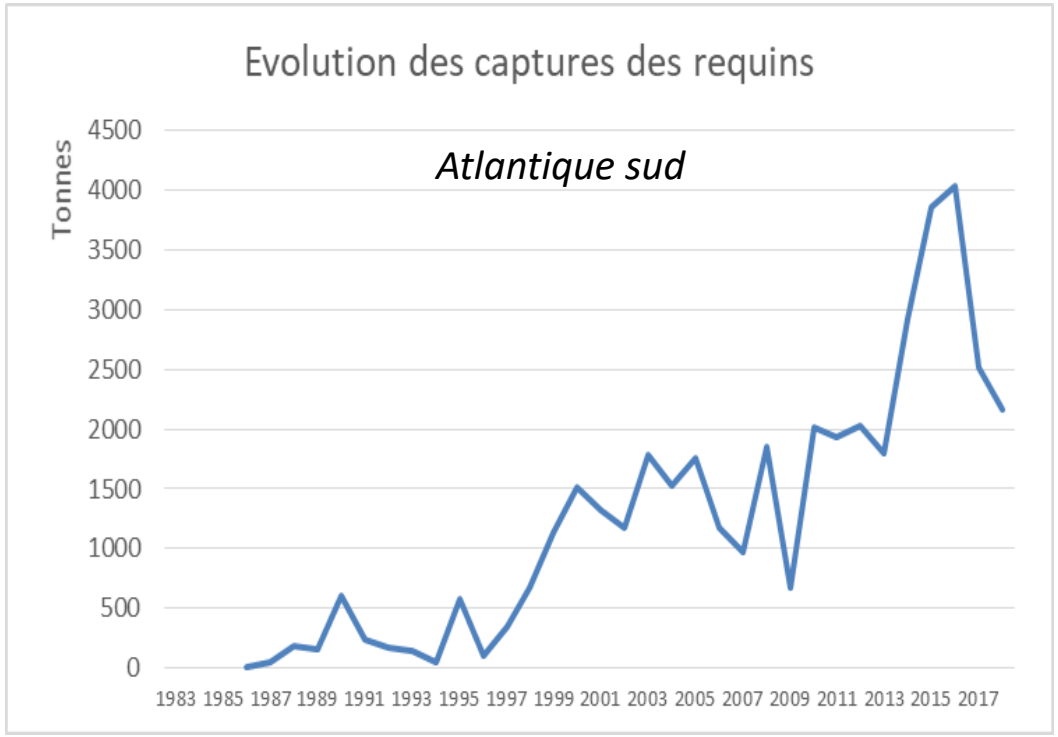


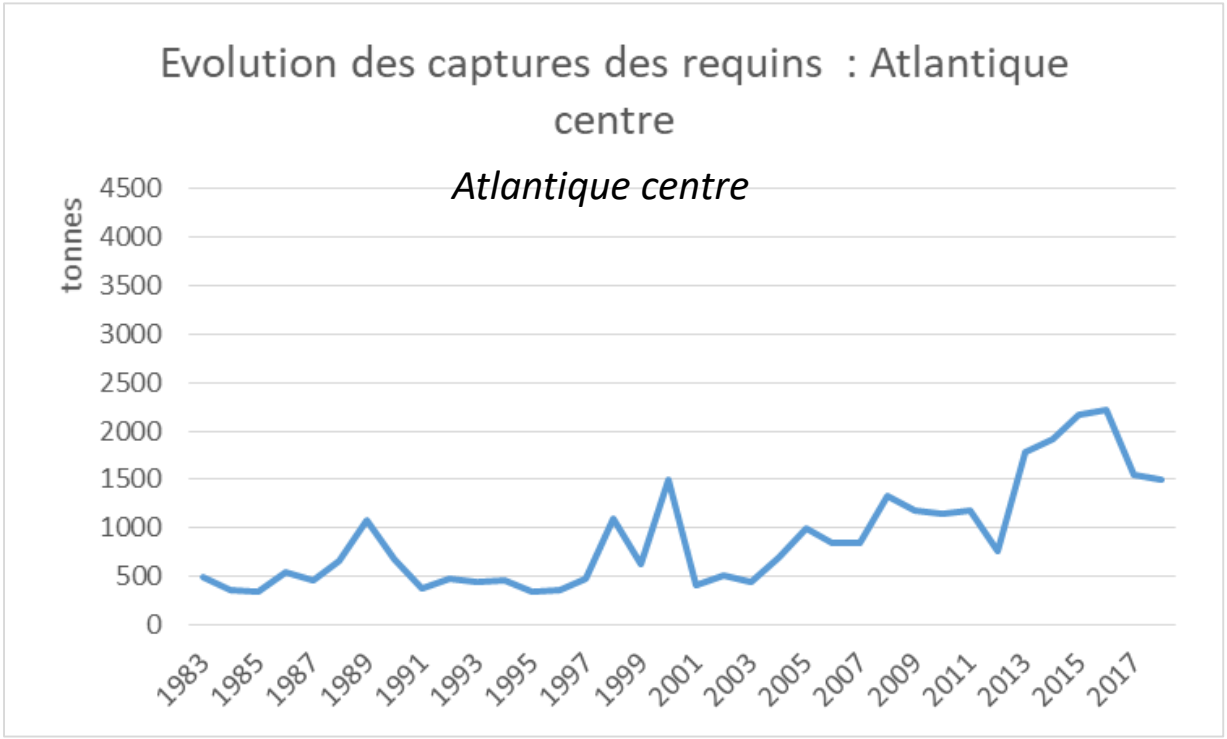
While, major and small tunas catch's shows fluctuations with relative stability, pelagic shark's catch has increased during the few las years.

Generally, the sharks are caught as a bycach associated to tunas and swordfish fisheries.

Proposition : Empirical approach

Evolution of catches of the main potentially predatory species of sardine
All Sharks (Benthic and pelagic)

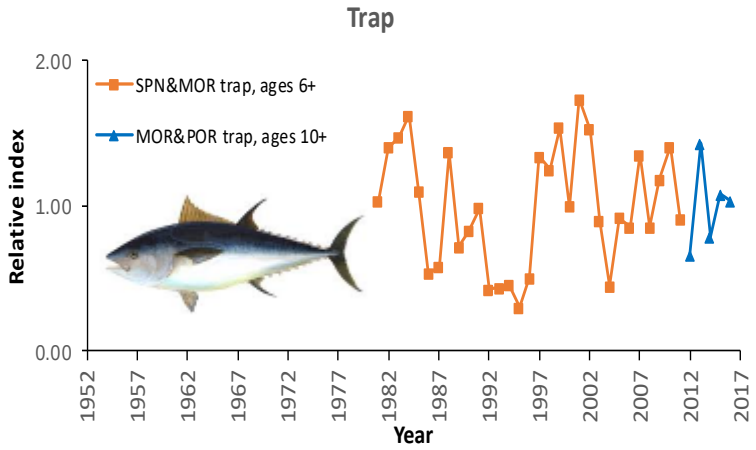




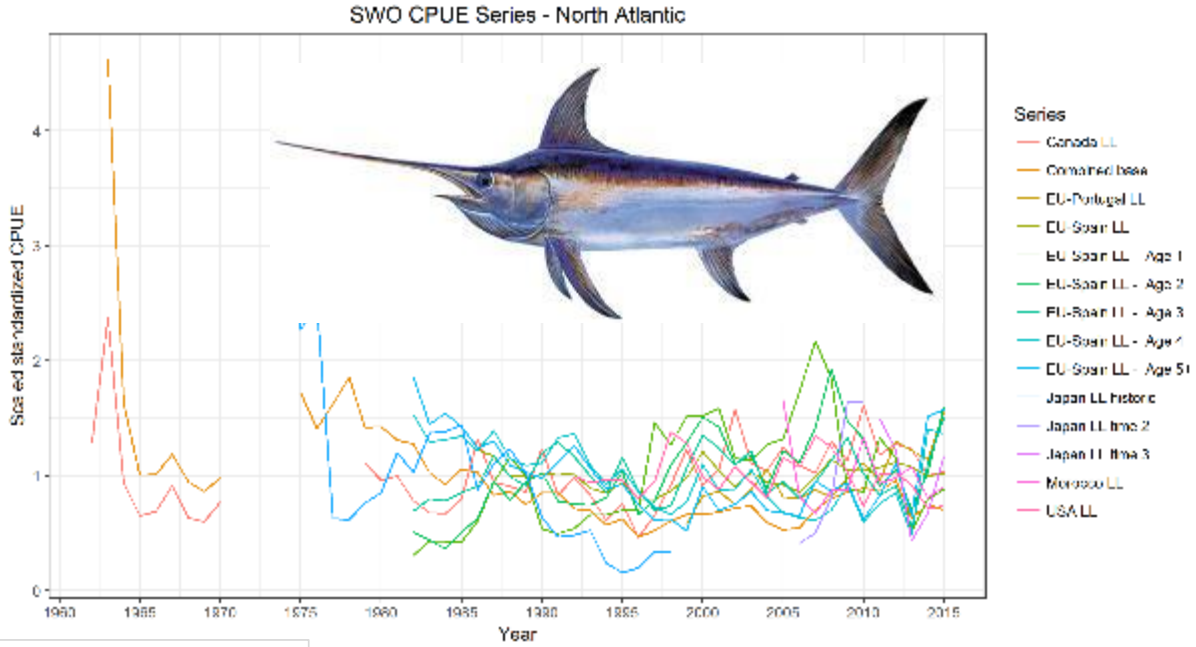
Upward trend of all shark's catch. **Generally, the sharks are caught as a bycach associated to other fisheries (tunas, swordfish, demersal fisheries…)**

Proposition : Empirical approach

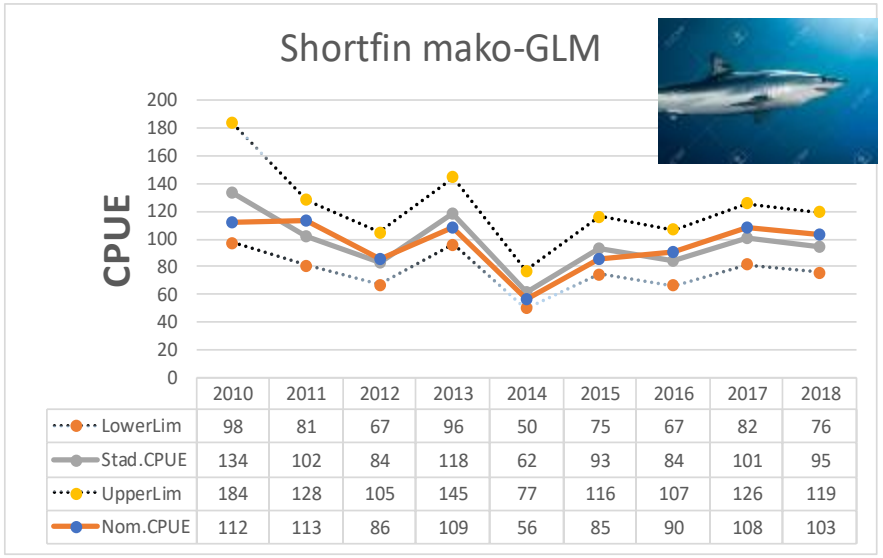
Evolution of Catch per effort unit of the main fleets targeting tuna



(ICCAT report, 2018)



(ICCAT report, 2018)



	2010	2011	2012	2013	2014	2015	2016	2017	2018
LowerLim	98	81	67	96	50	75	67	82	76
Stad.CPUE	134	102	84	118	62	93	84	101	95
UpperLim	184	128	105	145	77	116	107	126	119
Nom.CPUE	112	113	86	109	56	85	90	108	103

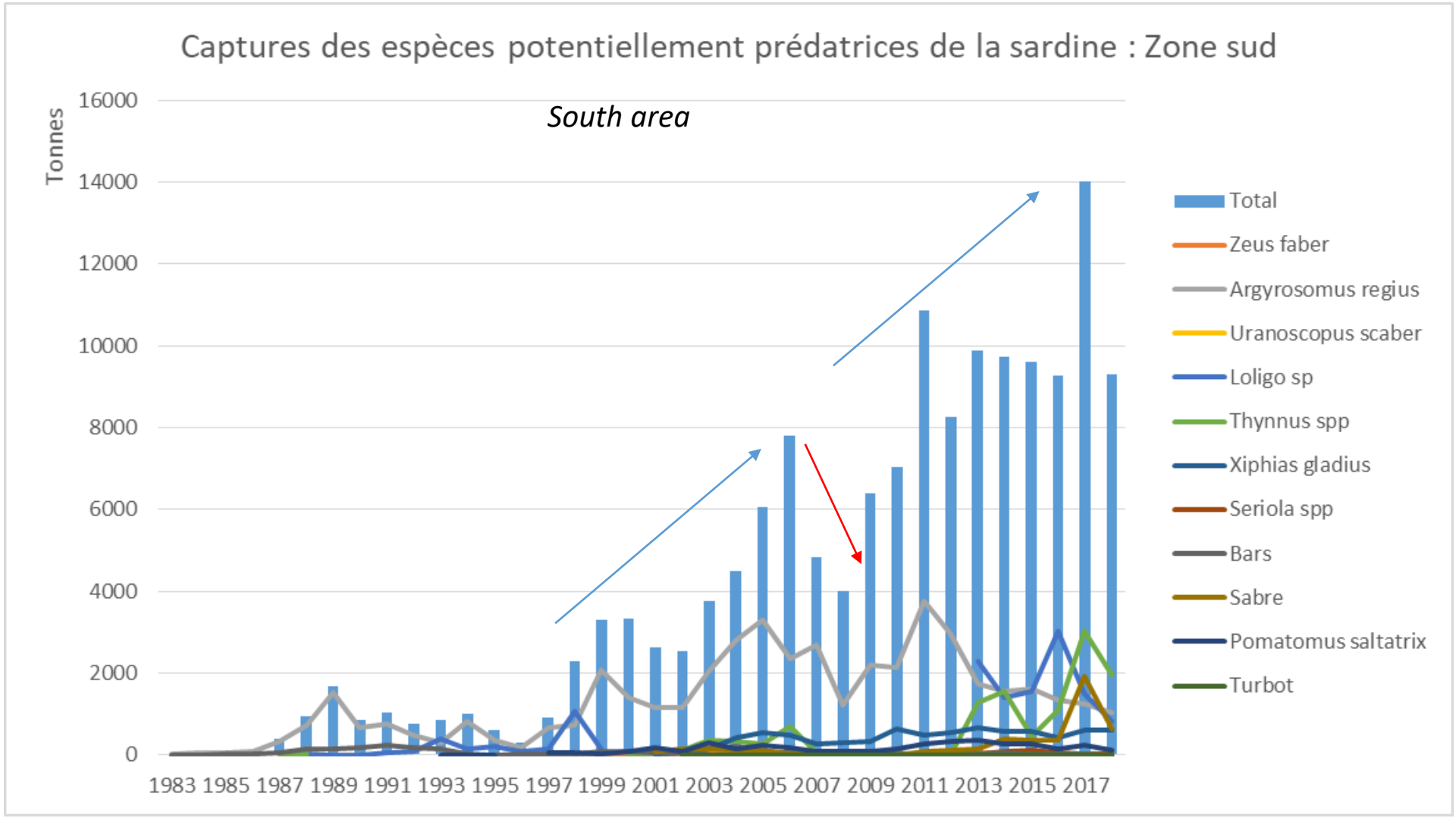
ICCAT SCRS/2019/084 in progress

Proposition : Empirical approach

Only small scale and coastal fisheries considered

Evolution of catches of the main potentially predatory species of sardine

Bonyfish



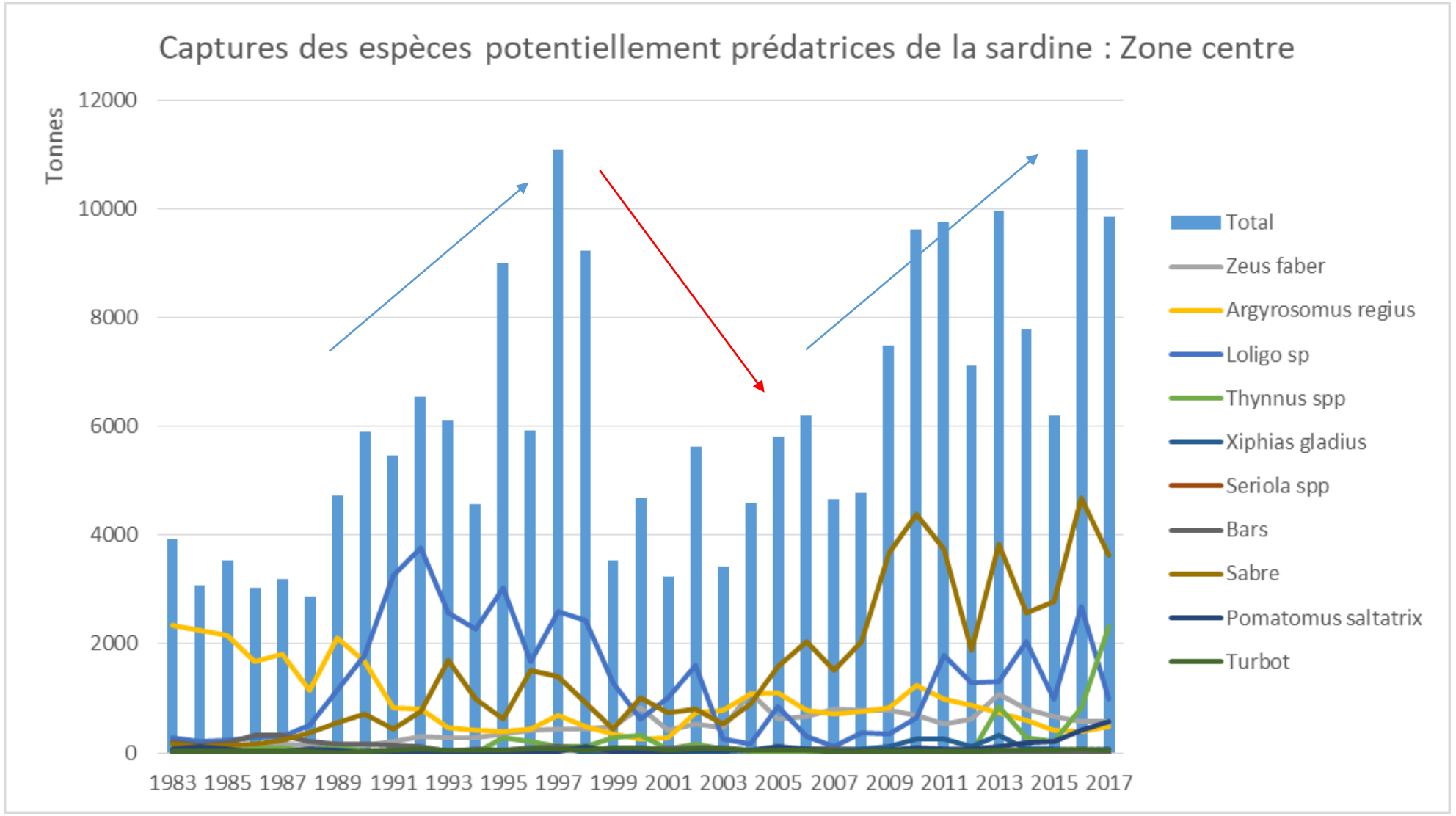
Even if individual catch of species fluctuates, the total catch of main potentially predatory species of sardine, caught by small scale and coastal fisheries, has increased since 1999 .

Proposition : Empirical approach

Only small scale and coastal fisheries considered

Evolution of catches of the main potentially predatory species of sardine

Bonyfish

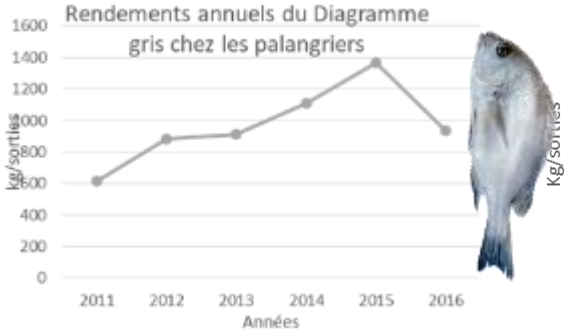


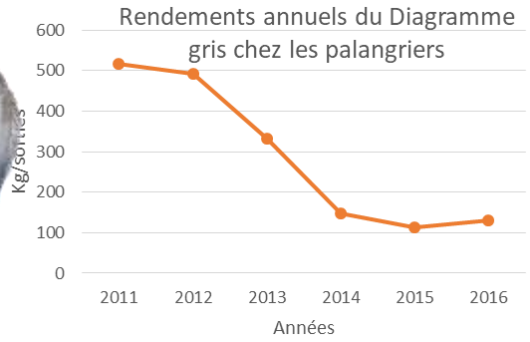
Catch of main potentially predatory species of sardine, caught by small scale and coastal fisheries, fluctuating but has increased since 1999 .

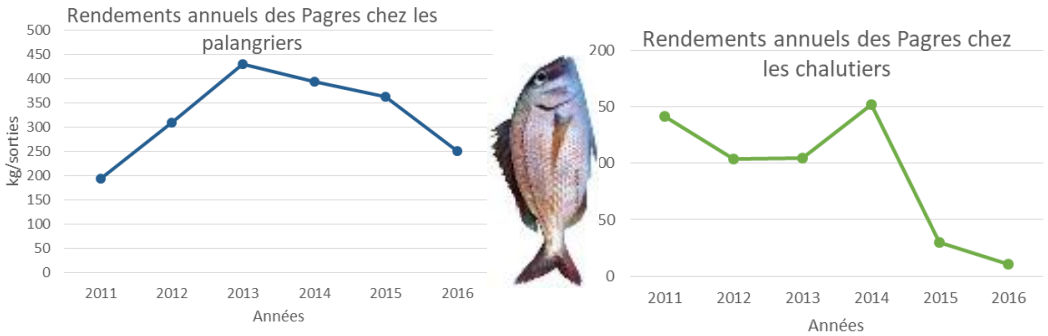
Proposition : Empirical approach

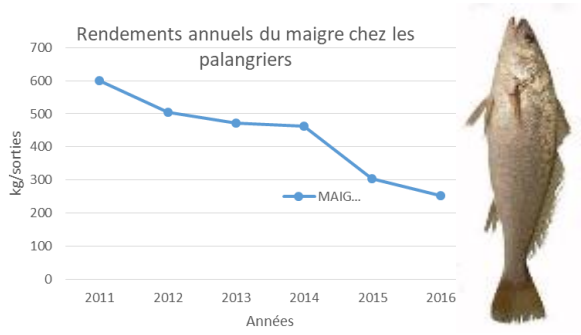
Other demersal species : Bonyfish

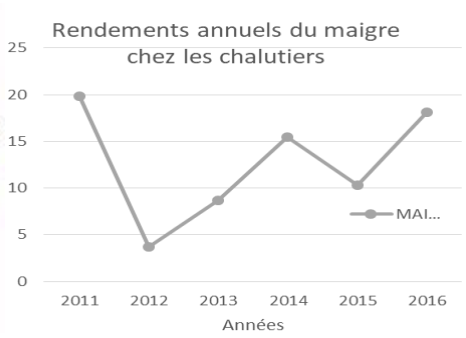
Evolution of Catch per effort unit of the main fleets targeting the demersals in the south



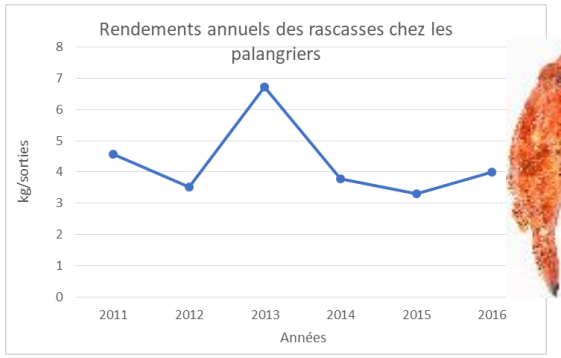


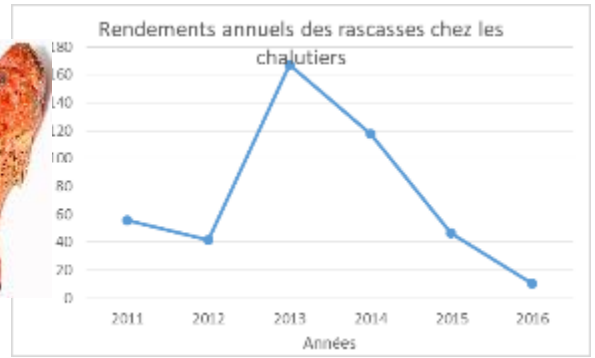


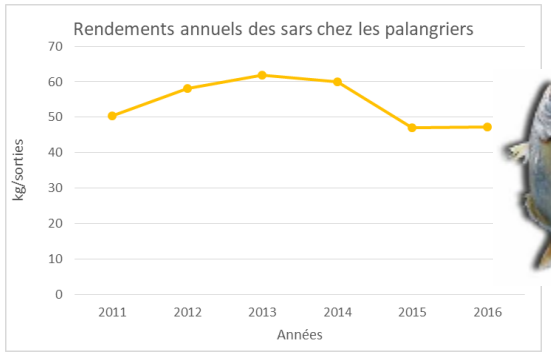


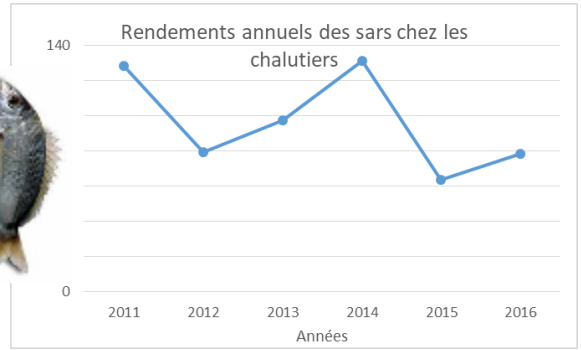


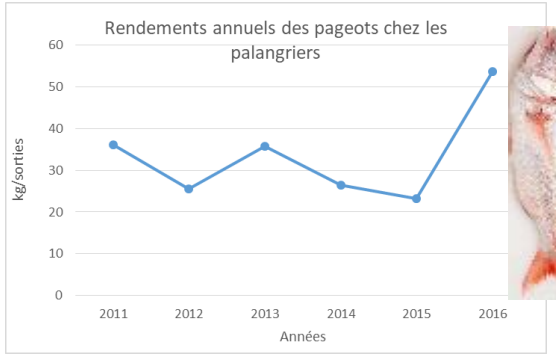
Different trends according to the species.

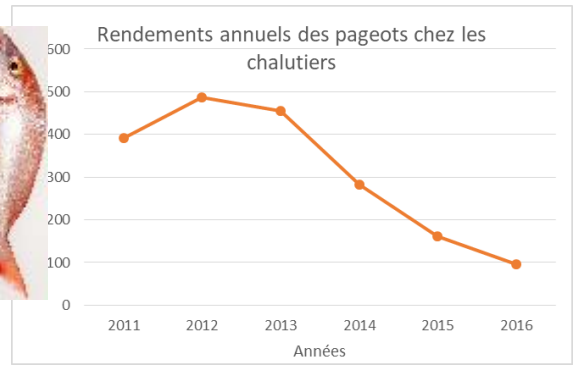












Morocco's fisheries scientific monitoring and management system

Morocco's fisheries management schemes

Morocco's institutional and legal framework

Statistical data-collection system (monitoring of industrial, artisanal fisheries, assessment surveys, etc.)

- *Surveys data (scientific vessel's) & commercial fleet boarding's data*
- *Biological sampling data (sites and harbors)*
- *Socio-economic data (investigations)*
- *Oceanographic and environnemental data (Scientific vessel's and buoy)*

- *VMS data*
- *Fleet's technical caracteristic*
- *Offshore fishing declarations*
- *Coastal and artisanal fishing declarations : (SAMAC)*

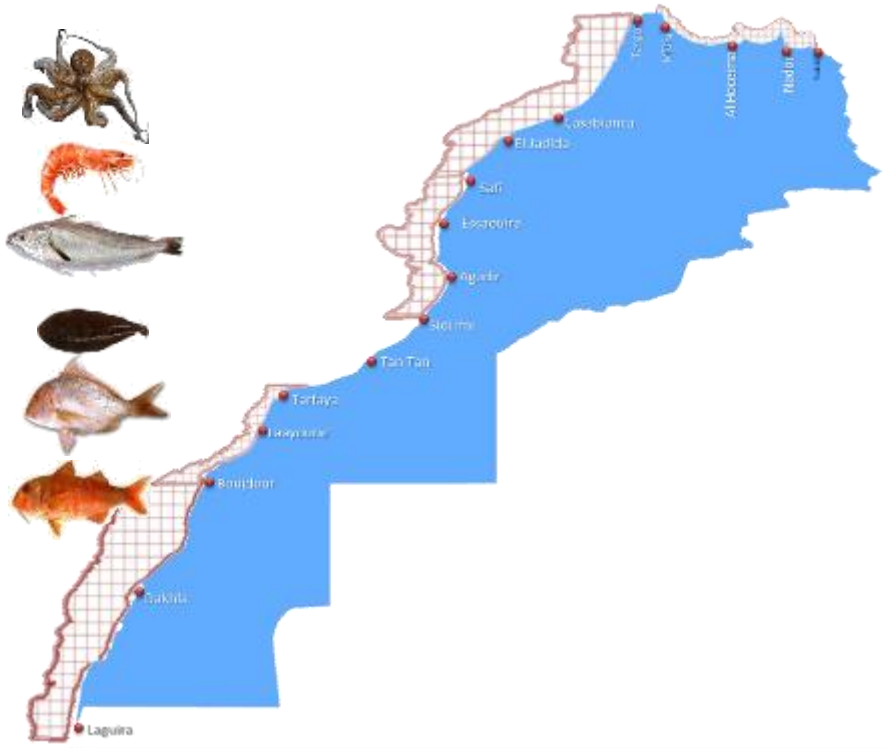
- *Daily statistical detailed data (MIAA)*
- *Destination of sea marine fishs*
- *Trading activity*

Morocco's fisheries management schemes

Morocco's institutional and legal framework

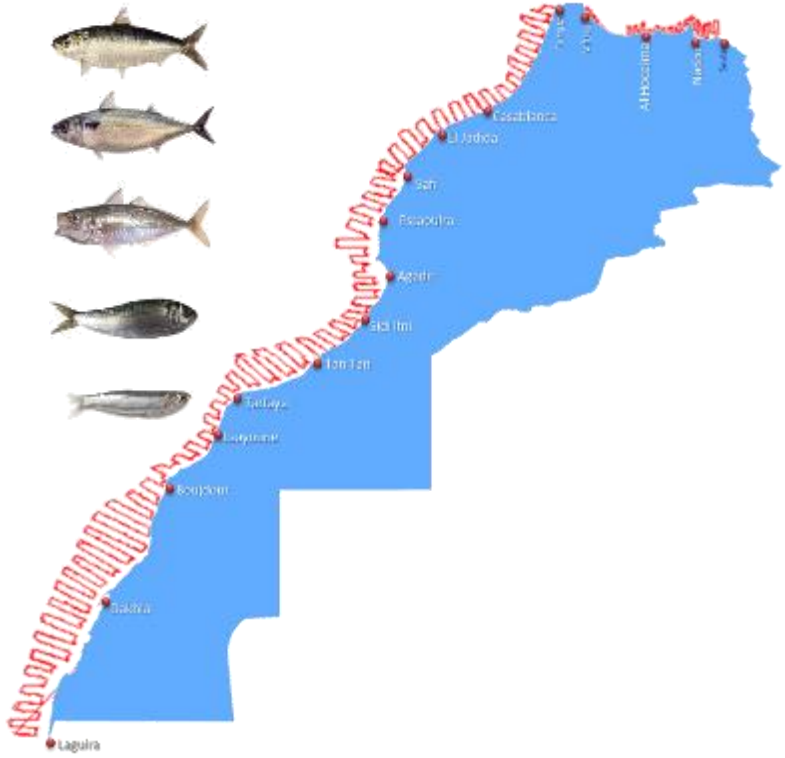
Research activities focusing on the assessment of fish stocks
Main scientific survey's

Demersal's fish



- ***Three areas covered with two national survey's on average per zone***
- ***Occasional surveys by Nansen FAO project***

Pelagic's fish



- ***Four areas covered with two national survey's on average per zone***
- ***Occasional foreigner's surveys (Russian and Nansen FAO project)***

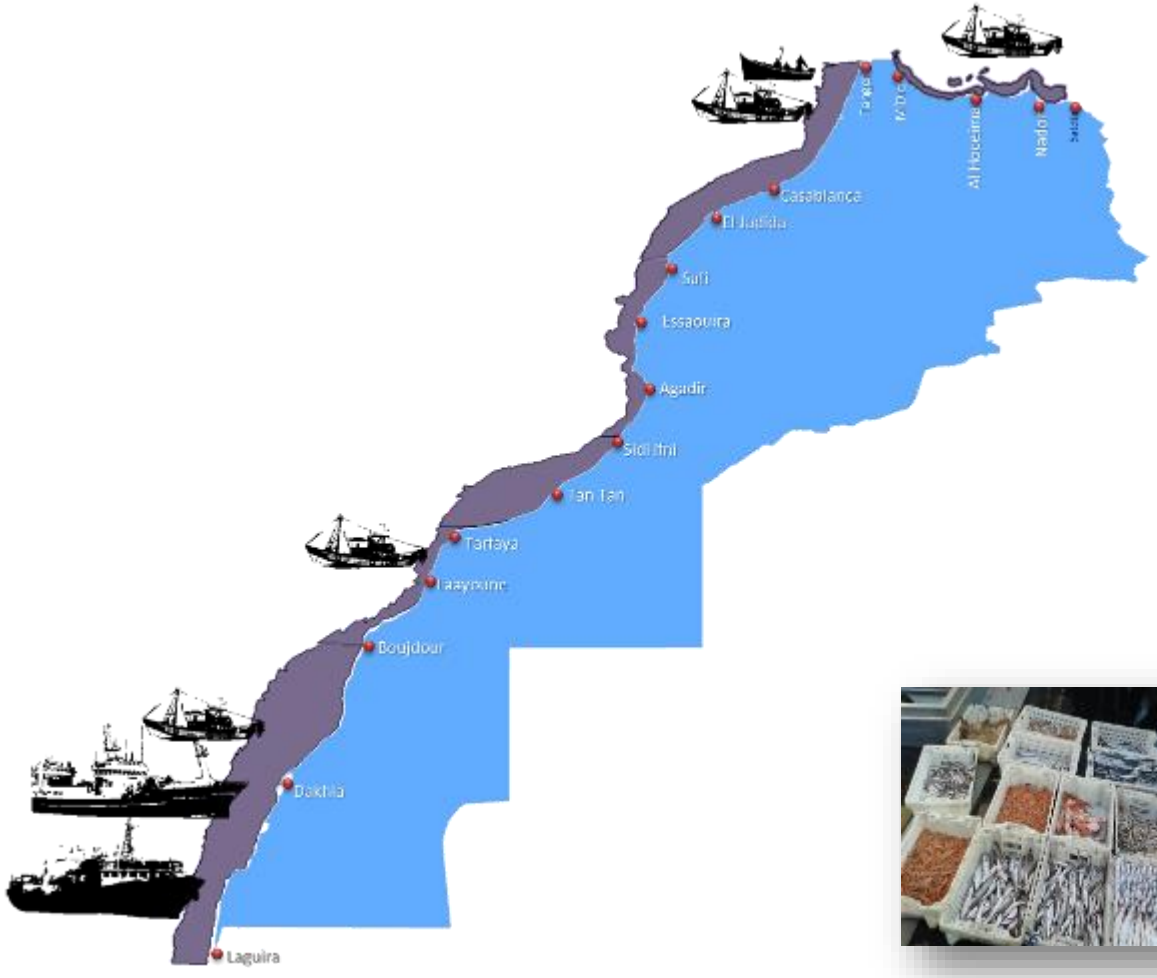
INRH

Morocco's fisheries management schemes

Morocco's institutional and legal framework

Research activities focusing on the assessment of fish stocks

Commercial fleet boarding's data



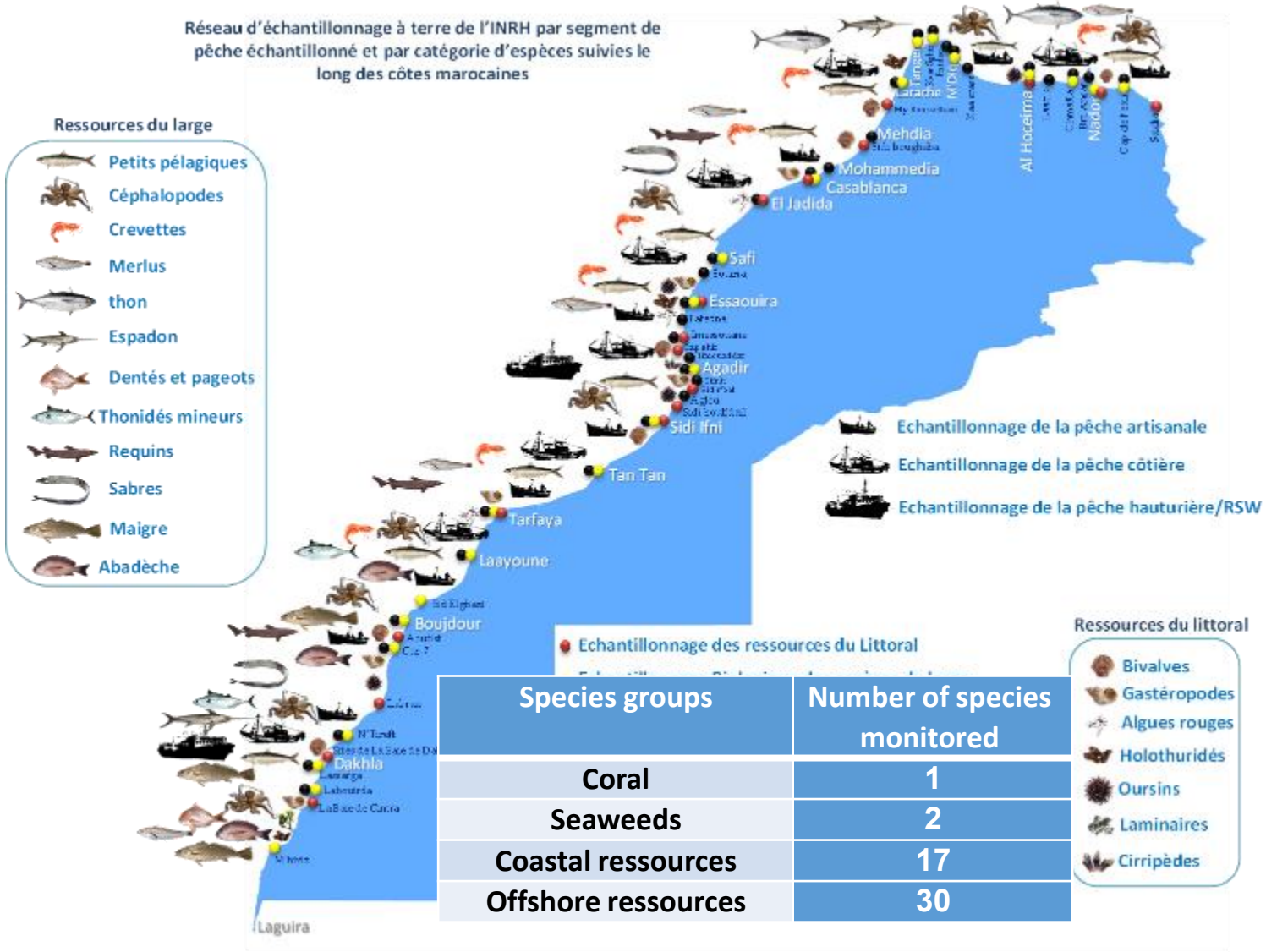
- ***For observing fishing operation and biological monitoring and discards estimation***

Morocco's fisheries management schemes

Morocco's institutional and legal framework

Research activities focusing on the assessment of fish stocks

Biological sampling data and socio-économic minotoring (sites and harbors)



Species groups	Number of species monitored
Coral	1
Seaweeds	2
Coastal ressources	17
Offshore ressources	30

Morocco's fisheries management schemes

Morocco's institutional and legal framework

Research activities focusing on the assessment of fish stocks

Oceanographic and environnemental data (Scientific vessel's and buoy)

Equipped with oceanographic sensors for continuous collection of observations of **waves, current, water temperature, water salinity, water turbidity, water dissolved oxygen, fluorescence, PH**, ... from the Dakhla area.

Equipped also with Global Positioning System (GPS) and AIS (Automatic Identification System), it allows **the real-time transfer of meteorological and oceanographic data, via satellite, to the data collection center based at INRH of Casablanca**

Data gathered

Scientific survey's

Data gathered

- Catch composition
- Fish distribution
- Biological sampling data
- Abundances and index
- Biomass and index
- Oceanographic data

Data

- Length-frequencies
- Stage of maturity
- Weigth (corporeal, gonads and liver)
- Foods
- Fat

Data gathered

Commercial fishery surveys concerns :

- ***Purseiners***
- ***Pelagic trawlers***
- ***Coastal trawlers***
- ***Longliner (Lobster and hakes)***
- ***Hake EU trawlers***
- ***Cephalopod Freezer Trawlers***
- ***Shrimp Freezer Trawlers***

Data gathered

Catch composition

Discards

Type of gear

Fishing areas

Biological sampling data

Data

- **Length-frequencies**
- **Stage of maturity**
- **Weigth**

Data gathered

Biological sampling in harbors

- ***Demersal fisheries*** *: hakes, pink shrimp, octopus, cuttlefish, demersal fish, squid*
- ***Pelagic fisheries*** *: sardina, chub mackerel, horse mackerel, anchovy, sardinellas*

Catch composition

Type of gear

Fishing areas

Fishing operation details

Biological sampling data

Data

- Length-frequencies
- Stage of maturity
- Weigth (gonads and liver)
- Foods
- Fat

INRH

Data gathered

Socio-economic and fleets investigations

Socio-economical data

Data

- Incomes
- Costs
- Profitability
- Employement
- Value chain

Catch composition & discards

Fleet's and gear's information

Fishing areas & strategies

Fishing operation details

Management measures and their impacts

Morocco's fisheries management schemes

Morocco's institutional and legal framework

Research activities focusing on the assessment of fish stocks

Preparing data

- Abundance and biomass indicators by stock,
- Catch and effort statistic
- Biological parameters : growth, LF, ALK, recruitment, reproduction….
- Socio-economic data

*Annual National WG**

- Analyzing data
- Discussion of trend and fisheries state
- Discussion of assessment models and statistical analysis
- Discussion and selection of reliable and appropriate data

Stock assessment

Different models applied according to :

- Life cycle of species
- Data available
- Keeping consistency with the previous assessment
- Model's adjustment quality

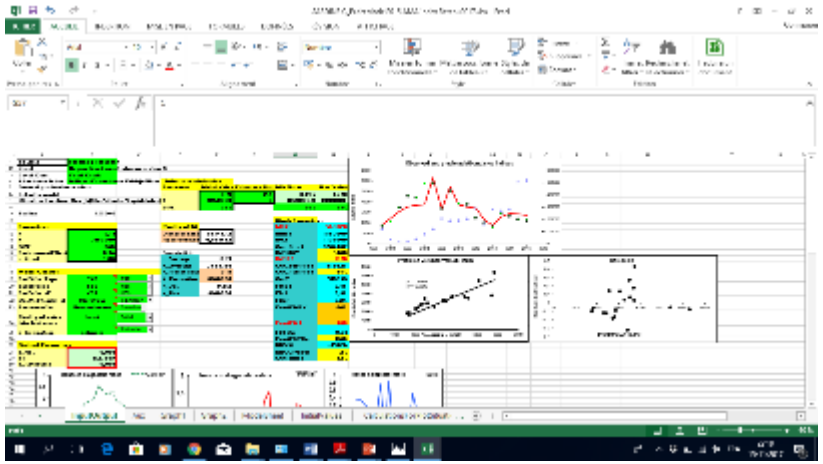
* Five WG per year

* There is other regional WG: CECAF, GFCM, …etc

Tools/software employed

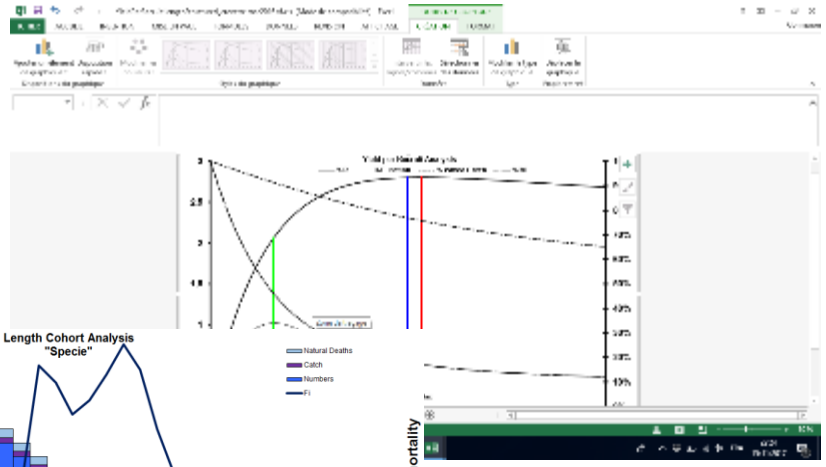
Dynamic version of the Schaefer model

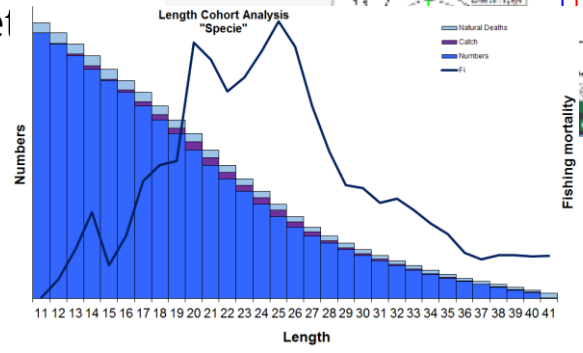
A spreadsheet implemented in Excel was developed to run the model with the observation error estimator method (Haddon, 2001)



Length composition analysis & Yield per recruit

A spreadsheet implemented in Excel was developed to run the model with LCA and YPR of Thomson et Bell. Both of models was descriped in Sparre et Venema (1996)

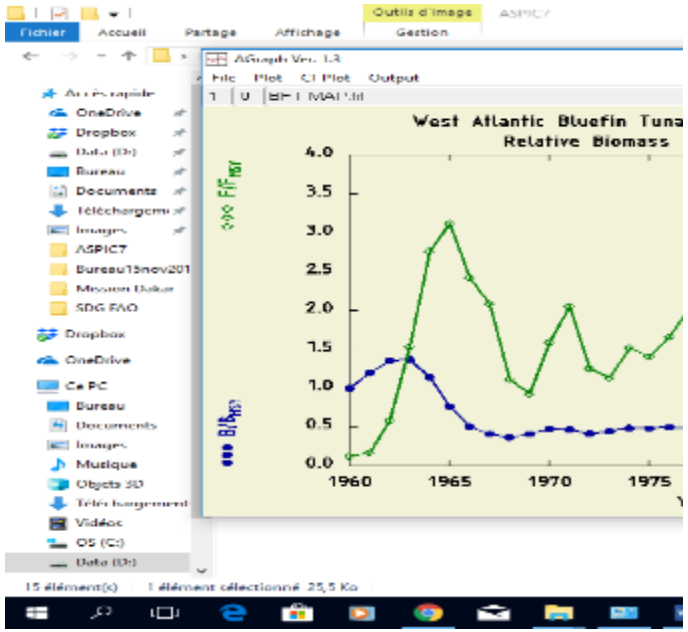




Tools/software employed

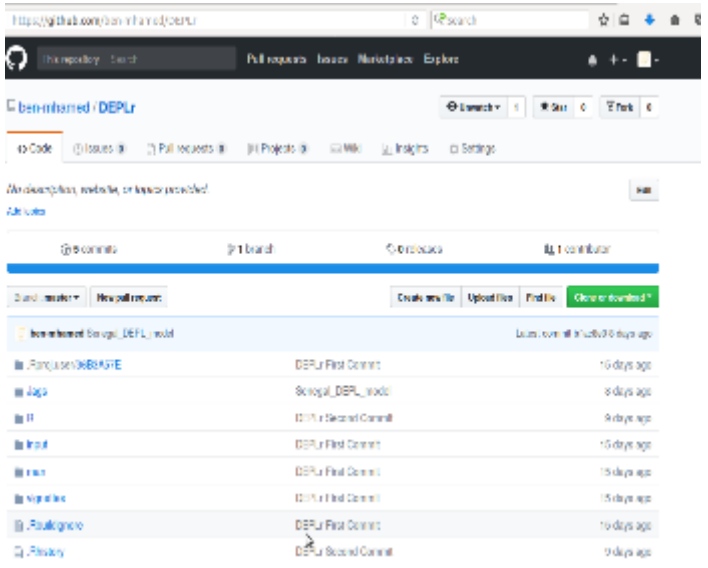
Non equilibrium stock production model (ASPIC)

Developed by Michael H. Prager — Prager Consulting and is written in standard Fortran 95 and is portable to other operating systems. Two versions used: in R and ASPIC.7.0



Depletion Model

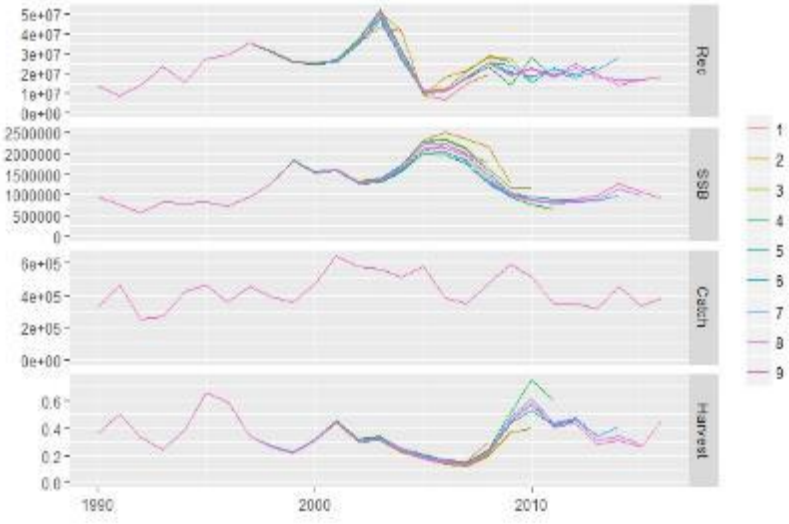
Applied to the moroccan octopus and developed by INRH. Available version was published on github : https://github.com/ben-mhamed/DEPLr



Tools/software employed

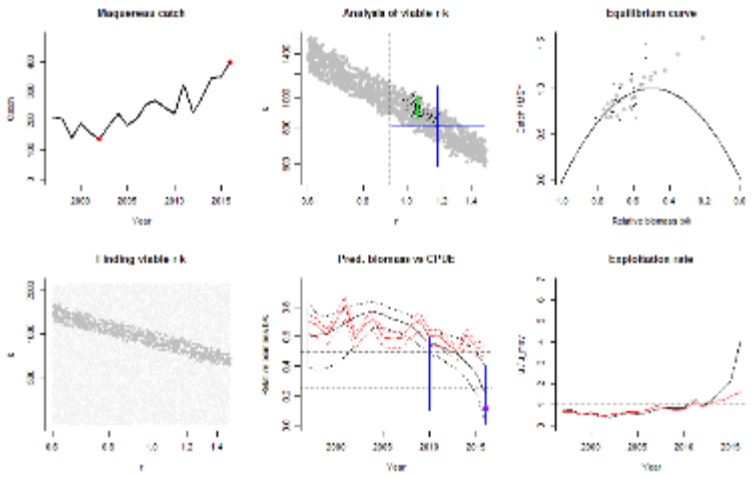
Virtual Population Analysis (VPA)

- **XSA (*Xtended Survivor Analysis*) Shephered 1999 (CECAF & FGCM)**
- **ICA (*Integrated Cohort Analysis*) Patterson & Melvin 1995 (CECAF working group)**



CMSY-method

Developped by Rainer Froese and al in 2014. It is a method for estimating (*MSY*) and related fisheries reference points from catch data and resilience. For the evaluation of the quality of CMSY prediction, a full Schaefer model using a Bayesian approach is also fitted.



Reference points (RP)

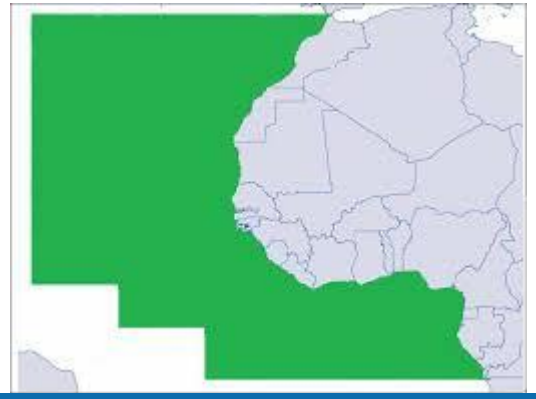
Current moroccan fisheries RP

***Limit** Reference Points*
Bcur/Bmsy
Fcur/Fmsy

***Target** Reference Points*
Bcur/B0.1
Fcur/F0.1

Bcur : Current biomass
Bmsy : Biomass at MSY
Fcur : Current Fishing Mortality
Fmsy : Fishing Mortality at MSY

F0.1 = 90% Fmsy is a precautionnary proxy of Fmsy
B0.1 = 110% Bmsy is a precautionnary proxy of Bmsy



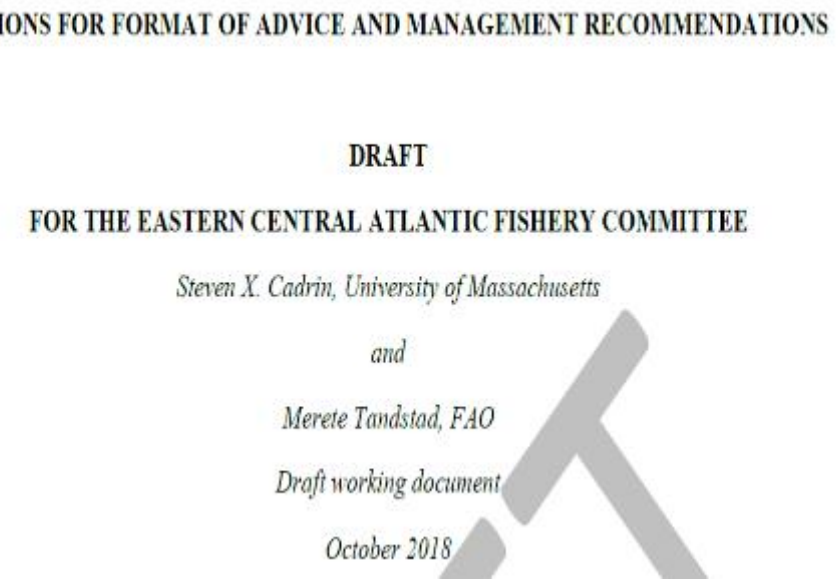
These RPs are recommanded and used by the Fishery Committee for the Eastern Central Atlantic (**CECAF**) /FAO scientific working group.

Other RP (exploratory) :

- Exploitation Rate (E) = F/Z
- F40%SSB

Organisation des Nations Unies pour l'alimentation et l'agriculture

Reference points (RP)


OPTIONS FOR FORMAT OF ADVICE AND MANAGEMENT RECOMMENDATIONS

DRAFT

FOR THE EASTERN CENTRAL ATLANTIC FISHERY COMMITTEE

Steven X. Cadrin, University of Massachusetts

and

Merete Tandstad, FAO

Draft working document

October 2018

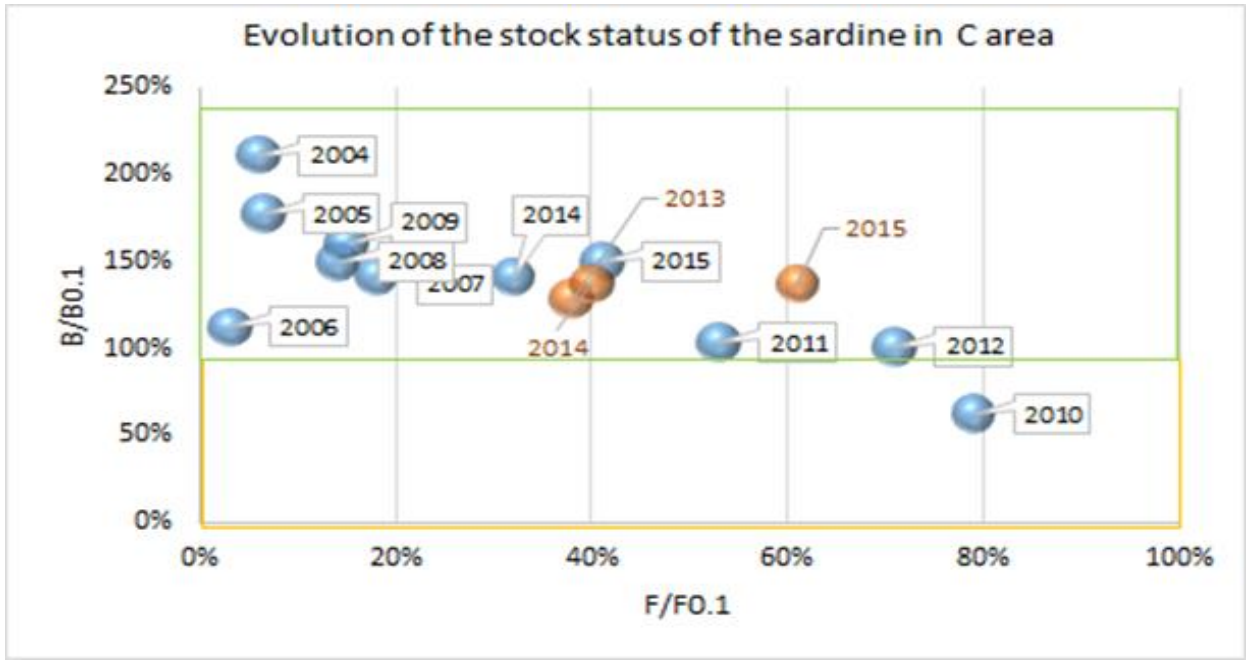
The information available for CECAF stocks and conventions for data-limited stocks suggest that the current target reference points (F0.1 and B0.1) are generally appropriate as proxies for achieving maximum sustainable yield objectives.

Recommendations

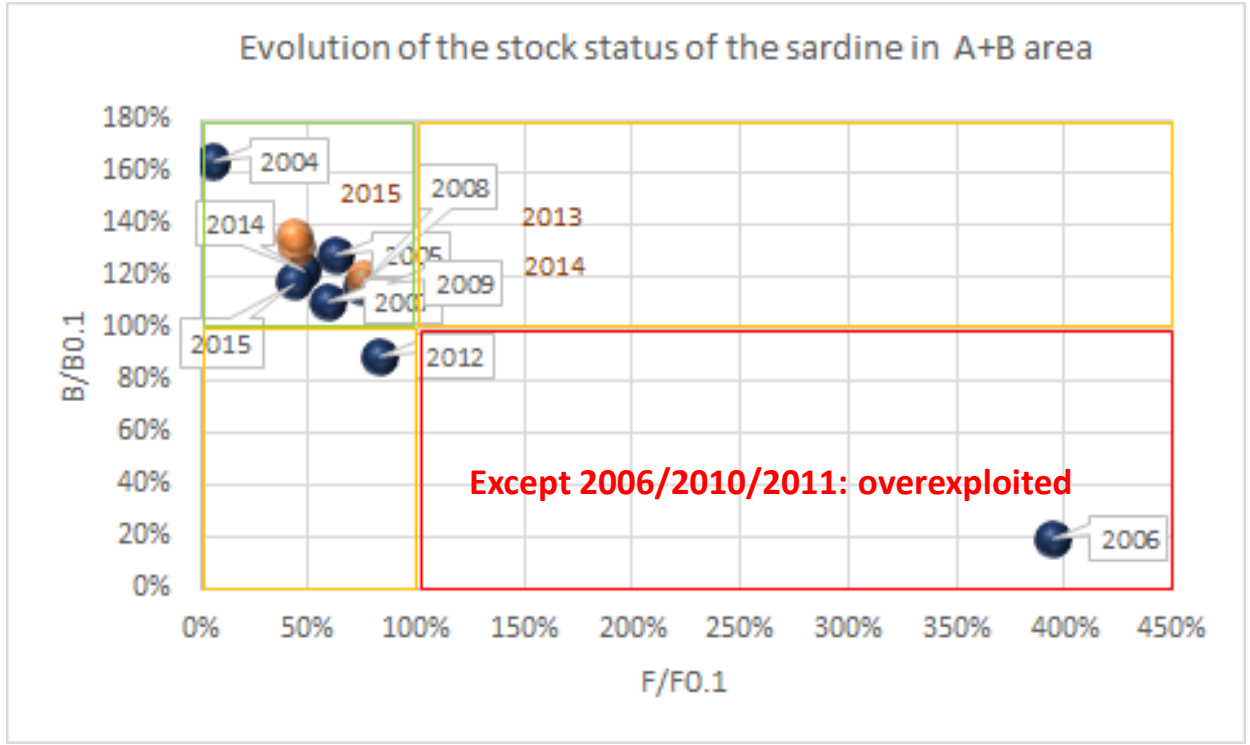
- For CECAF fisheries that catch a large portion of juvenile fish, alternative reference points (e.g., 30- 40% maximum spawning potential) may be more effective for maintaining productive fisheries, although information on spawning stock is currently limited.
- CECAF advice should continue to consider reduced fishing mortality targets (i.e., <F0.1) for low stock size conditions and to account for scientific uncertainty and risk aversion, and could consider a general harvest control rule with explicit precautionary targets to derive more consistent advice among stocks. For data-poor CECAF stocks with unknown status, empirical management procedures may be a viable alternative.
- Ecosystem conditions should continue to be considered in CECAF advice, particularly for small pelagic stocks.
- The performance of a revised advisory procedure should be simulation tested for representative CECAF stocks.

Reference points (RP)

Current moroccan fisheries RP



Frequent situations of healthy stock status of sardine (green zone) with respect to limit reference points (F_{msy} and B_{msy}) and target ($F_{0.1}$ and $B_{0.1}$)



Fisheries management system

Reference points (RP)

MSC RP

MSC defines the default precautionary reference points for management of key LTL species as either a biomass that is 75% of the unexploited level in the system, or a target exploitation rate of 0.5FMSY or 0.5M (natural mortality of the species). In fisheries where there is sufficient understanding of the system, these default reference points can be adjusted to specific levels appropriate to the fishery, which are shown not to have adverse ecosystem effects through the use of credible ecosystem models (MSC Fisheries Certification Requirements and Guidance, Version 2.0, 1 st October, 2014)

$B_{cur}/B_0=75\%$

$F_{cur}/F_{msy}=50\%$ and $F_{cur}/M=50\%$

Bcur : Current biomass
B_0 : Virgin biomass
Fcur : Current Fishing Mortality
Fmsy : Fishing Mortality at MSY
M : Natural Mortality

Morocco's institutional and legal framework

Main laws and regulations regulating the fishing operations

Fisheries Management Plan

The goals are fixed :

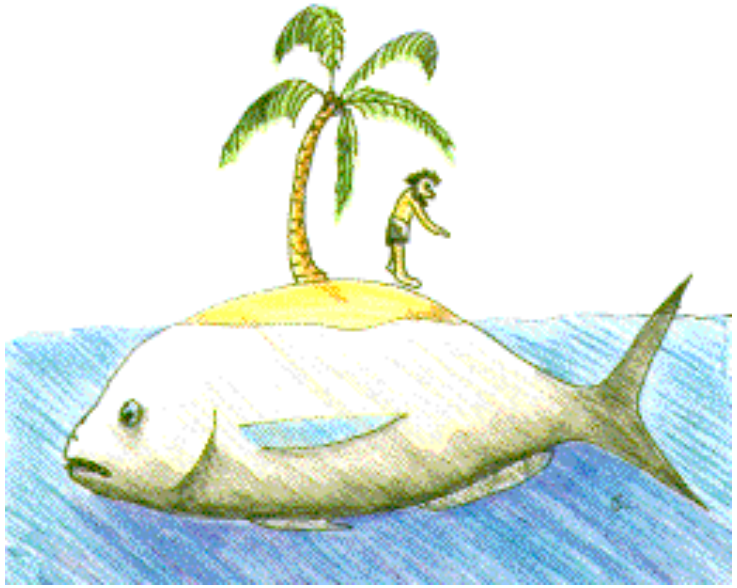
- **Preservation of the resource and marine ecosystems,**
- **Providing good visibility to professionals in order to stimulate investment.**

The Small Pelagic's Management Plan concerns five fisheries along the coast: Mediterranean (2014), North Atlantic (2014), Central Atlantic (2014) and South Atlantic (2010). The main measures are : TAC, Zoning, Spatio-temporal area closing, gears and minimal size landing...etc

Legislation

- Order of the Minister of Agriculture and Maritime Fisheries n. 4196-14 of 2 safar 1436 (25 November 2014) on the small pelagic fishery in the North Atlantic Mediterranean and the small pelagic fishery in the central Atlantic
- Decree No. 2-07-230 laying down the conditions and modalities for fishing for small pelagic species
- Arrêté du ministre de l'agriculture, de la pêche maritime, du développement rural et des eaux et forêts n°1520-17 du 20 ramadan 1438 (15 juin 2017) relatif à l'interdiction temporaire de certaines espèces pélagiques
- Arrêté du ministre de l'agriculture et de la pêche maritime n°3279-10 du 10 moharrem 1432 (16 décembre 2010) relatif à la pêcherie des petits pélagiques de l'Atlantique sud
- Arrêté du ministre de l'agriculture de la pêche maritime n°1175-13 du 27 joumada I 1434 (8 avril 2013) modifiant et complétant l'arrêté n°3279-10 du 10 moharrem 1432 (16 décembre 2010) relatif à la pêcherie des petits pélagiques de l'Atlantique Sud
- Arrêté du ministre de l'agriculture de la pêche maritime n°1332-14 du 16 joumada II 1435 (16 avril 2014) modifiant et complétant l'arrêté n°3279-10 du 10 moharrem 1432 (16 décembre 2010) relatif à la pêcherie des petits pélagiques de l'Atlantique Sud

Focus on the model EwE



Inputs of the EwE model

Predators of sardines (fishbase.org)

Pays	Groupes fonctionnels		Famille	Nom	Intégré Oui/Non	Remarques
Spain	finfish	bony fish	Carangidae	Seriola dumerili	Non	
Azores Is.	finfish	bony fish	Carangidae	Seriola rivoliana	Non	
	finfish	bony fish	Carangidae	Trachurus mediterraneus	oui	
Portugal	finfish	bony fish	Carangidae	Trachurus trachurus	oui	
Portugal	finfish	bony fish	Clupeidae	Alosa fallax		
Spain	finfish	bony fish	Coryphaenidae	Coryphaena hippurus	Non	
Portugal	finfish	bony fish	Merlucciidae	Merluccius merluccius	oui	Pas de prédation au sud
	finfish	bony fish	Scombridae	Sarda sarda	Non	il y a groupe Thonidés
Greece	finfish	bony fish	Scombridae	Scomber scombrus		
Spain	finfish	bony fish	Scombridae	Thunnus thynnus	Thonidés	Groupé en Thonidés
Spain	finfish	bony fish	Scophthalmidae	Lepidorhombus whiffiagonis	Non	
Greece	finfish	bony fish	Serranidae	Serranus cabrilla	Oui	Autres démersaux
Greece	finfish	bony fish	Serranidae	Serranus hepatus	Oui	Autres démersaux
Azores Is.	finfish	bony fish	Synodontidae	Synodus saurus	Oui	Autres démersaux
Spain	finfish	bony fish	Triglidae	Chelidonichthys lucernus	Oui	Autres démersaux
Spain	finfish	bony fish	Uranoscopidae	Uranoscopus scaber	Oui	Autres démersaux
	finfish	bony fish	Xiphiidae	Xiphias gladius	Non	
Portugal	finfish	bony fish	Zeidae	Zeus faber	oui	Autre Poissons benthopelagique
	finfish	bony fish	Sparidae	Oblada melanura	Non	
Portugal	finfish	bony fish	Gadidae	Trisopterus luscus	oui	Autre Poissons benthopelagique
Portugal	finfish	bony fish	Moronidae	Dicentrarchus labrax	oui	Autre poisson pélagique

Inputs of the EwE model

Sardine prey (fishbase.org)

Food I	Food II	Food III	Food name	Country	Predator Stage
zooplankton	plank. crust.	plank. copepods	Acartia clausi	Portugal	juv./adults
zooplankton	plank. crust.	plank. copepods	Candacia armata	Portugal	juv./adults
zooplankton	plank. crust.	plank. copepods	Candacia armata	Portugal	juv./adults
zooplankton	plank. crust.	plank. copepods	Candacia spp.	(not available)	adults
zooplankton	plank. crust.	plank. copepods	Candacia spp.	Turkey	juv./adults
zooplankton	plank. crust.	plank. copepods	Candacia spp.	(not available)	recruits/juv.
zooplankton	plank. crust.	n.a./other plank. crustaceans	Centropages typicus	Turkey	juv./adults
zooplankton	plank. crust.	plank. copepods	Centropages chierchiae	Portugal	juv./adults
zooplankton	plank. crust.	plank. copepods	Centropages spp.	(not available)	adults
zooplankton	plank. crust.	plank. copepods	Centropages spp.	(not available)	recruits/juv.
zooplankton	plank. crust.	plank. copepods	Centropages typicus	Turkey	juv./adults
plants	phytoplankton	dinoflagellates	Ceratium spp.	Portugal	juv./adults
zooplankton	other plank. invertebrates	n.a./other plank. invertebrates	Cirripedia	Turkey	juv./adults
zooplankton	plank. crust.	plank. copepods	Corycaeus spp.	Portugal	juv./adults
zooplankton	plank. crust.	plank. copepods	Corycaeus typicus	Turkey	juv./adults
plants	phytoplankton	diatoms	Coscinodiscus spp.	Portugal	juv./adults
zooplankton	other plank. invertebrates	n.a./other plank. invertebrates	Cypris larvae	Turkey	juv./adults
zooplankton	other plank. invertebrates	n.a./other plank. invertebrates	decapod crustacean larvae	Turkey	juv./adults
plants	phytoplankton	dinoflagellates	Dinophysis spp.	Portugal	juv./adults
plants	phytoplankton	diatoms	Diploneis spp.	Portugal	juv./adults
zooplankton	plank. crust.	plank. copepods	Euterpina acutifrons	Portugal	juv./adults
zooplankton	plank. crust.	plank. copepods	Euterpina acutifrons	Portugal	juv./adults
zooplankton	plank. crust.	plank. copepods	Euterpina spp.	(not available)	adults
zooplankton	plank. crust.	plank. copepods	Farranula rostrata	Turkey	juv./adults
zooplankton	plank. crust.	plank. copepods	Isias clavipes	Turkey	juv./adults
zooplankton	plank. crust.	plank. copepods	Microsetella rosea	(not available)	adults
zooplankton	plank. crust.	plank. copepods	Microsetella rosea	(not available)	recruits/juv.
zooplankton	plank. crust.	mysids	mysids	Turkey	juv./adults
zooplankton	plank. crust.	plank. copepods	Nannocalanus minor	Turkey	juv./adults
zooplankton	plank. crust.	plank. copepods	Oithona nana	Turkey	juv./adults
zooplankton	plank. crust.	plank. copepods	Oithona spp	(not available)	adults
zooplankton	plank. crust.	plank. copepods	Oncaea media	Turkey	juv./adults
zooplankton	plank. crust.	plank. copepods	Oncaea mediterranea	Turkey	juv./adults
zooplankton	plank. crust.	plank. copepods	Oncaea spp.	(not available)	adults
zooplankton	plank. crust.	plank. copepods	Oncaea spp.	Portugal	juv./adults
zooplankton	plank. crust.	plank. copepods	Oncaea spp.	(not available)	recruits/juv.
plants	phytoplankton	diatoms	Paralia sulcata	Portugal	juv./adults
zoobenthos	benth. crust.	benth. copepods	Pleuromamma gracilis	Portugal	juv./adults
zooplankton	plank. crust.	plank. copepods	Pleuromamma gracilis	Portugal	juv./adults
plants	phytoplankton	dinoflagellates	Prorocentrum micans	Portugal	juv./adults
plants	phytoplankton	dinoflagellates	Protoperidinium spp.	Portugal	juv./adults
zooplankton	plank. crust.	plank. copepods	Temora stylifera	Turkey	juv./adults
zooplankton	plank. crust.	plank. copepods	Temora longicornis	Portugal	juv./adults
zooplankton	plank. crust.	plank. copepods	Temora spp.	(not available)	adults

Model considered only microzooplankton, mesozooplankton as prey

Prey for sardine are not dispatched (grouped) or the species shows some preference for particular prey (weighting problem therefore).

Model considered only microzooplankton, mesozooplankton as prey

In the southern zone, phytoplankton dominate sardine intake (Masski et al, 2015).

Inputs of the EwE model

Remarks on diet matrix (South's Model as example)

These groups integrate species that are not predators of sardines. These aggregation of species that do not consume LTL stocks will lead to overall higher connectivity scores of LTL stocks ((Essington and Plagànyi, 2013)

Année	Poulpe	Seiche	Calamar	Autres céphalopodes	Maquereau	Chinchard	Thonidés	Autre poisson pélagique	Maigre	Autre Poissons benthopelagique	Merlu	Autre poissons demersals	Raie	Requins	Cétacées	Phoques	Tortues	Oiseaux marins
2014	0,043	0,0739	0,263	0,055	0,231	0,0037875	0,224	0,03	0,35	0,197	0,5	0,11	0,00993382	0,203	0,02601275	0,03	0	0,341
2010	0,043	0,0939	0,313	0,055	0,231	0,0037875	0,257	0,03	0,35	0,197	0,49	0,117	0,00993382	0,203	0,026	0,03	0,2896176	0,341

Why the différences?

Mainly fed on benthic invertebrates, where epibenthic crustaceans, lamellibranchs and fish were the most important groups in defining trophic guilds (S. Abdellaoui et al, 2017)

Feed mainly on egg and larvae in other areas. In these area the productivity is very hight (upwelling ecosystem) and the predation of egg and larvae seems to be very low.

Are these consistent? : same value suppose no change in dynamic for 4 years!!

Inputs of the EwE model
Additional information

- Analysis of diet for 14 fish species were collected in the Saharan Bank (21–26°N; Eastern Atlantic; Southern Morocco)**(S.Abdellaoui et al, 2017)**

- The selected species were the most abundant demersal fish species in the Saharan Bank; they occupied ranks 1–32 in relative biomass and 1–26 for percentage occurrence

G1 : fish feeders
SG1 : crustacean and fish feeders
SG2 : mollusc and crustacean feeders
SG3 : Mollusc, crustacean and feeders
Chelidonichthys obscurus* and *S. cantharus : crustacean feeders

The rise of the proportion of epibenthic crustaceans in their diet was a common feature, a possible consequence of the benthic productivity of this highly productive upwelling ecosystem.

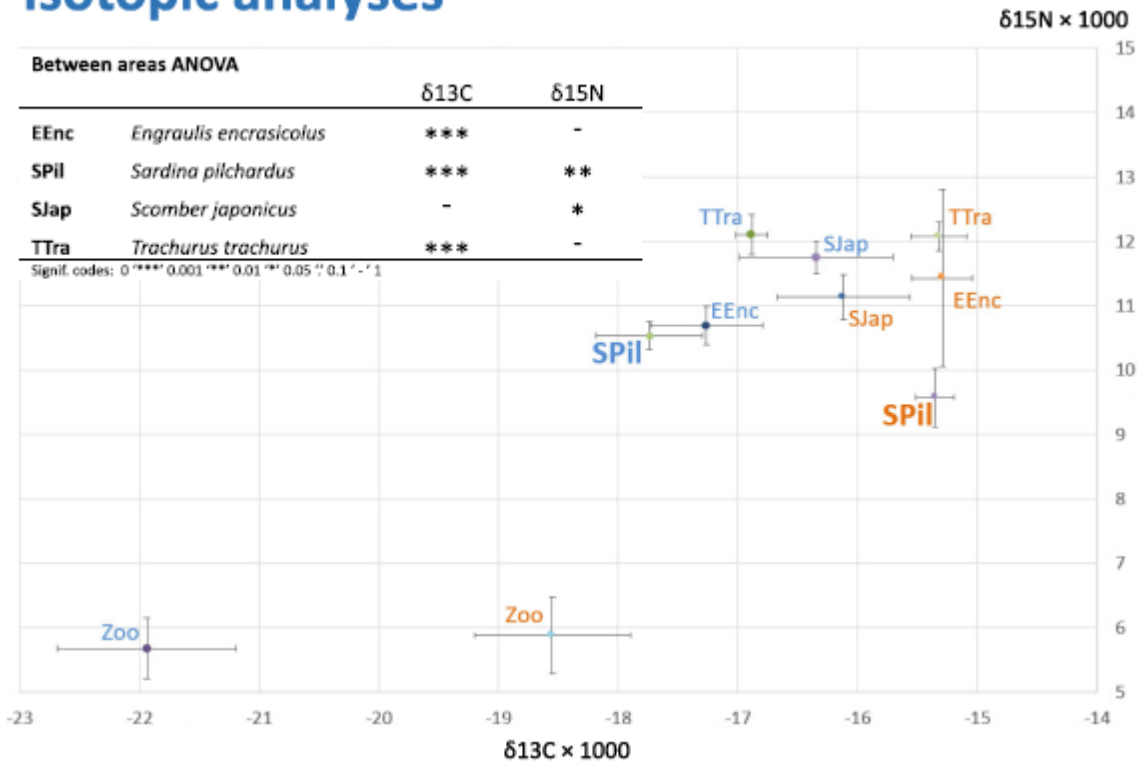
Inputs of the EwE model
Additional information

Isotopic analyses

Between areas ANOVA

		δ13C	δ15N
EEnc	*Engraulis encrasicolus*	***	-
SPil	*Sardina pilchardus*	***	**
SJap	*Scomber japonicus*	-	*
TTra	*Trachurus trachurus*	***	-

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1



Exploring fidelity of forage fish to feeding grounds using stable isotope analyses (C, N) and otolith microchemistry

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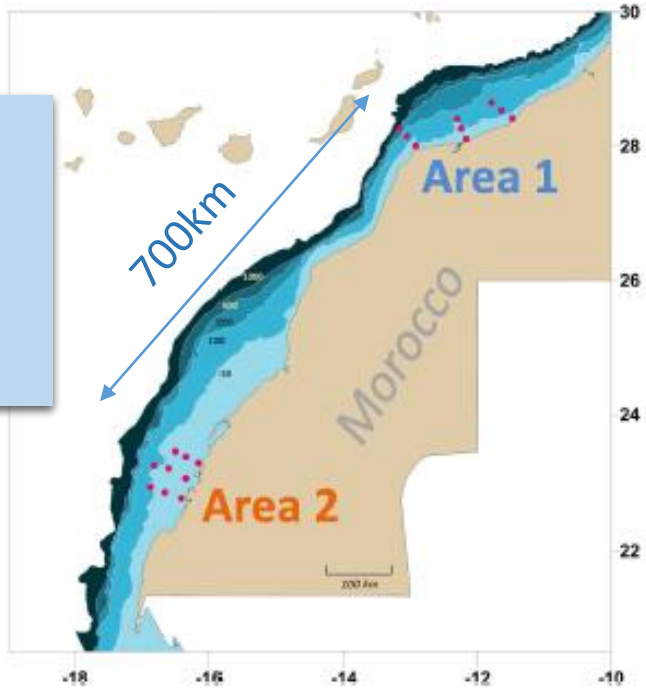
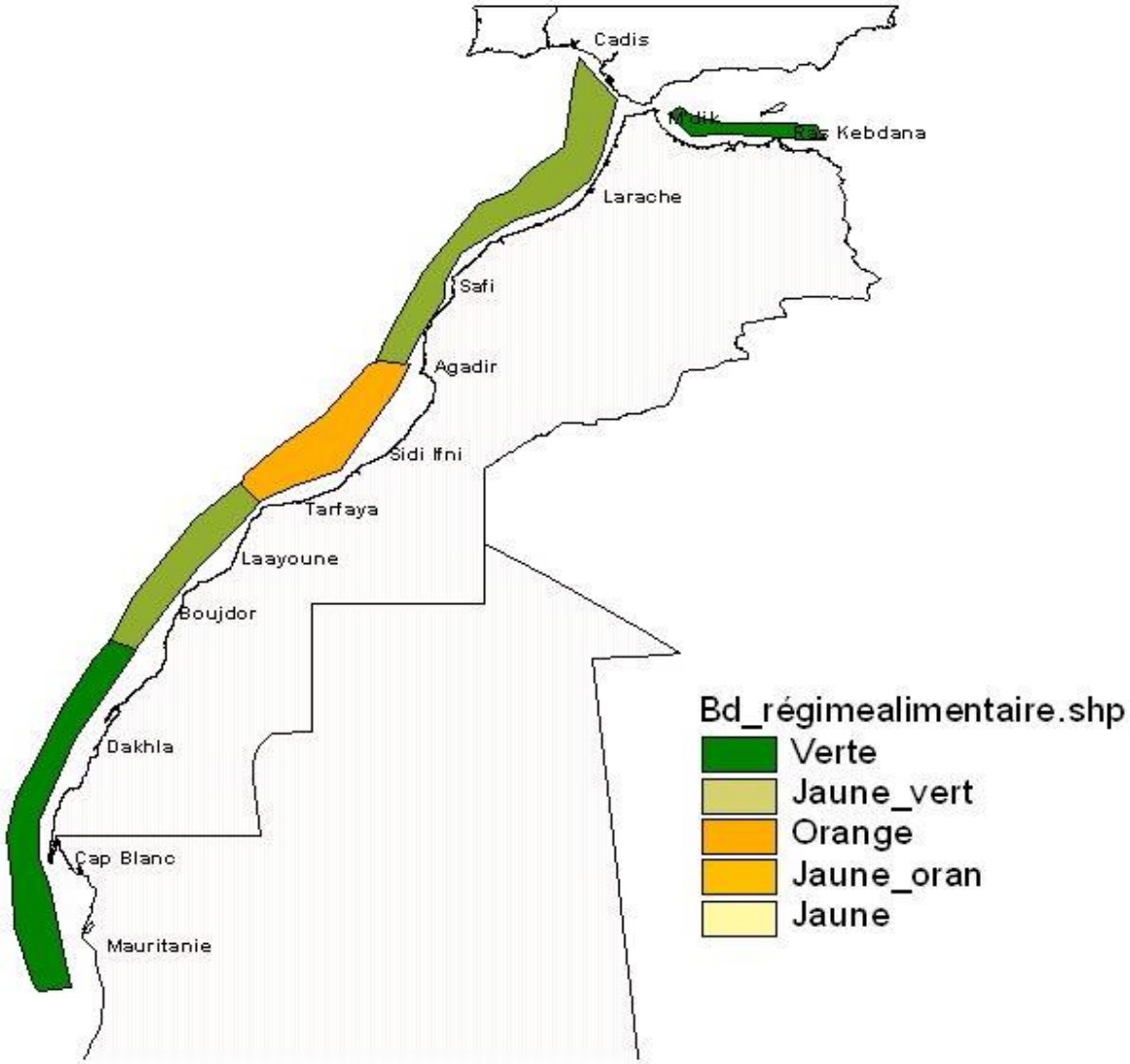
Stable isotope analysis + Otolith microchemistry



- For the southern individuals of sardines , the phytoplankton is more important in their diet
- Significant differences for both sardines and zooplankton between the two areas were found and pointing hig fidelity for sardine individuals towards their feeding grounds
- Sardine Microelements profiles reinforced the sedentary behavior hypothesis of sardine

Inputs of the EwE model
Additional information

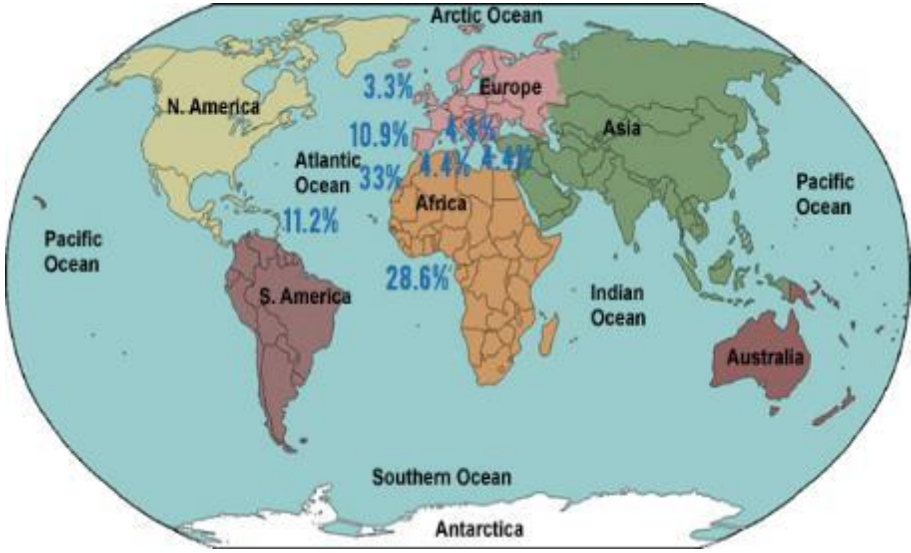


Map of diet elements colors for sardines for the period 2004-2006 (Chlaida and Houssa., 2009)

Inputs of the EwE model

- Some communities such as mesopelagics, which can affect ecosystem dynamics, are not considered by the model. Moreover, there is no biomass relating to these species : work has just started under the EFA Nansen project

- In a context of high pelagic and demersal biodiversity, it is difficult to estimate biomasses for the major number of species
- Some species potentially prey or predators are not taken into account by the model: either they are absent or aggregated in groups and thus their dynamic and impact on the model is not considered. Moreover, aggregation of predator species that are widely known to consume LTL species leads to a reduction in LTL connectivity scores (Essington and Plagànyi, 2013)



- Specificities related to the upwelling system where enrichment, concentration and retention mechanisms could contribute to the enhancement of biological productivity and successful reproduction of organisms (Bakun, 2006).

- Only 33% of the trophic and biomass data come from the studied area, while the other zones have different hydrological and biotic characteristics (no upwelling, biodiversity, …etc.).

Consultant's opinion on the EwE model

Consultant's Remarks

- **Prediction :** the predicted values do not look much like the observed values. In the best case, that of the group of Other cephalopods, the biomasses seem adequately predicted but the catches are not. The model is also unable to predict the evolution of biomasses and catches of other species
- **Precision**: The model suffers from several uncertainties related to the biomass estimates of certain groups.
- **Data :** The effort series are incomplete and do not accurately reflect the actual fishing effort dynamics.
- **Relating to environmental data**, only temperature and chlorophyll are used, or the short time series (7 years) is not enough to understand the complexity of upwellings impact and their effect on system productivity.

Consultant's Conclusions :

- ***It is not recommended to use an Ecosim model for predictive purposes in this project.***
- ***The tests of use of the Ecosim model described above show that there is still a lot of work to do before we can predict the dynamics of this ecosystem.***
- ***Using such a model to explore inter-species dynamics for academic purposes is one thing, but using it for management predictions would be unjustifiable at this stage of knowledge***

Advantages and disadvantages EwE in the actual context

- Model provides an image about the ecosystem and the different relationships between communities. However, the developed model could provide a pedagogical and scientific exploration tool. Quantitative use for management purposes remains haphazard in light of major uncertainties

- Although sardine may be a forage species, it must be treated in the context of Moroccan coasts characterized by specific hydrodynamic conditions. Also, the species develops particular reproductive and recruitment strategies that must be taken into account

- SURF index connectivity is sensitive to a number of decisions about model structure and the way to consider species individually or aggregated (Essington and Plagànyi, 2013)

- When predator groups are not represented in a model, additional diet data should be gathered to more fully capture likely predators in an ecosystem. This may include developing new data matrices that incorporate predator species that are missing from the models (Essington and Plagànyi, 2013)

Some MSC certified fisheries

Essington and Plagànyi, 2013

Table 1. List of stocks and ecosystems in analysis (stocks marked * assumed to be key LTL).

Stock	Certification status	Ecosystem/Area
Anchoveta	Pre-Assessment	Humboldt Current
Sandeel*, Herring, Sprat*	Herring certified	North Sea
Capelin*	Unknown	Barents Sea
Menhaden	Unknown	Chesapeake Bay
Sardine, Anchovy*	Unknown	Benguela
Herring, Sprat	In assessment	Baltic Sea
Herring, Sardine, Sprat	Certified/ In assessment	Celtic Sea
Sardine, Thread Herring	Certified/ In assessment	Gulf of California
Krill*	Certified	Southern Ocean
Cornwall Sardine, Sprat, Herring	Certified/ In assessment/ Unknown	English Channel
Anchovy	Certified	Southwest Atlantic (Argentine and Uruguayan seas) in Food and Agriculture Organisation (FAO) statistical area 41
Mackerel	Certified	International Council for the Exploration of the Sea (ICES) areas II, III, IV, V & VI, VII, VIII, XII and XIV
Herring	Certified	Atlanto-Scandian
Sardine	Certified	Bay of Biscay
Sardine	Unknown	California Current
Sardine	Unknown	Canary Current
Gulf Menhaden, Bay Anchovy*	Unknown	Gulf of Mexico
Small Pelagics (Sardinops, other)	Unknown	Southeast Australia

- **360 fisheries around the world certified MSC and 110 are under evaluation**
- **Only 1 sardine fisheries is assessed like a LTL species**

Conclusions

- Given the complexity of the ecosystem, its particular dynamics and variability and its high biodiversity
- Given the difficulty of developing an ecosystem model dedicated to quantitative management because of the huge uncertainties and shortcomings identified
- Given that the results will have management applications that will impact large fisheries, which fisheries are the source of livelihood for thousands of people

1- It is recommended to take an empirical approach that evaluates all available historical time series on sardines, small pelagics, demersal fish communities and other trophic groups potentially impacted.

2- The analysis of these series shows a stability of the ecosystem with respect to fishing with no evidence that the exploitation of sardine affects the health of other communities.