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RESEARCH ARTICLE

Artisanal fishery of small pelagic: diagnosis and prospects Case of Moroccan Atlantic center.

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Abstract

In Morocco, artisanal fishing is practiced by small boats that use a simple technology and target a variety of species living in coastal areas. However, in the central Atlantic region between Cape Cantin (32°32'N) and Cape Boujdour (26°07N), about 30% of artisanal boats have converted in recent years their fishing activity to the small pelagic resources, historically exploited by the coastal and offshore fleets. This artisanal fleet use the small purse seine deployed at depths generally less than 25 fathoms. In 2014, an important part of small pelagic is landed by artisanal fleet at the central Atlantic region. The sizes exploited are dominated by adult individuals with a primary mode of 15 cm for sardine and 21 cm for chub mackerel. Considering the small pelagic resources dynamism and their instability and in order to assess the impact of the artisanal fishery pressure on these resources, this study illustrates the key indicators of this activity including operating and biological indicators necessary to implement sustainable management strategies.

Introduction:-

Artisanal fishing involves about 90% of the world's fishers (FAO, 2005), with about 200 million people participating in this activity (McGoodwin JR, 2001). In developing countries, these fisheries make an important contribution to food security and poverty reduction (Delgado et al. 2003; Staples D, Satia B; Gardiner PR, 2004 ; Pauly, 2006; Zeller et al ., 2007; FAO, 2008). It is difficult to estimate the real importance of artisanal fisheries in the world economy, but it is generally agreed that it is extremely important (Berkes F, R Mahon, McConney P, 2001; Andrew NL, Bene C. Hall SJ Allison EH, Heck S, Ratner BD, 2007). However, fishing strategies, main target species, fish landings, fishing effort and spatial distribution of artisanal fishing fleets worldwide are neglected in fisheries researches, with only few studies carried out at local and regional scales (Silva L, Gil J, Sobrino I, 2002). The lack of information on artisanal fishing hinders, therefore, the development of sustainable management strategies (Guyader O, Berthou P, Koutsikopoulos C, Alban F, Demanèche S, Gaspar MB et al, 2013). Currently, there is a growing consensus worldwide on the need to implement specific management procedures for artisanal fisheries (Berkes F, 2003).

Recently, small scale fisheries worldwide know an evident dynamism in terms of technical, social and economical aspects. Developed motorization and increased engine power, expanding markets and fisheries subsidies have helped to increase catches and fish trade (Lenselink, 2002). Contrary to industrial fishing, the artisanal fleet is based on investments of small capitals, and is characterized by using several fishing gears (Farruggio et al., 1993), targeting a wide variety of species that represent 5.5% of the world marine fauna (Fredj et al., 1992). Artisanal fishing activities show large variations from one region to another, not only based on different biological and environmental conditions, but also on social, economic and historical contexts where fishermen live (Farrugio et al., 1993).

Monitoring the development of these resources is constrained by the lack of reliable data and information from these fisheries, which are a key to effective fisheries management (Goffinet, 1992). Indeed, in many cases, unreliable fisheries statistics and under-reported data lead to undervaluation of resources and therefore partly explain the failure of many development programs and fisheries management (PNUE, 2004). On the other hand, the rapid development of artisanal and industrial fleet has led to competition or even conflict on fish stocks (Pauly, 2006).

In Morocco, small scale fisheries are a major stakes in the economic and social levels (DPM 2015). In terms of employment, this activity generates over 60,000 direct jobs and over 100,000 indirect jobs. The artisanal fleet is around 15,000 small boats that target different species of small depths (DPM 2014). In 2014, the national artisanal fisheries landed about 55300 tons (DPM 2015), largely intended to supply local market with fresh products. The specific composition of this catch is dominated by small pelagic fish with 50%, demersal fish contributed to 26% of the production while cephalopods constituted 20% (ONP, 2015).

Small pelagic resources constitute the most important fishing potential in the Moroccan Exclusive Economic Zone (EEZ) with almost 80% of the national fishing production (DPM, 2014). These resources are mainly composed by common sardine (*Sardina pilchardus*, Walbaum, 1792), chub mackerel (*Scomber colias*, Gmelin, 1789), horse mackerel (*Trachurus trachurus*, Linnaeus, 1758), european anchovy (*Engraulis encrasicolus*, Linnaeus, 1758), round sardinella (*Sardinella aurita*, Valenciennes, 1847) and flat sardinella (*Sardinella maderensis*, Lowe, 1838). Availability and abundance of these resources are closely related to the environmental factors, in particular the intensity, seasonal and interannual variability of the coastal upwelling occurring in the Grand Canary Ecosystem of which the area is subject mainly in summer (Benazzouz, 2014; INRH, 2015).

In this context, this study aims to assess the development and evolution of the small pelagic artisanal activity over the years and to establish a knowledge state on biological indicators of the small pelagic fishes landed by this fleet. These indicators will help in decision making in the management of this fisheries (INRH, 2015), especially that some targeted fish stocks are considered fully exploited to overexploited and it is imperative to take necessary measures to protect these resources to ensure a rational and sustainable exploitation (HCP, 2006).

Methodology:-

The approach used to diagnose the small pelagic artisanal fishery was derived from studies conducted by Zeller et al. (2007) and Belhabib et al. (2014) by looking for different information sources, assembly the existing data that are supplemented by surveys and investigations with artisanal fishermen.

Study area:-

The study area is the Moroccan Atlantic center area between Cape Cantin and Cape Boujdor (32°32'24" N- 26° 07′ 59″ N). The choice is argued by:

- ❖ The concentration of more than 35% of the national fleet and more than 40% of national production of the artisanal fleet;
- ❖ The importance of small scale fisheries using the seine at the Atlantic coast. This fishery is much more active in the area between Safi and Boujdor;
- ❖ Specialization of some artisanal boats in the small pelagic fishery. Indeed, some boats have special equipment to target the small pelagic species in this region.

Data used:-

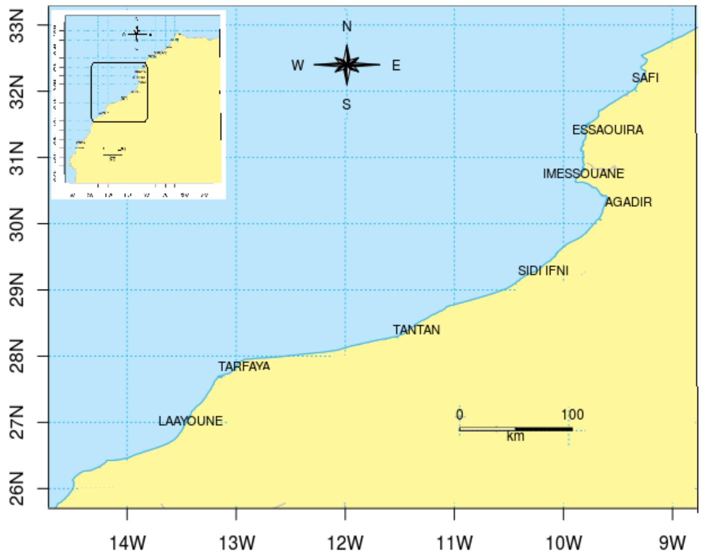
To analyze the issues related to the small pelagic artisanal fishing activity, we used multiple data sources, these are:

- ❖ Data on field surveys conducted by scientists from the National Institute of Fisheries Research (INRH), through the monthly monitoring program of the artisanal fleet. The collected information is related to the equipment of the artisanal boats, the fishing gear dimensions, areas and fishing effort, catch species and value;
- ❖ Average spatial distributions of sardine and chub mackerel at the Moroccan central Atlantic area, established from acoustic surveys carried out by the research vessel "AL Amir Moulay Abdellah" (R/V AMA-INRH) during the period from 2003 to 2013;
- ❖ Data on the technical characteristics of the artisanal boats from the Department of Marine Fisheries (DPM), namely the name of the boat and the registration code, the fishing port, the power engines and exerted activity ;
- ❖ Available fishery statistical data on the artisanal fleet for the period between 2011 and 2014 from the National Office of Fisheries (ONP). They concern the fishing port, the name of the boat and the registration code, the fishing day, the species fished, catch and selling value;

- Data from the biological sampling of the artisanal landings. Data collected concern the total length (Lt) measurements, weight of each individual, sex determination and sexual maturity stages.

Sampled ports and sampling system:-

Sampling focused on the most important ports of the study area where the small pelagic artisanal fisheries occur. These ports were selected using the official statistics data supplemented by surveys conducted along the Moroccan Atlantic coast. These sites are shown in the following map.



Map 1: Geographical location of the study area at the Moroccan Atlantic coast

Concerning sampling system:

- The selected sites were visited monthly in order to collect the information concerning the operating indicators (effort and catch). In total 65 field surveys were conducted in 2014;
- The sampling target population consists of active artisanal boats targeting small pelagic resources with purse seine (the fishing unit) and which are selected randomly;
- Samples of landed fish are collected and measured. Measurements concern the total length of individuals. In total 3230 individuals of chub mackerel and 428 individuals of sardines were analyzed.

Selected Indicators:-

The indicators used for this work are chosen so as to allow assessment of trends in relation to sustainable development objectives (Garcia, S. M. 1997). They consist of operational and biological indicators:

Operating indicators:-

- The technical specifications of the artisanal boats: engine power, equipment and load capacity;
- The dimensions of used fishing gear: length, width and mesh size;
- Operation and fishing techniques: description of the fishing unit, the frequented fishing areas (distance to the port and from the coast, depth);
- Fishing effort and production: the number of fishing trips made by the artisanal boats and landed quantities for each species.

Biological indicators:-

- The trend in the demographic structure: it shows the length ranges in the landed catches;
- The sex ratio: is defined as proportion of each sex determined by macroscopic observation of gonads in the samples.

The $\chi 2$ test was used to compare proportions of sex. It involves testing the equality of observed and theoretical values: $\chi^2_{obs} = \Sigma\,(n_{obs} - n_{the})^2 / n_{the}$

Where n_{obs} is the observed number of sex in samples and n_{obs} is the theoretical number calculated of sex in samples.

Null hypothesis supposes that we have equal sex ratio while the alternative claims that we have a significant difference between the sex proportions:
If $\chi_{obs} < \chi\ \mu$; 0.05, null hypothesis is accepted. If $\chi_{obs} > \chi\ \mu$; 0.05, null hypothesis is rejected.

- The length-weight relationship: It is also used in fish biology to estimate the changes that can cause the growth morphology of the species. It results in the equation: $W (t) = aL^b$

Where W (t) is the weight at age t, L is a total length, a is the intercept and b is allometric coefficient. a and b are determined by fitting the linearized function using logarithm to the observed data.
Two cases are distinguished:
If b>3, the weight is growing faster than the length and allometry is majorant.
If b<3, the weight is growing slower than the length and allometry is minorant.

- The size at first maturity (L_{50}): Knowledge of this size is very useful in determining the minimum legal size. It corresponds to the total length at which 50% of specimens achieve the sexual maturity. The sexual maturity stages are determined on the basis of FAO macroscopic scale (1978) which comprises five stages (Stages I and II: period of sexual inactivity; Stage III: maturing; Stage IV: spawning and stage V: post-spawning). For sardines and chub mackerel, stages 3 to 5 corresponding to maturing. The size at first maturity was deduced using the theoretical maturity curve that corresponds to the regression between P and the fish size.

$$P = 1 / (1 + e- (a + b * L))$$ (Pope et al 1983)

Where P is a mature proportion by class size, L is a total length, a is an intercept and b is a slope. The linearization of this formula by introducing the natural logarithm gives: $-\ln ((1 – P) / P) = a + b * L$
The regression between Ln (P/1-P) and total length (L) allows the estimation of a and b. So $L_{50} = -a / b$

- Linear growth: we are interested in the mathematical model of individual growth developed by Von Bertalanffy (1938), which is the most used in fish biology as it was compatible with the observed growth of most fish species.

This model is represented by the following equation: $L (t) = L \infty (1-\exp -K (t-to))$
Where L (t) is the total length at age t, $L\infty$ is the asymptotic length, K is the growth coefficient and t_0 is the theoretical age at which the average length is zero.

Results and Discussions:-

Operating Indicators:-

Under 2014, the active artisanal fleet (Table 1) is around 15,000 boats realizing a production of about 55300 tons, while the selling value is 1.7 billion Moroccan Dirhams “MAD” (1.00 $ USA equal 9.8 MAD). The central Atlantic area contributed by 40% in weight and 26% in value.

Table 1 :- Importance of artisanal activity by region in 2014 (ONP, 2015 ; INRH, 2015)

Moroccan regions	Number of active boats (%)	Weight (%)	Value (%)
Mediterranean area	16,2	7,8	9,2
Northern area	16,2	5,2	6,4
Central area	34,7	39,6	25,8
South area	32,9	47,4	58,7

Central Atlantic area is the largest in terms of production with more than 53% of coastal and artisanal national production in 2014 (ONP, 2015) and more than half of national landings in small pelagic fish (INRH, 2015). The artisanal fleet contributes at 5% to the catch with a declared total puncture of 22,000 tons corresponding to a value of more than 440 million MAD. This catch is dominated by small pelagic with 50%, followed by demersal species (Sparidae) with 26% and cephalopods (octopus, cuttlefish and squid) with 20% (Figure 1). Various and different fishing Gears are used: Nets (simple gillnet, trammel nets and purse seines); long lines (bottom long lines at sea bream, drifting long lines and hand lines; octopus and squid fishing jigs as well as traps.

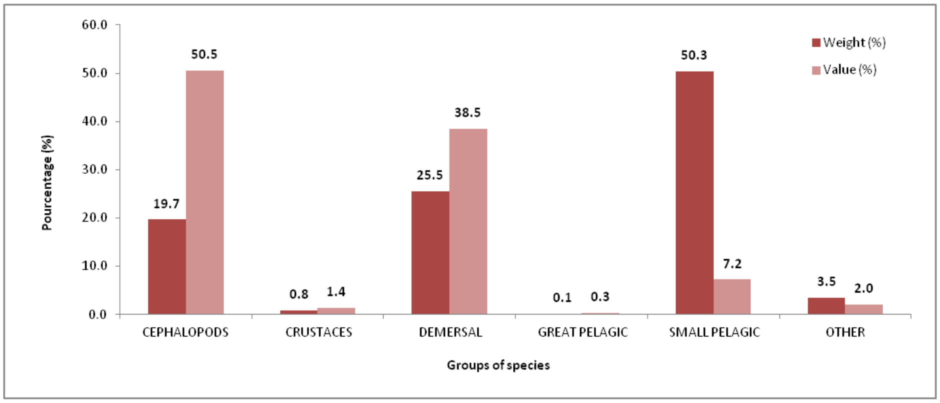


Figure 1:- Diversity by species group of landings of the artisanal fleet at the Atlantic central area in 2014

❖ Distribution of artisanal boats:-

In the Atlantic central region, artisanal activity is practiced by more than 5000 small boats from 37 sites including 7 ports, 4 fishing villages (VDP) and 7 managed landings points (PDA). The number of fishing units targeting small pelagic in this area is around 1600 boats representing approximately 30%. The ports of Sidi Ifni, Agadir, Tarfaya and VDP of Immessouane concentrate about 70% of these units in this region (Figure 2).

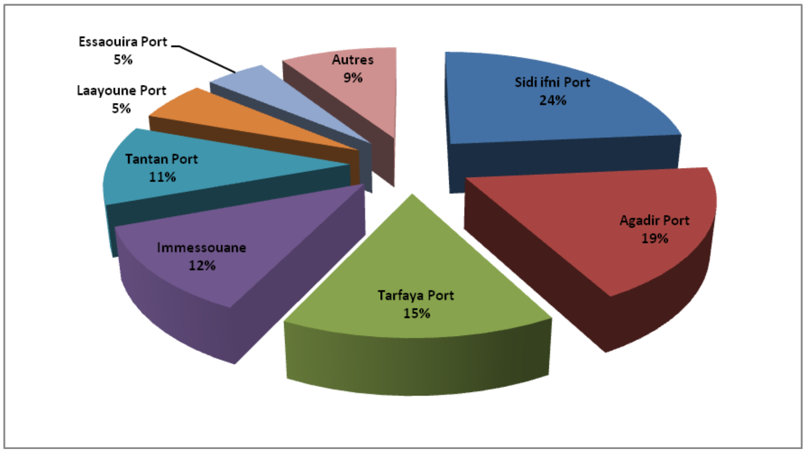


Figure 2:- Distribution of artisanal boats operating with a purse seine at the central Atlantic area

According to surveys carried out by the INRH scientists, the fishing unit consists of one to three boats of the same size, while the groups of two boats are the most operted. The first boat is carrying the crew and the purse seine while the second carries the catch. The engine is located outboard and the mean power is between 15 and 18 Horse Power (HP). The majority of these boats are equipped with sonar, VHF radio, GPS and winch.

The boats loading capacity practicing small pelagic fishery varies between 1000 and 1500 kg with a maximum of 2000 kg of fish. The ice transported in order to condition the fish varies between 0 and 300 kg.

❖ Gear and fishing operation:-

The purse seine used by artisanal fleet is a rectangular net, supported in surface by a headline floats. It is held vertically by the weight of the rope from the bottom in order to allow the purse seine to reach the quickly bottom (Roullot et Fahfouhi, 1984). In general, the length of the purse seine is between 90 and 160 fathoms and the width between 10 and 18 fathoms. The mesh size is 9 mm.

Almost all fisheries targeting pelagic species benefit from the gregarious character of pelagic fish and produce great catches using efficient gear (Freon, 1999).

The artisanal boats are prospecting fishing area ranging up to 25 nautical miles on either side of the port of departure. The depth varies between 8 and 25 fathoms. In general, once the fish is detected, its size is measured using the "sonar". The first boat bypasses the fish that will be trapped by closing the bottom part of the purse seine.

The catch is concentrated gradually by pulling the net to board the boat. The catch will be loaded into the hold of the secondary boat.

❖ Catch and fishing effort:-

Two types of fleets target small pelagic in the Moroccan central Atlantic area: coastal seiners and the artisanal fleet. Given the unavailability of historical statistics related to artisanal fisheries, the analysis was limited to the period between 2011 and 2014. The trend of the annual catch of artisanal activity targeting small pelagic shows a clear upward trend with an increase of around 200% in this period. Indeed, the number of boats has increased from 1046 boats in 2011 to more than 1600 boats in 2014 with an increase of 55% (Figure 3). Fishing effort has also increased from 9000 trips to more than 17000 trips (Figure 4). Catch has also increased by 200% from 3400 tons to over 10000 tons (Figure 5).

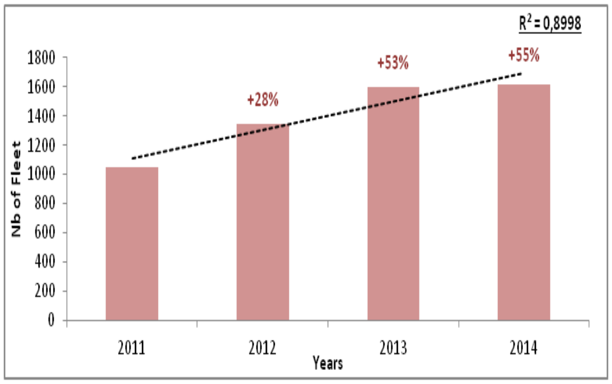


Figure 3:- Annual number of artisanal fleet targeting small pelagic species during the period 2011 and 2014

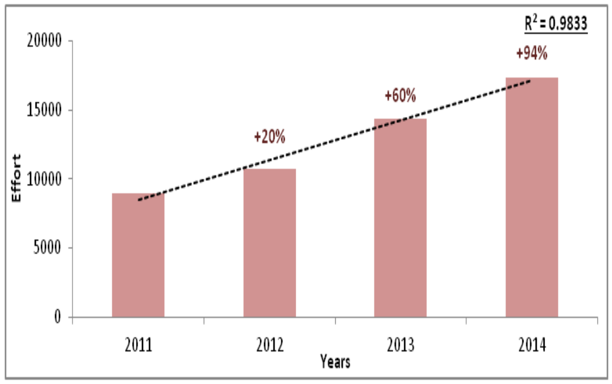


Figure 4:- Annual fishing effort of artisanal boats targeting small pelagic during the period 2011 and 2014

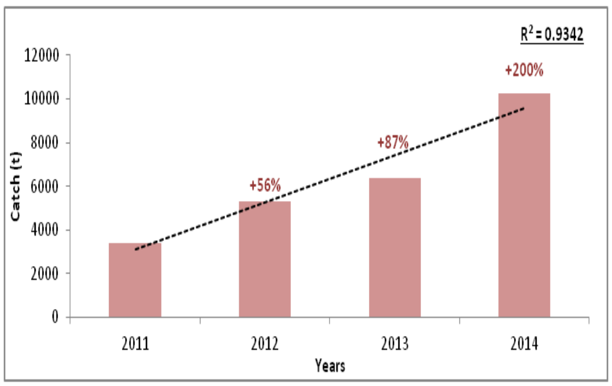


Figure 5:- Annual artisanal catch of small pelagic during the period 2011 and 2014

In terms of species, sardine (*Sardina pilchardus*) and chub mackerel (*Scomber colias*) dominated the artisanal catch and they present more than 80% of the production of small pelagic fish in the Atlantic central region.

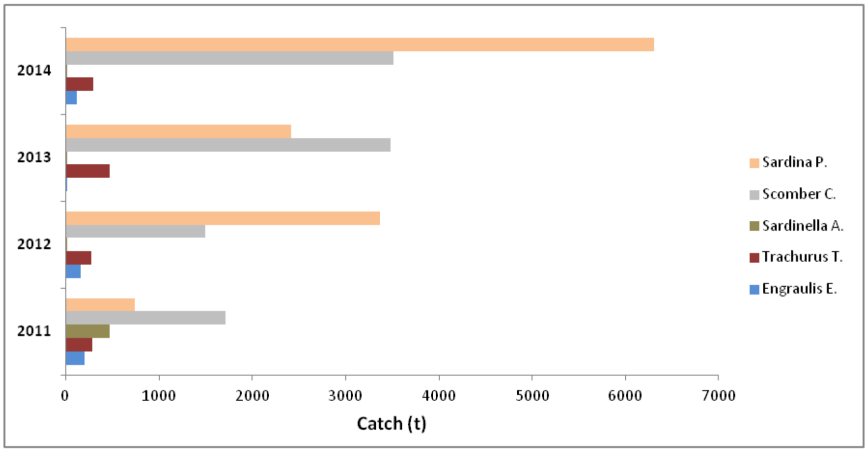


Figure 6:**-** Annual evolution of production of small pelagic species in the period between 2011 and 2014

The ports of Sidi Ifni, Tarfaya, Agadir, Essaouira and the VDP of Immessouane include on average 98% of the artisanal catch of small pelagic resources at the central Atlantic area. The main port is Sidi Ifni who alone participated with 50% of the artisanal catch in central Atlantic area. The evolution of the small pelagic catch over the past four years is illustrated by the graphs below.

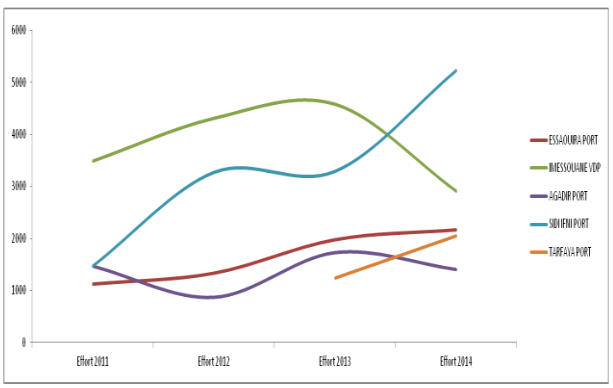


Figure 7:**-** Annual evolution of artisanal fishing effort of small pelagic in the main ports during the period from 2011 to 2014

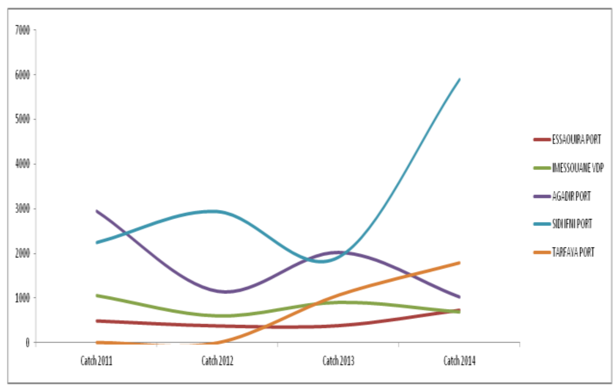
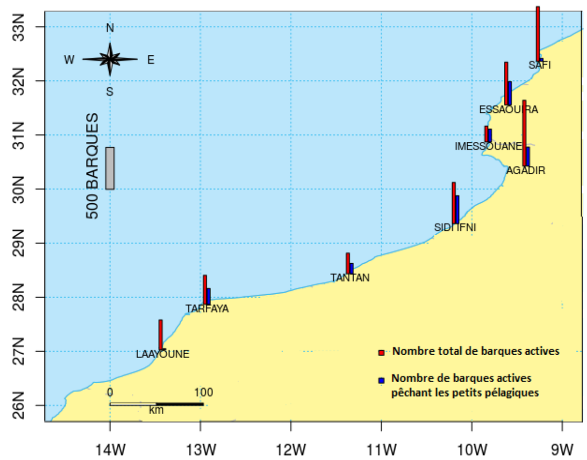
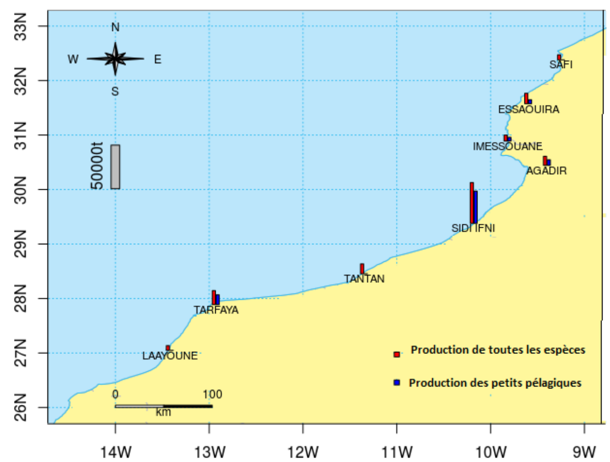


Figure 8:**-** Annual evolution of the small pelagic catch of in the main ports during the period from 2011 to 2014

The importance of landings at the port of Sidi Ifni might be explained by an important fishing effort which represents 31% of the entire effort of the central Atlantic region and also by the availability of the resource in the surrounding areas of the port. The maps below (Maps 2 and 3) illustrate the importance of this activity in terms of the active fleet and catch. Indeed, the results of the sea surveys in this area conducted in the autumn 2014 by the Moroccan research vessel “AL Amir Moulay Abdallah”, have shown that the distribution of the sardine is continuous throughout the coast with highest densities located at the coastal band on both sides of Sidi Ifni and at Tan Tan (INRH, 2015). Concentrations remain also important north between Safi and Essaouira. The distribution is continuous between Agadir and Tarfaya. As for sardines, chub mackerel has also a very broad and continuous distribution. High concentrations were detected at Cape Cantin. The largest concentrations are further offshore along the area between Sidi Ifni and Tarfaya. Further south, a relatively large density is near the coast south of Laayoune (INRH, 2015).



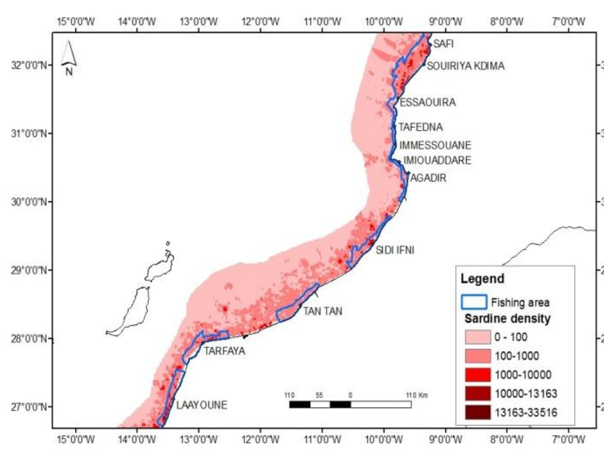
Map 2:- Importance of active artisanal boats fishing small pelagic



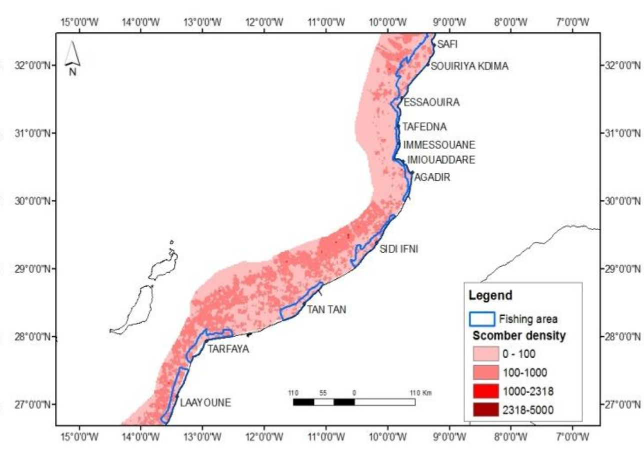
Map 3:- The importance of small pelagic catches by artisanal fleet

Indeed, in the case of sardines, most of the production is carried out at the port of Sidi Ifni with over 90% of catches. The average spatial distribution map produced through acoustic surveys confirmed the important presence of this species in fishing areas invested by the artisanal boats near the port (Map 4), but they did not reveal a significant difference in terms of densities compared to other ports. Indeed, this high production can be explained by the importance of the fishing effort targeting this species, which represents in 2014 approximately 35% of the total effort in the central area, as a result of strong demand from the market consumption and transformation industries.

The catches of chub mackerel are dominated by the landings in the port of Tarfaya which alone presented 51% of central Atlantic area production, while fishing effort represented only 12% in this area in 2014. As noted by the average spatial distribution map, the highest concentrations of chub mackerel are located further offshore, usually less accessible to artisanal boats operating in more coastal area (Map 5). This high production could partly be due to the accessibility of concentrations of this species in the southern part of the port of Tarfaya which is characterized by a very narrow continental shelf compared to other regions of the central area and then the concentrations of mackerel in this area are nearer.



Map 4:- Average spatial distribution map of sardine with the fishing area of artisanal fleet



Map 5:- Average spatial distribution map of chub mackerel with the fishing area of artisanal fleet

Biological indicators:-

The sardine is a coastal small pelagic living in abundant dense schools, inhabiting the depths from more or less 25 meters (m) to 80 m in the day and from 15 to 40 m at the night (Holden et al. 1974). Its distribution depends on the water temperature; the most favorable temperature is between 12°C and 20°C with an optimum between 16°C and

18°C (Furnestin, 1952). For chub mackerel, it is highly bound to surface waters that can exceed 30 meters (FAO, 1998). The movement of this species is generally governed by the seasonal dynamics of isotherms ranging in 19°C to 20 °C.

❖ lengths structure of landings:-

The analyze of temporal variations of lengths frequencies gives an idea of the demographic structures of the species and provide indicators on the state of exploited stocks. The lengths frequency distribution was determined from the sampling on artisanal boats landings, weighted to the catch of the day, the month, the port and finally to studied region. During 2014, a biological sampling on the artisanal fleet landings has covered the two main species, sardines and chub mackerel, mainly at the ports of Agadir and Essaouira.

The demographic structure of the sardine shows a bimodal distribution: A major mode is at the size 15 cm while a secondary mode is located at the size 19 cm. Concerning chub mackerel, the demographic structure has a bimodal shape, the main mode is located at 21 cm while the second mode is located at 17 cm. The sampled sizes range from 12 cm to 21.5 cm for sardines and from 13.5 cm to 30.5 cm for chub mackerel (Figures 9 and 10).
The average length is about 15.6 cm for sardines and 20.2 cm for chub mackerel. According to the study of Barkova, the population of sardines located between latitudes 20°N to 28°N is characterized by relatively large lengths ranging from 6 cm to 27 cm while the lengths of the north population located between latitudes 28°N to 35°N are distributed from 4.5 cm to 21 cm (Barkova et al., 2001).

Sardines grow rapidly especially during the first year of life. Longevity does not exceed 6 years in the central Moroccan Atlantic (Amenzoui, 2010). Females typically grow faster than males. The maximum size is 28 cm and was observed in the south regions of Laayoune and Dakhla (INRH, 2015).

The growth of chub mackerel is rapid during the first years of life and gradually slowed after sexual maturity (Krivospitchenko, 1979). It can achieve a maximum fork length of 50 cm while the common size is generally between 15 and 30 cm (FAO, 1998).

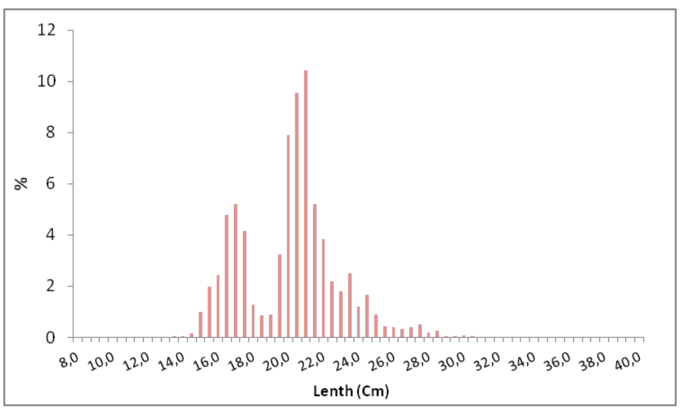


Figure 9:- Demographic structure of chub mackerel landed by the artisanal fleet in the central Atlantic area in 2014

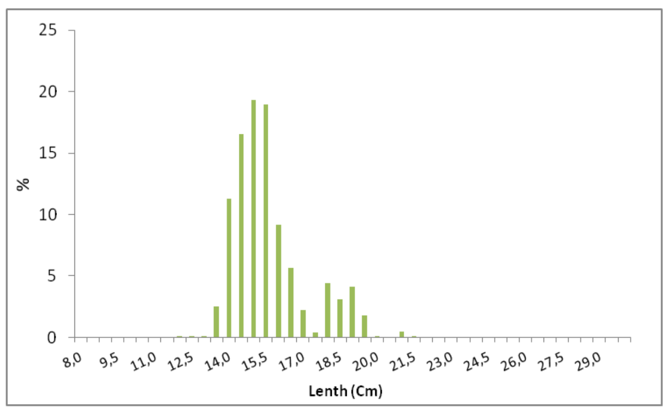


Figure 10:- Demographic structure of sardines landed by the artisanal fleet in the central Atlantic area in 2014

❖ Growth:-

Weight gain: The length-weight relationships of sardines and chub mackerel fished in the central Atlantic region by artisanal fleet show that the coefficient of allometry (b) is significantly greater than 3, indicating majorant allometry where weight increases proportionately more quickly than the size. The graphs below show the weight of some sampled individuals according to their sizes (INRH, 2015). The parameters (a and b) are very sensitive to monthly sample numbers and the size composition of each species (Fréon, 1988). This variability of the length-weight relationship is linked to that of trophic conditions (Furnestin, 1957; Somoue, 2004) and hydrological condition (Makaoui, 2005).

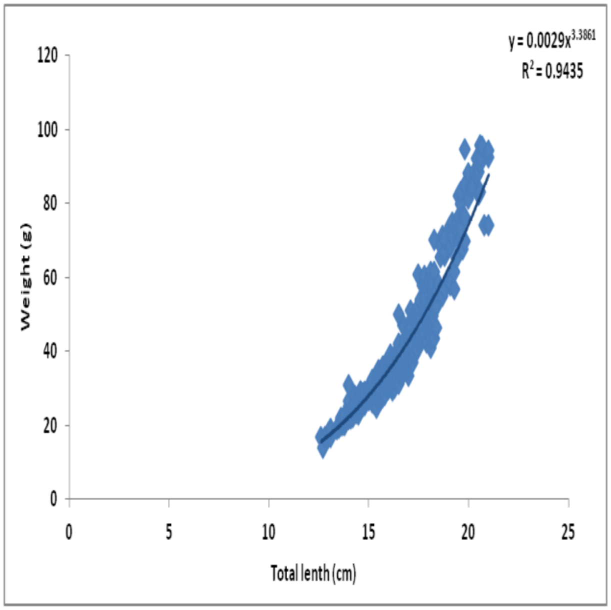


Figure 11:- length-weight relationship of sardine landed by the artisanal fleet in Atlantic center area in 2014

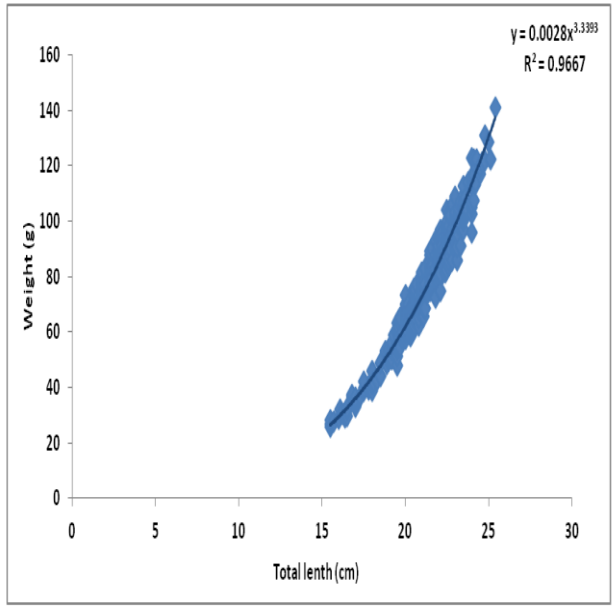


Figure 12:- length-weight relationship of chub mackerel landed by the artisanal fleet in Atlantic center area in 2014

Linear growth: Von Bertalanffy Parameter (L∞, K and t0) were estimated using the software FISAT ELEFAN program using sample sizes of structures of the artisanal fleet realized mainly at the ports of Agadir and Essaouira. The table below shows the growth the results of the parameters.

Table 2:- Von Bertalanffy Parameters estimated by various studies

Species	Reference/Areas	Type of fleet	L_∞ (cm)	k	t_0
Sardines	This study	Artisanal	25.50	0.40	-0.69
	INRH, 2015	Coastal	31.9	0.59	-0.56
	Amenzoui, 2010 (Moroccan Atlantic center, « Agadir port»)	Coastal	21,21 (M) 21,34 (F)	0,29(M) 0,27(F)	-4,11 (M) -4,91(F)
	Amenzoui, 2010 (Moroccan Atlantic center, « Laayoune port »)	Coastal	28,11 (M) 29,25 (F)	0,29(M) 0,24(F)	-2,36 (M) -2,79 (F)
	Delgado et al. 1985 (Moroccan Atlantic)	Coastal	21,6	0,88	–0,129
	Kada et al, 2010 (Moroccan Mediterranean)	Coastal	21,3	0,56	–0,67
Chub mackerel	This study	Coastal	33.49	0.23	-0.86
	INRH, 2015	Coastal	35.78	0.27	-0.78

(M: Male) and (F: Female)

It should be noted that the theoretical maximum size (L∞) depends on the size of the sampled individuals. Generally, this size may fluctuate in relation to the region, the gear used and the type of fishing.

❖ Reproduction and maturity :-

Sex ratio: For sardines and chub mackerel, the sexes are separate and there is no external sexual dimorphism, dissection of individuals is necessary to determine the sex and sexual maturity.

309 individuals of sardines and 325 individuals of chub mackerel were sampled at the central Atlantic area. The proportions of male and female sampled are shown in the table below.

The sex ratio is in favor of females. It is about 56% for sardines and 69%, for chub mackerel; this difference between the sexes was statistically tested and was significant for the two species (Table below). This result reached is the same as the results found by several authors. Indeed, for the "Clupeidae", Boëly (1980) concluded that females are slightly more likely than males. In the Balearic Islands, Andreu & Rodriguez-Roda (1952) also notes a significant predominance of females, particularly during the breeding seasons.

Table 3:- Sex ratio of sardines and chub mackerel of artisanal fleet sampled at the Moroccan Atlantic center

Species	Number of males	Number of females	$\chi2$ obs	$\chi2$ (1 ; 0.05)	Rule decision
Sardina pilchardus	135 (44%)	174 (56%)	4,91	3,84	Significant difference between proportions of sexes
Scomber colias	87 (31%)	193 (69%)	40,13	3,84	

This predominance of female sardines was also reported in Moroccan Atlantic (Belvèze, 1984; Amenzoui et al., 2006) and in the northern Spanish coast (Garcia et al., 1991). Conversely, male sardines dominate the Senegalese coast (Fréon and Stéquert, 1979) and in the Aegean (Cynahgyr, 1996). However, a balanced sex ratio has been mentioned in some populations of sardines like the Moroccan coast (Belvèze and Rami, 1978; Barcova, 2001) and the Canary Islands (Mendez-Villalmil Mata et al., 1997).

First maturity length: Overall the length (L_{50}) to which 50% of sardine specimens was mature is calculated trough this sampling, while for chub mackerel, it was not possible as almost all of the sampled chub mackerel individuals where immatures.

The L_{50} of the sardine is estimated to 13.73 cm (figure below). The following table shows different L_{50} values of sardines calculated in different regions and years.

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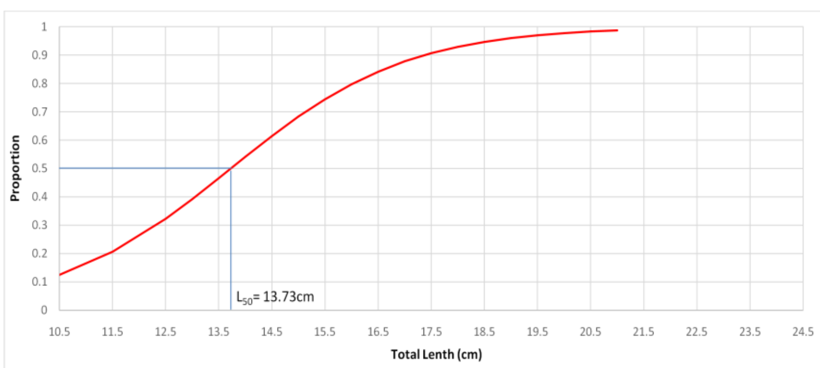

Figure 13:- Length at first sexual maturity of S. pilchardus caught by artisanal fleet in central Atlantic area

For chub mackerel, immature individuals are present all the year, with a high abundance from April to November. According to (INRH, 2015), the highest proportions of mature fish are recorded between November and March-April, while individuals in spawning season are greatest between December and February.

Table 4:- The size at first maturity of sardines and chub mackerel by various study

Species	Reference	Type of fleet	Area	L_{50} of both sex (cm)	L_{50} of male (cm)	L_{50} of female (cm)
Sardines	This study	Artisanal	Moroccan Atlantic center	13,73		
	INRH, 2015	Coastal	Moroccan Atlantic center	13,17		
	Amenzoui et all, 2010	Coastal	Moroccan Atlantic center (Agadir port)		14,1	14,4
	Amenzoui et all, 2010	Coastal	Moroccan Atlantic center (Laayoune port)		15,4	15,9
	Perez *et al.* (1985)	Coastal	Galicia		15	15,2
	Mendez-Villamil Mata *et al.* (1997)	Coastal	Canary Islands	15,5		
	Barcova (2001)	Coastal	Moroccan northern Atlantic	13,9		
	Silva *et al.* (2006)	Coastal	Southern Portugal	16,2		
	Silva *et al.* (2006)	Coastal	Mauritania	14, 5		
Chub macherel	INRH, 2015	Coastal	Moroccan Atlantic center	23,61		
	INRH, 2014	Coastal	Moroccan Atlantic center	21,52		
	Wahbi et all, 2011	Coastal	Moroccan northern Atlantic	21,62		

Conclusion:-

Artisanal fishing of small pelagic is an important activity in terms of exploitation, technological and socio-economic levels. The present study was conducted to illustrate the importance of this fleet in the Moroccan central Atlantic region, and highlight the development of this activity over time by producing operating indicators of the fleet and biological indicators of the main landed species. Knowledge of these parameters is essential for proper management of this fishery.

Those results based on official statistics and surveys confirm the significant importance of small pelagic artisanal fisheries in this area which is one of the most important region in Moroccan fisheries.

Therefore, the increase in this activity, its overlap with other fleets in the same fishing zones, its quick development in capacity and fishing technology will certainly lead to increased competition on small pelagic resources in many regions of the Moroccan coast. This deserves more scientific follow-up for sustainable management objectives of those primordial resources in the Moroccan fisheries.

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