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Estimation of biological and economic parameters of the sardine population: Case of the Moroccan Centre Atlantic

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Abstract

The present study aims to realize, analyze and to make recommendations of management for the small pelagic fisheries in the Central Atlantic Morocco. To be done, the work will consist primarily on a descriptive examination of the fisheries, then on a combined study of two types of analyses. The first one is the technical-economic and financial analysis; and the second one is the bio-economic analysis, based on MEFISTO model. This analysis showed clearly that the recommended fishing effort to answer the objectives of fisheries management of sardine, should range between 170 and 180 day/year. This corresponds to an average reduction in 10% compared to the total effort currently observed. These proposals would seem to be the best to apply without damaging neither the biomass nor the fishing activity. In the same way, the analyses showed that to maintain levels of sustainable profits and to preserve the investments in the sardine fisheries, the authorities intervention is sincerely recommended if the fuel prices increase more than with the currently observed thresholds.

Key words: biological and economic parameters; Sardine population; Moroccan Centre Atlantic; Northern Zone; Zone A; Zone B; Zone C.

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1 Introduction

Through this present paper, we will attempt to present the analysis methods that can allow us to understand the mechanisms and to approach as possible the reality that going fishing activity. Thus, the definition will be presented in the fishery studied the biological and demographic parameters of the stock, as well as economic and technical data. Will also be presented the methods of obtaining or estimating each data and the tools and methods of analysis.

The choice of base year is mainly justified by the availability of data on one hand and on the other, by recency order to apply the results of socio-economic surveys to be undertaken in 2015. Thus, we retain the 2014 for reference. Having said that all the variables or biological, technical and economic parameters that represent the bio-economic basic status of the fishery in 2014 correspond to the year $0(t_0)$ of the bio-economic model.

The study area is defined in terms of geographic coordinates as the area of the Atlantic Ocean that corresponds to the hosting of the central stock of Moroccan sardine area (Figure 1). This area is related to the area A between Safi and Sidi Ifni (32 ° 30N, 29 ° 30'N) and the B area between Sidi Ifni and Cape Bojador (29 ° 30'N-26 ° N).

The resources exploited are the species targeted by the small pelagic fishery, including the sardine (Sardina pilchardus), anchovy (Engraulis encrasicolus), Spanish mackerel (Scomber japonicus) and horse mackerel or horse mackerel European (Trachurus trachurus).

The evolution of the annual production since 1983 of all pelagic species in the study area shows that the production of sardine remains the most dominant both in terms of weight and in terms of value (Figure 2 and 3). The production trend is on the rise even though it has fluctuated over the years. The sardine is considered to be the main target species by purse seiners of the Moroccan Atlantic center.

Other species, including anchovy, mackerel and horse mackerel present production levels low in weight and value. Thus, they are considered secondary species for purse seiners in the area. Other species are also caught but very low production. These species, of negligible value, were not considered in this study.

In summary, this study, sardines will be treated as the main species targeted by purse seiners operating in the study area and anchovy, mackerel and horse mackerel as the secondary target species.

After an evaluation of this Nile perch fishery for the period 1986 – 2000, when it constituted more than 60% of the catch, it is evident that a severe over fishing problem exits and that the fishery has never been managed for economic efficiency. All economic rent from this fishery has been and continues to be dissipated. The effort in 2000 is 64% higher than that required to take MEY and 44% higher than that required to harvest MSY.

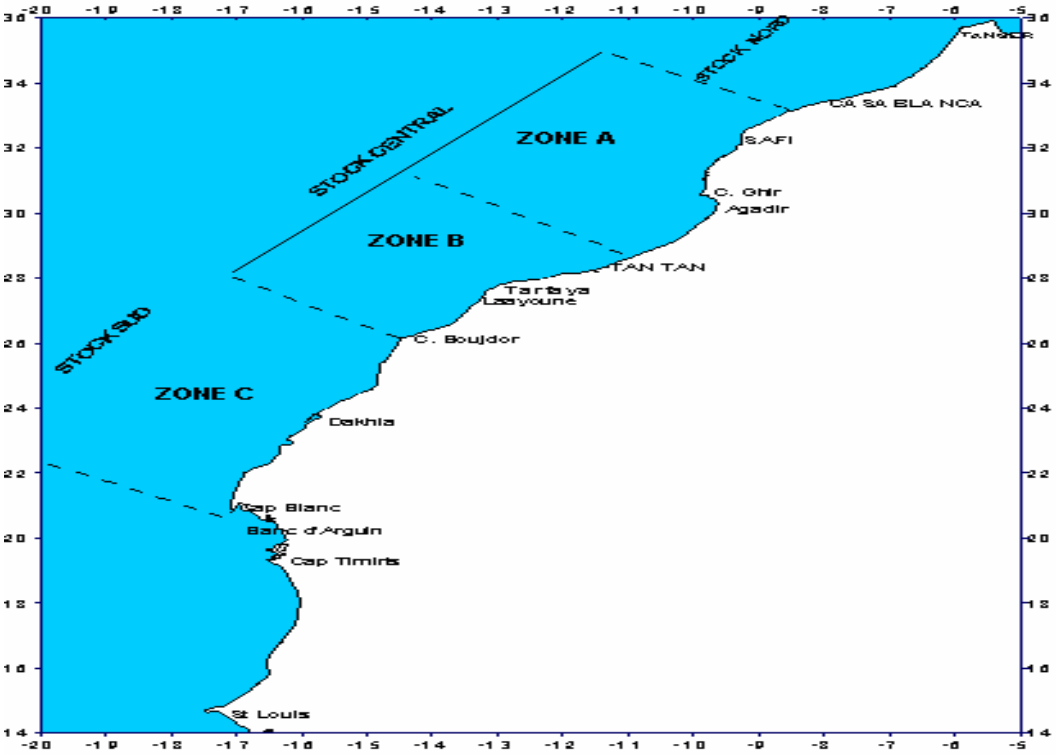

Figure 1: Spatial identification card stocks Moroccan sardine.

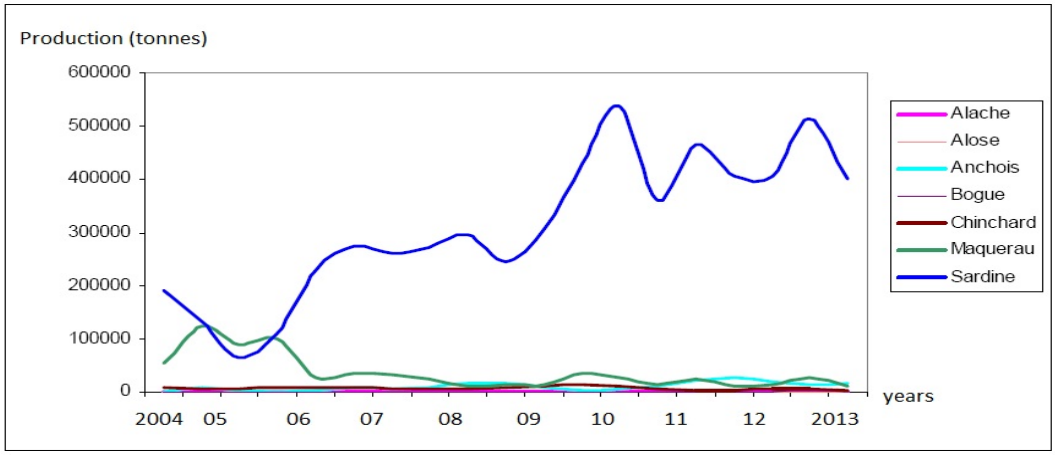

Figure 2: Production of small pelagic species in Central Atlantic Morocco between 2004 and 2013 (in terms of weight).

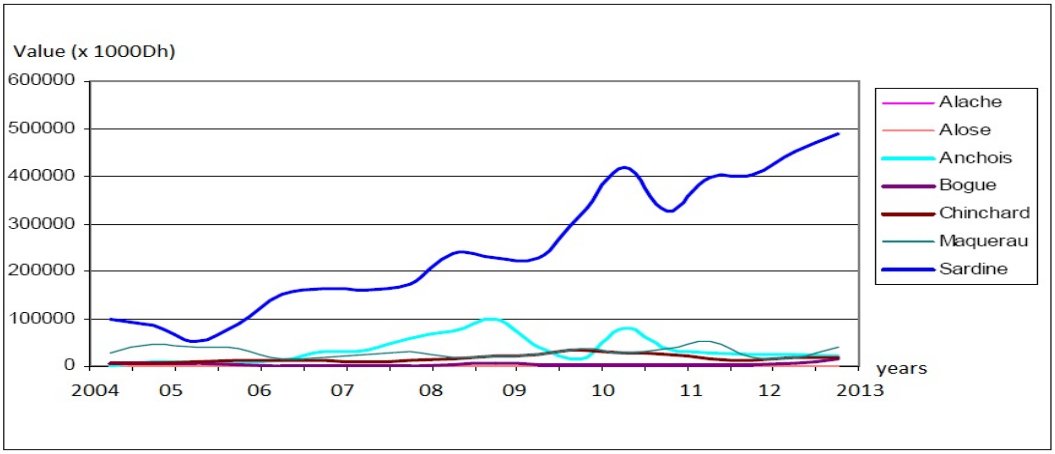

Figure 3: Production of small pelagic species in Central Atlantic Morocco between 2004 and 2013 (in value terms).

The total cost of fishing effort at OAE is 44% higher than that at MSY and 62% higher than that at MEY. The total cost of fishing effort at MSY is 33% higher than that at MEY.

This open access fishery is the victim of excess fishing effort which, seems to be growing even further whilst harvests plummet. The objectives of fishery management often based but not entirely on political considerations, should be subjected to economic analysis to determine their consequences on the fishery. The resultant optimal management strategy should in addition incorporate views of all stakeholders in both design and implementation.

The sardine found off the Northwest African coast, mainly between Cape Spartel and Cape Blanc, is divided in four fishing zones (Figure 4):

Northern Zone:	35°45'N-32°N	(Cape Spartel-Eljadida)
Zone A:	32°N-29°N	(Safi-Sidi Ifni)
Zone B:	29°N-26°N	(Sidi Ifni-Cape Bojador)
Zone C:	26°N-Southwards	(Cape Bojador-Southern extent of species)

For evaluation purposes, the various stock units have to be defined. This problem was highlighted during the first working groups on the sardine. The first studies looking into this were carried out by Furnestin (1950-1970). Since the seventies different biological studies have taken place to clarify this point, particularly on morphometry and meristics, the number of vertebrae (Krzeptowski, 1975-1978; Bravo de Laguna et al., 1976; Belvèze and Rami, 1978; in FAO, 1978); the study of proteins by electrophoresis (Baron, 1972; Thompson, 1974; Omeltchenko, 1975; Barkova et al., 1976; Biaz, 1976), etc.

Based on the results of these studies, at the time of the 1978 Working Group

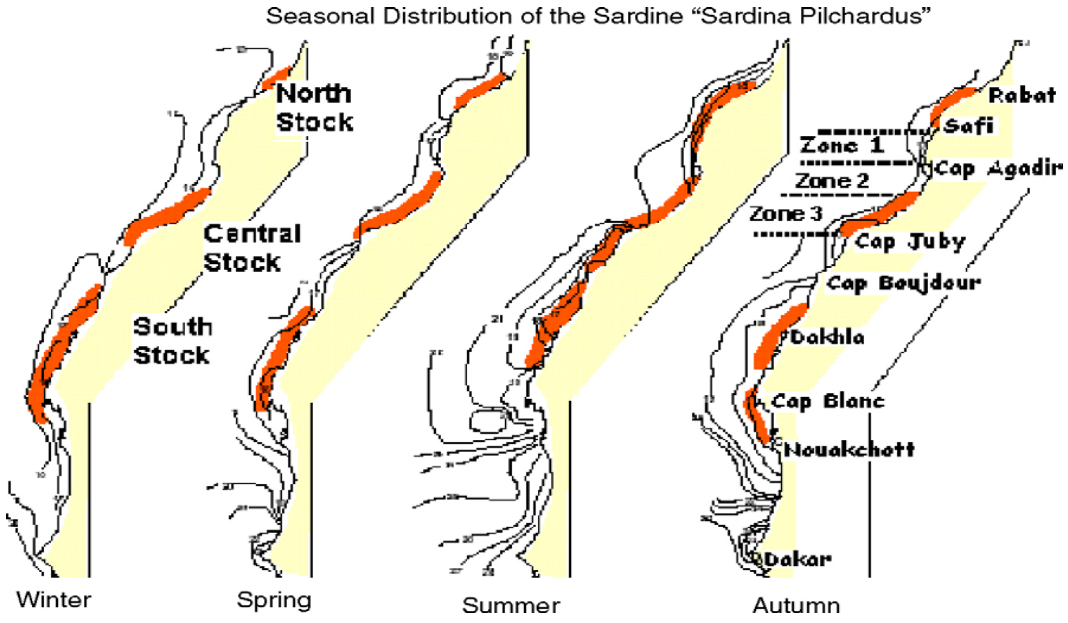

Figure 4: Seasonal distribution of Sardina pilchardus along Moroccan Atlantic coasts.

(FAO, 1979) the evaluation of the sardine in Zones A, B and C was carried out as if they were distinct stocks. After observations made on the migration of sardines from Zone A to Zone B however, evaluation was limited to two distinct stocks, Zones A+B and Zone C.

The Working Groups which followed (FAO 1985, 1990, 1997) chose to adopt three separate stocks:

Northern Stock	(35°45¢N-32°N)
Central Stock	(32°N-26°N) (Zones A+B)
Southern Stock	(26°N- the southern extent of the species) (Zone C)

The evaluation of sardine was made on two stocks: The Central Stock (Zones A+B) and the Southern Stock (Zone C) (Figure 4).

Recent studies on sardine distribution between the 35°N and 19°N parallels have shown the existence of two sardine populations (28°N-35°N) and (27°N-20°N). One study on sardine stock identity, based on methods such as genetics, is currently being carried out by the National Fisheries Research Institute of Morocco (INRH).

2 The fisheries

In the whole of the CECAF zone, four sardine fishing grounds have developed from the north to the south. The fleets operating in these fishing grounds are

very diverse and composed of traditional small purse seiners, freezer-purse seiners, pelagic trawlers and mother ships with their purse seiners.

2.1 Northern Zone (Cape Spartel-Eljadida)

A Moroccan fleet composed of around a hundred traditional-type purse seiners (gross tonnage 40 tones and 250 HP) operates in this area, based for the most part in the ports of Larache and Casablanca, the landings from these two ports represent over 80% of the sardine catch for the whole Northern Zone. During the last ten years, whereas the fishing effort of the fleet has remained stable, sardine catches have decreased, passing from the 24 000 tones registered in 1993 to less than 5000 tones in 1999.

2.2 Zone A (Safi-Sidi Ifni)

This zone is fished exclusively by the Moroccan fleet. The number of purse seiners operating in this zone is around 150 during the fishing season (May-September). The fishing effort of these purse seiners which have the same characteristics as those that operate in the Northern Zone, is progressively decreasing (in terms of positive trips). The catches have also been declining since the beginning of the 90s.

2.3 Zone B (Sidi Ifni-Cape Bojador)

Since 1983 the Moroccan fishing fleet has become quite important in Zone B following the transfer of a part of the fleet that operated in Zone A to the new ports of Tan Tan, Laâyoune and Tarfaya, which were opened respectively in 1982, 1989 and 1994. From 1990 to 1999 the total number of active vessels in this zone was around 200, with a gross tonnage of between 50 and 55 tones and an HP of between 250 and 300. The average annual catch of the fleet was 350 000 tones.

The Spanish fleet, composed of purse seiners, has traditionally fished for sardine between the Straits of Gibraltar and Cape Juby. Part of this fleet, coming from peninsular Spain, fished in the zone north of Casablanca, while the other part of the fleet, based in the Canary Islands, fished in Zone B. In 1976 the total number of vessels was forty purse seiners with an average gross tonnage of 130 and around 400 HP engines. Since then there has been a progressive decline in the size of the fleet.

2.4 Zone C (Cape Bojador-the southern extent of the species)

Two types of fleet operate in Zone C: the purse seiners (Moroccan and Spanish) and the pelagic trawlers (Russian, Ukrainian and others).

The Moroccan fleet is composed of approximately ten purse seiners operating in the Dakhla zone. The Moroccan catch from this zone has been increasing since 1996.

In 1983 the fleet that began working in Zone C was made up of thirty vessels with a gross tonnage of 214 tones and 659 HP on average. Smaller vessels were replaced by larger ones, but always within the limits established by the fishing agreements signed by Morocco and the European Union. In 1995 the fleet had been extended by eleven vessels of which 70% were between 250 and 500 GRT.

Since 1996 the fleet of Spanish purse seiners has only fished in Zone C following a transfer of effort imposed by the last fishing agreement between Morocco and the EU which was signed in 1995. The conditions of this agreement made provision for an annual closure to fishing during February and March and that the fishing zone which had originally been established at two nautical miles from the coast be moved to fifteen miles from 1998.

In the Zone north of Cape Blanc, the number of Russian vessels operating within the framework of the Morocco-Russian fishing agreements was between 14 and 12 from 1995 to 1999 with a quota of between 200 000 tones and 90 000 tones.

During this period, catch and effort of the trawlers has undergone changes connected to the conditions established by the fishing agreement. After 1996, the sardine quota for the Russian vessels was fixed at 5% of the total annual catch. The Russian fleet during this period targeted mackerel, horse mackerel and other species.

In addition the annual closure to fishing between September and October was required to meet the conditions of the fishing agreement mentioned above. Furthermore, the fishing zone established beyond twelve nautical miles from the coast was changed to twenty-five miles.

The other pelagic trawler fleets (Ukrainian and others) operating on a charter basis, increased from fifteen vessels in 1995 to twenty-seven vessels in 1999. These charter vessels land their catch at the ports of Laâyoune and Agadir.

It should also be noted that it is forbidden to fish for pelagic fish along the coast for 15 nautical miles between 24°-25°N. This measure was put into place in 1998 in order to replenish sardine stocks.

In Mauritania, the Russian pelagic trawlers are geared towards horse mackerel, mackerel and sardinella fishing. The sardine catch in the Mauritanian EEZ is not important. Sardine is also caught by EU and other fleets south of Cape Blanc, but it is not the target species.

3 Sources and description of data

The data used in the bio-economic modeling were based in part on biological sampling data, carried out on the landings of small pelagic port of Agadir in the year 2014 the other hand, on data technical and economic collected from government and on the basis of interviews and socio-economic surveys of fishermen. Collected data is carefully processed to test their degree of adaptability to the peculiarities of bio-economic model employee.

All data concerning biological sampling were carried out by the department of fisheries resources at the Regional Center of the National Fisheries Research Institute (INRH) in Agadir (Table 1). These data were collected as part of the program of the service said on monitoring the structure of the landings of the fishing effort of the sardine fleet and biological sampling of catches at the port of Agadir.

Species	Fishing Areas						Total	
	Cap Cantin-		Cap Juby-		Cap Bojador-			
	Cap Juby		Cap Bojador		Cap Blanc			
	Stock central (Zone A+Zone B)				Stock C			
	2003	2004	2003	2004	2003	2004	2003	2004
Sardine	660	840	330	430	4400	5730	5390	7000
Round sardinella	--	--	--	--	930	1110	930	1110
Flat sardinella	--	--	--	--	220	570	220	570
Atlantic mackerel	20	2	5	6	290	162	315	170
Mackerel cunene	--	--	--	--	850	580	850	580
Mackerel	210	340	15	15	320	150	545	505
Anchovy	8	32	4	5	18	43	30	80

Table 1: Instantaneous biomass of small pelagic estimated based on direct assessments in November-December 2003 and 2004 (in thousand tonnes).
Source : INRH & IMR 2003 - 2004.

For each operation biological sampling, a sample of approximately 3 kg of sardine is taken at random from commercial purse seine catches to determine the size composition of the catch. The sampling strategy is simple type of random and that the plugs are placed in bulk in the holds. The biological parameters collected correspond to the size, weight, sex, maturity stage and gonad weight by sex. Otolith are also collected and stored for use in the reading of the age. The measurement of height is performed using a ichtyomètre and total length (L_t), taken from the tip of the snout to the tip of the tail is measured at less than $\frac{1}{2}$ cm. The weight of each specimen was measured using a precision balance to nearly 0.1 g (NHRI-Agadir, 2014).

4 Estimation of biological and demographic parameters of stock

The parameters required to start the bio-economic program (MIFESTO) are expressed through those equations trimmers weight and linear growth.

The parameters a and b of length-weight relationships were estimated based on the formula Ricker (1980): $P = aL^b$, where P is the fish weight (in grams); L is the total length (cm); b is the condition factor or constant Allometric; and a is the proportionality constant. The results obtained for sardine (sexes combined) are $a = 0,0067$; $b = 3,061$.

The growth parameters of the equation of Von Bertalanffy (1938) were also estimated through the basic equation: $L(t) = L_\infty \left(1 - e^{-K(t-t_0)}\right)$, where $L(t)$ is the length of poison; L_∞ is the total length of the fish if it continues to grow indefinitely; K is the growth rate; t_0 is the theoretical age as the fish if its size is theoretically zero; and t is the age of the fish.

The L_∞ and K parameters can be estimated from simple linear regression called Ford Walford what the form : $L_{(t+1)} = \bar{a} + \bar{b}L(t)$, where $L(t)$ is the size of fish at time t (year); $L(t+1)$ is the size of fish at time $t+1$; $\bar{a}$ is the constant; and $\bar{b}$ is the slope. Thus $L_\infty = \frac{\bar{a}}{1-\bar{b}}$ and $K = -\ln \bar{b}$. t_0 is determined for each age group by the following formula: $t_0 = t + \frac{1}{K} \ln \frac{L_\infty - L_t}{L_\infty}$. The results obtained for sardine (sexes combined) are: $L_\infty = 29.598$ cm; $K = 0.22$; and $t_0 = -2.6$.

The proportion of mature individuals by size class (L) is estimated based on the equation of Bakhyokho (1980): $P = \frac{1}{1+e^{-(\tilde{a}+\tilde{b}.L)}}$. The size at first maturity is considered to be the size at which 50% of individuals are mature: $L_{50} = -\frac{\tilde{a}}{\tilde{b}}$, where $\tilde{a}$ and $\tilde{b}$ are regression coefficients and L between the size of the natural logarithm of the percentage fraction of the mature individuals and immatures: $\ln \frac{p}{1-p} = \tilde{a} + \tilde{b}L$.

It should be noted that the only observable stock fraction is analyzed. We define therefore the recruitment age as the one corresponding to younger individuals observed (age 0 for the case of the sardine). The recruitment function considered for testing the quality of data in the zero state simulation is of type: $R = N_0 e^\epsilon$, 'constant recruitment' with random variability.

To start the model while considering the variability in prices and in the recruitment of sardines, the recruitment function chosen is linear with random variability: $R = (\alpha_3 + \beta_3 SSB_{t-k})e^\epsilon$ with R is the recruitment and SSB mean biomass spawning stock. α_3 and β_3 are parameters to be estimated on the basis of a series of R and SSB, estimated every year with virtual population analyzes.

Natural mortality (M) was estimated based on the method of Pauly (1980) using the software FISAT-II (Fish Stock Assessment Tools) (FAO, 2002). This method requires knowledge of the average annual temperature of the medium.

The empirical equation of Pauly for estimating natural mortality is as follows: $\log(M) = -0,0066 - 0,279\log(L_\infty) + 0,6543\log(K) + 0,4634\log(T)$, where L_∞ is the asymptotic total length of the fish; K is the constant growth function Von Bertalanffy; and T is the average annual temperature of the medium.

The average annual temperature of the medium is estimated for the entire Atlantic coast of Morocco at $19.35°C$. The average temperature is calculated based work Orbi A. et al in 1998 based on the average temperatures of surface waters observed during the 1997 winter season ($19°C$) and the summer season of the same year ($19.7°C$). This temperature was confirmed by H. El Habouz 1998-1999 Atlantic Moroccan center as part of the project SARVAL.

The application of the method to give a natural Pauly sardine mortality of about 0.56.

Von Bertalanffy parameters					Natural	Number of
a	b	L_∞	K	t_0	mortality (M)	cohorts
$0,0067$	$3,0610$	$29,6000$	$0,2200$	$-2,6000$	$0,5600$	$7,0000$

Table 2: Biological and demographic parameters of the sardine stock.

5 Estimated data interactions

In addition to biological parameters available, starting the simulation program requires the establishment of a baseline on the initial state of the stock. This implies the need to have the vectors of fishing mortality and the initial number of individuals by age (F and N) class. F and N were estimated using a virtual population analysis (VPA) by using the VIT program (Lieonart and Salat, 1997). The main results are prepared in Table 3:

Age cohorts	Sexual Maturity	Number of individuals	Fishing mortality (F)
0	0,1996485	1902301836	0,044
1	0,5299009	1040280427	0,833
2	0,9284522	258350890	0,717
3	0,9997889	72069578	0,185
4	1	34209229	0,241
5	1	15355904	0,093
6	1	7988799	0,024

Table 3: Estimated data of sexual maturity, the number of individuals and fishing mortality by age group.

Due to lack of selectivity and studies Catchability, valuescorresponding to these variables have been given so as not to influence on the basic model. Thus, these data were estimated as follows:

- The selectivity factor $S = 1$.
- Coefficient of initial catchability $qa = 1$.

For proportions Release sardine boat and age class (d), it was estimated that they are void. Indeed, fishermen check the molds of fish after being caught and even before removal. In addition, the part that does not match the legal or machined molds, quality requirements or market saturation is practically designed for plants byproducts.

6 Estimation of parameters related to the sardine market

With regard to the technical data, namely the characteristics of the vessels (Tonnage Gross Tonnage (GRT), motor Engine power ...), they were collected at the Delegation of Marine Fisheries in Agadir (DPM-Agadir).

Regarding the socio-economic data, it is to distinguish between official data, such as on landings, obtained from the National Board of Fisheries (ONP), and data collected on the basis of interviews and socio-economic surveys of owners, fishermen and accounting officers of the sector. And to cover all categories of boats, missing data were collected by homogeneous groups of boats in each group and a representative sample was considered.

In the small pelagic fishery, the owner receives a premium fillet from the buyer. An allowance equal to 10% of sales in the case of fish for the canneries and 45Dh / tonne in the case of fish for the plant byproducts.

Accounting point of view, the premium is considered to be an additional source of income for the owner. The problem is that MEFISTO 3.0 does not take into account such data. Therefore, in order to adapt to the requirements of this bio-economic model used, the premium was added to the remaining income after subtracting the common costs and the share of income accruing to the amateur was recalculated to 47% instead of 40% which is the part of the shipowner obtained by the sharing system known in the region. The recalculated share, or 47%, is the one in the database MEFISTO.

As for the estimation of parameters related to the sardine market, regressions were performed on the basis of data collected from the ONP:

(i) The regression coefficient of the relationship between age (or mold, ie number of individuals per kg) and the price of sardines is estimated at $g_2 = -0.005$. This value means that the increase of the size of the sardine automatically does not mean an increase in the price thereof. This can be explained by the fact that the canneries especially looking fish of average size corresponding to mold around 25 units/kg. Therefore, the large fish may be diverted to the plant by-products at

lower prices.

(ii) The regression coefficient between the price and production of sardine is zero. This value is justified by the fact that the prices of sardines are fixed for the tonnages for the canning factories and byproducts. The value used for this study is the null value; $g_3 = 0$.

(iii) The relationship between the production of secondary species "C_j" (anchovy, mackerel and horse mackerel) and the production of the main species "C_i" (sardine) is expressed by the following equation: $C_j = 21140 + 0,2809.C_i$; $R2 = 0.60$.

7 Discussion and conclusion

Two types of analyzes are to be realized through this study:

(A) Technical, economic and financial analysis of the fishery, which will focus on the following: (i) Analysis of the technical characteristics of the boats; (ii) Analysis of the fishing effort; (iii) Analysis of the organization of the fishery and marketing of fishery products; (iv) Analysis of indicators of social returns (employment generated, sharing systems, income, investment ...); (v) Analysis of the cost structures of the purse (labor costs, common costs, expenses to be borne exclusively by the owner); (vi) Analysis of the operating accounts; (vii) and Comparative analysis of the profitability of vessels by class GRT.

(B) A bio-economic analysis conducted on two levels: (i) The first level of analysis is to introduce changes management alternatives or parameters to test the response of the elements of the modules to these changes. The data will be processed sardine in this case, regardless of the differences between the possible trading opportunities (fish Tide, canned fish for the factory by-products). (ii) The second level of analysis will aim to make projections into the future while taking into account the different categories marketed sardine. This analysis will assess the impact of change management measures on the structure of production locations and therefore respond to the problem of lack of information on the relationship between measures of management and development of sardine. This analysis is necessarily based on the assumption of the absence of the effect of other factors in the short and medium term, ie for example the development of infrastructure, transport.

From a practical point of view, the performance of this analysis requires some technical adjustments in the database used for the bio-economic model. This gave rise to a new database based on virtual three species of sardines, all considered key in the fishery and have the same biological parameters. These three virtual cash match: (i) Sardine 1: Sardine intended for human consumption or fish tide; (ii) Sardine 2: Sardine for canning; (iii) and Sardine 3: Sardine for mills byproducts.

The analysis assumes as if the sardine stock is divided into three sub-stocks. A virtual population analysis (VPA) is needed to re-estimate the missing data for each virtual species (vectors of fishing mortality, the initial number of individuals in each age group).

Initial production of each virtual case is the base year 2014 on different parts of sardines intended to major shopping outlets (food, canned and byproducts) (Table 4).

	sardine1	sardine2	sardine3	Freezing	Total
	(Tide)	(Preserve)	(Byproducts)	and Bait	sardine(kg)
Weight	124.428.595	147.466.195	261.066.787	26.940.130	559.901.707
Percentage	22%	26%	47%	5%	100%

Table 4: Key trading opportunities sardine during 2014.

Given that the destination of the production seiners studied is not always the same for each boat, it is assumed in this second analysis, there is only one fleet that operates simultaneously on three under Virtual sardine stocks .

The concept of division of the sardine stock into three virtual stocks corresponding to the three possible business opportunities, is essentially based on the normal laws of supply and demand of fish and therefore subject to availability and based on the price of each category of fish.

- Average price of sardines for human consumption =1,841Dh/kg.
- Award for sardine canning (fixed price) = 1,636Dh/kg.
- Award for sardine factories-products (fixed price) = 0,405Dh/kg.

In both of these analyzes will be simulated the baseline to zero state. And thereafter, different scenarios will be reconstructed by changing the parameters and management measures.

The working methodology emphasizes the importance of combining between two types of analysis: analysis of the economic structure of the fishery and bio-economic analysis that considers scenario simulations in the future. The main limitation of this method of work, is the fact that the analyzes require a very large base of data to be collected and, in the absence of good information sources, data quality becomes weak and scientific certainty the results obtained are set games.

Excluding depreciation and the opportunity cost, the analysis of the overall structure of operating costs and costs related to taxes and finance charges (Figure 5) shows a clear dominance of the cost of work which alone occupies more than half the cost, or 51.10%. Common expenses are in second with 29.89%. In third place are the running costs incurred solely by the owner with a percentage of 10.21%. The remaining costs are split between the two entries for interest expense (5.74%) and general income tax (3.06%).

Common costs rank second in total costs with 29.89% (Figure 5). These ex-

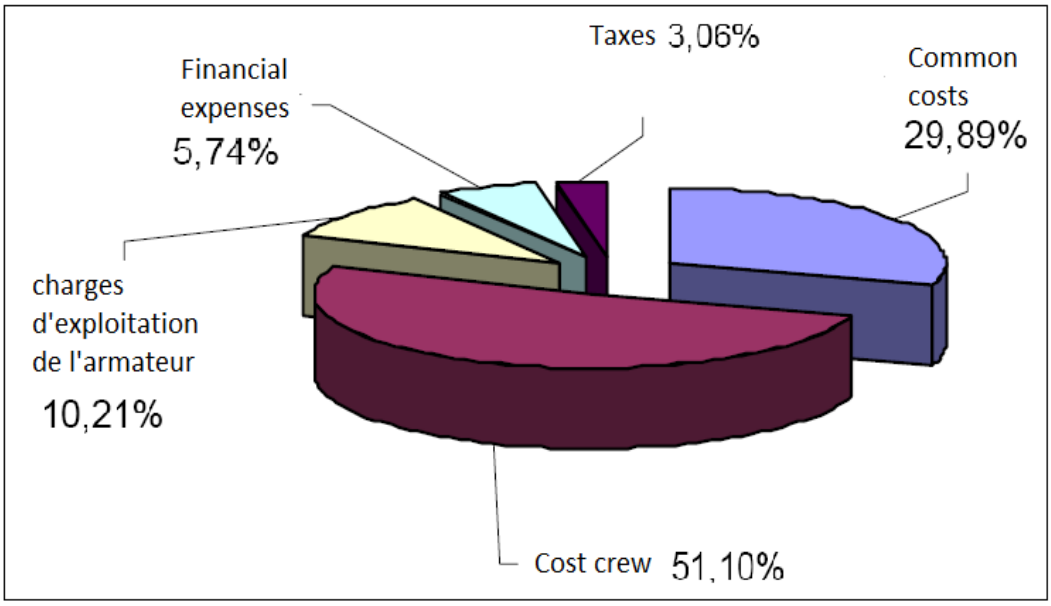

Figure 5: Structure of the total costs of a coastal seiner kind.

penses consist of several costs which 44.65% is monopolized only by the fuel cost. So fuel is the main element that can break the profitability of the fishing unit. The second part of the costs that weigh heavily on the profitability of the boat is that relating to the collection of the National Social Security Fund (NSSF) with 23.10%. Marketing costs (tax tolls, taxes and weighing cess) absorb all 11.79% of the common costs. The food occupy 8.59% of the common costs. The rest of the common costs, or 11.87%, is distributed among the samples of the Committee of Social Works Professional Fishing Resort Agadir (COSPPCA) (4.52%), the Relief Fund (1.54%) and the Royal Lifesaving Work of (ORS) (0.77%), as well as interviews and maintenances (2.75%), lubricants (1.17%), water (0.17%) and regional taxes ODEP and ONP (0.94%).

Part of the charges borne exclusively by the shipowner is dominated mainly by the cost of insurance (AT and body) with a percentage of 63.16%. Major repairs ranks second with 26.56% and ghosts levies associations or unions represent 8.46%. Tax fishing license absorbs 0.98% while the remaining part in other taxes and duties, considered together, hardly exceeds 0.84%.

The results of the acoustic survey carried out at the edges of the vessel Dr Fridtjof Nansen, showed that the sardine stock between Cap Blanc and Cap Cantin (central stock (zones A and B) and C stock), has improved markedly between 2003 and 2004 during the period from November to December. Total biomass increased from 5,000,000 400,000 tones in 2003 to 7,000,000 tones in 2004, recording an increase of 30%. The contribution of each fishing area in the total biomass

remained the same in 2003 and 2004 Thus, the estimated between Cape Cantin and Cape Juby biomass represents 12% of total biomass, estimated that between Cape Juby and Cape Bojador represents 6 %, while that between Cap Blanc and Cap Bojador represents the largest share with 82%.

The results of the acoustic survey of Atlantic Center box (Agadir (Cape Ghir) - Bojador (Cape Bojador)), conducted between May 25 and June 5, 2005 by the research vessel INRH "Al Amir Moulay Abdellah, "showed that sardine biomass estimated between Cape Ghir and Cape Bojador was about 630 thousand tons. Compared with assessments in November-December, 2004, aboard the R / V Dr. Fridtjof Nansen, the sardine stock has fallen in the area since the biomass was estimated at 1 million 56 thousand tons in December 2004.

According INRH, sardine stock of the Mediterranean is fully exploited, that of the northern stock (Cape Spartel- El Jadida) and the central part of the stock on the A zone (Safi- Sidi Ifni), is overused. Sardine Zone B (Sidi Ifni- Cap Bojador) central stock is fully exploited to overexploited, while the stock C (Bojador- Cap Cap Blanc) of the sardine is the only stock underexploited.

The adverse effects of the high pressure of the fishing activity on the central sardine stock have been felt since the 80s because the results of acoustic surveys carried out by the Norwegian ship "Dr. Fridtjof Nansen "in 1986, 1989 and 1992 confirmed the collapse of the central sardine stock. Thus, the estimated instantaneous biomass for this stock was down 2 million tons in 1986 to 1 million 700 thousand tons in 1989 and then dropped to 300,000 tones at the beginning of 1992 (S. Ben Cherifi et al, 1993).

In front of the socio-economic importance to the state of play characterizing small pelagic fishery in Morocco fishery that is becoming increasingly worrisome to his state of overexploitation seen in most stocks, the Moroccan manager is called to intervene urgently and effectively to reorganize and direct the fishery. According to E. Meuriot in 1987, the Moroccan small pelagic fishery of the Moroccan Atlantic center can be considered "a fishery at risk" to the extent that a collapse of the sardine stock is a possibility that can not be ruled out. Indeed, cases of collapse of small pelagic fish are not uncommon (Peruvian anchovy, sardine and mackerel California sardine Namibia, Japanese sardine, herring in the North Sea ...). It is in this sense that this study comes to contribute to understanding the mechanisms that regulate the activity of the small pelagic fishery in Atlantic Moroccan center.

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