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Characterization of artisanal bait fishing using juveniles of round Sardinella (*Sardinella aurita*) and flat Sardinella (*Sardinella maderensis*) off Hann Bay (Dakar region, Senegal)

Mor Gueye, Dr. Massal Fall, PR Malick Diouf and Dr. Bocar S Balde

Abstract
The present study is an attempt to characterize the fishing activity of *Sardinella aurita* and *Sardinella maderensis* juveniles according to the type of vessels, gears, areas, depths and fishing periods at Hann Bay, in the region of Dakar, Senegal. The results showed that landings of these juveniles are mostly made of purse seines. The generalized linear model (GLM) implemented showed that the abundance of catches of juveniles of both species varies monthly, from one season to another, depending on the types of fishing gear and at different depths. In established histograms, ¾ of measured individuals have very small sizes with lower modes to heights prohibited by the Code of marine fisheries of Senegal in progress. This work will serve as a benchmark for proposing deterrent mitigation measures, especially since it is an abuse of juveniles (individuals who have not reached the size of first sexual maturity and who therefore would not have yet reproduced).

Keywords: Juveniles, Sardinellas, Senegal, overexploitation, size structure, spatiotemporal variability

Introduction
Senegalese marine waters in West Africa are characterized by their richness in fishery resources given their particular hydrodynamics, geomorphology and favorable local climate [1]. Fishing is one of the most important economic activities with nearly 200 billion FCFA (local currency, 1 € = 656 FCFA) of revenue per year and more than 600,000 direct and indirect jobs [2]. It also plays a crucial role in local population feeding with an average contribution of about 70% in the dietary intake of animal protein and an average fish consumption of 26 kg per capita per year [3]. The small-scale fisheries sector provides more than 80% of fish production. It ensures the supply of the domestic market and over 50% of the needs of fisheries products export industries. Nearly 85% of fish landings are represented by small coastal pelagic resources, consisting mainly of round and flat sardinellas (*Sardinella aurita* and *Sardinella maderensis*, respectively), bonga or ethmalose (*Ethmalosa fimbriata*), Atlantic horse mackerels (*Trachurus trece* and *Trachurus trachurus*), false scad (*Caranx rhonchus*) and Atlantic chub mackerel (*Scomber scolias*) and anchovy (*Engraulis encrasicolus*) [4]. In Senegal, the two species of Sardinella represent 83% of the landings of these small coastal pelagic resources [5].
The site of Hann is located in the peninsula of Cape Verde, actually Region of Dakar, capital of the country. It has become a national reference an important artisanal fishery products landing site, like others such as Saint-Louis and Kayar in the North, Mbour and Joal in the Centre. Juveniles of small coastal pelagic fish, particularly round and flat Sardinellas, are of great importance among the landed products. The fishing of these fringes is an old activity which purpose is very varied. Indeed, for the artisanal sector, these juveniles can be used as bait or be transformed into products known as "tambadiang". The pole-and-line tuna vessels, which range among industrial fleets, use them as bait from a direct or indirect fishing while local manufacturers produce from them as raw material fish meal, fish oil and other vitamin and mineral complexes (VMC) for animal feeding: poultry, pigs as for aquaculture purposes. Finally, small sardines can also be self-consumed, sold to those who have small fry consumption habits or fail to buy bigger fish due to poverty. This special form of fishing of

course, affecting the most vulnerable segment of fishery resources, is a major source of national concern. Indeed, it's commonly accepted that it represents a serious threat for the conservation of the resources and, consequently, for the sustainability of fishing activities in general. In addition, the Sardinellas stocks are considered as overexploited since 2006 [6] by the both national and foreign fleets operating legally (including in the framework of bilateral agreements) or not with respect to illegal, unreported and undeclared fishing known as IUU/INN [7]. Last but not least, the adverse effects of climate change, evidenced by higher surface temperatures of oceans [8], sea level rising and a reduction in biological productivity [9], could further darken this picture. The purpose of this article is to characterize the local fishing activity of sardinellas juveniles at a bio-ecological level (spatial and temporal distribution, landings, size frequency and variability of catches according to fishing gear, seasonality and depth strata) but also to measure the impact of this fishery on the sustainability of fisheries in the Bay of Hann. *In fine*, it proposes mitigation measures for this potentially harmful fishery for the sustainable exploitation of Sardinella stocks off Senegal, without neglecting that that these taxa are shared within the Sub-Regional Fisheries Commission (SRFC) space (Mauritania, Senegal, Gambia, Guinea Bissau, Guinea and Sierra Leone).

2. Material and methods

2.1. Study area

Senegal is a Sahelian country open to the Atlantic Ocean, with a vast maritime area of 198,000 km^2 and a shallow continental shelf covering an area of 23,600 km^2 unequally distributed according to the isobaths [10]. The coast, of about 718 km long, is divided into three areas: the North with a large coastline stretching from Saint-Louis (16°04N) to the Almadies Point (14°45N), the South or natural region area of Casamance that runs from southern Senegal border with the Gambia (13°04N) to the southern border of Senegal with Guinea-Bissau (12°20N, Cape Roxo) and the Central zone which goes from the tip of Almadies (14°45N) to the northern border of Senegal with The Gambia (13°45N) including "Petite Côte", the estuarine complex of Saloum islands and an important coastal strip located in the Dakar region on its southern coastal part: *Hann Bay* (Figure 1). Hann Bay is located, in a restricted manner, between Cape Manuel and the village Mbao and extends generally from the tip of Bel-Air (southern tip of the Autonomous Port of Dakar) to Bargny, including the following fishing or landing sites: Bel-Air, Thiaroye, Mbao and Rufisque [11].

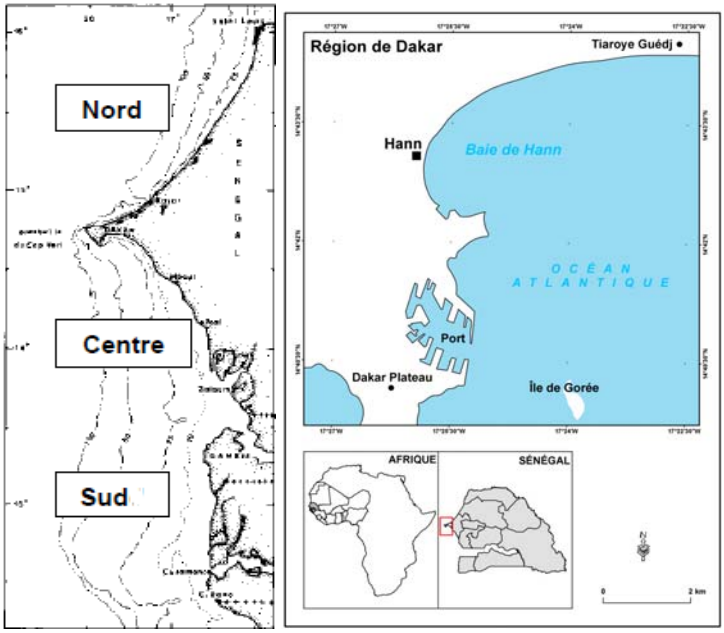


Fig 1: The Senegalese Coast, on the left, with its North (Great Coast), Center (Petite Côte and Saloum) and South (Casamance) areas and the map of Hann Bay on the peninsula of Cape Verde on the right.

2.2. Data collection

The analyzed data come from a biological sampling conducted in Hann bay sites, namely Hann itself, Thiaroye, Rufisque and Bargny, from May 2016 to May 2017. This field work has focused exclusively on artisanal canoes landing juvenile round and flat sardinellas. A database length (LT) of 5 634 individuals of these two taxa and belonging to of 75 samples was collected in cm and using a measuring board or ichtyomètre of 50 cm long. In addition to these biological data, the following parameters were recorded: type of fishing gear, date, month, season and fishing time (temporal variables), sites of origin port, fishing area, fishing location, depth and depth strata (spatial variables) (Table 1).

Table 1: Variables in the "database" file and their terms.

Variables	Types	Terms of modalities
Pirogue	Ordinal	The number of pirogues surveyed. Ex: *88*
Date	Ordinal	Date of the survey. Ex: *03/06/2016*
Months	Nominal	Months of the survey. Ex: *April*
Season	Nominal	Cold, Hot, Warming or Cooling

Site	Nominal	Landing site. Ex: *Thiaroye*
Homeport	Nominal	Homeport of pirogue surveyed. Ex: *Sendou*
Fishing area	Nominal	North, Center ou South.
Fishing place	Nominal	Fishing place used by the surveyed pirogue. Ex: *Gorée*
Gears	Nominal	Gear used for fishing the species. Ex: *Purse seine*
Depth	Quantitative	Depth of fishing expressed in meters. Ex: *30 m.*
Layered depth	Ordinal	Prof-1, Prof-2, Prof-3, Prof-4, Prof-5 ou IND
Species	Nominal	Scientific name of the species. Ex: Sardinella maderensis
Total catches	Quantitative	Quantities of fish landed in kg. Ex: 300 kg
Importance of Juvéniles	Ordinal	Percentage of juveniles present in catches (50%, 75% or 100%)
Juveniles catches*	Quantitative	Quantities landed in juvenile sardines in kg. Ex: 80 kg
Fishing time	Quantitative	Time is taken by the pirogue to fish. Ex: 4h
CPUE*	Quantitative	Catch per unit effort in kg / h (catches / fishing time). Ex: 1.84 kg / h.

For depth, it is distinguished as follows: Prof-1 (0 - 20m), Prof-2 (20 - 40m), Prof-3 (40 - 80m), Prof-4 (80 - 160m), Prof-5 (Depth> 160 m) and IND (indeterminate depth).* Variables "juvenile catch" and "CPUE" are calculated from the variables "total catch", "juvenile importance" and "fishing time".

Meanwhile, the degree of specialization of canoes fishing Sardinella juveniles is taken into account considering the relative proportion of juveniles among their total landings. Thus, these fishing units are distinguished as follows: specialized (75 to 100% of juveniles), semi-specialized (50 to 75%) and opportunistic canoes (less than 50%).

2.3. Statistical analysis

Basic statistical parameters (minimum, maximum, mean, standard deviation and coefficient of variation) were determined using MS-Excel®, regarding the depth, fishing effort and the both overall fish and juvenile of Sardinella catches. The fishing effort (f) is nominal and expressed in hours (h) as the difference between day of arrival (DA) and day of departure (DD) including start time subtraction (ST) and return time (RT) addition, as follows: **f** = $[(DA - DD)x24] +$ **RT – ST**. The size frequency data has been grouped with graphical representations determination of some basic statistics: minimum, maximum, mode and effectives sampled. The studied unit parameter is the total length (TL, cm). Generalized linear models (GLMs) are now increasingly applied in bio ecological research [12-14]. The GLM is applied in this study to quantify the role of the studied variables on the variability in catches of juvenile sardines. Targeted variables are the season (with 4 modalities: cold, hot, warm-up and cool-down period), the month (11 modalities: from January to December), fishing gear (PSs, BSs, BSGs, SSGs, BDGs, SDGs, SGs and T: 8 modalities) and fishing depth range [Prof-1 : 0-20 m, Prof-2 : 20 to 40 m, Prof-3: 40-80 m, Prof-4: 80-160 m, Prof-5 : > 160 m and IND: for undetermined depths ➔ 6 modalities). R language – originating from the name of the software used in its version 3.2.3 – is implemented to describe the relationship between the dependent variable (catches of round and flat Sardinella juveniles) and its potential explanatory variables (season, month, gear fishing and depth), as follows:

Model = glm (CaptureJuv ~ Season + Month + Fishing Gear + Depth, data = Curve, test = " F ")

In the GLM modeling, it is assumed that the response variable (CaptureJuv) follows a Gaussian distribution, which is usually appropriate to describe the spatial heterogeneity and abundance data. The statistical treatments are carried out using the same software R based on a significance level set at 5%. The selection of the most appropriate model is made with reference to the AIC [15], which compares the quality of the different models tested to choose the best of them [16, 17, 14].

3. Results

3.1 Descriptive statistics

Table 2 summarizes basic statistical parameters (minimum, maximum, mean, standard - deviation and coefficient of variation) values with respect to Depth (m), fishing effort (h), overall catches (kg) and round and flat juvenile sardinellas catches (kg). Juveniles catches are performed at depths ranging from 4 to 200 m and are globally estimated at 415 265.5 kg, that is to say 66% (± 2/3) of the overall fish catches (630 288 kg). The fishing effort varies from 1 to 216 h per trip or fishing trip, with an average of 25.10 hours (~ 1 day). According to their coefficients of variations, total catches and juvenile catches display quite the same values (190-205%, respectively) expressing their both high heterogeneity.

Table 2: Descriptive Statistics for the Depth, Fishing Effort and Catches Variables

Variables	Minimum	Maximum	Mean	Standard deviation	CV	Total catches (kg)
Total catches (kg)	4,00	12 500,00	807,03	1 531,78	190%	630 288
Juvenile catches (kg)	2,00	10 000,00	531,71	1 088,92	205%	415 266
Depth (m)	4,00	200,00	56,23	61,69	110%	
Fishing effort (h)	1,00	215,50	25,10	31,38	132%	

Meters = m, hours = h, kilograms = kg, CV = Coefficient of Variation (ratio of standard deviation to mean).

3.2 Fishing effort and landings

Of the 781 canoes we visited during our survey, 203, that is substantially 26% of this sample, are strictly specialized in fishing round and plate Sardinella juveniles which represent almost 100% of their catches. The rest of the canoes (74%) displays, however, lower proportions of juveniles to 50% of catches (opportunistic canoes). For specialized canoes, fishing gear consist of 96% of PSs while the rest is being represent by SDGs (3%) and BSs (1%), exclusively reported to Hann. The PSs ensures nearly 87% of CPUE of juvenile catches followed by SDGs (12%) and BSGs, SSGs, SGs and BSs which together absorb the remaining 1% (Figure 2). In the Bay of Hann, most important catches are realized at April and May (Figure 3), although two other peaks are also observed

during cold season months (November and January) (Figure 4). It is also important to note that the catches of juveniles *Sardinella maderensis* are observed until May unlike those of *Sardinella aurita* are captured almost throughout the year (except August) (Figure 5). Furthermore, major catches are obtained in shallow fishing areas (0 to 100 m) (Figure 6).

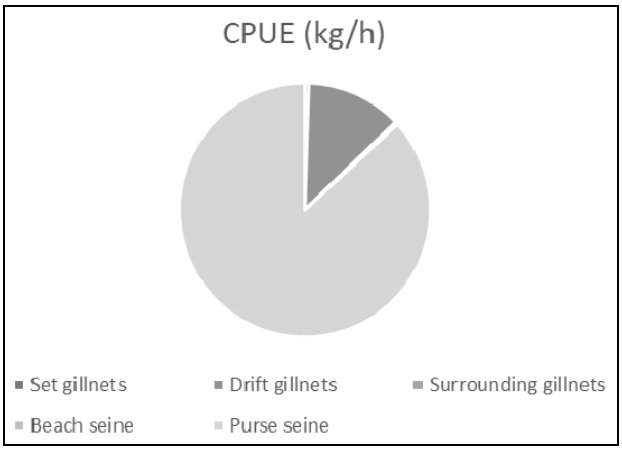


Fig 2: Catches of juvenile *S. aurita* and *S. maderensis* following the main gears

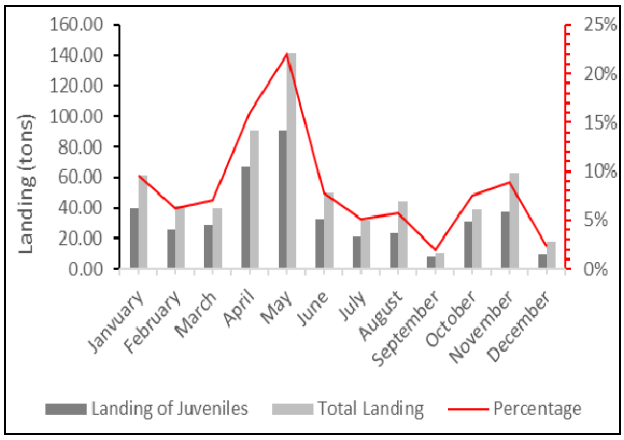


Fig 3: Importance of juvenile's sardinella (dark grey bars) in total catches (light grey bars) at the Hann Bay

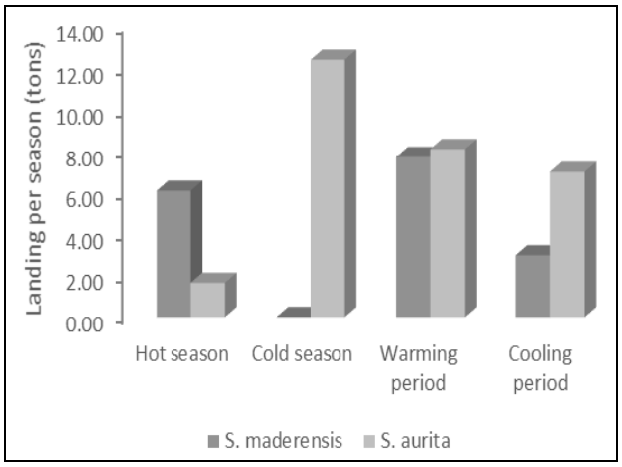


Fig 4: Catches of juvenile *S. aurita* and *S. maderensis* following hydrological seasons.

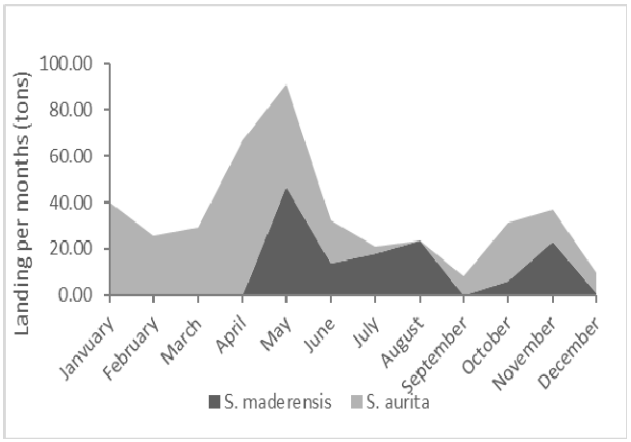


Fig 5: Annuals catches of juveniles of *S. maderensis* (dark grey area) and *S. aurita* (light grey area) at Hann Bay

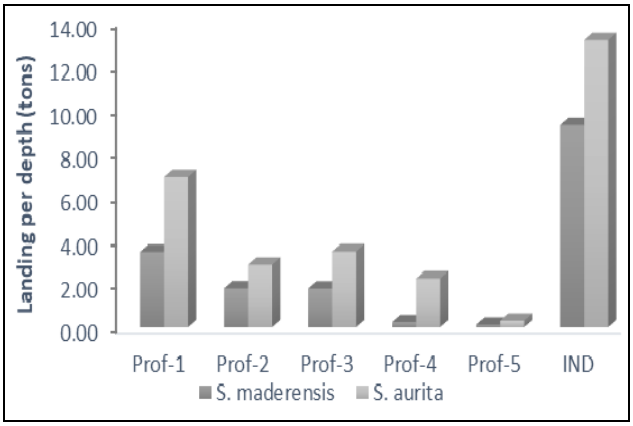


Fig 6: Captures of juveniles of S. aurita and S. maderensis following the depth

3.3 Variability of catches of juvenile sardinella

The results of the GLM (adjusted R^2 = 0.33 and p-value <0.001) explain 50.5% and 37.9% of the total deviance observed in the data set on the catches of *Sardinella aurita* and *Sardinella maderensis* juveniles, respectively (Table 3). Concerning the variability of juvenile catches for *S. aurita*, fishing gear accounts for 25.8% while the monthly variability and seasonality are also important and explain respectively 8.2% and 15.7% of the total deviance. For *S. maderensis*, the highest part of the total deviance observed variability is also attributed to fishing gear (27.6%) knowing that the remaining parts rely on monthly variability (7.4%), seasonality (1.8%) and depth (1.1%) (Table 3). These results indicate, for both species of sardinellas, that the abundance of juvenile catches varies mainly according to the type of gear (almost 26% - 28% respectively) than to season (16 – 2%) and month (8 - 7%) variability. Depth for the 2 species and season for flat Sardinella have no significant impact. The different modalities identified as having a significant or very highly significant impact on two Sardinellas species juvenile catches are illustrated in Table 4. The resulting models explain 31% and 44% of the variation in catch of round and flat Sardinellas, respectively. The less significant factors are month of July for the 1st species and the gear SDG for the 2nd one.

Table 3: Adjustment quality statistics for GLM adjusted for catches of juvenile *S. aurita* and *S. maderensis* (variance function: Gaussian) deviance; F and P (F) are the values of the last variable included in each model; the residual deviance and per cent deviance explained are the model values.

Variables	df	Deviance	Residual df	Deviance residual	% Deviance explained	P(F)
Sardinella aurita						
NULL			250	31746087		
Season	2	26805347	248	292940741	15.73	4.20 e-7 (***)
Months	4	28042219	244	264898521	8.23	3.41 e-6 (***)
Gears	3	65850549	241	199047972	25.77	2.80 e-14 (***)
Depth	26	15895086	215	183152886	0.72	0.84
Sardinella maderensis						
NULL			529	605123157		
Season	3	4760122	526	600363035	1.80	0.15
Months	7	45275829	519	555087206	7.35	2.15 e-8 (***)
Gears	4	97136847	515	45790359	27.61	2.20 e-16 (***)
Depth	40	10133627	415	417816732	1.14	0.26

Significance: (***) Very highly significant difference (p-value <0.001), (**) highly significant difference (p-value <0.01), (*) significant difference (p-value <0.05), and insignificant difference (p-value> 0.05).

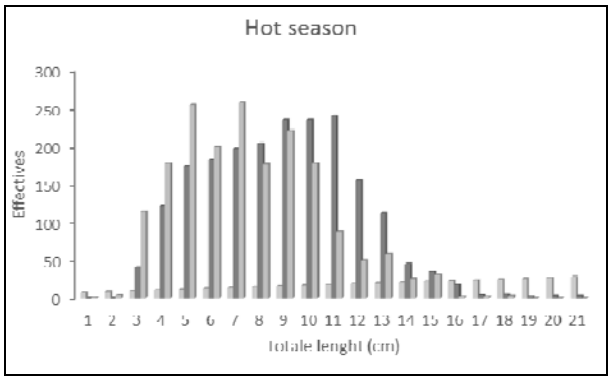
Table 4: Test conditions of the factors a significant factor on changes in catches of juvenile sardinella (*S. aurita* and *S. maderensis*) at the Hann Bay via the GLM.

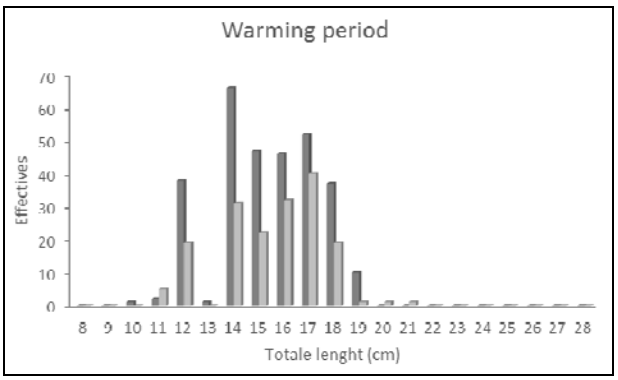
Modality of variables	Estimate	Std. Error	t value	p-value	R^2	Signifiance
Sardinella maderensis						
Cold season	1148.66	243.95	4.709	3.28e-06	0.3095	***
Month of February	-976.26	199.61	-4.891	1.38e-06		***
Month of January	-925.27	177.32	-5.218	2.71e-07		***
Month of July	2010.65	982.66	2.046	0.04129		*
Month of March	-1035.56	182.07	-5.688	2.25e-08		***
Gears PS	1205.70	153.66	7.846	2.86e-14		***
Depth 160	2198.94	549.74	4.000	7.34e-05		***
Depth 60	1086.63	386.05	2.815	0.00508		**
Sardinella aurita						
Warming period	1198.623	246.387	4.865	2.30e-06	0.4416	***
Month of June	-1152.935	302.386	-3.813	0.000182		***
Gears SDG	476.258	216.872	2.196	0.029228		*
Gears PS	1462.375	249.553	5.860	1.86e-08		***
Depth 50	1434.512	576.453	2.489	0.013636		**

Significance: (***) Very highly significant difference (p-value <0.001), (**) highly significant difference (p-value <0.01), (*) significant difference (p-value <0.05), and insignificant difference (p-value> 0.05)

Size structure

In all, a total of 5 634 individuals belonging to two species of Sardinellas were measured. The size spectrum for *Sardinella maderensis* is unimodal in any season with one mode - 14 cm LT - observed during the transition periods (heating and cooling) and another one, 9-11 cm, during the hot season. For *S. aurita*, smaller modes are obtained during the warm and heating seasons with respectively 14 cm and 16 cm (LT). The larger sizes of *S. aurita* juveniles are observed during transition periods particularly with a multimodal size spectrum in the cooling period. For *S. aurita*, the presence of juveniles was observed in all seasons, unlike *Sardinella maderensis*, where measurements were only made during the warm season, during warming and cooling periods. Figure 7 shows the size distribution histograms of *Sardinella aurita* and *S. maderensis*, in terms of numbers, in relation to different hydrological seasons.





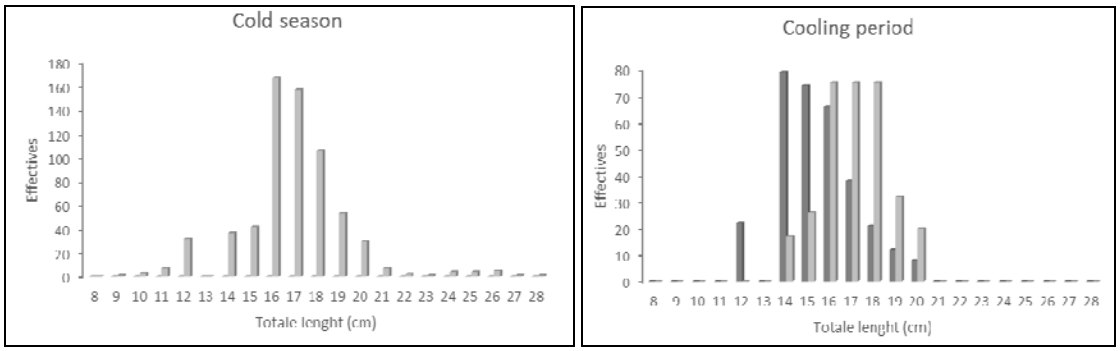


Fig 7: Histogram of size-frequency of *S. maderensis* (dark grey) and *S. aurita* (light grey) following the main hydrological seasons

Discussion

Based on the use of live bait consists of small coastal pelagic fish, mainly sardinellas (round and flat) fishing juvenile was initiated in Senegal in 1950 off the coast of Dakar. Today, it is practiced exclusively in the Hann bay and, sometimes, in the south of the bay (towards Djifere) according to the availability of the resource. Indeed, many fishermen are regularly engaged in this type of fishing in Bargny, Hann, through Thiaroye and Rufisque. The results of this study led us to characterizing the juvenile's fishery off the Hann bay, with respect to spatiotemporal distribution in terms of abundance of catches, spectrum sizes of the two species but also the influence of certain factors their juvenile catches. The fishery extends all over the bay and is almost yearly. The results are consistent with those of Diouf [18] which confirmed that the extended operation time can be justified by the availability of stock of Sardinella juveniles at the coast throughout the year. Indeed, juvenile Sardinellas are always present in the Petite Côte, which is the main spawning area and nursery of the two target species [17, 19, 20]. This coastal area is characterized by a continental wide and shallow tray, a strong phytoplankton biomass and a high content of chlorophyll-a during periods of upwelling, optimal conditions to provide a suitable incubator [21]. This spatial distribution is confirmed by the observation that the central region is a growth area and the particularly large individuals migrate north in deeper areas [22].

The absence of Thiaroye, a fishing port of Hann Bay, is justified by a lack of space to land even though most fishermen from this village are specialized in juvenile-bait fishing in the framework of a contract with Spanish tuna fleet. This practice is explained by the fact that the fishing of juveniles is more accessible because it is exercised within few meters from the coast. Fishermen therefore spend less energy, and earn more time. This exploitation of juveniles is similar to that observed in the Congolese artisanal fishermen at the black tip Bay in Congo [23, 24]. The diversity of fishing techniques (fishing gear used) is also good materialized at the Hann Bay like the great centers of landings in Dakar. Indeed, all the different fishing strategies and tactics used, depending essentially on the ethology and ecology of target species and their commercial value, are practiced. In fact, following the fishing effort of specialized units on fishing for juveniles of sardines, 96% of these are canoes operating with purse seines. In terms of catches, more than 4/5 of catches of sardinella juveniles (round and flat) are active purse seines. These results are similar to the work of Freon [25] which showed that the exploitation of coastal pelagic fish with lines, beach seines and gillnets was high, in terms of weight contribution, compared to other types of fishing image purse seines. Also in terms of landings, flat sardinella juvenile catches are observed until May unlike those of round sardinella caught most of the year with peaks in March and April. The study is based on the application of a generalized linear model (GLM) to explain the variability in catches of juveniles of both species of sardinella. It shows that the factor "gear" is the most important predictor strongly influencing this variability. From this point of view, the purse seine is by far the factor most affecting catches of both species of Sardinella (very highly significant difference). In our opinion, this is mainly due to the fact that the PSs is technologically the gear most suited to the ethology of sardinella. These findings are supported by the work of Diankha [14] which showed that the effects of fishing are closely related to the effectiveness and efficiency of fishing gear used. According to Jennings and Kaiser [26], the effects of fishing depends on the type of fishing gear used and the habitat characteristics where they are deployed. The impact of fishing gear on Sardinella is mainly reflected by purse seines which essentially are very effective for the capture of species moving bench like the sardines [27]. Moreover, artisanal fishers who supply bait in bait boats mainly use purse seine, kind of small PS, manipulated by some sea fishermen in Hann Bay, near the port of "Gorée". Temporal variability in catches of Sardinella juveniles, emerged in the results of GLM also depends on seasonality. This seasonal effect is more pronounced in Sardinella aurita with a very highly significant difference especially in times of change. However, the variability in catches of S. maderensis is also noted during the cold season especially from January to March. These results are consistent with those of Ba%. [19] and Sarr%. [28]. For the latter, the monthly evolution of the sexual maturity stages of Sardinella aurita shows a strong presence of immature (juveniles) from June which corresponds to the period of sexual rest separating the two main reproduction periods (in March and November). For S. maderensis, analysis of sexual stages showed that immature juvenile are present after the two times of reproduction. The first breeding season occurs from April to October and the second with a continuous spawning (more intense) from January to end of February [19]. These results can be explained also by the migratory nature of sardinella species [29]. The round sardinella (Sardinella aurita), dynamic enough, makes seasonal migration from Morocco to the Bijagos Islands in Guinea Bissau, through Mauritania and Senegal unlike the flat sardinella (S. maderensis), less active and prone to migration. In this same vein, the Senegalese artisanal fishing sardine is mainly practiced during transitional periods that correspond to periods of high abundance of S. aurita [30, 17].

The results obtained from the measurements show that the size spectra are almost uni-modal for both species. The modes

vary between 14 cm and 18 cm for *S. maderensis* and between 14 cm and 16 cm for *S. aurita*. Based on the work of several authors [18, 19, 21, 29, 31-35], the sizes of the first maturity sardinellas (males and females) are respectively included between 18.4 cm and 24.7 cm for *S. aurita* and between 17 cm and 17, 2 cm for *S. maderensis*. The size spectra then obtained in the present study clearly show that it is indeed an over-growth of sardinella species, so juvenile. Moreover, it is mentioned in the decree implementing the new Law No. 2015-18 of 13 July 2015 and bearing the Marine Fisheries Code [36], Article 38, prohibiting the capture, transportation, transfer, possession, sale, for the sale and purchase of several species of fish including sardinella (*S. aurita* and *S. maderensis*) having less than or equal to 18 cm. It thus appears from the results obtained, with regard to this regulatory text governing sea fishing in Senegal that sampled Sardinella individuals are subject to size restrictions. Although the units used here are different (LT), it is important to remember that overall, the sampled sizes are considerably offset to the left with corresponding modes Banned sizes. This confirms again that it is an abuse of juveniles as being individuals (i) who have not attained the size or the minimum weight allowed by the Code of Fisheries (ii) that would be not reproduced at least once (iii) normally absent in the catch of regulatory machinery for mesh sizes of nets or hooks. Beyond these observations, inventory rebuilding is under threat because of the abuse of these juveniles and this constitutes a serious threat to the viability and sustainability of fisheries. Considered overexploited since 2006 [6], the small coastal pelagics, especially sardines, are very vulnerable to fishing because of their behavior embodied by their displacement bench, including [28]. As a result, very high fishing pressure especially on immature individuals could erode their stock [37] thus affecting the fishery [38], the structure and functioning of the marine ecosystem. A collapse of small pelagic stocks could disrupt the food chain, affecting their main predators, formed by fish-eating fish, seabirds and marine mammals [39; 40].

5. Conclusion

The bait fishery for juveniles at Hann Bay is practically year-round because of the large spawning area of this bay. A characterization of this fishery has made it possible to more concretely determine the spatio-temporal distribution of juvenile sardinella (*Sardinella aurita* and *Sardinella maderensis*) and shows that the abundance of juvenile catches has varied widely from one season to the next, depending on the types of fishing gear and at different depths. The sizes of the mature individuals have clearly indicated that this is an abuse of juveniles because they are individuals who have not reached the minimum size or weight authorized by the Fisheries Code, who would not have yet reproduced at least once and which normally should be absent in the catch of regulated gear in terms of mesh sizes of nets or hooks.

6. References

1. Roy C, Cury P, Fréon P, Deamrcq H. Environmental and resource variability off Northwest Africa and in the Gulf of Guinea. *Elsevier Amsterdam*, 2002, 121-139.
2. Kébé M. Le secteur des pêches au Sénégal: Tendances, enjeux et orientations politiques. Rapport de Programme Kurukan Fugan (Union Européenne/Gouvernement du Sénégal/Enda Graf/GRET), 2008, 26.
3. Diankha O, Demarcq H, Fall M, Thiao D, Thiaw M, Sow BA,%. Studying the contribution of different fishing gears to the Sardinella small-scale fishery in Senegalese waters. Aquat. Living Resour. 2017; 30:27.
4. Diei-Ouadi Y. Minced sardinella fillets in fish landings and marketing sites in Senegal. FAO Fisheries Circular No. 999, Rome, Italy, 2005, 20.
5. FAO. Report of the FAO Working Group on the Assessment of Small Pelagic Fish off Northwest Africa. FAO Fisheries and Aquaculture Report, Banjul, Gambia, 2017, 279.
6. FAO. FAO working group on the assessment of small pelagic fish off Northwest Africa. FAO Fisheries Report 2006; 78:52.
7. Belhabib D, Koutob V, Sall A, Lam VWY, Pauly D. Fisheries catch misreporting and its implications: the case of Senegal. Fish Res. 2014; 154:1-11.
8. Belkin MI. Rapid warming of Large Marine Ecosystems. Prog. In Ocea. 2009; 81:207-213.
9. Diankha O. Finalisation des diagnostics de base et des états de référence écologiques et environnementaux de la ZPP de la Petite Côte (Mballing, Nianing, Pointe Sarène et Mbodiène). 2016, 48.
10. Domain F. Contribution à la connaissance de l'écologie des poissons démersaux du plateau continental sénégalo-mauritanien. Les ressources démersales dans le contexte général du Golfe de Guinée. Thèse de Doctorat d'Etat, Université Paris VI et Muséum National Histoire Naturelle, 1980, 342.
11. DEEC Sénégal. Projet de dépollution de la baie de DEEC SENEGAL Phase 1 - Synthèse environnementale – Rapport numéro 10.37 - V4.0, 2011, 142.
12. Guisan A, Edwards TC, Hastie T. Generalized linear and generalized additive models in studies of species distributions: setting the scene. Ecological Modelling, 2002; 157:89-100.
13. Thiaw M. Dynamique des ressources halieutiques à durée de vie courte: cas des stocks de poulpe et de crevettes exploités au Sénégal. Thèse de Doctorat, mention Halieutique, Université de l'Agrocampus Ouest, Rennes, 2010, 194.
14. Diankha O. Dynamique des populations de Sardinella aurita et Sardinella maderensis dans les eaux sénégalaises : aperçu des effets des variables climatiques et non climatiques. Thèse de Doctorat Unique, Université Cheikh Anta Diop de Dakar, 2017, 168.
15. Akaike H. A new look at the statistical model identification. IEEE Transactions on Automatic Control, 1974; 19(6):716-723.
16. Thiaw M, Fall M, Thiam N. Évaluation par l'approche globale du stock Sénégalais de crevettes profondes, Parapenaeus longirostris (Lucas, 1847). J. Sci. Halieut. Aquat. 2013; 7:255-270.
17. Thiaw M, Auger PA, Sow FN, Brochier T, FAYE S, Diankha O%. Effect of environmental conditions on the seasonal and inter-annual variability of small pelagic fish abundance off north-West Africa: the case of both Senegalese Sardinella. Fisheries Oceanography. 2017; 26:583-601.
18. Goudiaby KD, Samb B, Sylla M. Contribution à la connaissance de la biologie des sardinelles (Sardinella aurita et Sardinella maderensis) du littoral sénégalais. FAO Comptes rendus des pêches et de l'aquaculture n°18, Rome, 2010, 39-56.
19. Ba K, Thiaw M, Lazar N, Sarr A, Brochier T, Ndiaye I%.

Resilience of Key Biological Parameters of the Senegalese Flat Sardinella to Overfishing and Climate Change. PLoS ONE. 2016; 11(6):20.
20. Baldé BS, Sow FN, Ba K%. Variability of key biological parameters of round sardinella Sardinella aurita and the effects of environmental changes. J Fish Biol. 2019, 1-11.
21. Tiedemann M, Brehmer P. Larval fish assemblages across an upwelling front: indication for active and passive retention. Estuarine, Coastal and Shelf Science, 187, 2017, 118-133.
22. Krakstad JO, Sarr A, Sow I, Mbaye EM, Skalevik A. Distribution of clupeid species on the Senegambian shelf. FAO report, 2013, 23.
23. Gheno Y et Poinsard F. Observations sur les jeunes sardinelles de la baie de Pointe-Noire (Congo). Cah ORSTOM, *Ser Oceanogr.*1968; 6:53-67.
24. Gobert B. L'exploitation des juvéniles de sardinelles par les pêcheurs artisans congolais de 1981 à 1984, 1985, 16.
25. Freon P, Weber J. Djifère au Sénégal la pêche artisanale en mutation dans un contexte industriel. *Reu*. Trau. *Inst. Pêches marit.* 1983; 47(3, 4):261-304.
26. Jennings S, Kaiser M. The effects of fishing on marine ecosystems. Adv Mar Biol. 1998; 34:201-352.
27. Brehmer P, Gerlotto F, Laurent C, Cotel P, Achury A, Samb B. Schooling behavior of small pelagic fish: phenotypic expression of independent stimuli. *Mar. Eco. Prog. Series*, 2007; 334:263-272.
28. Sarr A, Ndiaye I, Faye A, Thiaw M, Diouf M, Ba K%. Reproductive Biology of Round Sardinella (*Sardinella aurita*) (Valenciennes, 1847) in Senegalese Coastal Waters. Journal of Biology and Life Science. 2018; 2157-6076.
29. Longhurst AR, Pauly D. Ecology of Tropical Oceans. Academic Press: New York, London, Sydney, Toronto. 1987, 407.
30. Fréon P. Introduction d'une variable climatique dans les modèles globaux de production. ORSTOM, Paris, France, 1991, 395-424.
31. Conand F. Oeufs et larves de la sardinelle ronde (Sardinella aurita) au Sénégal: distribution, croissance, mortalité, variations d'abondance de 1971 à 1976. Cahiers ORSTOM, Série océanographique, 1977; 15(3):201-214.
32. Boëly T, Chabanne J, Fréon P, Stequert B. Cycle sexuel et migrations de Sardinella aurita sur le plateau continental ouest africain des îles Bissagos à la Mauritanie. Rapport du Conseil International pour l'Exploration de la Mer, 1982; 180:350-355.
33. Camarena-Luhrs T. La croissance de Sardinella maderensis (Lowe, 1841) au Sénégal. Océanographie tropicale. 1986; 21:143-151.
34. Fréon P. Réponses et adaptations des stocks de Clupéidés d'Afrique de l'Ouest à la variabilité du milieu et de l'exploitation: analyse et réflexion à partir de l'exemple du Sénégal. Thèse de Doctorat, Université d'Aix Marseille II, 1988, 287.
35. Diouf PS. Les peuplements de poisson des milieux estuariens de l'Afrique de l'Ouest: l'exemple de l'estuaire hyper salin du Sine-Saloum. Thèse de Doctorat, Université de Montpellier II. 1996, 267.
36. JORS. Loi n° 2015-18 du 13 juillet 2015 portant Code de la Pêche maritime. Journal Officiel de la République du Sénégal : 160ème année, Numéro spécial, n° 6865, 2015; 19.
37. Hay DE%. Taking stock: An inventory and review of world herring stocks in 2000. Herring: Expectations for a New Millennium, eds Funk F,%. (Alaska Sea Grant College Program, Anchorage, AK), 2001, 381-454.
38. Schindler DE%. Population diversity and the portfolio effect in an exploited species. Nature, 2010; 465(7298):609-612.
39. Cury PM, Boyd IL, Bonhommeau S, Anker-Nilssen T, Crawford RJM, Furness RW%. Global seabird response to forage fish depletion – one-third for the birds. Sciences, 2011; 334:1703-1706.
40. Smith ADM, Brown CJ, Bulman CM, Fulton EA, Johnson P, Kaplan IC%. Impacts of fishing low – trophic level species on marine ecosystems. Science. 2011; 333:1147-1150.