E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2020; 8(1): 219-235

www.fisheriesjournal.com
Received: 24-11-2019
Accepted: 28-12-2019

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Operational sustainability and length-weight relationship for the fish species most exploited in Cameroon coast, central Africa

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Abstract
Biometric studies in fisheries can provide new indicators essential for fisheries management. Among the different statistical elements that can be obtained from biometric data, the skewness of the population distribution and the relationship between the length and the weight of a fish can help assess the level of sustainability of a resource. Biometric data on marine fish were collected at 19 landings sites along the Cameroon coast for 6221 individual fish during several research campaigns. This paper provides the length-weight keys for 27 species of marine fishes mostly found in Cameroon fish landings, also providing insights in their level of exploitation. Overall, 62.05% of the fish species studied have a total length of less than 30 cm. *Ilisha africana* and *Lutjanus* sp. are the most and least exploited fish species respectively. The mean skewness of 0.838 suggests the resource is generally under pressure. This pressure varies amongst species, with *Galeoides decadactylus* (2.463) being under more pressure and *Tylosurus* sp. (-0.644) being the best exploited. The coefficient of allometry for all the species studied (2.718) indicates that fishes on the Cameroonian coast are generally thin (i.e., grow more in length than in biomass). This may result from fishing practices, the physiological state of the resource (sex, maturation of the gonads) and the state of health of coastal and marine ecosystems. Further research needs to be undertaken to provide more information on the issue.

Keywords: fish species, sustainability, size-weight key, cameroon coast

1. Introduction

The Cameroon coast, Western Africa, is approximately 402 km long, extending from Campo in the 'South' region, to the boundaries with Nigeria in the 'Southwest' region, the 'Littoral' region being in between (Figure 1) [1]. Small-scale maritime fishing is practiced mainly by rural, cosmopolitan populations in those three coastal regions of the country. Over 80% of fishers operating in Cameroon waters are foreigners (e.g., Nigerian, Beninese, Ghanaian, Senegalese) [2]. The 'Ocean Department', an area part of the South region, remains the only area along the coast where Cameroonian fishermen outnumber foreign fishermen, with more than 80% of the fishermen are Cameroonians [3].

Despite its strong socio-economic and ecological potential, the current knowledge of artisanal marine fishing remains poor in Cameroon, in a context of a rapid increase of the human impact related to the construction of ports and industries (e.g., industrial-port complex of Kribi, SOCAPALM, HEVECAM, thermal power plant of Kribi). Previous studies have mainly focused on characterizing communities of fishing villages in Cameroon, socio-economic activities in fishing, and conducting inventories of marine fish in the Gulf of Guinea [4, 5, 6, 3, 7]. However, little is known about biometric properties of fish populations, an information often seen as being critical for supporting fisheries management.

This paper aims to assess the level of exploitation of the main fish species caught and landed on Cameroon's coast and to establish length-weight keys of the coastal and marine fish species observed in this region. Similar studies along the coast of West Africa, Europe and South America have made it possible to provide information systems on the ecology of fish not described in FishBase, and at regional or country level [8, 9, 10]. This research tests two hypotheses: (1) that the Cameroonian marine fish resource is over-exploited, and (2) that landings on Cameroon's coast are dominated by juvenile fish.

2. Materials and Methods

2.1 Study area

The study was carried out in two coastal regions of the Republic of Cameroon (Figure 1): the Littoral and the South regions. The highly urbanized Littoral region (i.e, the city of Douala and its periphery) is home to large river bodies, such as the country's longest river (the Sanaga) and the Nkam-Wouri estuary [11]. This region contains an international seaport, landing stages, as well as the Douala-Edéa National Park, half of which is marine. The South region also has several rivers: the Loukoundjé, Lobé, Ntem. These rivers and their related systems host remarkable and threatened fisheries biodiversity, placing Cameroon in the list of priority countries with the United Nations [12]. Their good ecological status is however threatened by industrial-port infrastructures, hydroelectric dams, mining installations, agro-forestry industries that have developed in watersheds. Only two out of three coastal regions were studied, due to security, accessibility and logistical factors. Indeed, the Southwest region has recently witnessed a political instability [13].

Fishermen are using different types of gears, including gillnets (circling and set bottom), hawks, hand line, and bottom longlines. The gears used depends on the target fish species, and are often deployed from 6 to 7 meter long dugout canoe, often with a single fisherman on board that can work with 400 to 600 hooks per day [4]. Gillnets and hawks allow capturing pelagic and demersal species (e.g., sardinella, ethmaloses, bars). The hand line, bottom longlines, with branch lines from 15 to 25 cm long in monofilament of variable diameter spaced about 3 meters apart, mainly seek species like barracudas, jacks, rays, and captains [4]. These gear types vary according to the different coastal zones, the commercial demand, and the fishing seasons. Analyses were carried out without comparing all the types of fishing gears.

2.2 Data collected and sampling method

The data collected come from surveys conducted at 19 different landing sites. They were carried out from 2014 to 2019, considering the different hydrological and fishing seasons. At the sites, landing points or fish markets, simple random sampling was used in situ to obtain quantitative data (i.e., length, weight). Each fish landed (sampling unit) had the same probability of being selected (P = 1 / N), with N representing the size of the sample (the total catch of a fisherman or the heap of fish made by a seller) in a population corresponding to a fishing village or even a landing point.

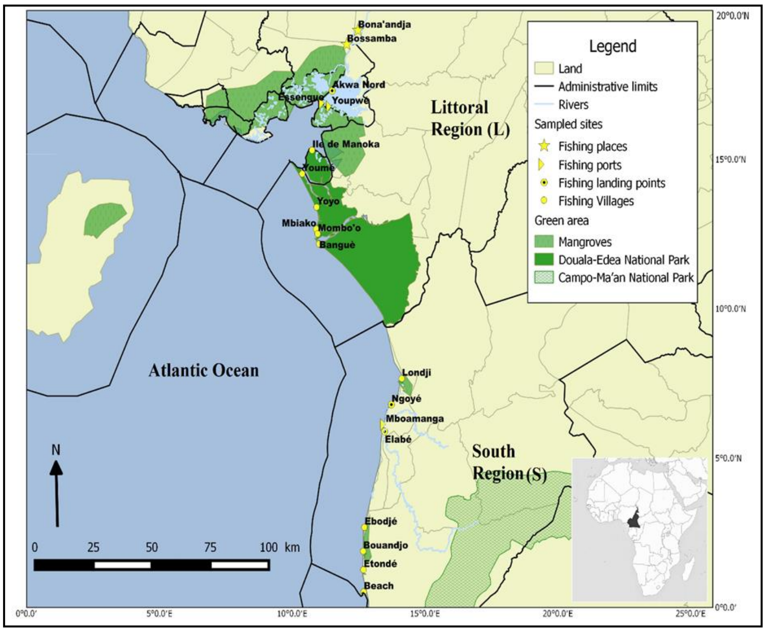

Fig 1: Map of sites sampled on the two coastal regions of Cameroon, central Africa

All the fish encountered with different morphological characteristics were kept and brought to the laboratory for further identification using keys from the United Nations Food and Agriculture Organization (FAO) for commercial marine resources in the Gulf of Guinea [5, 14]. Subsequently, fish sizes were measured to the nearest centimeter and fish weights were measured to the nearest gram in the fresh fish state [15]. Overall a total of 6221 individuals represented by 27 species targeted by small-scale fishing were studied, six of which remain undetermined. Each species was the subject of an analysis of the population size, with an emphasis being put on the distribution skewness, and the size-weight relationship.

Table 1: Distribution of sampling sites by year

Cameroonian coastal region	Divisions	Number of sampling sites	Area of fishing	Years of data collection
Littoral	Sanaga Maritime	5	Yoyo*, Youmé*, Mbiako*, Mouanko¥, Mombo'o*, Banguè*	2018, 2019
	Wouri	4	Youpwé£, Ile de Manoka*, Essengue£, Akwa Nord¥	
	Nkam	1	Bona'anja**, Bodiman**	
	Moungo	1	Bossamba**	
South	Ocean	8	Londji¥, Ngoye¥, Mboamanga£, Elabè¥, Beach*, Etondè*, Bouandjo*, Ebodje*	2014, 2015, 2017

Fishing villages*; Fishing places**; Fishing landing points ¥; Fishing ports £.

2.3 Data analysis

The level of exploitation of a fishery can be analyzed using several parameters (e.g., biological, statistical). Here, the "skewness", or coefficient of asymmetry, was selected [16]. This coefficient measures the asymmetry of a distribution [17] around the catch sizes (total length in cm), providing information on each species' their departure from the normal distribution (i.e, a negative skewness is an asymmetry on the left, while a positive skewness is an asymmetry on the right). This coefficient was also calculated by study areas, where the value of the asymmetric coefficients of a site is the mean value of all the asymmetric coefficients for each species of fish encountered at the given site. The central values chosen are the mode (Mo) or size class with the largest sample size and the arithmetic mean of the sample (μ).

$$\text{Skewness} = \frac{\mu - Mo}{\text{Standard deviation}}$$

Since a standard deviation is positive, the sign of the skewness coefficient varies between the mean, the mode and the median (Figure 2 and Table 2). In the case of a positive asymmetry (skewness > 0), we have within the sample sizes of a species of fish: Mo (Mode) < Md (Median) < μ (Mean). For a negative asymmetry (skewness < 0), the values will be arranged as follows: Mo (Mode) > Md (Median) > μ (Mean). Perfect symmetry is observed when the asymmetry coefficient is equal to 0 (approaching a normal distribution), that is: Mo (Mode) = Md (Median) = μ (Mean).

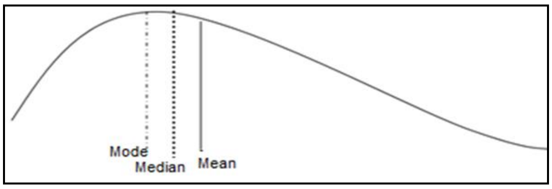

Fig 2: Example of asymmetry to the right (positive skewness)

In order to estimate the size-biomass relationship, the allometric models of 6221 individuals belonging to the 27 fish species the most encountered on the Cameroonian coast were established. This equation is noted: $Y = aX^k$, with Y representing the fish weight, X the total fish length, "a" being the condition index, and "k" being the coefficient of allometry [18]. The correlation coefficient 'r' was used as an indicator of the quality of the models produced.

Here, we considered that the coefficient k varies between 2 and 4, but is in general close to 3 when the growth is isometric (i.e., the shape of the body and the density do not vary with the size). When 'k' departs from 3, growth is said to be allometric. A 'k' coefficient greater than 3 (major allometry) indicates better growth in weight than in length, while coefficients smaller than 3 (minor allometry) indicate lean fishes [19].

3. Results

3.1 Distribution and level of exploitation of the resource based on sites

The size structure of fish landed in the 19 sampled sites shows a dominance of small individuals (Figure 3). The modal class of this sample is [20 -30[, or 32.38% of the catch, with over 62.05% of the fish measured having a total length of less than 30 cm.

Analysis of the degree of asymmetry (Figure 4 and Figure 5) has provided novel information on the level of exploitation of the 27 most fished and landed species along the Cameroonian coast. A classification based on the asymmetry coefficients has been developed in Figure 4. Overall, for a confidence interval of 5%, 22% of the catches show no dissymmetry, 18% of them are larger than mean (asymmetry coefficient < 0), and 41% are under significant pressure with more than 41% (the value of skewness > 1).

Species the most over-exploited are Galeoides decadactylus, Pseudotolithus typus, Polydactylus quadrifilis (skewness values: 2.463, 2.346, 2.299). The fish resources, which are not subjected to fishing pressure are Tylosurus sp., Drepane africana, and Sardinella maderensis, with asymmetry values of -0.644, -0.428, -0.193 respectively. They are mainly landed in the Cameroon coastal region.

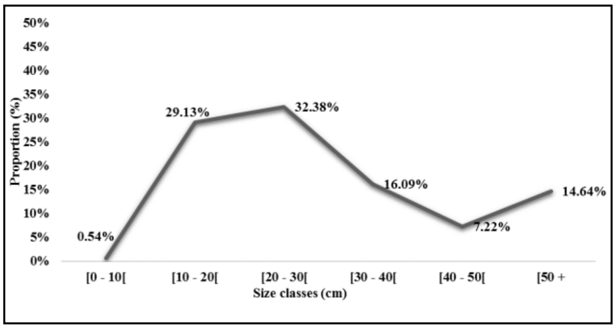

Fig 3: Distribution of fish sizes landed along the South and the Littoral regions of Cameroon's coast (2014-2019)

Marine fishing activities differ depending on the part of the coastal area studied. Figure 5 presents information on the level of exploitation by site. Landing observations shows that the marine fishery in the South coastal region is more under pressure than the one of the Littoral region. The places set up for the embarkation and disembarkation of fishing canoes (landing stages) do not have (Youpwé, Essenguè, Yoyo) or experience (Londji, Mboamanga) low fishing pressures in relation to the sizes of fish landed (Figure 5). The fishing villages and landing points are mainly under pressure by the presence of juvenile fish in the landings (i.e., Elabé in the South region).

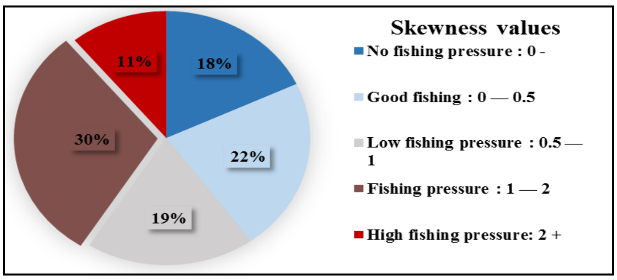

Fig 4: Levels of exploitation based on the skewness of captured fish distribution (2014 to 2019).

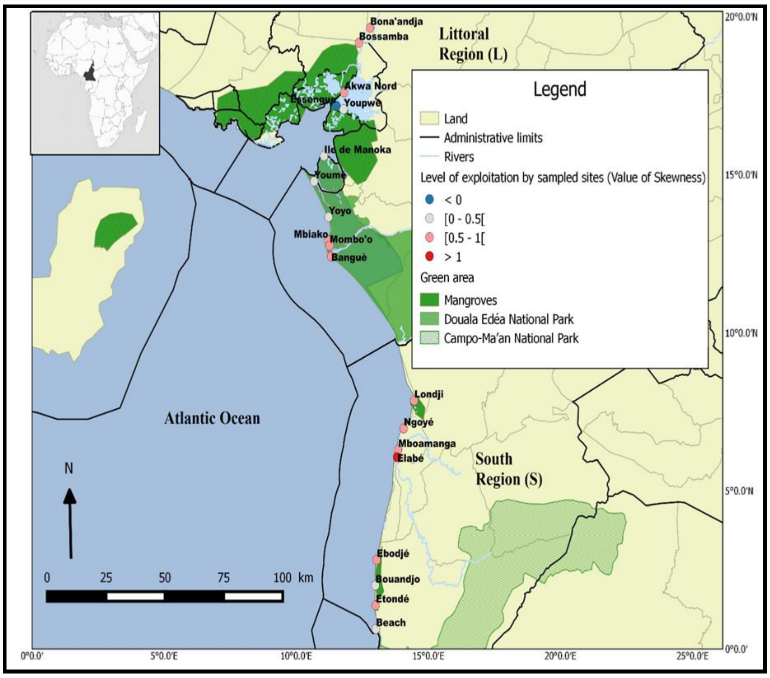

Fig 5: Map of fish levels of exploitation by sampled sites

Table 2: Biometric measurements and classification of the level of exploitation (ordered by skewness) of 27 marine fish species for the coast of Cameroon.

Families	French Names *(Common / vernacular)*	Scientific Names	Mean (cm)	Median (cm)	Min.	Max.	Skewness	Se(S)	N	OD
Polynemidae	Petit capitaine (*Capitaine*)	*Galeoides decadactylus*	30.22	21	12	58	2.463	0.129	360	LS
Sciaenidae	Otholithe naka (*Bar/ tchokolobi*)	*Pseudotolithus typus*	31.89	29.25	11.8	100	2.346	0.153	405	LS
Polynemidae	Grand capitaine (*Capitaine de mer*)	*Polydactylus quadrifilis*	65.10	29	6.2	170	2.299	0.179	196	LS
Haemulidae	Grondeur sompat (*Dorade grise/ Mboh/ Ngowèh*)	*Pomadasys jubelini*	24.13	20.40	13.7	57	1.758	0.276	134	LS
Mugilidae	Mulet (*Mboh*)	*Mugil cephalus*	30.63	29.50	20	58	1.703	0.279	74	L
Carangidae	Carangue (*Moutondoh/Mbem*)	*Chloroscombus chrysurus*	23.62	20	10.3	32	1.603	0.281	73	L
Clupeidae	Ethmalose (*Bounga/ Bifaga*)	*Ethmalosa fimbriata*	23.53	21	10	52	1.49	0.159	1040	L
Sphyraenidae	Bécune (*Brochet Barakuda*)	*Sphyraena* sp.	62.33	49.75	9	153	1.421	0.237	102	S
Sciaenidae	Courbine pélin (*Boma penda*)	*Pteroscion peli*	16.42	15	9	28	1.334	0.251	92	S
Clupeidae	Alose rasoir *(Rasoir/ Miyo)*	*Ilisha africana*	17.34	16.43	11	38	1.161	0.191	1103	LS
Sciaenidae	Otholithe sénégalais (*Faux bar*)	*Pseudotolithus senegalensis*	29.95	27.50	11	66	1.155	0.335	56	S
Ariidae	Machoiron banderille (*Machoiron*)	*Arius* sp.	38.36	32	21	65	0.807	0.311	95	S
Polynemidae	Capitaine royal (*Bierbier/ Barbillon*)	*Pentanemus quinquarius*	18.55	18	8	34	0.773	0.132	342	LS
Sphyrnidae	Requin marteau (*Requin*)	*Sphyrna couardi*	52.07	49	26	75	0.663	0.567	38	LS
Sciaenidae	Bossu (*Nyendi/ Nyondeh/ Cococo*)	*Pseudotolithus elongatus*	23.04	23.50	6	53	0.601	0.091	731	LS
	Ombrine bronze (*Bossu noir*)	*Umbrina canariensis*	32.30	31	13.3	62	0.549	0.095	664	LS
Cynoglossidae	Sole de langue sénégalaise (*Sole noire*)	*Cynoglossus senegalensis*	34.19	33	13	46	0.481	0.481	43	S
Lutjanidae	Carpe noire (*Epondji*)	*Lutjanus* sp.	43.28	48.03	14	58.3	0.455	0.132	29	S
	Vivaneau brun (*Carpe*)	*Lutjanus dentatus*	38.12	37.20	18	64.5	0.424	0.350	37	L
Dasyatidae	Raie (*Nyomo/ Coverpot*)	*Dasyatis margarita*	99.50	99	32.5	158	0.17	0.302	63	S
Psettodidae	Turbot épineux tacheté (*Turbot*)	*Psettodes belcheri*	33.10	30.50	20	48	0.165	0.374	40	LS
Carangidae	Carangue noire (*Ngogno*)	*Caranx* sp.	36.35	33	13	57	0.146	0.274	79	LS
Cynoglossidae	Sole de langue guinée (*Sole*)	*Cynoglossus monodi*	42	44	15.9	50.5	-0.04	0.192	159	LS
Bagridae	Machoiron noir (*Nyenda/ Kwakoro*)	*Chrysichthys* sp.	38.23	39	24.6	53.5	-0.144	0.337	57	L
Clupeidae	Sardinelle (*Sardine/ Muyanyah*)	*Sardinella maderensis*	17.24	17.50	10	25	-0.193	0.314	53	LS
Drepaneidae	Disque (*Ekèké*)	*Drepane africana*	16.03	16.85	6.3	25	-0.428	0.228	104	L
Belonidae	Aiguille crocodile (*Couta/ Ndoroh*)	*Tylosurus* sp.	93.56	108	14	110	-0.644	0.327	52	L

Skewness = Coefficient of asymmetry; Se(S) = Skewness standard error; Min. = Minimum size observed (total length in cm); Max. = Maximum observed size (total length in cm); OD = Origin of data (L = Littoral Region; S = South region; LS = Coastal regions of the Littoral and the South).

3.2 Length-weight relationship

Table 3 establishes size-weight keys for the 27 most commonly observed marine fish species in the study area. The coastal regions (Littoral or South) where the data were collected are specified for each allometric model. When species were observed in both regions, all the information collected was considered in the construction of the models.

The species Ilisha africana landed in the Littoral and South regions, have total lengths ranging from 11 (min) to 38 cm (max), with a strong correlation between fish length and weight (r = 0.948; Table 3). Furthermore, the species Lutjanus sp., observed in South region is the least represented with 29 individuals and sizes ranging from 14 to 58.3 cm (r = 0.979; Table 3).

The lowest correlation coefficient is for Mugil cephalus (r = 0.845, Table 3). This result is likely due to the small data range and the large mass dispersion for sizes between 30 and 40 cm. Overall, the correlations established are high, with only 7 of the 27 allometric keys presenting correlations between 0.90 and 0.95. The other 19 keys have correlation coefficients greater than 0.95. The strongest correlations are observed for Pomadasys jubelini and Polydactylus quadrifilis, with r = 0.994.

4. Discussion

4.1 Analyze the level of exploitation

The information on the structure of the size classes of fish includes all the geographic areas sampled. For several species encountered such as *Pseudotolithus senegalensis*, *P. elongatus*, *P. typus*, *Cynoglossus* sp. and *Pteroscion peli*, Cameroonian standards and the work of researchers on these fish in the Gulf of Guinea place the minimum catch sizes (total length) between 20 and 30 cm [20, 18]. For a particular species Sardinella maderensis, the minimum catch size is 19 cm [20]. Several species of marine fish (Polydactylus quadrifilis, Drepane africana, Cynoglossus sp., Pseudotolithus sp.) fished by industrial boats towards end of twentieth century in Cameroon [21] are currently observed in landings of artisanal fishermen. These catches show that Cameroonian artisanal fishing is practiced with more important equipment.

The modal class observed, although measured for all 27 species encountered (Figure 3), poses a problem on the level of exploitation of living resources in these waters. Sow *et al.*, [22] who studied fisheries in Senegal obtained information different from that observed on the Cameroonian coasts. Their work carried out on the West Africa coastline made it possible to observe a percentage of the modal class of 62% for sizes between 60 and 70 cm. The observations are very different since Sow's studies in Senegal focused on a single marine species, the grouper Epinephelus aeneus.

Table 2 shows that the mean coefficient of asymmetry and the standard error of the 27 fish species are 0.838 and 0.258 respectively. This finding validates the hypothesis that individuals of small sizes abound within the fish population catches and landings along the Cameroonian coast. Indeed, the size (Total length) obtained within the population of each species (for the 27 studied), the modes and the medians are generally lower than the mean sizes. The combined skewness confidence interval for the 27 species is 0.838 ± 0.516. Such results indicate that the most caught and landed fishes on the Cameroonian coast are under pressure. This level of exploitation remains more or less dynamic by species.

Figure 5 shows that the fish catches and landings on the Cameroonian coastal area are under pressure. This confirms the hypothesis that juvenile marine fish are abundant in the landings. The mobility of marine fishermen being open on an aquatic territory [23] puts a doubt on the conclusion that the southern region is more badly exploited than that of the littoral, insofar as the fish landed in a place could be caught far beyond regional borders [24]. In the same logic, the logistical, seasonal and accessibility conditions encountered have led the present work to slight disparities in the sampling rate by sites studied.

Table 3: Size-weight relationship established for 27 most fished fish species landed on the Cameroonian coast

Families	French Names *(common / vernacular)*	Scientific names	Min.	Max.	a	k	r	N	OD	TG
Clupeidae	Alose rasoir *(Rasoir/ Miyo)*	*Ilisha africana* (Bloch, 1795)	11	38	0.021	2.84	0.948	1103	LS	-
	Ethmalose (*Bounga/ Bifaga*)	*Ethmalosa fimbriata* (Bowdich, 1825)	10	52	0.056	2.181	0.951	1040	L	-
Sciaenidae	Otholithe bobo (*Nyendi/ Nyondeh/ Cococo*)	*Pseudotolithus elongatus* (Bowdich,	6	53	0.159	2.13	0.959	731	LS	-
	Ombrine bronze (*Bossu noir*)	*Umbrina canariensis* (Valenciennes,	13.3	62	0.014	2.96	0.958	664	LS	0
	Otholithe nanka (*Bar/ Tchokolobi*)	*Pseudotolithus typus* (Bleeker, 1863)	11.8	100	0.159	2.12	0.963	405	LS	-
Polynemidae	Petit capitaine (*Capitaine*)	*Galeoides decadactylus* (Bloch, 1795)	12	58	0.027	2.71	0.981	360	LS	-
	Capitaine royal (*Bierbier/ Barbillon*)	*Pentanemus quinquarius* (Linnaeus,	8	34	0.007	3.003	0.969	342	LS	+
	Grand capitaine (*Capitaine de mer*)	*Polydactylus quadrifilis* (Cuvier, 1829)	6.2	170	0.018	2.83	0.994	196	LS	-
Cynoglossidae	Sole de langue guinée (*Sole*)	*Cynoglossus monodi* (Chabanaud, 1949)	15.9	50.5	0.006	2.891	0.952	159	LS	0
Haemulidae	Grondeur sompat (*Dorade grise/ Mboh/*	*Pomadasys jubelini* (Cuvier, 1830)	13.7	57	0.026	2.75	0.994	134	LS	-
Drepaneidae	Disque (*Ekèké*)	*Drepane africana* (Osorio, 1892)	6.3	25	0.065	2.414	0.958	104	L	-
Sphyraenidae	Bécume (*Brochet Barakuda*)	*Sphyraena* sp. (Artedi, 1793)	9	153	0.016	2.686	0.975	102	S	-
Sciaenidae	Courbine pélin (*Boma penda*)	*Pteroscion peli* (Bleeker, 1863)	9	28	0.006	3.3	0.953	92	S	+
Ariidae	Machoiron banderille (*Machoiron*)	*Arius* sp. (Valenciennes, 1840)	21	65	0.004	3.153	0.953	95	S	+
Carangidae	Carangue noire (*Ngogno*)	*Caranx* sp. (Lacepède, 1801)	13	57	0.004	3.229	0.984	79	LS	+
	Carangue (*Moutondoh/ Mbem*)	*Chloroscombus chrysurus* (Linnaeus,	10.3	32	0.103	2.167	0.942	73	L	-
Mugilidae	Mulet (*Mboh*)	*Mugil cephalus* (Linnaeus, 1758)	20	58	0.155	2.071	0.845	74	L	-
Dasyatidae	Raie (*Nyomo/ Coverpot*)	*Dasyatis margarita* (Günther, 1870)	32.5	158	0.083	2.849	0.944	63	S	-
Bagridae	Machoiron noir (*Nyenda/ Kwakoro*)	*Chrysichthys* sp. (Bleeker, 1858)	24.6	53.5	0.006	3.067	0.978	57	L	+
Sciaenidae	Otholithe sénégalais (*Faux bar)*	*Pseudotolithus senegalensis*	11	66	0.008	2.941	0.946	56	S	0
Clupeidae	Sardinelle (*Sardine/ Muyanyah*)	*Sardinella maderensis* (Lowe, 1838)	10	25	0.033	2.5	0.989	53	LS	-
Belonidae	Aiguille crocodile (*Couta/ Ndoroh*)	*Tylosurus* sp. (Cocco, 1833)	14	110	0.132	2.151	0.937	52	L	-
Cynoglossidae	Sole de langue sénégalaise (*Sole noire*)	*Cynoglossus senegalensis* (Kaup, 1858)	13	46	0.002	3.164	0.901	43	S	+
Psettodidae	Turbot épineux tacheté (*Turbot*)	*Psettodes belcheri* (Bennett, 1831)	20	48	0.001	3.512	0.903	40	LS	+
Sphyrnidae	Requin marteau (*Requin*)	*Sphyrna couardi* (Cadenat, 1951)	26	75	0.048	2.416	0.968	38	LS	-

Lutjanidae	Vivaneau brun (*Carpe*)	*Lutjanus dentatus* (Duméril, 1861)	18	64.5	0.029	2.811	0.991	37	L	-
	Carpe noire (*Epondji*)	*Lutjanus* sp. (Bloch, 1790)	14	58.3	0.096	2.56	0.979	29	S	-

Min.= Minimum size observed (total length in cm); Max.= Maximum observed size (total length in cm); a = Condition index; k = Coefficient of allometry; r = Coefficient of correlation; N = Number of individuals (many to small); OD= Origin of data (L: Littoral Region; S: South region; LS: Coastal regions of the Littoral and the South); TG = Type of growth (+: Positive allometry; –: Negative allometry; 0: Isometry)

4.2 Study of the coefficient of allometry (variable k)

The variable k representing the coefficient of allometry (Figure 6; Table 3) in the context of this study, varies from 2.071 (Mugil cephalus) to 3.512 (Psettode bennett). For the 27 fish observed on the Cameroonian coasts, the mean of the coefficient k is 2.718. This suggests the fish observed have a diminishing or negative growth (2.718 < 3), indicating that the Cameroonian marine fish has growth generally better in length than in weight (biomass). This is in contrast to the work of Mikembi *et al*. [25] on 13 species of freshwater fish in Congo that obtained a mean of the coefficient of allometry of 2.901. In addition, similar work on Lake Chad and the West African lagoons on 58 and 52 fish species respectively showed mean coefficient of allometry of 3.01 and 2.969 respectively [26, 9].

4.3 Spatial analysis, relationship between A and K

The points in Figure 6 are distributed in an agglomeration of points, notwithstanding the geographic origin of the data. This representation seems to indicate clearly that the allometric models do not take into account the marine ecosystems or the sampling places (coastal, southern sites). However, two of the 27 species, Lutjanus sp. and Dasyatis margarita mainly encountered in the Southern region are gradually moving away from point clouds. This difference shows a specificity by ecosystems for these two species. Similar results have been obtained in the lagoons of West Africa [9]. Out of 52 fish species studied, only two species (Eucinostomus melanopterus and Galeoides decadactylus) presented different relationships by ecosystem.

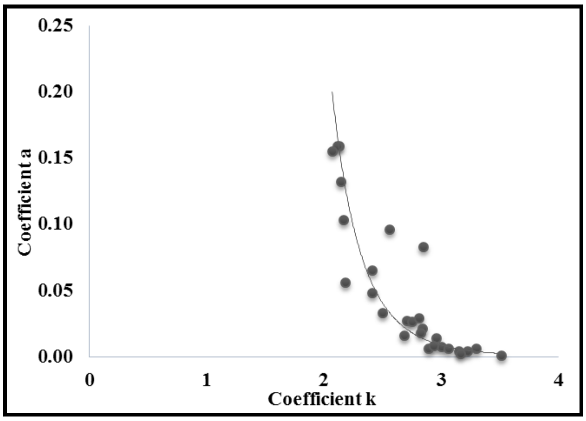

Fig 6: Distribution of the relationship of the k-a coefficients for 27 fish species

Although the values of the variable k can vary depending on the parameters of the environment (the state of health of the ecosystems), the sex of the fish, the growth phase, the stomach contents, and the level of gonad development [27, 28], this observation on the type of growth (depending on the variation of the variable k) of fish caught and landed at the Cameroonian coast, poses the problem of nutrient scarcity in these ecosystems. The latter are becoming vulnerable to the proliferation of industrial activities likely to directly or indirectly impact the availability of essential food [29] for better growth of fishery resources.

5. Conclusion

This study provided a first regional baseline of class size distribution for 27 common fish species. It provides new size-weight keys for each species, helping assess potential levels of exploitation for the 27 species. Those keys can help support a more sustainable management of artisanal maritime fisheries at a national scale by identifying species that may benefit from different regulations as well as regions where fisheries management may require more attention. The study has shown that many species have a larger proportion of juvenile fishes in landings, such as Pseudotolithus typus, P. elongatus and Galeoides decadactylus. This was mainly the case in the South region. Analyses also highlighted a fluctuation in the sizes of the fish populations landed, characterized by a modal class of [20 - 30[, with a percentage of 62.05%. In addition, the average coefficient of asymmetry for all the species sampled (0.838) suggests an overall high fishing pressure on marine ecosystems along the Cameroonian coast.

Conserving, protecting and rehabilitating the coastal and marine environments of Cameroon while integrating maritime activities such as fisheries, is becoming a major challenge that ecologists and environmental managers have to face in Cameroon. Coastal and marine fish absent from this study are present in neighboring marine fisheries and wharves, such as those in Southwest region or those of other central African states. It would be beneficial to extend this work to the entire Cameroonian coast and in the Central African sub region, since these marine resources occupy the same living space and can move from one country to another.

6. Acknowledgements

This research was supported by the Ministry of Higher Education of the Republic of Cameroon through the modernization research allowances and the assistance from research mobility grant of French Embassy in Cameroon. The authors would like to thank Rodolphe Devillers, Director of Research at IRD-France for useful comments on the manuscript. They also thank the master's students (Mrs. Mube, Jiotsa, Tindo, and Tchouagou Rodrigue) from fishery resources laboratory at the University of Douala for their assistance in obtaining fish samples.

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