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# Evaluating the sustainability of fishery resources and fishing gears: Case study of Ngoyè and Elabè, Kribi, South Cameroon

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**Abstract**
Evaluating fishing methods and associated gears over the time is one key to understanding the sustainability of fisheries resources. Well-managed fishery is expected to use gear that catch most of the available species at sizes that do not undermine sustainability. This study investigates effects of two fishing gears used in two landing sites of Kribi and sustainable exploitation of fishery resources. The semi-direct survey included questionnaire interview from fishermen and direct observation of fishing gears at the time of operation was chosen to collect information. A total of 299 bottom-set gillnets with mesh sizes ranging from 15 mm to 100 mm and 17 beach seines were listed at both landing sites. Beach seine catches combined as well as pelagic, demersal or benthic species. Among the species caught, *Ilisha africana* was the dominant species followed by *Pseudotolithus senegalensis*, *Pseudotolithus typus*. Cath profile of bottom-set gillnet showed that *Pseudotolithus typus*, *Pseudolithus senegalensis*, and *Cynoglossus* sp. were the three dominant species. No growing stage is spared by the beach seine catches and the minimum size obtained was 4 cm for *Selenne dorsalis* and *Pseudotolithus senegalensis*. The reduction in size and relative high number of landed species result from pressure on fishery resources, non-compliance with regulations in terms of gear and fishing techniques.

**Keywords:** Beach seine, bottom-set gillnet, fishing resources, mesh size, sustainable fisheries

## Introduction
Cameroon is a coastal country in Central Africa located in the Gulf of Guinea and covering an area of 475,000 km². The length of the Atlantic coast is 402 km, spread over three regions: South-West, Littoral and South Regions [1]. Fishing is an essential sector in the food supply of populations and in the socio-economic life of Cameroon. Spread over the entire coast, Cameroonian artisanal maritime fishing is generally practiced in the 3-mile zone [2]. It is largely concentrated in estuaries, creeks, mouths and the coastal zone, on bottoms less than 20 m deep. As the main occupation of the local populations of the littoral zone, fishing ensures food security with a fish consumption of 17 kg/capita/year, with 49.7% coming from artisanal fishing [3]. Fishery employs nearly 200,000 people, 62.5% of whom work in artisanal fishing. The fishing sector contributed 1.7% to the creation of national wealth in 2003, or 119.4 billion FCFA, with a contribution from artisanal fishing of 52.4 billion [4].
Artisanal maritime fishing is also characterized by the use of multiple gears which include: pull or beach seines, set nets, drifting gill nets, bottom-set gill nets, surface gill nets, hand lines and longlines [5]. The Bottom-set gill nets are the most widely used and therefore exert great pressure on resources. Hence demersal species are recognized to be in a state of overexploitation. This state of overexploitation, which dates back to 1986, has been documented by several authors including [6, 7, 8, 9, 10, 11]. Indeed, the use of unselective gear near the coast endangers fish breeding areas. Other practices considered destructive, in particular monofilament nets and nets with very small meshes (known as mosquito nets) and seine nets are all recurring techniques in artisanal fishing.
A few years ago, the seas and oceans were considered inexhaustible. Unfortunately, today more than half of fish stocks in the world are in danger [12]. These threats do not only arise in economic terms, they also integrate the environmental aspect with regard to the degradation of

bio-aquatic resources and their habitats under the combined effect of the rapid increase of the population and the not responsible fishing techniques. If the exploitation of marine resources constitutes a potentially promising economic sector, it should nevertheless be part of the long term. Fishery resources must give rise to sustainable exploitation based on good fishing practices, able to guarantee their sustainability [13].

[6] draws up the state of demersal species and their exploitation in Cameroon and [5] shows the dynamism of artisanal maritime fishing in Limbé and Kribi, while [14] insists on conservation techniques, processing and fish distribution networks in the same country. Finally, [15] provides information on the socio-economic contribution of fishing to the creation of wealth in Cameroon, however they have often ignored the ecological aspect, i.e. the impact of fishing gear on the ichthyofauna. Because the sustainable management of a resource first requires good knowledge of the resource itself, as well as the fishing techniques and gear used for its exploitation. This study aims to investigate effects of two fishing gears used in two landing sites of Kribi and sustainable exploitation of fishery resources.

## 2. Materials and Methods

### 2.1 Study areas

Studies were undertaken at two landing sites (Fig.1) called Ngoyè and Elabè Longitude (09º50'36"to 09º49'50"E and Latitude (03º33'26"to 03º31'42N located on the coast of Kribi, in the south region of Cameroon. Both landing sites are smallest ones, of the seven landing sites in kribi that offer the possibility of monitoring the activity of small-scale fishermen using bottom gill nets and beach seines. Artisanal maritime fishing is the most common activity in the study area and the majority (Around 95%) of those involved are Cameroonians. The bottom-set gillnet is the most widely used fishing gear in the area and the beach seine is used very close to the coast in the forbidden areas by some fishermen despite its ban.

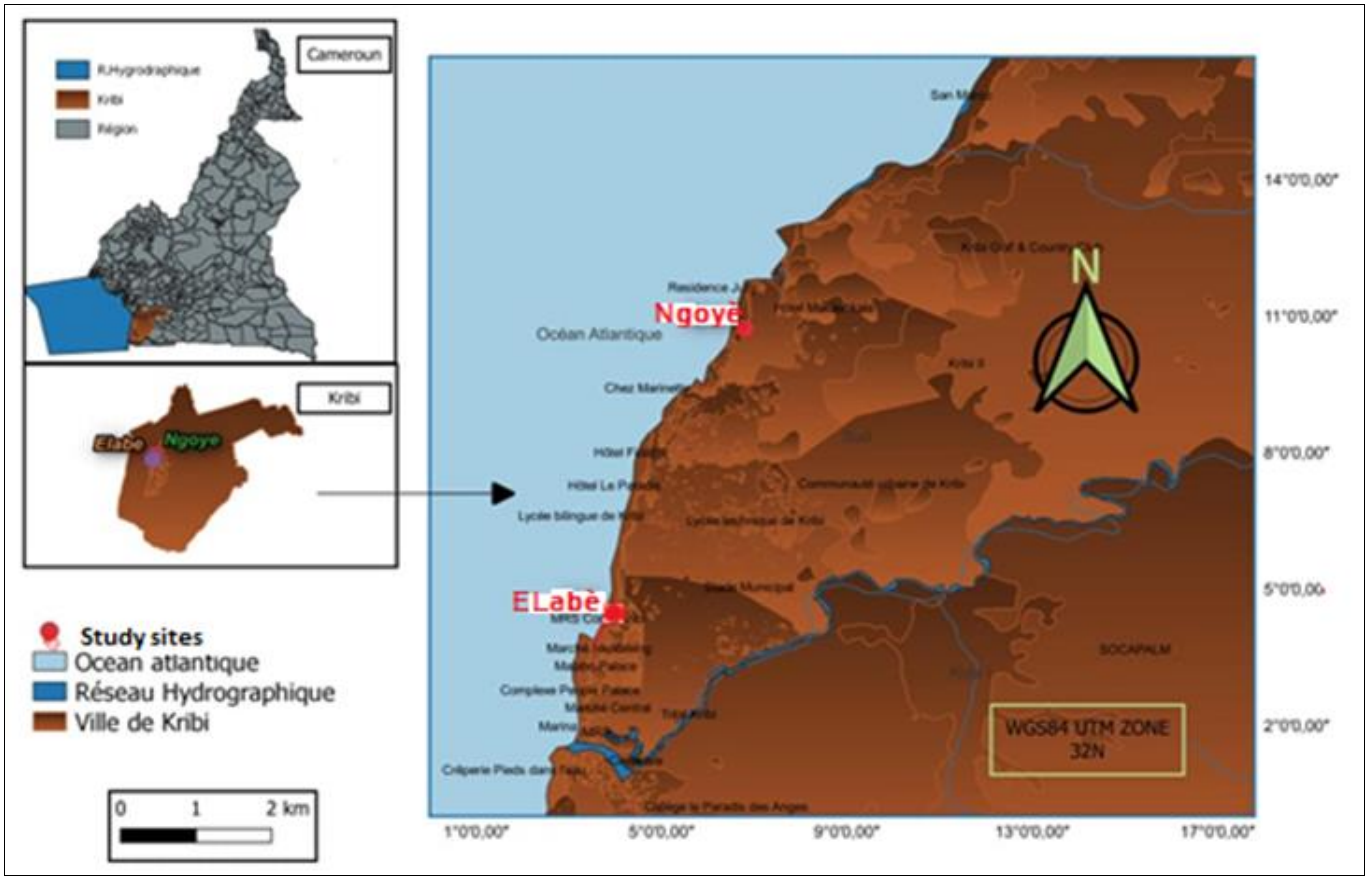



**Fig 1:** Localisation study area

### 2.2 Data collection

The semi-direct interview is the main data collection technique used during our field trips. It was therefore necessary to first construct a maintenance grid which enabled us to set the framework and objectives. The approach was chosen because it has the deserve to aim for well-framed and very precise data while leaving actors a freedom to express themselves. This is why the interview grid was made up times of closed and open questions to collect the different opinions of fishermen on their future through what they earn from their work, the quality of their catches and the sustainability of fisheries through the gear and fishing techniques they use in particular the bottom gillnet and the beach seine. The interview involved fishing communities and ship owners. Discussions with fishermen and ship-owners focused on the fishing activity, the choice of use such fishing gear or techniques, the yield of the gear, the choice of meshes, the duration of use of the gear, the disadvantages of using a particular gear or fishing technique.

Once the catches have been landed, sorting is carried out according to the different species present, then the following information is taken: species identification, total length (TL) and standard length (SL) in order to have the minimum, maximum and average sizes by species, the weight, according to the gear used, using the fish measurement guide [16, 17] identification key permitted to determine scientific name of different species.

### 2.3 Data analysis
The number and distribution of the different fishing gears according to the meshes were showed at both landing sites. The catch profile of each gear was established and the size frequencies of the three most caught species were determined. Analysis was used to find the average size of fish species landed at these two landing sites. This is to show the impact of fishing gears on the resource, as the size informs on the development of individuals.

## 3. Results
### 3.1 Fishing gears characteristics at the two boat landing sites
Beach seines are very fine fishing gears composed of layers of nets of different meshes. It is made up of pieces of net with different mesh sizes. The ones that constituted the seine are 10 mm and the rest 15 mm. In the two sites 17 beach seines are listed. The figure 2 below shows the distribution of beach seines at the two sites.

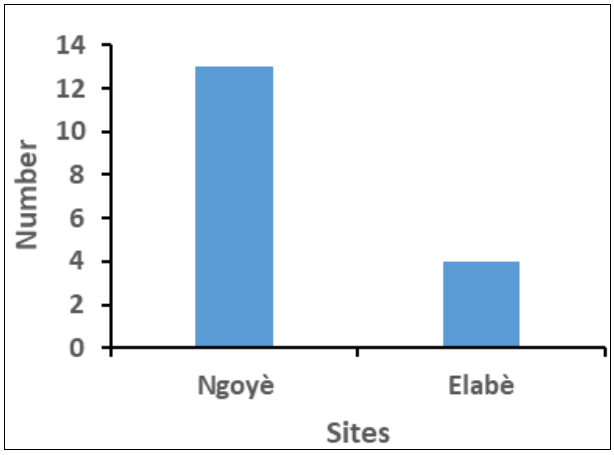



**Fig 2:** Distribution of beach seines according to mesh size

The mesh sizes of the bottom gillnets at both sites ranged from 15 mm to 100 mm. In Ngoyè 208 bottom gillnets were identified. Among these nets the most used meshes are the three fingers (30 mm) followed by the four fingers (40 mm). Albeit in Elabè, 91 bottom gillnets have been identified. The most used meshes are 2.5 fingers (25 mm) followed by 2 fingers (20 mm) (Fig 3).

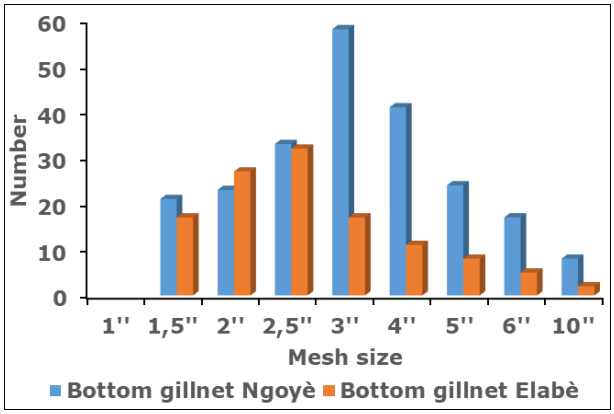
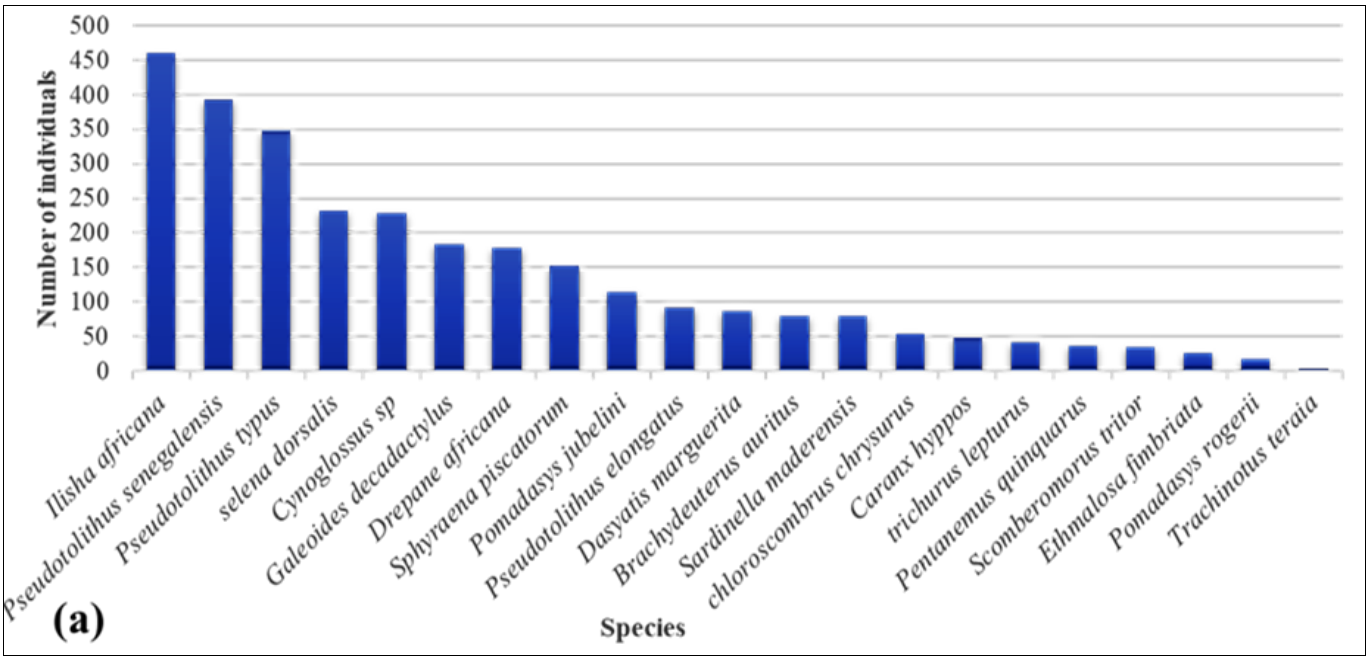



**Fig 3:** Distribution of bottom gillnets according to mesh size

### 3.2 Catch profile of the different gears
Depending on the type of fishing gear and the fishing technique used, catches vary from one gear to another. The catch profile of the two different fishing gears independently of the landing site is given in fig. 4. Beach seine catches (Fig. 4a) combined as well as pelagic, demersal or benthic species. Among the species caught, *Ilisha africana* was the dominant species followed by *Pseudotolithus senegalensis*, *Pseudotolithus typus*, *Selenne dorsalis* and *Cynoglossus* sp. Less captured species are *trachinotus teraia* and *Pomadasys rogerii*. Cath profile of bottom-set gillnet (Fig. 4b) showed that *Pseudotolithus typus*, *Pseudolithus senegalensis*, and *Cynoglossus* sp. were the three dominant species. The gear captures are demersal or benthic species.



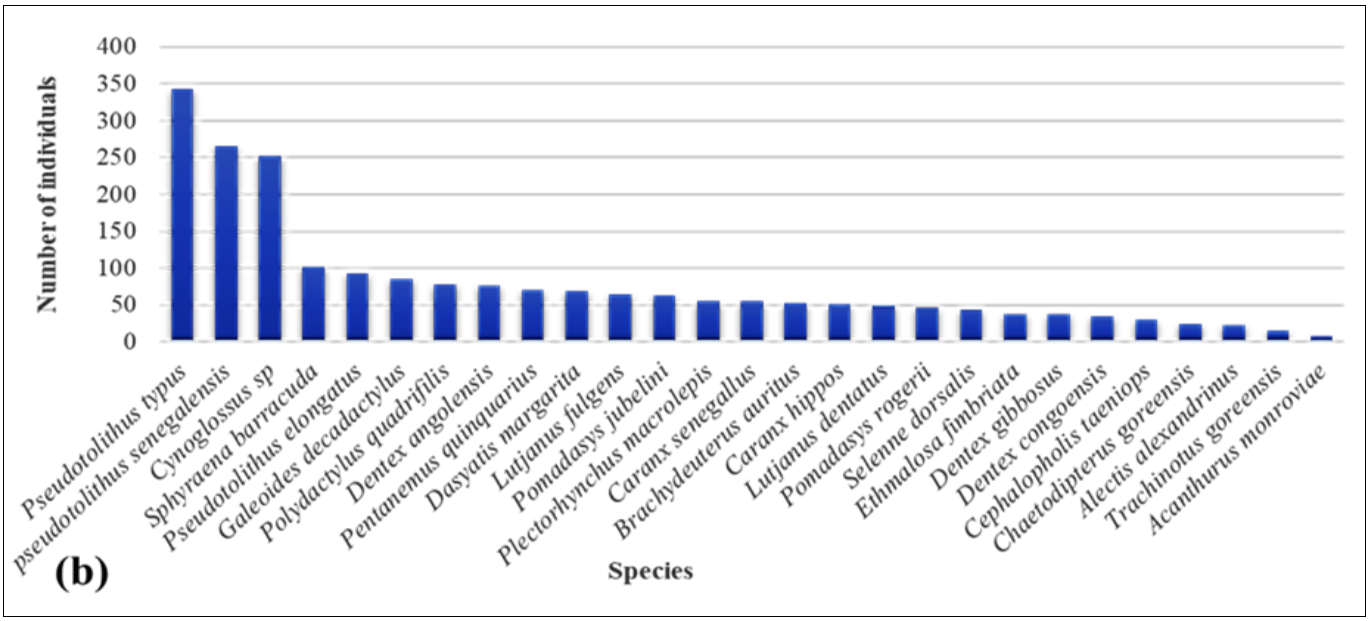



**Fig 4:** Catch profiles: a) Beach seine; b) bottom-set gillnet

### 3.3 Sizes of fish species caught by the two fishing gears

On the whole, the fish caught are getting younger and younger. No growing stage is spared, especially in the beach seine catches. In the case of the beach seine the minimum size obtained was 4 cm for *Selenne dorsalis* and *Pseudotolithus senegalensis* and the maximum size obtained was 30 cm. For the bottom gillnet a slight progression in minimum sizes is observed. The minimum size obtained was 10 cm for *Pseudotolithus elongatus*, *Caranx hyppos* and many other species and the maximum size was 35 cm for *Polydactylus longifilis* and 38 cm for *Trichurus lepturus* (Table 1).

**Table 1:** Sizes of the main fish species caught by beach seine and bottom gillnet

| Family names | Scientific names | Beach seine | | | Bottom gillnet | | |
|---|---|---|---|---|---|---|---|
| | | Min size (cm) | Max size (cm) | Mean (cm) | Min size (cm) | Max size (cm) | Mean (cm) |
| Clupeidae | *Ilisha africana* (Bloch,1795) | 5 | 20 | 13,02±3,68 | - | - | - |
| Sciaenidae | *Pseudotolithus senegalensis* (Valenciennes, 1833) | 4 | 28 | 16,62±6,02 | 11 | 32+ | 20,46±6,56 |
| | *Pseudotolithus typus* (Bleeker, 1863) | 6 | 30 | 16,16±5,48 | 13 | 33+ | 22,63±7,43 |
| | *Pseudotolithus elongatus* (Bowdich, 1825) | 10 | 22 | 16±2,41 | 10 | 26 | 17,57±3,19 |
| Clupeidae | *Ethmalosa fimbriata* (Bowdich, 1825) | 14 | 27 | 20±3,73 | 12 | 31 | 23,4±7,03 |
| | *Sardinella maderensis* (Lowe, 1839) | 10 | 19 | 12,73±4,77 | 11 | 29 | 19,21±3,47 |
| Drepanidae | *Drepane africana* (Osorio, 1892) | 10 | 22 | 14,97±4,12 | 10 | 27 | 18,69±4,58 |
| Polynemidae | *Galeoides decadactylus* (Bloch, 1795) | 11 | 18 | 15,29±5,25 | 12 | 19 | 15,49±1,44 |
| | *Pentanemus quinquarius* (Linnaeus, 1758) | - | - | - | 11 | 15 | 14,12±2,41 |
| Carangidae | *Selene dorsalis* (Gill, 1816) | 4 | 13 | 9,41±2,76 | 10 | 12 | 7,81±1,80 |
| | *Caranx senagallus* (Cuvier, 1833) | - | - | - | 13 | 22 | 20,32±5,58 |
| | *Caranx hippos* (Linnaeus, 1766) | 8 | 16 | 11,11±4,34 | 10 | 19 | 14,38±2,91 |
| | *Alectis alexandrinus* (Geoffroy Saint-Hilaire, 1817) | - | - | - | 12 | 27 | 16,6±6,89 |
| | *Chloroscombrus chrysurus*(Linnaeus, 1776) | 11 | 19 | 13,05±4,81 | 10 | 23 | 16,23±3,43 |
| Pomadasyidae | *Pomadasys jubelini* (Cuvier, 1830) | 9 | 27 | 16,35±4,78 | 10 | 29 | 18,33±4,25 |
| | *Pomdasys rogerii* (Cuvier, 1830) | 10 | 25 | 15±4,58 | 12 | 27 | 18,97±5,52 |
| Trichuiridae | *Trichurus lepturus* (Linnaeus, 1758) | 17 | 29 | 22,57±4,04 | 20 | 38 | 29,69±563 |
| Sphyraenidae | *Sphyraena barracuda* (Walbaum, 1792) | 9 | 26 | 20±5,72 | 17 | 32 | 28±6,24 |
| Cynoglossidae | *Cynoglossus sp* | 11 | 28 | 17,85±5,80 | 12 | 33 | 24,87±3,13 |
| Dasyatidae | *Dasyatis marguerita*(Gunther,1870) | 15 | 26 | 17±4,42 | 16 | 36 | 22,44±3,81 |
| Haemulidae | *Brachydeuterus auritus(*Valenciennes,1832) | 7 | 15 | 11,89±3,59 | 10 | 17 | 13,04±2,67 |
| Scombridae | *Scomoberomorus tritor*(Cuvier, 1830) | 13 | 29 | 19,47±2,66 | 16 | 32 | 25±2,88 |
| Sparidae | *Dentex gibbosus* (Rafinesque, 1810) | - | - | - | 14 | 26 | 19,38±4,08 |
| | *Dentex congoensis* (Poll,1954) | - | - | - | 15 | 27 | 16,6±6,76 |
| Lutjanidae | *Lutjanus fulgens(*Valenciennes, 1830) | - | - | - | 13 | 22 | 20,03±4,94 |
| | *Lutjanus dentatus* (Dumeril, 1860) | - | - | - | 10 | 18 | 18,97±5,52 |
| Polynemidae | *Polydactylus quadrifilis* (Cuvier, 1829) | - | - | - | 17 | 35+ | 28,48±1,44 |
| Serranidae | *Cephalopholis taeniops* (Valenciennes, 1828) | | | | 15 | 30 | 23±9,94 |
| | *Chaetodipterus goreensis* (Valenciennes, 1830) | | | | 12 | 23 | 22,51±10,56 |

### 3.4. Size structure of the three most caught species

#### 3.4.1 By the beach seine

Among the species landed by the beach seine, *Ilisha africana* represented nearly 60% of the catches. It was the main target species for beach seine fishermen. The analysis of Size structure of *Ilisha africana* landed by beach seine at Ngoyè and Elabè showed a high percentage of immature individuals with sizes varying from 6cm to 20cm and a spike at 16cm (Fig. 5a). The second most landed species by beach seine fishermen was *Pseudotolithus senegalensis*. The large proportion of the catch was made up of immature fish with the sizes ranging from 6 cm to 26 cm with spikes at 20 cm (Fig. 5b). However, more than half of the specimens of this species was juvenile fish. The third species that also accounts for a significant portion of beach seine catches was *Pseudotolithus typus*. There is a very great similarity with the first two species in terms of proportion of immature. The size structure of *Pseudotolithus typus* varied from 6 cm to 28 cm with spike at 22 cm (Fig. c). Despite this, juveniles still remain an important part of its catches.

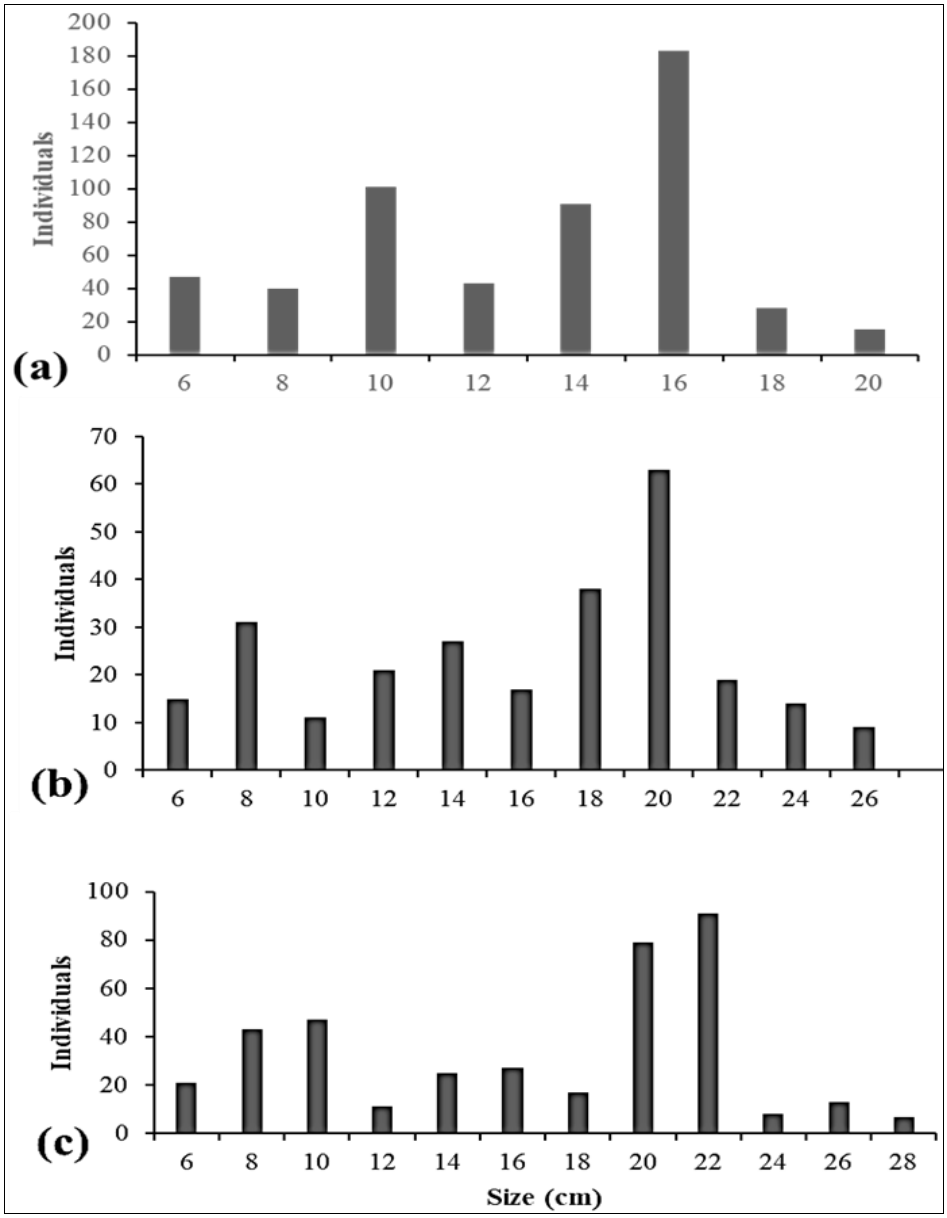



**Fig 5:** Size structure of the three most fish species caught by beach seine: a) Ilisha Africana; b) *Pseudotolithus senegalensis*; c) *Pseudotolithus typus*

#### 3.4.2. By the bottom-set gillnet

According to the census of the different species landed by this fishing gear, it appears that the three species dominated in these catches in Elabè and Ngoyè were: *Pseudotolithus typus*, *Pseudotolithus senegalensis* and *Cynoglossus* sp.The size structure of *Pseudotolithus typus*, the most landed species in bottom-set gillnet catches varied from 14 cm to 36 cm, the specimens which dominated were whose size was 24 cm (Fig. 6a). The proportion of juveniles was low. More than half of the catches are made up of mature fish. The second most landed species at the two landing sites was *Pseudotolithus senegalensis*. Together with *Pseudotolithus typus* they represent more than half of all species caught by bottom-set gillnets. The size structure of *Pseudotolithus senegalensis* varied from 12 cm to 30 cm, with spike at 24 cm (Fig. 6b). The third most landed species after the two previous ones was *Cynoglossus* sp. It appears that in the captures of *Cynoglossus* sp the specimens which dominated were those whose size was 28 cm (Fig. 6c).

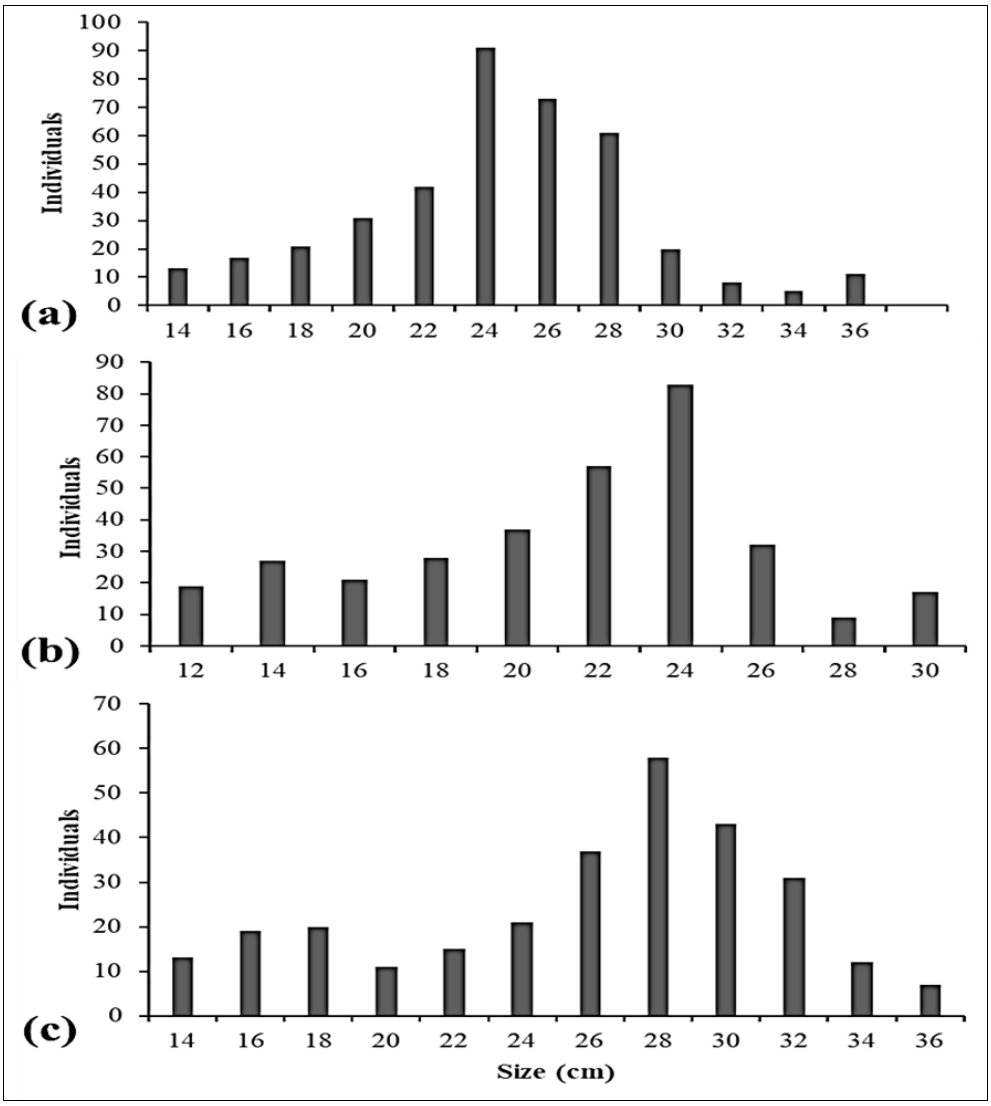



**Fig 6:** Size structure of the three most fish species caught by bottom-set gillnet: a) *Pseudotolithus typus*; b) *Pseudotolithus senegalensis*; c) *Cynoglossus* sp.

## Discussion

The bottom-set gillnet is the most commonly used fishing gear in the Kribi area. It is a passive fishing gears, it can be fixed or drifting. It mainly targets demersal species. The diversity of species that make up the catches landed by bottom-set gillnet fishing shows that the sizes are very varied, almost 20% of catches are juvenile fish or immature fish. It has been previously observed [18] that bottom gillnet fishing lands around 15% of juveniles. As reported by [6], the coastal demersal resources of Cameroon, their biology and the exploitation of the main ichthyological species show that the size at first maturity of species such as *Pseudotolithus senegalensis* and *Pseudotolithus typus* is 26 cm, while that of *Pseudotolithus elongatus* is between 19.5 to 22 cm. However, at the various landing sites in Elabè, the common size observed for *P. senegalensis* and *P. typus* is 23 cm, and at the level of Ngoyè, the common size of these two species is greater than the size of first maturity of these two species.

To guarantee the sustainable exploitation of its fisheries resources and ensure the food security and well-being of its populations, the Cameroonian government has drawn up regulatory texts which set standards on the minimum sizes of some commercial species Order No. 0002/MINEPIA of 1st August 2001. In particular, Law No. 94/01 of 20 January 1994 on the forest, wildlife and fisheries regime, which was supplemented by Order No. 0002/MINEPIA of 1st August 2001, which sets the minimum sizes of species caught. From the tip of the snout to the posterior end of the caudal fin, as follows: *Sardinella maderensis* (sardinelle, Etolo, Trong kanda, Belolo) 19 cm; *Pseudotolithus senegalensis* and *Pseudotolithus typus* (Bars) 25 cm; *Pseudotolithus elongatus* (humpback) 22 cm and *Cynoglossus canariensis* (sole) 25 cm (Order No. 0002/ MINEPIA of 1st August 2001). Today, fish are caught younger and younger because Order No. 0002/MINEPIA of 1st August 2001 on the protection of fisheries resources is not respected. It fixes in its chapter V the minimum sizes and weights of the target species. In the same Order in its chapter IV, it gives the characteristics (meshes) of certain fishing gears. Article 7 of order No. 0002/ MINEPIA of 1st August 2001 stipulates that the use of gear for artisanal fishing in maritime waters under Cameroonian jurisdiction is subject to the following rules: bottom gillnets: minimum mesh size (50 mm). However, the meshes observed in the field are increasingly fine with meshes that vary from 15 mm to 100 mm. The presence of 15, 20 and 30 mm meshes are observed in the field and yet this is prohibited in the same Order in its chapter III. The material also used to make the gear poses a problem. Most bottom gillnet fishing gear is made of monofilament nylon although this increase catches and creates damage to resources, as abandoned or torn nets

that remain at sea and continue to fish are responsible for the ghost fishing.

Beach seine fishing is strictly prohibited throughout Cameroon according to the Order of 1st August 2001, which considers it a prohibited fishing technique that impacts both fishery resources and their environment. Over 80% of landed catches are juveniles. It is an active, non-selective fishing gear that captures everything in its path. It is a destructive gear of resources mainly juveniles. The finding is similar in Benin with the work of [19, 20, 21]. The mesh is too fine between 8 mm and 15 mm. The Clupeidae dominate in the catches with a species *Ilisha africana* which represents more than 60% of the catches. The meshes are so fine that certain species such as *Selene dorsalis* are captured almost at the larval stage and are abandoned in large quantities on the beach. This reduction in catch size has already been reported by [22] and [23] for bars species (*Pseudotolithus elongatus*: 11.55 cm; *Pseudotolithus senegalensis*: 14 cm and *Pseudotolithus typus*: 12.5 to 15 cm) by industrial fishing at the size of sexual maturity.

In addition, the destruction of resources, the beach seine also degrades habitats. It is a fishing gear that is deployed mainly on the coast, which is an area where the juveniles of several species of fish spend their first life stage. On its way, this spawning ground or feeder zone for young fish is disrupted or destroyed. The larvae and juveniles that must ensure recruitment are thus trapped before reaching sexual maturity in order to reproduce at least once to ensure the survival of the species. This reduces the relative abundance of the different species in the catches. This observation is also made by [24] which demonstrates that the fishing technique has an impact on the environment which impacts on the resource and the abundance of the different species in the catches. Today this fishing gear continues to be used despite its ban, it is necessary to set up a management plan to see the improvement of the meshes because it is very active on part of the beaches of the South coast of Cameroon. The reduction in catches can be explained by the fact that certain species, in particular *Pseudotolithus* spp, are already fully exploited or even overexploited as reported by [8, 11, 25, 26] as well as the increase in fishing effort and the reduction in the mesh size of the fishing gear used.

## Conclusion

This study on a evaluating of gillnet and beach seine fishing on the sustainability of fishery resources in Ngoyè and Elabè reveals that fishermen use bottom gillnets of different mesh sizes. The mesh of some of the machines is lower than the mesh recommended by Cameroonian regulations. The beach seine despite its ban on the Cameroonian coast continues to be used in places. It lands more than 80% of juveniles. In terms of diversity, it targets more than twenty species with Ilisha africana which represents more than 60% of its catches. The bottom gillnet targets about thirty species, mainly demersal species. More than 15% of its catches are juveniles. The reduction in catch size observed results not only from the reduction in the mesh size of the gear used, the increase in fishing effort, but also from the degradation of habitats and the pressure on fishery resources.

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