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Biodiversity of bottom trawl fishery and left-over marine resources along the Cameroonian coast

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Abstract
The objective of this study was to provide information on the diversity of catches, by-catches and discards by trawlers in the mouths of Sanaga (MSR) and Nyong (MNR) rivers along the coast of Cameroon. Samples were collected on board of a fishing vessel using the bottom trawling technique. Specimens were identified using 2104 and 2016 FAO identification keys. A total of 58 species belonging to 38 families and 5 super-classes were identified. Amongst, 72%, 14%, 10%, 2% and 2% were fish, mollusks, reptiles, crustaceans and cnidarians, respectively. We found 67.1% of marketable fish and shrimp and 32.9% of discards consisting of immature fishes. The MNR was richer in marketable fish species (p=0.0001) and discards (p=0.019) than MSR. The Cameroon coast is rich in biodiversity. However, it is today threatened by marine pollution and the non-respect of trawling which jeopardizes the sustainability of the fishing industry in Cameroon.

Keywords: Biodiversity, by-catch, Cameroon, coast, fishes, trawling activities

1. Introduction
Fish is one of the main sources of animal proteins for human populations. However, the intensity of fishing activities over the last century has caused some detrimental effects on marine ecosystems worldwide [1]. It has also resulted to accidental captures of non-targeted species or by-catch [2]. By-catch has become a serious conservation challenge for marine mega fauna worldwide [3, 4], which also faces additional pressure from many other activities such as oil spills and exploitation of mangroves [5, 6].
Intensive fishing activities are known to have detrimental effects on coastal and marine ecosystems [7]. Concerns about fishing activities continue to increase because of the extent of discards [8]. These unreported catches often jeopardize the sustainability of fishing activities, with subsequent threats on food safety and consumer's health [9]. Furthermore, a drop in fishing activities could put at stake the livelihoods of millions of fishermen and fishery workers [10]. The coastal-line of Cameroon which is 402 km long, is extended from the borders with Equatorial Guinea to that of Nigeria. Many companies are engaged in fishing activities in this marine area. From 2001 to 2013, the number of fishing vessels that trawled along the coast of Cameroon had significantly increased [11]. Therefore, it is absolutely necessary to monitor the evolution (quantitative and qualitative) of catches and the impact of fishing activities on the aquatic biodiversity on the Cameroon coast.
Very few studies have been carried out on the fish and marine diversity in the coastal border of Cameroon. Moreover, studies only focused on the fishery diversity and have been carried out on a very short period. This study therefore aims to characterize the fish and marine diversity of marketable and left-over products as well as diversity of wastes collected during fishing activities over the Cameroon coastal border during a complete 1-month boat tide. This study will contribute to the preservation of aquatic biodiversity in the fishing areas of the Cameroonian coast.

2. Material and Methods

2.1 Sites and period of the study

Sampling and data collection were carried out during a 27days trip (between 23rd January and 19th February, 2013) on a vessel using bottom trawling technique along the Atlantic coast of Cameroon. The sampling area was divided into two zones; the mouth of Sanaga river (latitude 3°24' - 3°49' N and longitude 9°18' -9°48' E) and the mouth of Nyong river (latitude 3°07' - 3°24' N and longitude 9°41' – 9°59' E) (Figure 1). The first zone was subdivided into 9 (nine) fishing sub-areas and the second in 2 (two) fishing sub-areas, making a total of 11sub-areas. The surface fishing-areas covered were 1327 km^2 and 600 km^2 for Sanaga and Nyong zones respectively. The temperatures recorded during this fishing period varied between 25 and 35°C.

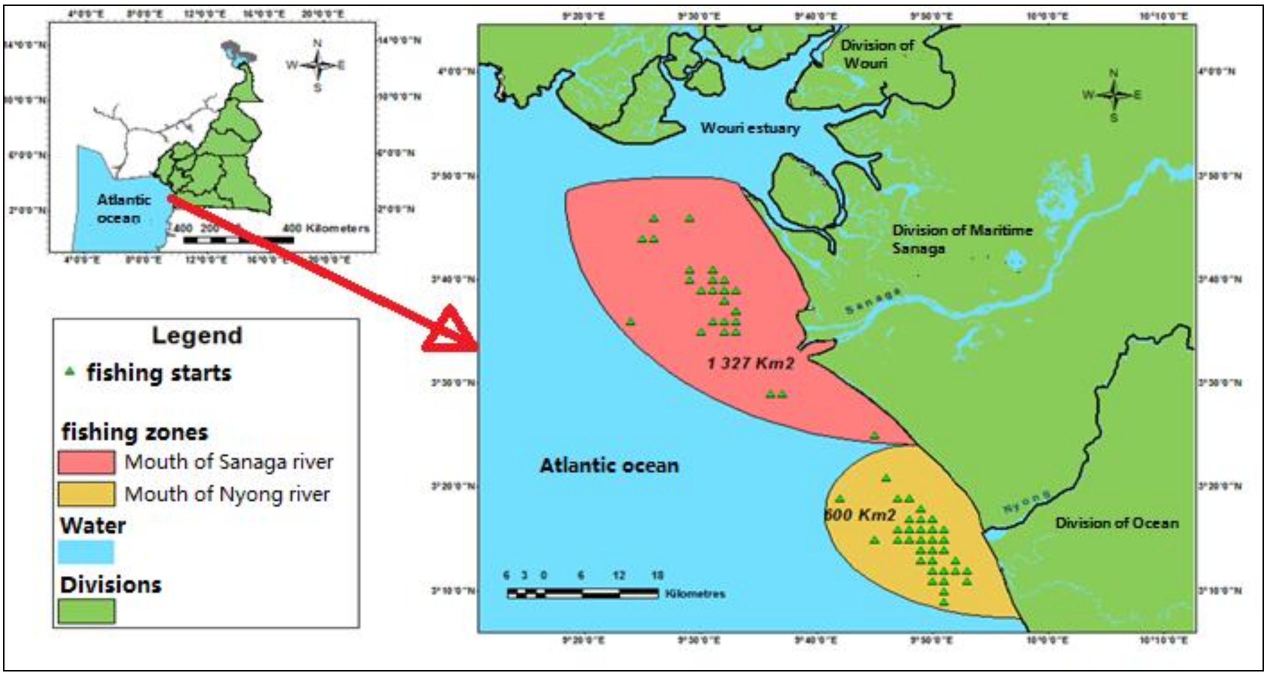

Fig 1: Map of Cameroon coast showing the Sanaga and Nyong river mouths

2.2 Sample collection

2.2.1 Characteristics of the vessels

The activity was carried out on board a trawler called AGIOS EFREM (SAINT EFREM) flying the Cameroonian flag registered K-02/IS/2010 with a power of 1081 kilowatts, gross tonnage (total loaded weight of the boat) 108 tons and a net tonnage (maximum load weight or useful weight) of 83 tons. The length and width of the boat were 50.2 meters and 8.3 meters respectively. The vessel had on board as fishing gear a trawl with its component parts such as floats, hatches, rigging, chains, arms, trawl back, trawl leader, trawl extension, codend and ropes. The boat stayed 27 days at sea and areas of mangroves were carefully avoided along the boat's route

2.2.2 - Geographic coordinate registration

Longitude and latitude were measured using a Navigator®GPS; fishing depth was measured using a Koden Bloter®sonar. A Koden Bloter®radar determined the distance from each fishing zone to the inland shore and the Douala fishing port.

2.2.3 Fish collection

A trawl netting test was conducted in each fishing sub-area during 3 hours. Sufficiently productive, other castings were made for 4 hours each. The number of nettings made in a fishing sub-on the production and ranged from one to 77. Captured products were selected by type and sizes, preserved in bulls of 20 kg and stored frozen in cold chambers after passing 24 hours in freezing tunnels. In each fishing sub-zone, a test mooring of the trawl was carried out for a period of around 3 hours. If the sub-zone was deemed sufficiently productive, further moorings were carried out for a duration of 4 hours each. The number of sets made in a fishing sub-area was a function of productivity and varied from one to 77 per sub-area. The catch product was sorted by type and size in 20 kg tubs and then stored by freezing in a cold room after spending 24 hours in freezing tunnels.

2.2.4 Selection of samples after the capture

Catches were made using a 70 mm mesh net to reduce the catch of immature species, according to Order No. 0002/MINEPIA of August 1, 2001 [12]. After the trip, the catches were dumped on the hold of the boat and then sorted according to their size and caliber. Individuals deemed immature were returned to the sea. Samples of marketable species were each time collected, characterized, measured, packaged, labeled and weighed, while samples of rejected species were each time collected packaged and labeled only. And the two samples collected by fishing sub-zone are kept in the freezing tunnels, then in the cold room of the ship for later analysis, before the dumping of the rest of the immature and non-targeted species at sea.

2.2.5 Characterization and analysis of captured samples

The total catch weight (weight of marketable fraction and left-over) was measured using a Camry scale. The identification and characterization of marketable fish specimens and left-over was conducted at the MINEPIA Regional Laboratory in Douala-Mboppi. Identification was made on the basis of morphological features, according to most recent FAO (Food and Agriculture organization) identification keys [13-16]. The species identified were then grouped by super-class, class, order and family.

The standard length and the total length were measured using a manual ichtyometer. The standard length was defined as the distance measured from the anterior end of the snout (or upper lip) to the tip of the caudal peduncle. Total length was defined as the distance measured from the anterior end of the snout to the posterior tip of the long ray of the caudal fin when the latter is in a natural position (According to the Department of Fisheries and Oceans Canada 2007), in its document of measurement and weighing of finfish. The weight of left-over was measured using a Kernelectronic precision scale (D-72468 Albstadt, Germany).

2.3 Data analysis
All the data collected were computerized using a Microsoft Excel 2010 software (Microsoft Inc., USA). The estimation of surface areas and mapping of fishing areas was made using ArcGIS 10 software (ESRI, Redlands, California, USA). This latest method is based on geographic locations recorded in the various fishing areas. Statistical analysis of data was performed using the Epi Info Version 7.1.1. (CDC, Atlanta, USA). Quantitative data were presented as mean±standard deviation (SD) and qualitative data as percentages. Data were compared between Nyong and Sanaga mouths using the student-t test and Chi2 test for quantitative and qualitative variables respectively. Differences were considered significant at $p<0.05$.

3. Results
3.1 Study overview
A total of 117 anchorages were realized with 79 in the Nyong mouth and 38 in the Sanaga mouth. The overall weight of catches was 46484 kg consisting of 31189 kg of marketable catches (67.1%) and 15295 kg of marine debris (32.9%).

3.2 Biodiversity of captures
Fifty-eight animal species belonging to 5 super-classes, 39 families and 58 species were identified. The superclass of fish was the most represented, with 51 species and 33 families while the least represented were the Cnidarians and Reptiles (Figure 2).

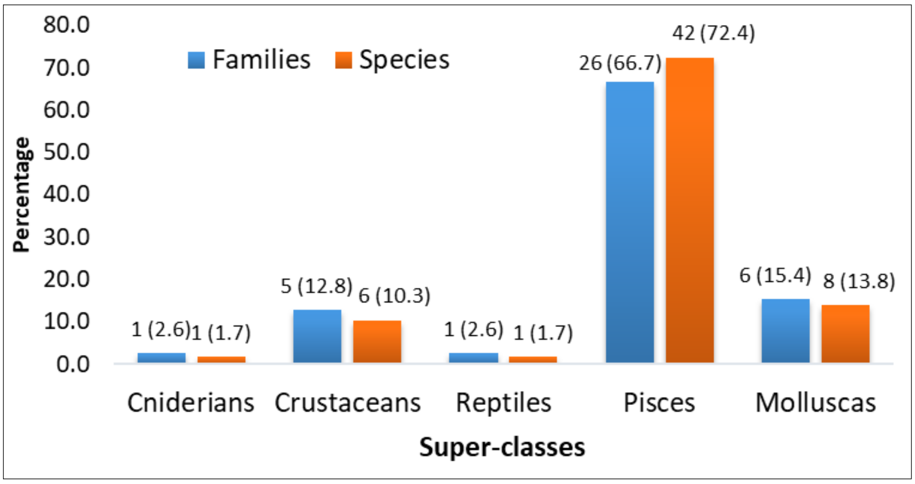

Fig 2: Diversity of animal catches

3.3 Analysis of marketable catches
Table 1 shows the average number of commercial species as well as the average weight of catches in each anchorage. The diversity of commercial species was significantly higher at the mouth of the Nyong river compared to the one of Sanaga river ($p<0.0001$). Considering the average weight of catches, the differences were not significant.

Table 1: Marketable species captured

	Total	Nyong Mouth	Sanaga Mouth	p
Anchorages	117	79	38	
Number of species	15±4	16±4	12±4	<0.0001
Mean weight (Kg)	266.6±116.8	274.0±118.9	251.1±112.1	0.3232

3.4. Characterization of left-over
3.4.1 Analysis of wastes
Overall 502g of wastes was collected in the study representing an average weight of 4,3g per anchorage. The overall weight of wastes collected in the Sanaga and Nyong mouths was 462g and 38g respectively. Figure 3 shows the average weight of debris collected in each anchorage. Average weight of plastic, plant and oil debris was higher in the Sanaga mouth compared to Nyong mouth. No Oil debris was collected in the Nyong mouth.

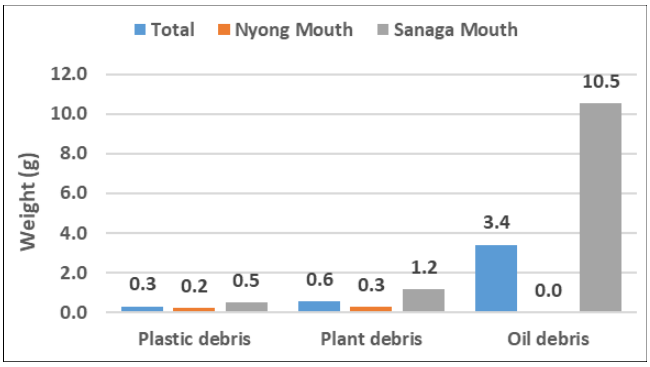

Fig 3: Average weight of debris

Table 2 shows the ratio of debris weight on bycatch weight in the study and compared between Nyong and Sanaga mouths. The overall mean was 0.12±0.13 and no significant difference was observed (p=0.75).

Table 2: Proportion of debris in the discards

Fishing zone	Anchorage	Ratio DW / BW±SD	Min-Max	p-value
Nyong	79	0.12±0.11	0.0018 – 0.5316	0.7547
Sanaga	38	0.13±0.16	0.0009 – 0.6707	
Total	117	0.12±0.13	0.0009 – 0.6700	

DW: Debris weight
BW: By-catch weight

3.4.2 Analysis of by-catches

Table 3 shows the average number of species left-over during by-catches as well as their total and average weight. Around 28 species were left over in each capture, ranging from zero to 98 species. The number of species left over in the Sanaga mouth was higher compare to Nyong mouth although difference was nearly significant. The total weight of left-over products was 15295 kg and the average was around 130 kg. This weight was significantly higher in the Nyong compared to Sanaga mouth (p=0.0192).

Table 3: Number and weight of species in left-over

Fishing zones	Total	Nyong mouth	Sanaga mouth	p-value
Number of species left-over	28±20	26±17	33±25	0.0538
Total weight (Kg)	15295	11075	4220	
Average weight (Kg)	130.7±63.4	140.2±68.2	111.1±46.9	0.0192

Tables 4 and 5 describe the classification of total catch and marketable catch respectively

Table 4: Biodiversity of the total catch made

Families	`	Common names
Fishes		
Ariidae	*Arius gigas* (Boulenger, 1911)	Cat fish
	Carlarius parkii (Gunther, 1864)	Cat fish
Balistidae	*Balistes capriscus* (Gmelin, 1788)	Tiger Fish
	Balistes punctatus (Gmelin, 1788)	Tiger Fish
Batrachoididae	*Halobatrachus didactylus* (Bloch &Schneider, 1801)	Lutsitanian cat fish
Carangidae	*Alectis alexandrinus* (Geoffroy Saint Hilaire, 1817) *Alectis ciliaris* (Bloch, 1787)	Alexandra pompano African pompano
	Caranx lugubris (Poey, 1860)	Black jack
	Caranx senegallus (Cuvier, 1833)	Senegal jack
	Chloroscombros chrysurus (Linnaeus, 1776)	Atlantic bumper
	Lichia amia (Linnaeus, 1758)	Leerfish
	Selene dorsalis (Gill, 1866)	African moonfish
Clupeidae	*Ethmalosa fimbriata* (Browdich, 1825)	Bonga shad
	Sardinella maderensis (Lowe, 1839)	Madeiransardinella
Soleidae	*Cynoglossus canariensis* (Steindachner, 1882)	Canary tongue sole
paralichthyidae	*Monochirus hispidus* (Rafinesque, 1814) *Syacium micrurum* (Ranzani, 1840)	Whiskered sole
Dasyatidae	*Dasyatis pastinaca* (Linnaeus, 1758)	Common stingray
Drepanidae	*Drepane africana* (Osorio, 1892)	Disk
Ephippididae	*Chaetodipterus goreensis* (Cuvier, 1831)	Disk
Haemulidae	*Pomadasys peroteti* (Cuvier, 1830)	Dorade
Lophiidae	*Louis vaillantii* (Regan, 1903)	Catfish Koakoro
Lutjanidae	*Lutjanus agennes* (Bleeker, 1863)	Red carp
	Lutjanus fulgens (Linnaeus, 1758)	Clear carp
Mugilidae	*Chelon labrosus* (Risso, 1827)	Mule
Orphichthidae	*Echelus myrus* (Linneaus, 1758)	Paintedeel
Polynemidae	*Galeoides decadactylus* (Bloch, 1795)	Lesser african threadfin
	Pentanemus quinquarius (Linnaeus, 1758)	Royal threadfin
Psettodidae	*Psettodes belcheri* (Bennett, 1831)	Sole US (turbot)
Rhynchobatidae	*Rhynchobatus lubberti* (Ehrenbaum, 1915)	African wedge fish
Sciaenidae	*Pseudotolithus senegalensis* (Valenciennes, 1833)	Cassava croaker
	Pseudotolithus typus (Bleeker, 1863)	Long neck croaker
	Pseudotolithus elongatus (Bowdich, 1825)	Bossus
Scombridae	*Auxis thazard* (Lacepède, 1800)	Tuna
Serranidae	*Epinephelus aeneus*(Geoffroy St, Hilaire, 1809)	Grouper
Sparidae	*Pagellus bogaraveo* (Brunnich, 1768)	pageot
	Pagrus pagrus africanus (Akazaki, 1962)	Southern common seabream
Sphyraenidae	*Sphyraema barracuda* (Edwards, 1771)	Great barracuda
Tetraodontidae	*Ephippion guttifer* (Bennett, 1831)	Pricklypuffer
	Lagocephalus lavigatus (Linnaeus, 1758)	Smoothpuffer
Trichiuridae	*Trichirius lepturus* (Linnaeus, 1758)	Large head hairtail
Uranoscopidae	*Uranos copus polli*(Cadenat, 1951)	White potted stargazer
Crustaceans		
Squillidae	*Squilla aceuleata calmani*(Holthuis, 1959)	Scorpion fish
Majidae	*Maja squinado*(Herbst, 1788)	Black crab
Palaemonidae	*Nematopaleomon hastatus* (Aurivillius, 1898)	Crayfish
Penaeidae	*Penaeus notialis* (Pérez-Farfante, 1967)	Shrimp
	Penaeus (*Melicertus*) *kerathurus* (Forsskal, 1775)	Gambas

Portunidae	*Callinectes marginatus*(AMilne Edwards, 1861)	Green crab
	Molluscas	
Melongenidae	*Pugilina morio* (Linnaeus, 1758)	Seasnail
Muricidae	*Murex duplex* (Roding, 1789)	Seasnail
	Thais nodosa (Linneaus, 1758)	Seasnail
Sepiidae	*Sepia orbignyana* (Férussac, 1826)	Squid
Ulmaridae	*Aurelia aurita* (Alexander Semenov, 2009)	Jellyfish or SeaOtitis
Coenobitidae	*Coenobita compressus* (Herbst, 1791)	Hermitcrab
Volutidae	*Cymbium cymbium* (Linnaeus, 1758)	Seasnail
	Cymbium pepo (Lightfoot, 1786)	Seasnail
	Reptiles	
Cheloniidae	*Chelonia mydas* (Linnaeus, 1758)	Green turtle
	Anthozoans	
Coralliidae	*Corallium rubrum* (Laubier, 2001)	Coral

Details of marketable species captured are shown in Table 2 below.

Table 5: Marketable Species captured

Famillies	Species	Common names
	Fish	
Ariidae	*Carlarius parkii* (Gunther, 1864)	Cat fish
Carangidae	*Alectisalex andrinus* (Geoffroy Saint Hilaire, 1817) *Alectis ciliaris* (Bloch, 1787)	Alexandra pompano African pompano
	Caranx lugubris (Poey, 1860)	Black jack
	Caranx senegallus (Cuvier, 1833)	Senegal jack
	Chloroscombros chrysurus (Linnaeus, 1776)	Atlantic bumper
Clupeidae	*Ethmalosa fimbriata* (Browdich, 1825)	Bonga shad
	Sardinella maderensis (Lowe, 1839)	Madeiran sardinella
Soleidae	*Cynoglossus canariensis* (Steindachner, 1882)	Canary tongue sole
Dasyatidae	*Dasyatis pastinaca* (Linnaeus, 1758)	Common stingray
Drepanidae	*Drepane africana* (Osorio, 1892)	Disk
Lutjanidae	*Lutjanus agennes* (Bleeker, 1863)	Red carp
	Lutjanus fulgens (Linnaeus, 1758)	Clear carp
Mugilidae	*Chelon labrosus* (Risso, 1827)	Mule
Polynemidae	*Galeoides decadactylus* (Bloch, 1795)	Lesser african thread fin
	Pentanemus quinquarius (Linnaeus, 1758)	Royal thread fin
Psettodidae	*Psettodes belcheri* (Bennett, 1831)	Sole US (Turbot)
Rhynchobatidae	*Rhynchobatus lubberti* (Ehrenbaum, 1915)	African wedge fish
Sciaenidae	*Pseudotolithus elongatus* (Bowdich, 1825)	Bossus
	Pseudotolithus senegalus (Valenciennes, 1833)	Cassava croacker
	Pseudotolithus typus (Bleeker, 1863)	Long neck croacker
Scombridae	*Auxis thazard* (Lacepède, 1800)	Tuna
Serranidae	*Epinephelus aeneus* (Geoffroy St Hilaire, 1809)	Grouper
Sparidae	*Pagellus bogaraveo* (Brunnich, 1768)	Pageot
	Pagrus pagrus africanus (Akazaki, 1962)	Southern common sea bream
Sphyraenidae	*Sphyraema barracuda* (Edwards, 1771)	Great barracuda
Trichiuridae	*Trichirius lepturus* (Linnaeus, 1758)	Long head hair tail
	Crustaceans	
Penaeidae	*Penaeus* (*Melicertus*) *kerathurus* (Forsskal, 1775)	Gambas
	Penaeus (*Farfantepenaeus*) *notialis* (Pérez Farfante, 1967)	Shrimp

4. Discussion

This study aimed at carrying out an inventory and characterization of by-catches and discards, this sample collection extended estuary to the mouth of Sanaga river right down to the mouth of the Nyong River. This study is of very great importance in the preservation of aquatic biodiversity fishing areas of the Cameroon coastal zone. However, Cameroon has not rated the significance of diversity in aquatic biomass.

In our study, we identified 58 commercial species with about 67.1% of catches and 32, 9% of discards in approximately 27 days of tides. Out of the total catch, the marketable species were evaluated at 31189kg and those discarded to 15295 kg, thus a significant difference in quantity observed between the mouths of the Sanaga and Nyong Rivers. The mouth of the river Nyong produced 21646kg of marketable species as compared to that of the Sanaga which had just 9543kg. On discards, 11075kg of discarded species were harvested at the mouth of the Nyong River and 4220kg at river Sanaga. These results are similar to other studies which showed that the expansion of fisheries is associated with a decline in the biomass of fishes, both target and incidental catch, and with subsequent ecological and biodiversity changes [17]. Declines in biomass are a necessary part of fisheries exploitation, but reducing the indirect effects on ecosystems and biodiversity is an increasing concern for modern fisheries' management and decision-making [18, 19]. Reducing biomass to 25–50% of unexploited levels typically maximizes their yields while going beyond this level can result in losses of diversity and other ecological processes [20]. Most of the developed country fisheries biomass levels had reached this level since the 1980s, while less developed regions approached this value since the mid-2000s [21]. Fishing effort continues to rise even though yields have stabilized or potentially declined slightly since the mid-1990s. Watson *et al*. [22] documented a 10-fold increase in the power used in offshore fishing, and the catch per unit power in 2006 was half of what it was in the1950s.

The discards are mostly made up of immature individuals of marketable species and organic/inorganic debris. The mouth of the river Nyong has an average discarded species estimated at 26 within the79fishing sub-areas visited whereas Sanaga has 33out of the 38species discarded in fishing sub-areas (table 4). Similarly, fuel discards despite of its very low frequency compared to other debris are only present at the level of the mouth of river Sanaga and weigh more than double the amount of debris. The high presence of immature individuals in the catches is related among others to non-compliance of the mesh of the net prescribed by Article 9 of Order N° 0002 / MINEPIA of 1st August 2001 laying down procedures for the protection of fisheries resources by the Minister of Livestock, Fisheries and Animal Industries, which states that the minimum mesh for industrial fishing nets in use in the maritime waters under Cameroonian jurisdiction are 70 mm for standard otter trawls (fish and cephalopods).Whereas, we observed the fact that the mesh used throughout our tide were (40 mm) well below the prescribed dimensions.

Five classes of fishery resources are represented in the catches of this study, including that of cnidarians (01species), the class of Crustaceans (06species), reptiles (01species), the phylum of mollusks (08species) and Superclass offish (42 species). We can notice the high representation of the class of fish among the captured fish stocks (72, 4% of overall catches). This result is similar to that obtained by Villanueva [23] on Biodiversity and trophic relations in some estuaries and lagoon environments of West Africa where fish was also the most represented among the captured marine species. This in so far as our study was carried out on board a trawler which is a trawl boat: towed net, consisting of a conical body, closed by a pocket and extended at the opening by wings. It can be towed by one or two boats, and depending on the type, operate on the bottom (bottom trawl) or between two waters (pelagic trawl) with the main target species: Fish (benthic and demersal, pelagic), langoustine, cuttlefish, squid, white scallop, etc.

Out of the 19 marketable families, 17 belong to the class of fish while two are that of crustaceans. The mouth of the river Nyong, relatively small in size than that of the Sanaga has a greater diversity of fish species and an average amount of marketable species caught estimated at 16±4 in 79 fishing sub-areas. While the mouth of the river Sanaga which is more than twice as large as that of Nyong river (Figure 1), has an average of 12±4 in the 38 fishing sub-areas. In terms of average weight of marketable catch, the mouth of river Nyong also has a greater production than that of the Sanaga: 274.0±118.9 vs 251.1±112.1 (table 2). This is due to the fact that the water drained upstream by the Sanaga river is not rich in plankton which is rich in nutrients, animal and vegetable waste these nutrients gradually settle and stratify in the Sanaga dam so that with the opening of the gates of the dam, the water flowing into the sea from the Sanaga river, is less rich in nutrients, animal and vegetable waste as compared to that of the Nyong river which has no dam.

Fuel debris, although having a very low frequency compared with other debris, weigh more than twice the mass of debris. given the industrial density in the coastal zone in Cameroon, including the oil industry located in the Limbe and Douala areas, the mouth of the Sanaga River is closer, so fuel debris are more present in the area and thus easily found in fish catches. In addition, the results of our catch, show that fuel debris which are toxic, is present at the mouth of the Sanaga and completely absent at the Nyong. This could explain the escape of fish species and their high migration to the mouth of the Nyong and the convergence of trawlers to this area in order to maximize their catch. This result corroborates with that of Ngongang [24], by the presence of 32,05g / m2 tar balls on the beach of Mbiako, in the estuary of the Sanaga river.

The number and diversity of the species vary from fishing areas and frequented depths. This variability at the species level is probably related to the preferences of the latter vis-à-vis the habitat of the area and according to the changes it may undergo over time. Moreover, this variability can also be linked to migration under the influence of natural phenomenon and/or anthropological. Maillard C, Raibaut in 1990 [25] attested that the migration of fish species is increasingly stimulated by human action which results in a brief domestication of aquatic habitat for development purposes.

In total, the halieutic nature of discards generally fall into three classes, particularly that of fish, crustaceans and finally the molluscs. It is noted that, of the 27 fish families surveyed in global catches, 24 families are in the discards. Moreover, these commercial species are generally small unmarketable sizes and, in most cases, are made up of immature individuals. Yet, Article 13 of Decree N° 0002 / MINEPIA of 1st August 2001 laying down the modalities of protection of fish resources of the Ministry of Livestock, Fisheries and Animal Industries in Cameroon, the species: *Sardinella maderensis* (19 centimeters); *Pseudotolithus senegalensis*, *Pseudocholinesterase* (25 centimeters); *Pseudotolithus elongatus* (22 centimeters); *Cynoglossuscanariensis* (25 centimeters); *Penaeusnotialis* with a weight of less than 11 grams, are mature from this size. It should also be noted that the decrease in size of species caught is an indicator of the relative decline in stock abundance and biomass [26].

The use of gear hanging below three thousand (3000) nautical miles from the baseline defined by decree is prohibited under Article 127 of Law n ° 94/01 of 20 January 1994 Plan of Forestry, Wildlife and Fisheries in Cameroon. This was not observed during the tidal follow. Hence the case of *Ethmalosa fimbriata*,*Penaeus notialis* and *Trichirius lepturus*, who's discards proportions were considerably high given the global catches. Over-exploitation of water and the non-compliance in terms of trawling and fishing areas, mesh, the non-taking into account the life cycle of fish species found are the different factors that undermines the activity of industrial fishing on the Cameroon coastal zone. In addition, species not listed in discards (*Lutjanus agennes* and *Lutjanus fulgens*, *Chelonlabrosus*, *Auxisthazard*) are fish of the families of Lutjanidae, of Mugilidae and Scombridae. The absence of immature species of these could be explained by the fact that they are not in their original biotope and have migrated to the fishing areas. Some authors showed that fish like many other animal species can migrate from their areas of origin in search of a breeding site, for the need of food oras a result of the phenomenon of intra- or inter-specific competition [25, 27].

The average weight of catch at the mouth of Nyong river is greater than that of the Sanaga river. However, this difference is not significant since the mouth of the river Nyong produced 21646 kg marketable species as compared to 9543 kg for the Sanaga river. On discards, 11075kg of discarded species were harvested at the mouth of the river Nyong and 4220kg at the Sanaga river. The most represented species are *Ethmalosa* *fimbriata* (30.2%), *Penaeus nottialis* (16.04%) and *Trichirius lepturus* (8.45%). The high presence of *Ethmalosa fimbriata* in the discards is linked to their immature characters. Given the biology of this species, it is possible that our fishing activity has taken place during the juvenile period of the life cycle of this species. The case of *Ethmalosa fimbriata*, Gerlotto in 1976 [28] revealed that its life cycle is divided into two phases during the year. The first is a sexual rest period extending from June to September while the second running from November to May corresponds with the period of activity. Furthermore, it is noted that there is a latency or slowdown, which generally occurs in the month of March. Fishing activity can take place both in the sexual rest period and in the period of activity. However, fishing occurring in the period of sexual activity that is to say from November to May, may coincide with the juvenile phase of the cycle. Our capture period extending from January 23 to February 19, 2013 intervened in the phase of sexual activity of the species, which could therefore explain the high representation of immature *Ethmalosa fimbriata* in the Catch that we performed.

There is no significant difference between the proportions of debris on discards in both mouths. The distribution of debris discards into the sea is much more diverse and represented in the mouth of the Sanaga River than at the river Nyong where debris are stuck together and dense. The high presence of plastic waste would be linked to the heavy industrialization of the Cameroon coastal zone. As for plant debris, they may be related to discards from man on the one hand and the mobilization of the mangrove as a result of movements as noted by MINEP in 2010 [29].

The mouth of the Nyong has an average of discarded species lower than that of the Sanaga. However, the difference was not statistically significant ($p > 0.0538$). In turn provides information on the average mass of the discards from the mouth of Nyong which is significantly higher ($p<0.0192$) to that obtained at the mouth of the Sanaga. This is due to the high density of the harvested biological diversity over the mouth of the river Nyong as compared to the Sanaga River. The mouth of the river Nyong proves richer than the mouth of the Sanaga River that is polluted, which makes us think that the migration of some species is due to some environmental conditions.

5. Conclusion

The aim of this study was to evaluate the diversity of living and waste products held by trawling activity in the Nyong and Sanaga mouth zone in Cameroon. We found in this study a rich marine diversity in the Nyong and Sanaga mouths constituted of 5 super-classes, 39 families and 58 species. The diversity of marketable species was significantly higher in the Nyong compared to Sanaga mouth were as diversity of left-over species was slightly higher in Sanaga compared to Nyong mouth. Wastes were abundant with a significantly higher average weight in Sanaga compared to Nyong mouth although waste weight on by-catch weight ratio was no significantly different between the two groups. This study emphasize the necessity of administrative authorities and fishing enterprises to take serious measures to significantly reduce the amounts of catches which will gradually lead to an increase in fish stocks of commercial value.

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