ASSESSMENT OF DOLPHIN BYCATCH IN ARTISANAL DRIFT GILLNET FISHERIES OFF THE NIGER DELTA NIGERIA

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ABSTRACT

This work provides the first data on landed bycatch of dolphin in the Niger Delta Nigeria from artisanal drift net longline and dug out Ghana canoes. The project originates from a survey on dolphin bycatch in artisanal fisheries in Lagos, Ondo, Bayelas, River and Akwa Ibom states. From these, two states and eight captains were selected in the two communities responsible for 50-75% of dolphin catches. A total of 315 dolphins were captured, during the 575 fishing trips. This was recorded from January 2017 to 2018, at the two-landing sites at Imbikiri, Bayelsa State and Finima, River State. The drift net longlines caught 26 different species, with a total of 38,037 individuals or more. Mitochondrial DNA (mtDNA) of 20 samples was analysed for species identification to ascertain the diversity of the dolphin bycatch species found in the Niger Delta of Nigeria. Short-beaked common dolphin represented 60% of the DNA samples. Fraser’s dolphin represented 20% of the DNA samples. The Atlantic spotted dolphin represented and Risso’s dolphin each accounted for 10% of the DNA samples. Of the 315 dolphins that were photo identified, the Atlantic spotted dolphin represented 57%, the short-beaked common dolphin 43%, the common bottlenose dolphin 10%, and the Fraser’s dolphin 8%. Unidentified dolphins represented 6% of the catches. Comparing the 20 samples analysed out of 315 photos identified, we determined that morphological identification of dolphin species was not accurate. The average number of dolphins per set of nets in each month for two years, per captain, July, August 2017 the highest catch of dolphin 51 and 30 on average per set is (0.6 and 0.4), with no catch of dolphin in September and October. Likewise, no catch was observed in September and October 2018. The maximum catch was July, March 27 and 20 giving the average (0.3 and 0.3). The total set of nets was 1,518 and the total bycatch of dolphin is 315, for the average of the two years, average of 0.20. This study has shown the amount and species composition of dolphin bycatch in the drift net longline fishery in the Niger Delta. It also provides information on the value of this fishery and will enable policy makers and regulators together with other stake holders, such as International NGOs to find way to tackle this problem.

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1 INTRODUCTION

Nigeria is a coastal state in West Africa. It borders with Benin to the west, Niger to the north and Chad and Cameroon to the east. Nigeria is well endowed with rivers, lakes and estuaries. The Atlantic coastline is 853 km and the Exclusive Economic Zone (EEZ) is about 217,000 km^2 which includes a joint maritime zone with Sao Tome and Principe (Figure 1) (Biang, 2009-2010). The population of Nigeria is over 200 million, by far the largest among African nations (Worldometers, 2018).

Figure 1: The coastline and EEZ of Nigeria.

Fish represent the most important dietary source of animal protein available, in terms of the number of people that depend on it in Nigeria (Oladimeji, 2017) The total fish demand for Nigeria based on the 2014 population estimate of 180 m is 3.32 m tons (t). In 2005, Nigeria imported 700,000t of fish and fisheries products at a cost of some USD 400 million (Raji, 2006).

Ten years later imports had risen to 1,900,000t reflecting both population growth and increasing demand for fish (Olaoye & Gbenga Ojebiyi, 2018). The policy thrust of the Federal Government is aimed at ensuring sustainable development of Nigerian fisheries for national food security through optimum resource utilisation and conservation. The policy focuses on employment generation, wealth creation, poverty alleviation and reduction in rural-urban migration (FDF, 2005) .The Nigeria fisheries sector is made up of the marine fisheries, inland fisheries and aquaculture. Inland fisheries are exclusively artisanal, while marine fisheries are divided into artisanal and industrial fisheries sector Ockiya, A., & ., J. (2000). In 2015, the total fisheries production was estimated at 1,027,000t with marine fisheries contributing 36%, followed by inland fisheries (33%) and aquaculture (31%). The sector is estimated to have contributed 0.5% to GDP in 2015 (FAO, Country profile on capture Fisheries, 2017). Statistics from the sector are generally considered to be poor and thought to be inflated. However, one study estimated statistics on marine fisheries to almost double the reported figure (Etim, Belhabib, & Paurly, 2015)

1.1 Industrial Fisheries

Industrial fisheries can be divided into shrimp and finfish fisheries. The length of the trawlers ranges from 13-27 m, gross tonnage is 100-150, the mode of propelling is from 165-800 horse power (Olaoye & Gbenga Ojebiyi, 2018). The industrial fishery operates outside 5 NM. The catches increased from 1,800t in the 1950s to about 200,000t in 2003 but had decreased to 140,000t by the end of the decade (Etim, Belhabib, & Pauly, 2015)The decline has continued as seen by the reduction in the number of trawlers (Figure 2) and an industry which was an important employer and supplier of fish now plays an insignificant role in Nigeria.

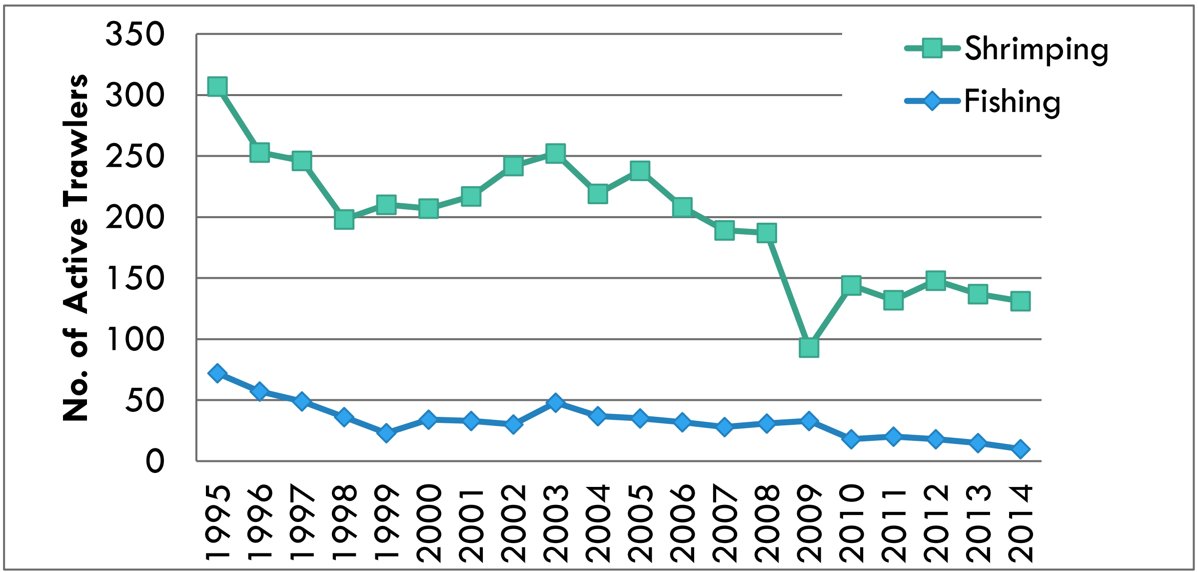

Figure 2: Number of active trawlers according to FDF (FDF 2007and 2017).

1.2 Artisanal Fisheries

Artisanal fisheries target primarily small coastal pelagics, such as the herring species called bonga *(Ethmalosa fimbriata)* and Sardinella. Most artisanal canoes range in size from 7–12m and are powered by 9.5 to 40 horse power. The fishing gears used by the artisanal fishermen include gill nets, drift nets, beach seines, large meshed shark drift nets, hooks and longline/handlines (Nedelec, C., & J, P. 1990; Nadreev, N. 1996). The demersal species exploited by artisanal fishing are: croakers *(Pseudotolithus),* threadfins *(Galeoides, Pentanemus* and *Polydactylus),* soles *(Cynoglossidae),* marine catfish *(Arius),* brackishwater catfish *(Chrisichthys),* snapper *(Lutjanus),* grunters *(Pomadasyidae),* and groupers *(Epinephelus)* (Etim, Belhabib, & Pauly, 2015) (Tobor, 1991). Some artisanal fishermen use larger vessels, such as the migrate fisher (Ghanaian fisher). A few of the Ghanian boats range from 21-38m, powered by 40 horse power motors, crewed from 6-24, the fishing methods used are drift net or purse seine. They target species like Bonga, croaker, sharks, sail fish, tuna and many others.

1.3 The Problem of Bycatch and Threat to Dolphin

Bycatch is the incidental capture of non-target species such as dolphins, marine turtles and seabirds. Bycatch also occurs when other marine species are caught unintentionally while catching certain target species. Large marine mammals like killer whales, dolphins, and sperm whales are drawn to the baited longlines. Every year, at least 7.3 million tons of marine mammals are caught incidentally in gear as bycatch (Rutherford-Fortunati, 2014). This happens because modern fishing gear is efficient and often covers an extensive area for fishing. Bycatch in developing countries is of growing concern as the efficiency of gear is increasing but there is no similar increase in monitoring and enforcement. Neither artisanal nor industrial fishermen are adequately monitored for compliance of fisheries regulations, such as, size of meshes used and type of species caught. Increased efficiency and effort in fisheries pose a threat to endangered species including endangered marine mammals. Often fishermen mishandle mammals caught due to ignorance and culture (Zydelis R Wallace, Gilman, & Werner, 2009). Fishing net is one major threat to small cetaceans including dolphins. About 300,000 die from fishing gear entanglement every year. WWF has suggested the complete removal of unselective fishing gears, because many species like vaquita from the Gulf of California (Bracho, et al., 2019) and Maui’s dolphin (Maas, 2013). Both artisanal and industrial fishing that commonly use gill nets, drift nets, long line, purse seine and trawls, that target relatively large species such as sharks, sail fish and yellow fin tunas, are of particular threat to small cetaceans like dolphins and porpoises (Reeves, Clellan, & Werner, 2013; Read, 2013; Young M & Ludicello, 2007; Dawson & Slooten, 1993). Cetaceans which inhabit coastal areas in developing countries are vulnerable, because there is lack of proper management in this sector, compared to the developed countries.

1.4 Fishing Gear

1.4.1 Gillnets

Gillnets are classified under passive fishing gears. This means that the fish must swim into the gear or meshes where it is caught by gilling, snagging, entangling or wedging (Hovgard & Lassen, 2000; Hovgard H., 1996a; Hovgard H., 1996b; Haraldur Einarrson, 2014). According to (Munprasit, et al., 1986), gillnets can be deployed in various ways, such as, the bottom of the sea bed, various depths in the water body or from the surface. Gillnets are among the most widely used fishing gear and often modified taking into consideration the target species, the area, the size and design of the fishing vessel (Larsen, Eigaard, & Jakob, 2002). The variety of fishing gear like trawl net, purse seine, long line, gillnets may have the greatest impact on the decline of small cetaceans like dolphin and porpoises (Jefferson, T., & Curry, B. E. 1994; Larsen, Eigaard, & Jakob, 2002) .Drift nets hang vertically in the water body and are usually not anchored to the bottom. Floats are used to keep the net vertical in the water by attaching them to a rope along the net top with leads on the bottom of the lead line (Figure 3).

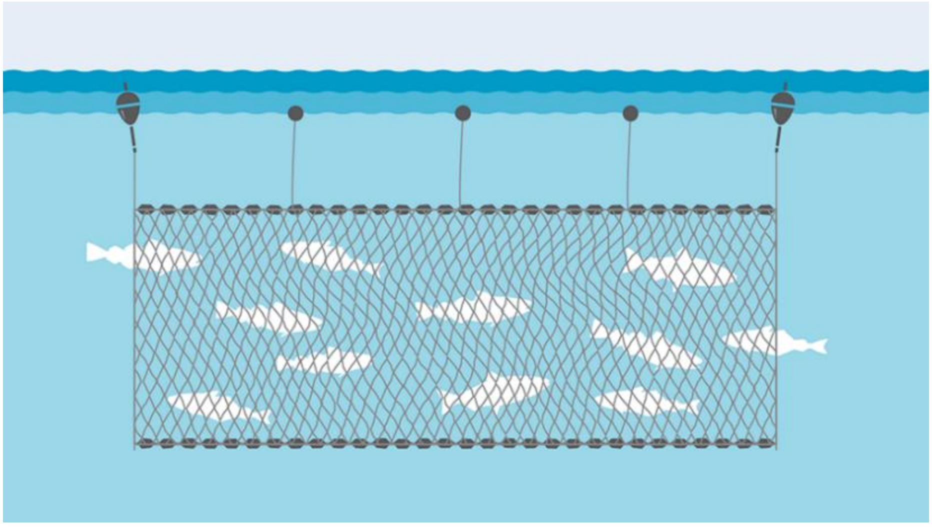

Figure 3: Schematic representation of a drift net.

Drift net is quite simple and relatively cheap to maintain (Hovgard & Lassen, 2000) and it is highly selective in terms of species and sizes of fish, which depends on the size of the mesh and the shape of the fish. Target species are pelagic fish such as sharks, barracuda, sail fish, tuna and squid but drift nets can also entangle marine mammals, sea turtles and birds, some of which are considered endangered (Hovgard & Lassen, 2000).

1.4.2 Longline

Longline fishing is practiced all over the world, both in artisanal and industrial fisheries. This uses a long line, called the main line, with baited hooks attached at intervals by means of branch lines called snoods. A snood is a short length of line, attached to the main line using a clip or swivel or can be tied directly to the main line with the hook at the other end. Longlines are classified as passive gear, when they are placed in the water column, the line can be at the surface or at the bottom. They can be set in various ways in the water column, lines can also be set by means of an anchor or left to drift. Hundreds or even thousands of baited hooks can hang from a single line (Figure 4). They commonly target swordfish, tuna, sharks, sablefish and many other species (Hameed & Boopendranath, 2000).

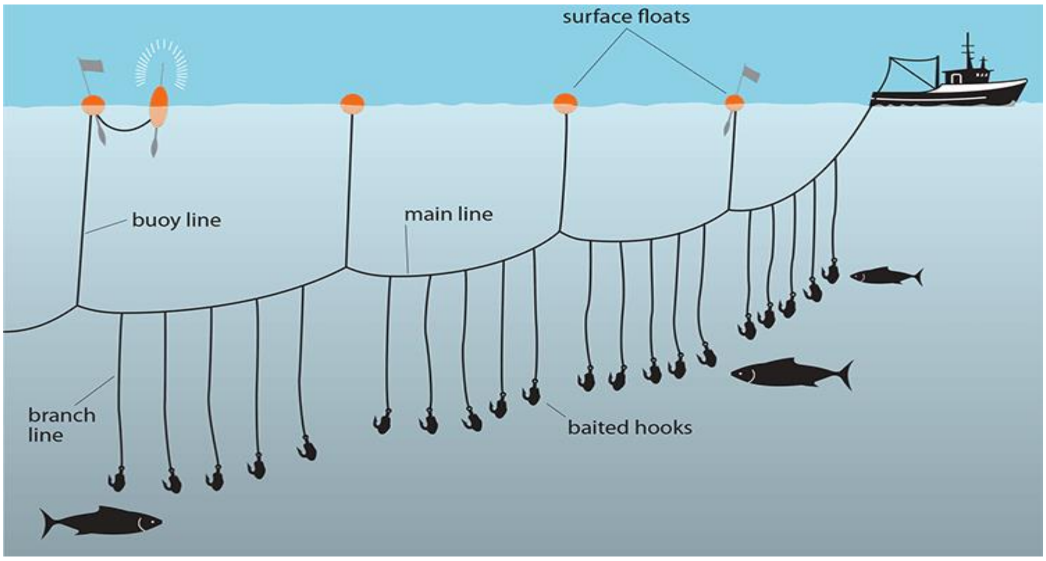

Figure 4: Schematic representation of a long line gear.

Longline fishing is prone to the incidental catching and killing of seabirds, sea turtles, and sharks, but can be considerably more ecologically sustainable than some other commercially significant harvesting methods (He, 2010). The incidental catch of marine mammals by any type of fishing gear can reduce their population which can lead to extinction (Lewison, Crowder, Read, & Freeman, 2004; Keller, 2005), (Heppell, Caswell, & Crowder, 2000). During several years, attention to the bycatch problem has focused almost exclusively on industrial fisheries (Soykan, et al., 2008) Moreover, recent evidence has highlighted the potential for artisanal fisheries in developing countries to have significant negative impacts on these taxa (Peckham, et al., 2007; Jaramillo-Legorreta, et al., 2007; Mangel, et al., 2010; Lum, 2006). The research suggests that, there is need to pay detailed attention to artisanal fisheries, as more than 95% of fisheries worldwide operate artisanal fishing, and this has an impact on marine mammals. This problem is of concern to official international bodies like the International Whaling Commission, which has recommended measures to ban the capture of dolphin in any type of fisheries (Shigueto, Mangel, & Van Waerebeek, 2008). Decline of cetaceans is not least the concern of the general public as seen through the large number of NGOs which are dedicated to this cause. Passive gear like drift net have been identified as a major threat for the small cetacean population (Jefferson & Curry, 1994), (Dawson S. , Slooten, DuFresne, Wade, & Clement, 2004), (Slooten, Dawson, Rayment, & Childerhouse, 2005), (Read, Drinker, & Northridge, 2006).

1.5 Aim and Objectives

Cetaceans are caught as bycatch in drift nets operated by artisanal fishermen off the Niger Delta in the Gulf of Guinea of the Eastern Equatorial Atlantic. A scientific understanding of the relationship between these resources and human activities is important for sustainable management. This project aims to study the dolphin in landed bycatch in the Niger Delta region of Nigeria. It will provide valuable information for conservation and sustainable management of these resources in Nigerian waters. This will represent the first detailed investigation into the dolphin landed bycatch in Nigeria.

Specific objectives of this study are to:

i. Describe the design and operation of the drift gill nets with hooks and attached longline, used by fishers in two communities in the Niger Delta.

ii. Determine the catch composition, effort and catch per unit effort from January 2017 to January 2019 by season, and the selectivity of drift net of different mesh sizes.

iii. Identify and assess the species composition of dolphins present in the bycatch of the two fishing communities, using genetic markers such as the mitochondrial DNA (mtDNA) D-loop region.

2 METHODOLOGY

This project originates from a survey on dolphin bycatch in artisanal fisheries in five out of eight coastal states namely, Lagos, Ondo, Bayelas, River and Akwa Ibom (from west to east) (Figure 5). Originally, 23 fishing communities were selected based on information I was able to obtain on their high access to fishing grounds, intensity of fishing activities and target species of interest (dolphin), and the presence of migrate fishermen, with the exception of Ondo which does not have migrant fishermen. The survey was conducted from January to June 2016. During the survey, eleven further fishing villages were added based on information from fishermen interviewed, making 34 fishing communities in all. In each community, I first paid a visit to the village chief to introduce myself and the research project and ask for permission. When the village head had given his approval, I interviewed 6-10 fishermen who were either coming back from sea, working on their boat, or repairing their nets. A questionnaire was used on only one person per boat, either a boat owner or crew member was interviewed. The questions were based on the type of catch, fishing gear, target species and their interaction with dolphins Six to ten fishermen were interviewed in each community (Table 1). In all the five states visited, almost all the fishing communities are using plank canoe (96%), ranging from 7-12 m and 99% utilised outboard engines, ranging from 9.5-40 horsepower. The fishing gear used are of various types, from monofilament to multifilament, drift net and bottom gill net, used to catch different species like Bonga *(Ethmalosa frimbriata*), Croaker (*Pseudotolitus* species), crayfish, barracuda (*Sphyraena* species), thread fin (*Galeoides decadacctylus*), Sole fish (*Cynoglossus* species), cat fish (*Arius*), large species of sharks, sail fish and red fish. For towed small mesh gear, the main target species are shrimp and crayfish. Hook and line are few from these 34 communities. Only eight communities from the 34 communities visited, from the 227 fishermen interviewed, the target species for the hook, and the hooks and line are, barracuda, catfish, tuna, grouper, red snapper, sharks. Beach seine was also reported by five fishermen. Dolphins were commonly reported in Bayelsa and Rivers States, which are both in the Niger Delta, by those who use Ghana boats which go far out and use drift nets. A few numbers of Ghana boats range from 21-38m, powered by 40 horse power motors, crews from 6-24, the fishing methods used are drift net or purse seine. They target species like bonga, croaker, sharks, sail fish, tuna and many others. In total, there is an estimated 36,000 fishermen, with about 12,000 active canoes and 300 active Ghana canoes in the five states, which is 2.5%. The non-motorised represents about 1% (159) of the effort and finally the fiber canoe also represents less than 1%. (21) Fishing operations in two villages, Imbikire in Bayelsa State and

Finima in Rivers State, were found to catch relatively large numbers of dolphins in drift nets. Detailed data was collected from eight captains of Ghana boats who mainly targeted shark and tunas using drift nets and hooks, either attached directly to the drift nets or in a long line. The fishermen from the two villages fished in the same fishing ground (Figure 5).

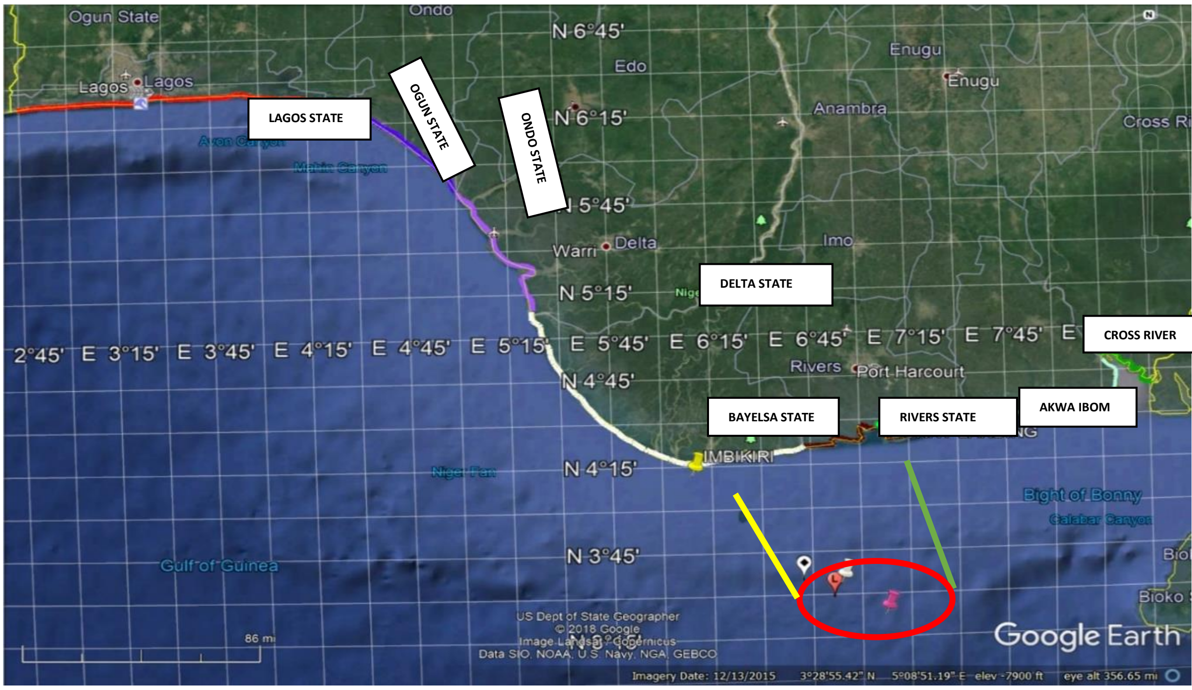

Figure 5: Coastal region of Nigeria showing the five states originally surveyed and the two communities eventually chosen for a detailed study of catch in drift nets combined with hooks and longline.

2.1 Study Area

The Niger Delta is on the Atlantic coast of southern Nigeria where the River Niger divides into numerous branches. It is the second largest delta region in the world with a coastline of about 450 kilometers and an area of about 70,000km^2 (27,000 sq. m) and makes up 7.5% of Nigeria's land. The delta has been described as the largest wetland in Africa and among the three largest in the world. (Whiteman, 1982) The population in the Niger Delta region was in 2005 about 31 million with more than 40 ethnic groups speaking about 250 different dialects (Nigeria population commission, 2006). Their major occupation is fishing.

Because of different habitats and the large number of fish species, each gear has different methods for fish capture (Tagago & Ahmed, 2011). The local and modern fishing gears that are used in Nigerian coastal fisheries have been well described (Moses, 1992). For this study, two fishing communities were chosen (Figure 5). These are Imbikiri in Brass of Bayelsa State with a GPS coordinate of N 04° 19′.491″ and E 006°14′705″ and new Finima longline G.A.Rs in Bonny in River State with a GPS coordinate of N 04° 24.049″ and E 007°09′880″ (Figure 5; Table 1).

2.2 Cetaceans in the Niger Delta

Cetaceans have been poorly documented in the Niger Delta region. Lack of knowledge and limited research exists on cetacean presence and bycatch. This is primarily because most information on cetaceans have been obtained from the fishermen, who are known to catch dolphin species through bycatch. A typical example is a report from the 8th March 2004. A group of dolphins was seen 130km offshore in the Niger Delta region where the depth was about 1300m. The dolphins were identifying as "maybe" Fraser's dolphins *Lagenodelphis hosei* (Weir, Canning, Hepworth, Sim, & Stockin, 2008), (Van Waerebeek, Ofori-Danson, & Derah, 2009). Nigeria has been cited as the country of origin for Atlantic humpback dolphin (*Sousa teuszii*) without any supporting evidence (Klinowska M., 1991; Rice, 1998). This was probably influenced by the species' type locality in Cameroon (Maigret, 1994) and (Van Waerebeek K, 2004) postulated that *S. teuszii* had most likely been abundant in the Niger Delta prior to oil exploration in the area which greatly impacted the environment. (Olakunle & Akanbi, 2014) reported three sightings of *S. teuszii* in western Nigeria, totalling 33 individuals, but without any documented evidence. Dolphins in the Niger Delta reportedly prefer shallow coastal and estuarine waters of less than 20m depth, especially during the bonga season (their prey) from February to June. Dolphins captured around Brass Island in the Niger Delta where many adult bonga fishes, mackerels, and 'jellyfish' occur (Michael Uwagbae & Koen, 2010). Dolphins are also said to occur near the surf zone along open, sandy shores and in mangrove areas especially during the month of March according to the local Ghanaian fishermen who operate in Nigerian waters. To clearly identify the species, (Bracho, et al., 2019) present in the bycatch and their relative proportion, and to avoid confusion due to similar morphological characteristics, molecular techniques, e.g. DNA, can be used. The genetic marker commonly used is the mitochondrial DNA (mtDNA) – D loop gene (part of the control region), which is known to be powerful in discriminating among almost all species, depending on the availability of proper DNA sequences in international databases (Chauhan and Rajiv, 2010).

2.3 Selected Communities for Research

Imbikiri is a fishing location/settlement situated at Brass Island in Brass Local Government Area of Bayelsa State (Table 1). It has a population of about 3,000 to 4,000 persons, of which about 90% engage in fishing, 8% in fish business, while 2% engage in other activities. New Finima, has a population of 10 –11,000, 12% engage in fishing, 1% in fish business, and 87% engage in other activities. Imbikiri has over 850 (98%) motorised fishing vessels while in Finima 953 (99%) motorised boats are registered.

Table 1: Fishing communities surveyed in 2016 to evaluate the impact of artisanal fisheries on dolphin populations in Nigeria. Survey of the fishing communities conducted (one x represents the community I personally selected and xx represent the fisher one).

States	**Communities**	**Date**	**Fishermen interviewed**
Lagos State		January & Feb 2016	
	1. Aivoji (x) 2. Gberefu (x) 3. Apakin (x) 4. Olomowewe (x) 5. Moba (x) 6. Osoroko (x) 7. Okun Ajah (x) 8. Okun Tiye(x) 9. Lekki (x) 10. Magbon Alade (xx) 11. Gbedrome(x) 12. Akodo (xx)		6 6 6 6 10 6 6 6 6 6 6 6 6
Ondo State		April 2016	
	1. Ebijimi (x) 2. Remoye (x) 3. Illepete (x) 4. Beku(xx) 5. Ayetoro(x)		6 6 6 6 6

	6. Ojumole(x) 7. Araromi(x) 8. Ogungbeje(xx)		6 6 9
Bayelsa State		May 2016	
	1. Imibikiri		10
Rivers State	Communities	June 2016	
	1. Light house(xx) 2. Peter side(x) 3. Ajalamuni(xx) 4. River seven(x) 5. Ukwumbi(xx) 6. Namata(x) 7. Ifoko(x) 8. Oyorokoto(xx) 9. Finima longline G.R.A(xx)		6 6 6 6 6 6 6 10 6
Akwa Ibom State		March-April 2016	
	1. Uta ewa(xx) 2. Ikot abasi(xx) 3. Ibaka(x) 4. Ibeno(x)		6 6 10 10
		Total	227

Data was collected from eight captains, five from Imbikiri and 3 from Finima over a period of two years, in 2017 and 2018. All fish caught in the gillnet were measured for each mesh separately. Although there is a considerable distance between Imbikiri and Finima, their fishing grounds are the same. Generally, the fishermen set out early in the morning (5-7AM) and get to the fishing ground around 4 and 5 PM. It takes about 1½-2 hours to set the net, but longer or 2-3 hours if the water is rough. After about eight hours they start hauling and keep the catch from different mesh sizes in separate partitions in the boat for sorting measuring and recording afterwards while travelling to a new location which usually takes 1-2 hours. This process is repeated 2-3 times normally over a period of 3 days, and rarely for 2 or 4 days. Most often each captain makes 2 to 4 trips per month depending on weather, time needed for net repairs and the size of the engine. The nets are arranged in different orders in the two villages, but generally smaller meshes are alternated with larger mesh size nets. In Imbikiri 40 nets of four different mesh sizes are joined, making a total length of 5840 m. A total of 120 hooks attached with a leader to the lead-line of the nets and another 60 hooks on a separate longline attached to the fleet of nets. The captains from Finima have 35 nets of five different mesh sizes a total of 5110 m of nets with 107 hooks and a separate longline with 90 hooks. The composition of nets for the different sites is detailed in Table 2.

Table 2: Value of the effort per captain for the year 2017 and 2018. The column Row Labels refers to the captain numbers (1-8)

Sum of TF	**Column Labels**		
Row Labels	**2017**	**2018**	**Grand Total**
1	109	99	208
2	97	112	209
3	103	75	178
4	103	95	198
5	100	93	193
6	100	78	178
7	83	89	172
8	85	97	182
Grand Total	**780**	**738**	**1518**

Table 3: Number of nets, number of hooks, length of nets and difference in mesh size used in the two investigated communities

	Number of nets of different mesh sizes							
	102 mm	127 mm	152 mm	178 mm	191 mm	number of nets	length of nets	number of hooks
Imbikiri 5 vessels	14	13	7	6		40	5840 m	120 + 60
Finima 3 vessels	12	11	6	3	3	35	5110 m	107 + 90

The Artisanal fishing is within 5 nautical miles (M), the Ghana fishermen from both communities go 40M and above, because the target species are mostly found between 40-150M or more. However, during the height of the dry season, between December-March, the fishermen come closer to the shoreline at about 5-30 meters to fish. This is because the sea is calmer during this time and less turbid from fluvial input. But they also go to the deep areas in this same season, depending on their catch in the shallow area and assess the water column in terms of wave and tide to know whether they can fish in the deep area. The gears used in the two-sampling sites are twisted multifilament polyamide drift nets. The drift net and hooks catch a diversity of species, such as sharks, sail fish, tunas and bycatch of marine mammals and sea turtles are commonly landed in both sampling sites (Figure 6).

Figure 6: Landing sites, shark, tuna, tunas in the hold and Atlantic spotted dolphins

2.4 Data Collection

The types of data in this study include:

i. Constructional details of the gear used.
ii. GPS positions of the fishing operations.
iii. Number of sets, setting time and soaking time.
iv. Length measurements for all species for each mesh size and the longline.
v. Numbers and length of Cetacean Bycatch, and 20 tissue samples from the Cetaceans.

2.5 Data Analysis

i. The gear and craft employed in the incidental capture of cetacean in the study area was described, analysed and presented.

ii. The bycatch of Cetaceans will be assessed and collected tissue samples were used for DNA genotyping in order to clarify the number of species involved.

2.6 DNA Sample Collection

The 20 tissue samples were collected from the driftnet at the two-landing sites in the Niger Delta, Nigeria. A small tissue piece of the different species was collected and preserved in 96% ethanol.

2.6.1 Mitochondrial DNA D-loop Laboratory Process

A total of 3 µl of DNA template was isolated with 15% Chelex 100 Resin (BioRad, cat.143-2832) (Walsh, Metzger, & Higuchi, 1991) and ProteinaseK. The mtDNA D-Loop was analysed with DNA sequencing with D-Loop primers designed at Matís. DNA amplifications were carried out in a total of 20 µl volume containing 2 µl DNA (5-20 ng/µl), 0,2 µl Taq DNA polymerase (New England BioLabs), 2,0 µl 10×Standard buffer (New England BioLabs), 0,4 µl of 10 mM dNTP, 0,1 µl of the forward primer (M.whale PCR F b, 100 µM) and 0,1 µl of the reverse primer (MW PCR r, 100 µM) (Table 3). The polymerase chain reactions (PCR) thermal profile was as follows: 4 min at 94°C, followed by 35 cycles of 45 s at 94°C, 45 s at 56°C, 1 min at 68 °C, with a final elongation step of 7 min at 68 °C. PCR reactions were performed on an Applied Biosystems 3730 Thermal Cycler (Life Technologies). PCR product was verified on agarose gel. PCR product cleanup was done by using the ExoSAP-IT kit according to the producer (Affymetrix, Inc; USB product), and the sequencing reactions were performed in both directions by using the BigDye Terminator 3.1 Cycle Sequencing Kit according to the manufacturer's protocol (Applied BioSystems). Sequencing primers were Minke whale PCR F b and MW_seq-R_b1. MAGBIO HighPrep Dye Terminator Removal Clean Up used to clean the sequencing products according to manufacturer's protocol. Sequencing of the fragments was done by using ABI 3730 sequencer (Applied BioSystems). The software Sequencher v5.2.4 (Gene Codes Corporation) was used to align the forward and the reverse sequences for each sample and the consensus sequence exported.

The obtained sequences of the 20 bycatch dolphins were first blasted against GENBANK depositary sequences database using nucleotide BLAST research engine online (https://blast.ncbi.nlm.nih.gov/Blast.cgi?PROGRAM=blastn&PAGE_TYPE=BlastSearch&LINK_LOC=blasthome).

The relationships among mtDNA sequences of bycatch individuals and references sequences retrieved from GENBANK were then depicted in Network4 (Bandelt, Forster, & Rohl, 1999). They selected the Neighbor-joining-tree implemented by the software Network4 (Bandelt, Forster, & Rohl, 1999), for being one of the most efficient network building methods available to date (Cassens, et al., 2003). The nodal support of these trees was assessed using 1000 bootstrap replicates.

Table 4: *PCR mixture used for the amplification of mtDNA D-loop sequences in 20 bycatch dolphins*

Mix	**µl**
M.whale PCR F b (100uM)	0,1
MW PCR r (100uM)	0,1
DNA	2,00
dNTP (10mM)	0,40
Std Buffer	2,00
Pol Taq	0,20
dH_2O	15,30
Total	20,00
Annealing	**56°C**
Cycles	**35**

3 RESULTS

The driftnets from the Niger Delta region, are made of twisted multifilament polyamide (Figure 7-8). At the Imbikiri landing site captains use four different mesh sizes, 40 nets in all, each net 146 m long the gang of nets being 5852m in total. At the Finima site captains use 35 nets of five different mesh sizes, 5110m in all. The composition of the fleet of nets in the two sites is shown in Table 4.

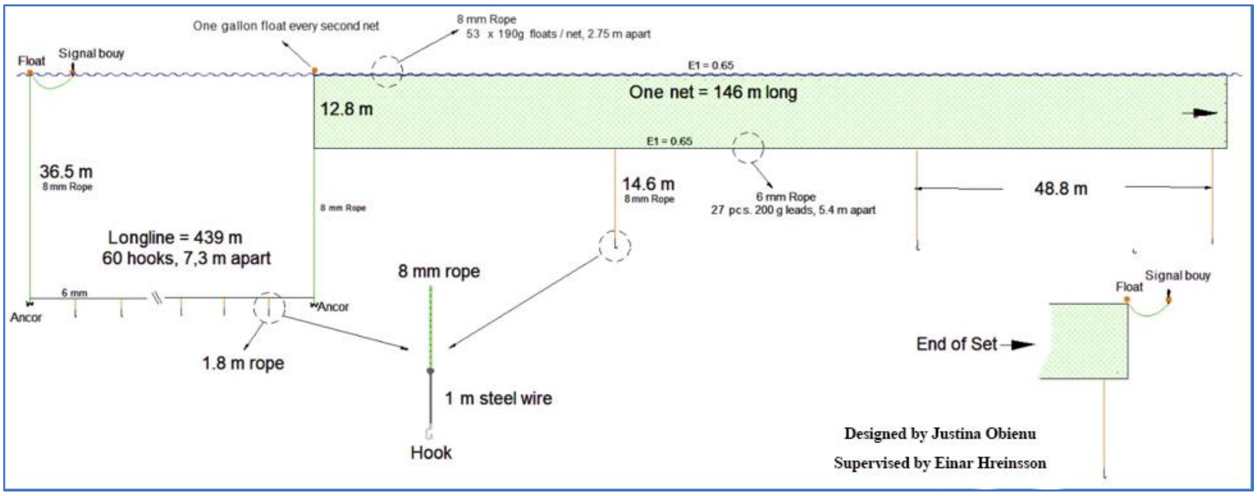

Figure 7: Example of set-up for a drift net used in Niger Delta.

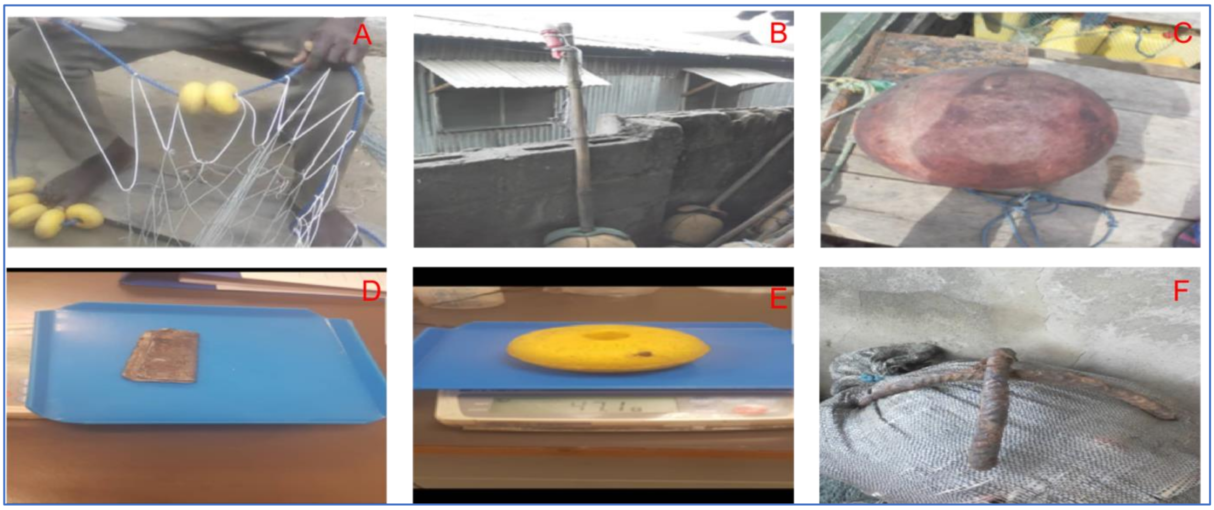

***Figure 8*:** A: Hanging ratio of drift Net; B: Signal light on the drift net and longline; C: Big Float for longline and drift net; D: Lead used on longline and drift net; E: Small float used on drift net; F: anchor used on drift net and longline.

3.1 The Longline Anchored to the Drift net

The long line is a special kind that is anchored directly on the lead line of the drift net, with rope length 12.8m (6mm). The length of the long line is 438.9m (8mm), with 60 pieces of hooks attached directly on the line at intervals of 7.3m. The length of rope with hook that is tired on the long line is 1.8m (8mm) with 1 yard of ion before the hook. The beginning of the long line was tied to the second anchor, of 36.5m (8mm) with a big float. Bamboo stick is attached to a big floater, on which a signal light is tired to the bamboo and then a rope of 12.8m (6mm) from the bamboo is then tied to the rope connecting the big float. Our big floaters are tied on the line at intervals of 146.9m and below the line we have 15 pieces of lead, that is placed at intervals of 29.26m each.

The bait used is mainly small tuna species, but also mackerel and dolphin. All dolphins caught are used for bait as fishermen have observed that dolphins' blood easily attract sharks. The bait must be fresh and strong on the hook. The bait weight on the hook is about 0.3kg (Figure 14).

Figure 9: Hook and baiting method utilised to catch large pelagics (e.g. shark and tuna).

Table 5: Number of Nets of different mesh sizes at the two landing sites

		Number of nets of different mesh sizes							
							number	length	number
		102 mm	127 mm	152 mm	178 mm	191 mm	of nets	of nets	of hooks
Imbikiri		14	13	7	6		40	5840 m	120 + 60
5 vessels									
Finima		12	11	6	3	3	35	5110 m	107 + 90
3 vessels									

3.2 Targeted Species

A total of 19 different species are currently targeted. The most common target species landed are eight different shark species namely, *Carcharinus* falciformis, *Alopias supercilliosus*, *Sphyrna diplana*, *Sphyrna lewini*, *Galeorhinus galus*, *Carcharhinus altimus*, *Isurus oxyrin chus* and *Prionace glauca*, followed by two different species of sail fish, *Makai nigirican* and *Istiophorous platypterus*, followed by 3 different tuna species, namely, *Katsuwonus pelamis*, *Euthynnus alletteratus*, and *Thunnus albacares*, followed by other species of bonny fish namely, *Coryphaena equiselis*, *Sphyraena*, andfollow) and squid (*Ommastrephes bartramii*). All these species occur at different depths, with examples of the shallow area ranging from 40 -146m and the deep areas ranging from 182m-548m (see Table 4 different depths and seasons).

3.2.1. The Bycatch Species

Many bycatch species were caught in the drift net, namely five different dolphin species were identified, the short-beaked common dolphin (*Delphinus* delphis), Risso's dolphin (*Grampus griseus*), the Atlantic bottlenose dolphin (*Tursiops truncatus*), the Atlantic spotted dolphin (*Stenella frontalis*), and the Fraser's dolphin (*Lagenodelphis hosei*), and two different species of sea turtle, Chelonia mydas and Dermochelys coriacea (Table 4).

Table 6: List of species caught by drift net at Imbikiri and Finima.

Family	Order	Scientific	Common	Local	Min/Max(cm)	Depth	Seasons
corphaenidae	Perciformes	Coryphaena equiselis	Pompano dolphinfish	Ape	15-122	**	***
Sphyraenidae	Scombriformes	Sphyraena	Barracuda	Jelee	30-94	***	***
Mobulidae	Mylibatiformes	Manta birostri	Manta ray	Begipali	130-175	**	
Ommastrephidae	Oegeopsida	Ommastrephes bartramii	Squide	Squid	48-122	**	**
Scombridae	Scombriformes	Katsuwonus pelamis	Skipejack	Tuna with line	10-61	**	**
Istiophoridae	Istiophoriformes	Istiophorus platypterus	Sail fish	Onyakiri	170-259	*	*
Istiophoridae	Indo-pacific blue marlin	Makai nigirica	Blue Marlin	Onyakiri	84-373	*	*
Scombridae	Scombriformes	Thunnus albacares	Yellow fin	Odaa	10-188	**	**
Scombridae	Perciformes	Euthynnus allettratus	Little tunny	Opuku	10-33	***	***
Carangidae	Perciformes	Caranx crysos	Blue runner	Kpetemeji	15-30	*	*
Caracharhinidae	Carcharhiniformes	Carcharinus falciformis	Sailk shark	Cop	30-180	***	***
Sphyrnidae	Carcharhiniformes	Sphyrna lewini	Scalloped Hammer head	Antoo	81-363	**	**
Triakidae	Carcharhiniformes	Galeorhinus	Tope shark	Chafobi	30-307	*	***
Caracharhinidae	Carcharhiniformes	Prionace glauca	Blue shark	Oyobo	178-348	**	**
Lamnidae	Carcharhiniformes	Isurus Oxyrinchus	Short fin shark	Sape	102-213	***	**

Family	Order	Scientific	Common	Local	Min/Max(cm)	Depth	Seasons
Alopiidae	Carcharhiniformes	Alopias supercilliosus	Bigeye thresher	Koote	170-518	**	**
Caracharhinidae	Carcharhiniformes	Carcharhinus altimus	Big nose	Chafobi	58-244	**	**
Sphyrnidae	Carcharhiniformes	Sphyrna diplana	Scalloped hammer	Antoo	30-218	*	*
Cheloniidae	Testudine	Chelonia	Green turtle	Hara	10-104	**	**
Dermochelyidae	Testudine	Delmochelys	Leather back	Kbosinya	86-196	***	***
Delphinidae	Cetacean	*Lagenodelphis hosei*	Fraser's dolphin	atui	86-229	***	***
Delphinidae	Cetacean	*Delphinus delphis*	Short-beaked common dolphin	atui	102-189	***	***
Delphinidae	Cetacean	*Delphinus capensis*	Long-beaked common dolphin	atui	104-249	***	***
Delphinidae	Cetacean	*Delphinus truncatus*	Atlantic bottlenose dolphin	atui	107-249	***	***
Delphinidae	Cetacean	*Stenella frontalis*	Atlantic spotted dolphin	atui	74-228	***	***
Delphinidae	Cetacean	Unidentified		atui	89-257	***	***

One star (*) indicates species found in shallow areas(6-24m); Two stars (**) species found in deep area (30-180m); Three stars (***) Species found in both deep and shallow areas; One star is dry season (*); Two stars are raining reason (**); Three stars are for both raining and dry seasons (***).

3.3 Importance of Drift Net Target Species

All the dolphins are seen in both seasons except for two months of September and October. Each shark species has four fins which are removed and processed by drying them under the sun, and during the wet seasons, they are dried at room temperature with 60-watt electric bulbs. Drying takes about 3-5days. Shark fining enables the fishermen to increase profitability, and this increases the number of shark harvests at sea, based on this, cetacean species are being targeted for bait to harvest more sharks because it was discovered by the fishermen that dolphin bait leads to more catches of shark. Apart from drift net bycatch, they also use spears to hunt the bycatch species. The fin is sold to Chinese people in Nigeria and some are exported to Ghana.

3.4 Total Effort from all Captains per Month

The total number of sets fluctuated between months, starting in January with 48 sets of nets (Figure 10). The minimum number of sets per month (per trip) in 2017 was 42 sets in the month of June and the maximum sets 80 and 82 in the months of July and August. For 2018 the minimum sets were 52 and 53 sets in the months of January, October, and December 2018. The maximum sets for 2018 was 81 and 68 sets in the months of July and August (Figure 10). Most importantly, the gear was typically set in the evening and recovered or hauled after 8 hours. This also shows some similarity for both years, the peak fishing season of drift net fishing in the Niger Delta is July and August.

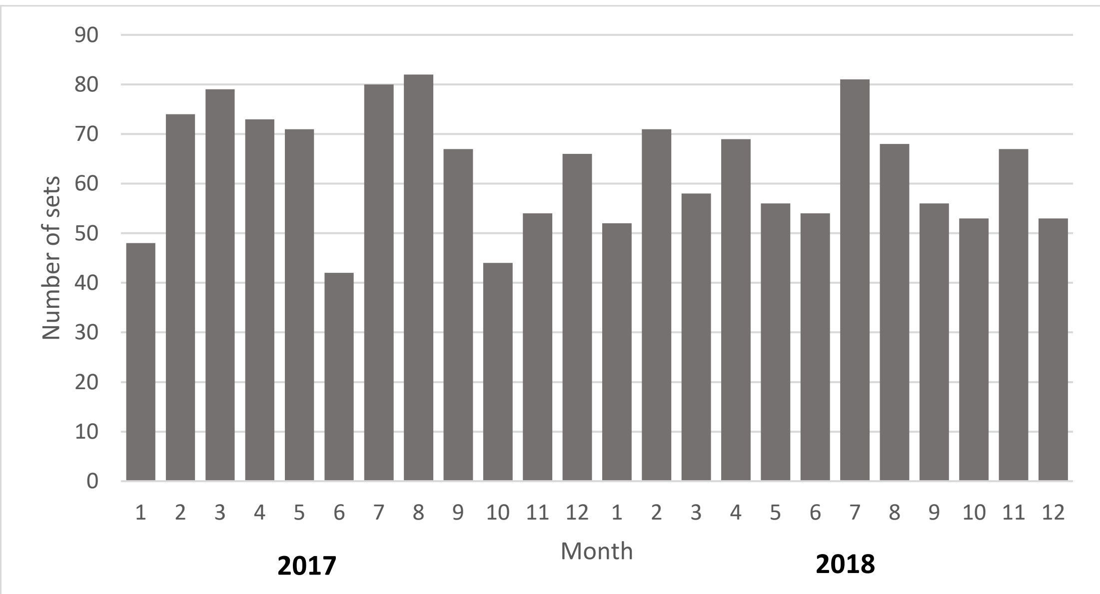

Figure 10: The total number of sets of net in each month (each trip) per captain for two years 2017-2018.

The total catches per set of fleets per month over a period of two years 2017-2018 is shown in Fig 11, showing the order Carharhiniformes (different species of sharks), the Istiophoriformes (Sail fish) the Perciformes (little tunny, blue runner, Pompano dolphin fish) and the Scombriformes (Barracuda, Skip jack, Yellowfin tunas). The catch fluctuates over different months. The minimum catch was less than 200 Kg in the month of March for 2017 and April and May for 2018. The maximum is in the month of July 2017 with just above 600kg and July 2018 which is about 380 kg.

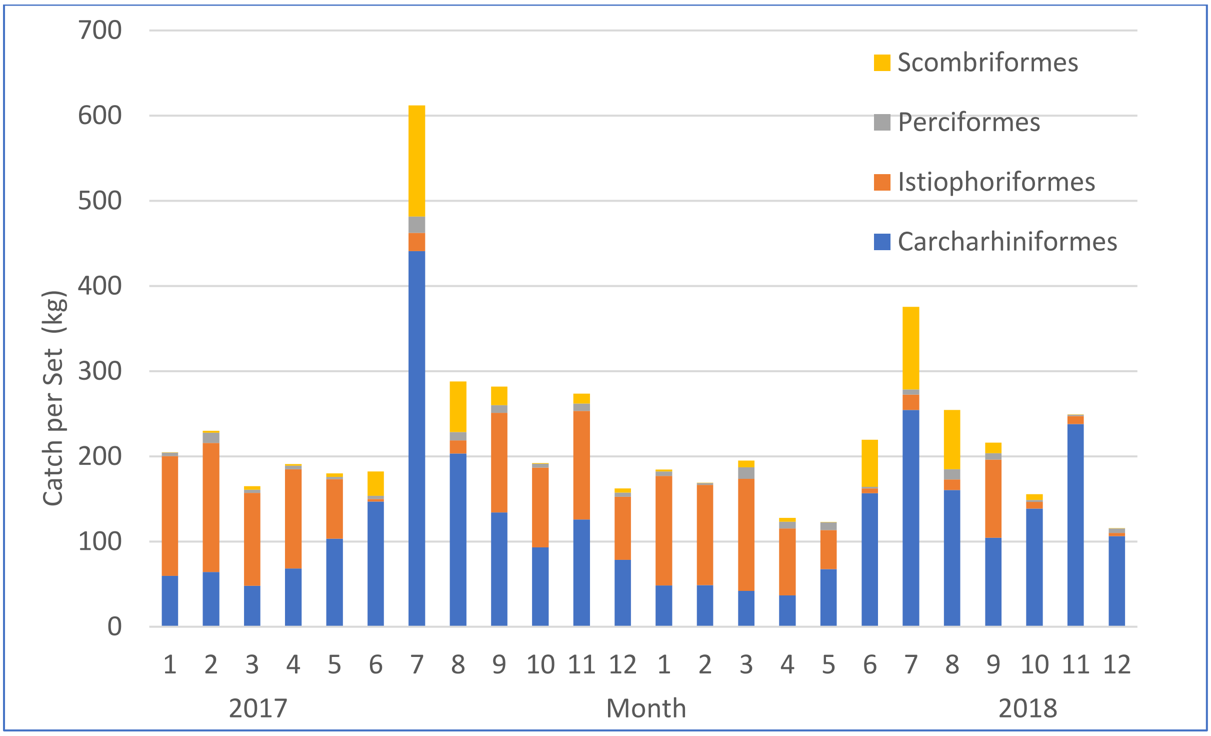

Figure 11: Total catches per set of fleets per month over a period of two years.

The number of dolphin catches varies each month per the number of sets. The minimum catch for 2017; number of dolphins was 2 each in the months of March and November and no bycatch in the months of September and October with a lot of effort. The maximum catch was in the months of July and August, 51 dolphins and 30 dolphins respectively, and with the same effort. A similar trend can be identified in 2018 (Figure 12).

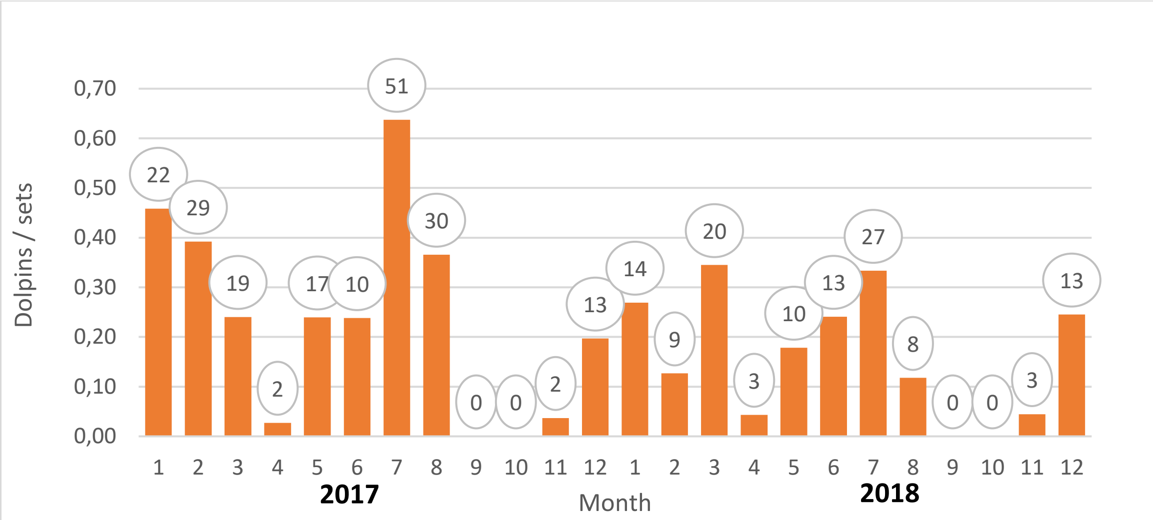

Figure 12: Number of dolphins caught as bycatch per set of fleets each month. Numbers on the top of the bars are the total number of dolphins caught that month.

Figure 13 shows that the catch per set of sharks and dolphins in the drift net longline catch follow a similar trend over the two years of the study (i.e., 2017 and 2018). More specifically, the plot indicates that there is a significant spike in catch per set of both dolphins and sharks in July of both years.

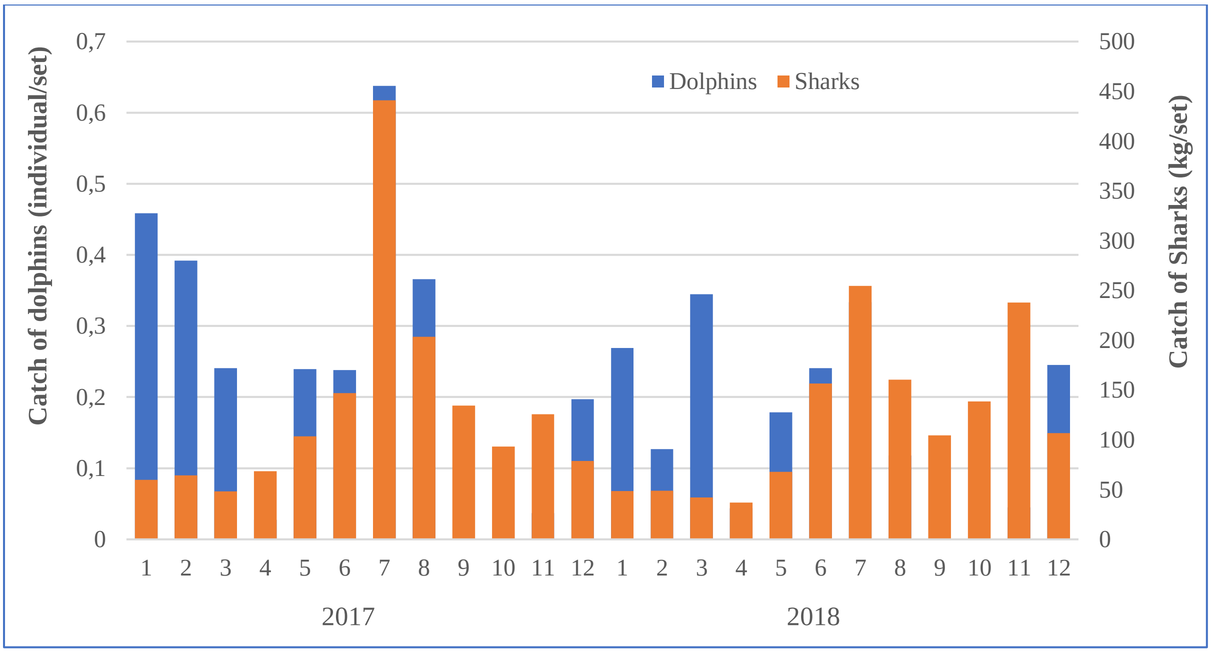

Figure 13: Comparison of landings of shark and dolphins in drift net longline in 2017 and 2018

The analysis of dolphin size and mesh size revealed that there is a clear selectivity in the mesh sizes, since a smaller mesh size is catching the smallest dolphins, and the bigger mesh sizes are catching the largest dolphins (Figure 14; see also Appendix I).

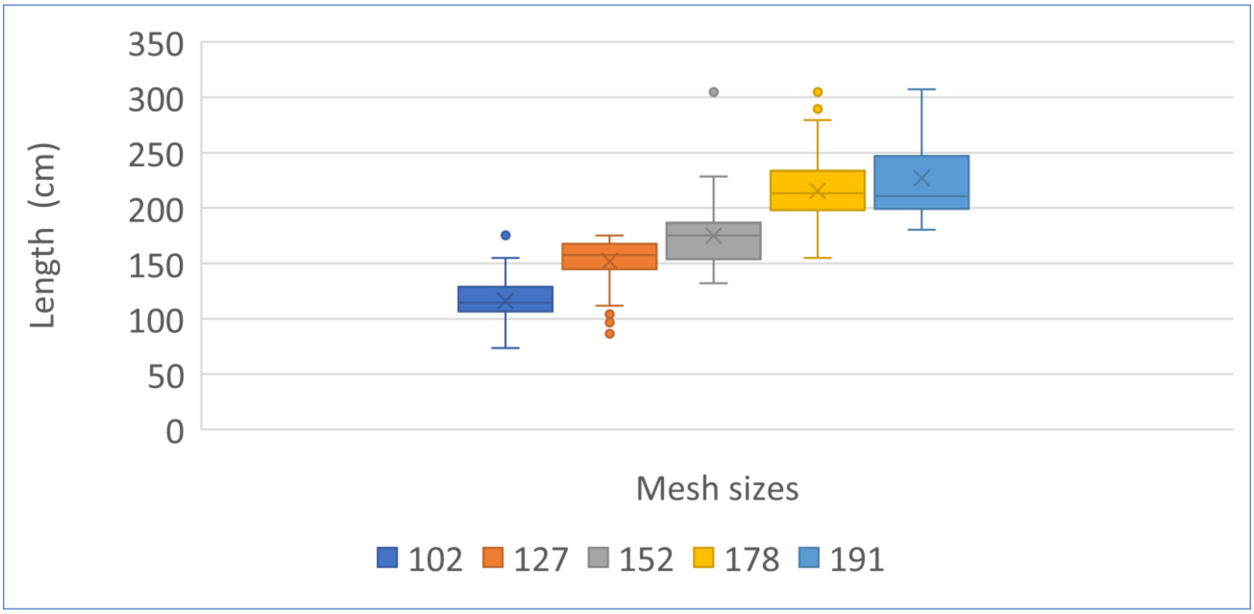

Figure 14: Length (cm) of captured dolphins in different mesh sizes. The X in the figure is the mean length of dolphin caught and the horizontal line in the box is the median. The box stands for the 25% and 75% quartiles and the whisker shows the 95% mark of the distribution and points are outliers.

3.5 DNA Test

Blast analysis carried out in the GENBANK revealed that most of the time the inter-specific sequences were too similar to discriminate between species, as shown for the D1 sequence. This D1 sequence was matched at 98% with good coverage to the short-beaked dolphin *Delphinus delphis*, the Indo-Pacific bottlenose dolphin *Tursiops aduncus* and the striped dolphin *Stenella coeruleoalba* sequences (see Appendix II). It was therefore complicated to estimate which sequences/species it was when only looking at BLAST results, although the distribution range of the Indo-Pacific bottlenose dolphin does not include Nigeria. On the contrary, for some sequences the matching was easier as in the case of D11 sequence (Risso's dolphin, *Grampus griseus*), which was matched at 99% with good coverage to only Risso's sequences (see Appendix II).The neighbour joining tree analysis (Figure 19) showed, with high certainty, that 12 out of 20 of our sequences were likely to be short-beaked common dolphin *Delphinus delphis*, 2 Risso's dolphin *Grampus griseus*, and 4 Fraser's dolphin *Lagenodelphis hosei*. A total of 2 sequences were suspicious, being matched to all Atlantic humpback with the tree but to the Atlantic spotted dolphin *Stenella frontalis* with the blast in GENBANK (Figure 19).

Based on both neighbour-joining tree analysis and the BLAST search, percentage of bycatches per species could be calculated. The largest catches were represented by the short-beaked common dolphin (*Delphinus delphis*, 60%), followed by the Fraser's dolphin (*Lagenodelphis hosei*, 20%), the Risso's dolphin (*Grampus griseus*, 10%) and possibly the Atlantic spotted-dolphin (*Stenella frontalis*) (Figure 20; Table 5).

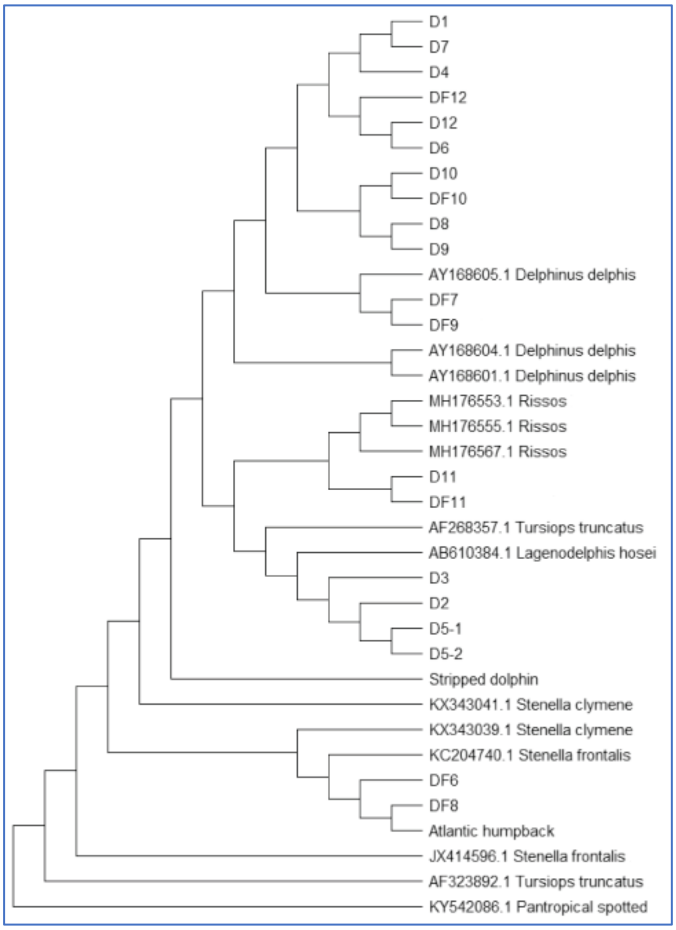

Figure 15: Results of the neighbour-joining tree including bycatch dolphins in the Nigeria Delta and reference sequences retrieved from GENBANK.

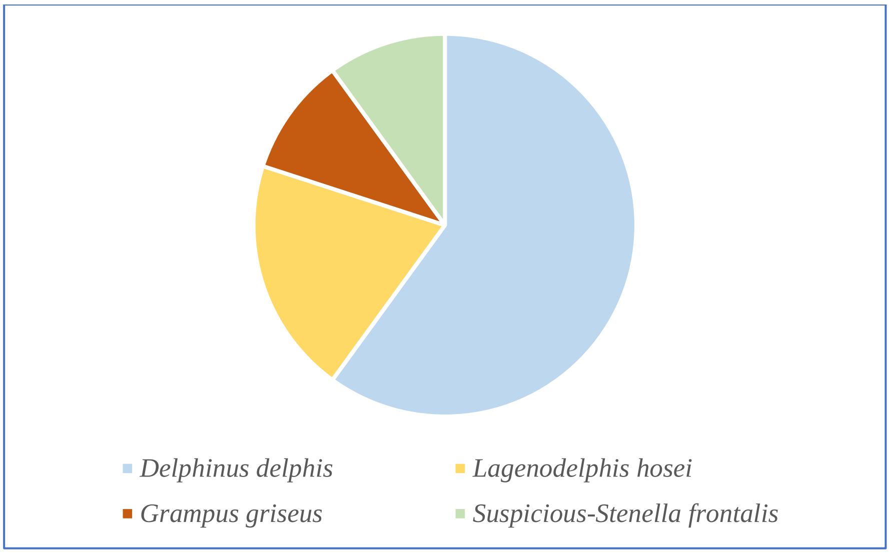

Figure 16: Percentage of dolphin catches in the bycatch in the Nigeria Delta, Nigeria.

Table 7: Comparison of species bycatch identification from morphological and genetic identification. Only 20 genetic samples were used. N depicts number, % percentage.

Species	Morphological Identification		Genetic Identification	
	N	%	N	%
Atlantic spotted dolphin	178	57	4	20
Short-beaked common dolphin	43	14	12	60
Fraser's dolphin	24	8	4	20
Atlantic bottlenose dolphin	21	7	0	0
Risso's dolphin	0	0	2	10
Long-beaked common dolphin	31	10	0	0
Unidentified	18	6	0	0
Total	315	100	20	100

4 SUMMARY AND DISCUSSION

4.1 Drift Net Construction, Operation, Advantages and Disadvantages

The drift net in the Niger Delta hang vertical in the water body with the help of a float attached to the rope along the net top, and with lead on the bottom, and are usually not anchored to the bottom. It is very effective in catching fish on the surface, when they are in groups or scattered, and reaches to about 12.8m depth in the water body. The netting material is made up of synthetic multifilament fibres namely polyamide (PA) the trade name is Nylon which have five different mesh sizes, the rope along the net is made of polyethylene (PE) the trade name is Nymplex. (Sala, et al., 2013).

Netting is available in different colours, the behaviour of fish captured is also in relation to the colour of the net in the water body; different colours may result in different catches (Wardle, Mojsiewiecz, & Glass, 1991). The colours used by the fishermen are white and blue colours, the fishermen prefer the blue colour because it is the same colour as the water body. When the net is put in the water body it appears invisible and catches more fish and a bycatch of dolphins and sea turtles. At the Imbikiri landing site captains use four different mesh sizes, 40 nets in all, each net 146 m long the gang of nets being 5852 m in total. At the Finima site captains use 35 nets of five differing sizes.

The hanging ration $E_1 =$ (0.6) for the drift net at both landing sites are the same. This is calculated using the length of the frame line on the driftnet to the stretched length of the netting, (the number of meshes x mesh size).

Based on fish capture, the hanging ratio and mesh sizes is the major parameter affecting the selectivity. The varieties of species in the pelagic water body are caught by a drift net because of the way it is designed or its position in the water body. (Sala A. , 2015).

4.1.1 Drift Net Characteristics

This project monitored 575 trips by artisanal drift net vessel. All the trips targeted different species of sharks (*Carcharinus falciformis*, *Alopias supercilliosus*, *Sphyrna diplana*, *Sphyrna lewini*, *Galeorhinus galus*, *Carcharhinus altimus*, *Isurus oxyrin chus* and *Prionace glauca*) followed by two different species of sail fish (*Makai nigirican* and *Istiophorous platypterus*), followed by 3 different tuna species, namely (*Katsuwonus pelamis*, *Euthynnus alletteratus*, and *Thunnus albacores*) followed by other species of bonny fish namely (*Coryphaena equiselis*, *Sphyraena*, and *Caranx crysos*) follow by Manta Ray (*Manta birostri*) and squid (*Ommastrephes bartramii*). It also catches dolphins and sea turtles as a bycatch. All these species occur at different depths, for example, the shallow area ranges from 6m -24m and the deep areas range from 30m-180m (different depths) and (seasons).

The data gathered in 2017-2018 during this study shows 26 different species or more were caught in this fishery and which in total amounts to 36,037 individuals.

Drift net has so many advantages. It is very easy to operate and maintain and is commonly used by artisanal fishermen. It is very efficient in catching a variety of species. (Sala A. , 2015). The disadvantages of drift nets are the major threat to small cetaceans including dolphins. About 300,000 die from fishing gear entanglement every year. WWF has suggested the complete removal of unselective fishing gears, because of experience with many species, such as, vaquita from the Gulf of California (Bracho, et al., 2019) and Maui's dolphin (Maas, 2013). About 315 dolphins were caught as bycatch during drift net longline fishing in the Niger Delta from 2017 to 2018, this has a serious impact on this dolphin species. The research suggested that, there is need to pay detailed attention to artisanal fisheries, as more than 95% of fisheries worldwide operate artisanal fishing, and this has an impact on the marine mammals. This problem is of concern to official international bodies like the International Whaling Commission which has recommended measures to ban the capture of dolphin in any type of fisheries (Shigueto, Mangel, & Van Waerebeek, 2008).

4.2 Catch Per Unit Effort

The total catch in kg of the four main orders Carharhiniformes (different species of sharks), the Istiophoriformes (Sail fish) the Perciformes (little tunny, blue runner, Pompano dolphin fish) and the Scombriformes (Barracuda, Skip jack, Yellowfin tunas) from drift net longline fishing, fluctuated over different months in both years. A high amount of Scombriformes catch was observed from June -September in both years, a low amount in kg of perciformes was observed throughout the months in both years. Istiophoriformes catch was lowest during the month where the Scombriformes where highest from June -August. Carcharhiniformes catch was high across all the months of both years. The catch is fluctuating in different months. The minimum catch was less than 200 kg in the month of March 2017 and April and May 2018. The maximum catch was in the month of July 2017 just above 600kg and in July 2018 which reached about 380 kg.

The number of dolphin catches varies in each month per the number of sets. Taking the minimum catch in 2017, the number of dolphins was 2 each during the months of March and November with no bycatch in the months of September and October with a lot of effort. The maximum catch was during the month of July and August with 51 dolphins and 30 dolphins respectively, and with the same effort. A similar trend was happening in 2018 (Figure 12). The total set of nets was 1,518 and the total bycatch of dolphin is 315. The average of the two years was 0.20. Meaning that for every 5th set of fleets, 20% will have dolphin bycatch.

Figure13 shows that the catch per set of sharks and dolphins in the drift net longline catch follows a similar trend over the two years of the study (i.e. 2017 and 2018). More specifically, the plot indicates that there is a significant spike in catch per set of both dolphins and sharks in July of both years. This shows that it will be very difficult for the fishermen to stop fishing, because it is a significant income for the fishers.

The analysis of dolphin size and mesh size revealed that there is a clear selectivity of the mesh sizes as the smaller mesh size catches the smallest dolphins, and the bigger mesh size catches the largest dolphins (Figure 18; see also Appendix I). Haraldur Einarrson, 2014, suggested that gill nets have a very strong selectivity, the clear selectivity of the five different sizes can enable the implementation or enforcement of a policy on the driftnet long line fishery.

4.3 DNA Analysis

DNA provides a perfect means of species identification as it is the DNA blueprint of an organism. The identification of these species will allow us to ascertain the diversity of the dolphin bycatch, and the respective representation of species in the catches. This remains important since some of the dolphin species on the IUCN list are endangered. This process of identification can enable us to improve the fisheries in order to avoid bycatches of these dolphins, and it will therefore improve conservation, environment sustainability, and tourism (promoting Ecotourism development) in the country.

The use of molecular genetics in fisheries research has been constantly increasing over the last decades, due to increased availability of techniques coupled with increased awareness of the value of genetic data for sustainable management. Several molecular techniques have been used to detect DNA markers and reflect the genetic background of fish populations (Liu and Cordes 2004). Various molecular techniques exist, such as RFLP, RAPD, microsatellites and single nucleotide polymorphisms (SNPs) and have mainly been employed to identify stock components and infer genetic structure in the context of management. Molecular markers are also used as tools for estimating the phylogenetic relationships of different kinds of organisms (Avis, 1994; Meyer, 1993) and identify species based on either the cytochrome oxidase subunit I (COI) of the mitochondrial DNA (mtDNA) or the D-loop which is part of the control region of the mtDNA. Genetic markers therefore provide crucial information which have importance in aquaculture practice and fisheries alike, such as: species identification, genetic variation and population structure study in natural populations, comparison between wild hatchery populations, assessment of demographic bottlenecks in natural population and propagation assisted rehabilitation programs (Chauhan T & K, 2010.)

The present study identified 4 species out of six that were potentially known to be captured through bycatch. The four species are commonly found in the Nigerian waters of the Niger Delta, but the Risso's dolphin has never been mentioned as a bycatch species whereas the short-beaked common dolphin and the Fraser's dolphin are known to be the most frequent ones in the catch. However, not all the dolphin bycatches were analysed because of the financial implications (collection of samples, manpower and the genotyping), which might affect the results observed here.

Short-beaked common dolphin, which is 60% of bycatch in the Niger Delta, has been shown to be heavily bycaught in the North Atlantic, however certain models indicate that bycatch effect on the reproduction of the species is greater than expected, and as compared with other species of dolphin (Mannocci, et al., 2012) About 1,000 short beak common dolphins are bycaught in the North Atlantic each year by either tuna drift, trawling and gillnetting. The regulation is that cetacean bycatch cannot be longer than 15 meters (Mannocci, et al., 2012) and this could become a problem because short-beaked common dolphins are only about 2.7 meters. Short-beaked dolphin is therefore covered by the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) and the Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS). The species is further included in the Memorandum of Understanding Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia and the Memorandum of Understanding for the Conservation of Cetaceans and Their Habitats in the Pacific Islands Region (Pacific Cetacean MoU).

The second most captured species, the Fraser's dolphin, is also covered by Memorandum of Understanding for the Conservation of Cetaceans and Their Habitats in the Pacific Islands Region (Pacific Cetacean MoU) and the Memorandum of Understanding Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (Western African Aquatic Mammals MoU). Some of the populations of Fraser's dolphins are listed in Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS), since they have an unfavourable conservation status or would benefit significantly from international co-operation producing tailored agreements.

Therefore, Nigeria data on bycatch composition using DNA markers might contribute to international action promoting the conservation of the dolphin species and contribute to a sustainable management of the ecosystem in the North Atlantic.

5 CONCLUSION

Based on the Bycatch data, the DNA analysis and the mesh size selectivity, this study can make up to 4 important recommendations:

1. A training course based on pictures/photos (see Appendix III) should be developed for the fishermen to help them to identify accurately the dolphin species that they catch;
2. A DNA sampling protocol should be developed for each species of dolphin caught in the nets and for which there is doubt about the identification;
3. A framework should be developed to protect dolphin species based on mesh size selectivity;
4. Banning mesh size to protect dolphin species will greatly influence the income of the fisheries and this should be assessed consequently.

This study has for the first time provided reliable information on the amount and species composition of dolphin caught as bycatch in the drift net longline fishery in the Niger Delta. It also provides information on the value of this fishery. It will enable policy makers and regulators, with other stakeholders, such as International NGOs to find ways to tackle this problem.

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8 APPENDICES

Appendix 1: Dolphin size and potential mesh size. Catching dolphins based on the selectivity analysis.

Species	Size range	Mesh size selectivity potential
Atlantic spotted dolphin	1.0-2.3m	178 and 191mm
Fraser's dolphin	1.0-2.6m	102, and 127mm
Risso's dolphin	2.5-3.8m	178 and 191mm
Long-beaked Common dolphin	1.9-2.5m	178mm
Atlantic bottlenose dolphin	2.5-3.0m	102, 127 and 152mm
Short-beaked common dolphin	1.7-2.0m	102, and 127mm

Appendix 2: Results of the Blast research for the sequence of mtDNA obtained D1 sequence.

Sequences producing significant alignments:

Select: All None Selected:0

Alignments Download GenBank Graphics Distance tree of results

Description	Max score	Total score	Query cover	E value	Ident	Accession
Stenella coeruleoalba mitochondrion, complete genome	1125	1125	100%	0.0	98%	EU557097.1
Delphinus delphis voucher CRI007520 mitochondrion, complete genome	1120	1120	100%	0.0	98%	MH000365.1
Tursiops aduncus isolate SA26 mitochondrion, complete genome	1120	1120	100%	0.0	98%	KF570359.1
Tursiops aduncus isolate SA116 mitochondrion, complete genome	1120	1120	100%	0.0	98%	KF570356.1
Tursiops aduncus isolate SA102 mitochondrion, complete genome	1120	1120	100%	0.0	98%	KF570354.1
Tursiops aduncus isolate SA101 mitochondrion, complete genome	1120	1120	100%	0.0	98%	KF570353.1
Tursiops aduncus mitochondrion, complete genome	1114	1114	100%	0.0	98%	MG762973.1
Tursiops aduncus isolate SA98 mitochondrion, complete genome	1114	1114	100%	0.0	98%	KF570361.1
Tursiops aduncus isolate SA133 mitochondrion, complete genome	1114	1114	100%	0.0	98%	KF570358.1
Delphinus capensis mitochondrion, complete genome	1114	1114	100%	0.0	98%	EU557094.1
Delphinus delphis isolate BS_23 mitochondrion, complete genome	1112	1112	99%	0.0	98%	MF669498.1
Tursiops aduncus isolate SA99 mitochondrion, complete genome	1109	1109	100%	0.0	98%	KF570362.1
Tursiops aduncus isolate SA95 mitochondrion, complete genome	1109	1109	100%	0.0	98%	KF570360.1

Appendix 3 Results of the Blast research for the sequence of mtDNA obtained D11 sequence.

Sequences producing significant alignments:

Select: All None Selected:0

Alignments Download GenBank Graphics Distance tree of results

Description	Max score	Total score	Query cover	E value	Ident	Accession
Grampus griseus mitochondrion, complete genome	1205	1205	100%	0.0	99%	EU557095.1
Grampus griseus mitochondrial DNA D-loop region	1157	1157	98%	0.0	98%	AB018584.1
Tursiops truncatus isolate EMED7 mitochondrion, complete genome	1026	1026	100%	0.0	94%	KF570323.1
Pseudorca crassidens voucher SWFSC:72692 mitochondrion, complete genome	1026	1026	100%	0.0	94%	JF289173.1
Pseudorca crassidens voucher SWFSC:72696 mitochondrion, complete genome	1022	1022	100%	0.0	94%	JF289174.1
Tursiops aduncus isolate IPTA4 mitochondrion, complete genome	1020	1020	100%	0.0	94%	KF570338.1
Tursiops truncatus isolate EMED8 mitochondrion, complete genome	1020	1020	100%	0.0	94%	KF570324.1
Tursiops truncatus isolate EMED6 mitochondrion, complete genome	1020	1020	100%	0.0	94%	KF570321.1
Globicephala melas isolate GlomelG5 mitochondrion, complete genome	1020	1020	100%	0.0	94%	JF339972.1
Globicephala melas mitochondrion, complete genome	1020	1020	100%	0.0	94%	HM060334.1
Tursiops aduncus isolate IPTA9 mitochondrion, complete genome	1018	1018	100%	0.0	94%	KF570343.1
Tursiops aduncus isolate IPTA7 mitochondrion, complete genome	1018	1018	100%	0.0	94%	KF570341.1
Tursiops aduncus isolate IPTA3 mitochondrion, complete genome	1018	1018	100%	0.0	94%	KF570337.1
Tursiops aduncus isolate IPTA1 mitochondrion, complete genome	1018	1018	100%	0.0	94%	KF570335.1
Stenella coeruleoalba mitochondrion, complete genome	1018	1018	100%	0.0	94%	EU557097.1

Appendix 4: Results of the Blast research for the sequence of mtDNA obtained; DF6 sequence.

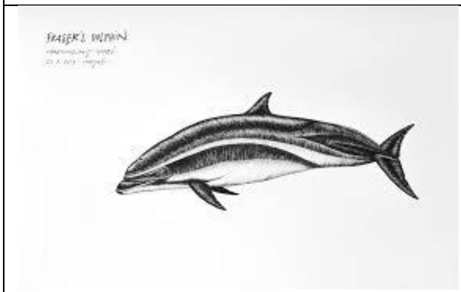
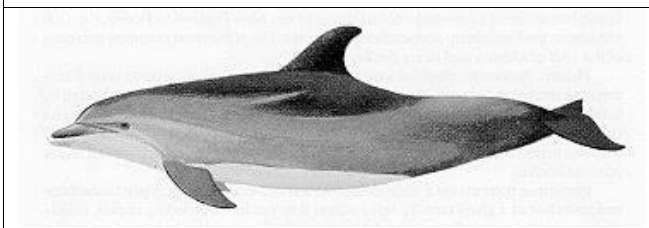
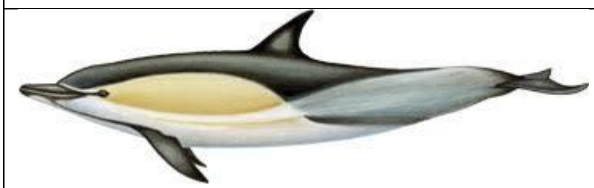
Sequences producing significant alignments:

Select: All None Selected:0

Alignments Download GenBank Graphics Distance tree of results

Description	Max score	Total score	Query cover	E value	Ident	Accession
Stenella frontalis isolate BR_199 D-loop, partial sequence; mitochondrial	593	593	100%	9e-166	99%	KC204734.1
Stenella frontalis haplotype SF22 control region, partial sequence; mitochondrial	593	593	100%	9e-166	99%	GQ504182.1
Stenella frontalis haplotype Sf42 tRNA-Pro gene and control region, partial sequence; mitochondrial	588	588	100%	4e-164	99%	JX414571.1
Delphinus sp. 1 AN-2013 haplotype KS0525 D-loop, partial sequence; mitochondrial	588	588	100%	4e-164	99%	KC295619.1
Stenella frontalis isolate SFM44 tRNA-Thr gene, partial sequence; tRNA-Pro gene, complete sequence; and D-loop, partial sequence; mitochondrial	588	588	100%	4e-164	99%	EF682838.1
Stenella frontalis isolate SFM12 tRNA-Thr gene, partial sequence; tRNA-Pro gene, complete sequence; and D-loop, partial sequence; mitochondrial	588	588	100%	4e-164	99%	EF682806.1
Stenella frontalis isolate SFM05 tRNA-Thr gene, partial sequence; tRNA-Pro gene, complete sequence; and D-loop, partial sequence; mitochondrial	588	588	100%	4e-164	99%	EF682799.1
Stenella frontalis isolate SFA88 tRNA-Thr gene, partial sequence; tRNA-Pro gene, complete sequence; and D-loop, partial sequence; mitochondrial	588	588	100%	4e-164	99%	EF682733.1
Stenella frontalis isolate SFA81 tRNA-Thr gene, partial sequence; tRNA-Pro gene, complete sequence; and D-loop, partial sequence; mitochondrial	588	588	100%	4e-164	99%	EF682726.1
Stenella frontalis isolate SFA53 tRNA-Thr gene, partial sequence; tRNA-Pro gene, complete sequence; and D-loop, partial sequence; mitochondrial	588	588	100%	4e-164	99%	EF682700.1
Stenella frontalis isolate SFA37 tRNA-Thr gene, partial sequence; tRNA-Pro gene, complete sequence; and D-loop, partial sequence; mitochondrial	588	588	100%	4e-164	99%	EF682683.1
Stenella frontalis isolate SFA22 tRNA-Thr gene, partial sequence; tRNA-Pro gene, complete sequence; and D-loop, partial sequence; mitochondrial	588	588	100%	4e-164	99%	EF682668.1
Stenella frontalis haplotype SF23 control region, partial sequence; mitochondrial	588	588	100%	4e-164	99%	GQ504183.1
Stenella frontalis haplotype SF10 control region, partial sequence; mitochondrial	588	588	100%	4e-164	99%	GQ504173.1
Stenella frontalis haplotype SFLBB007 D-loop, partial sequence; mitochondrial	588	588	100%	4e-164	99%	FJ971625.1

Appendix 5: Pictures ID Guide of Dolphin Species which occur in Nigeria.

	Atlantic spotted dolphin
	Fraser's dolphin
	Risso's dolphin
	Long-beaked common dolphin
	Atlantic bottlenose dolphin
	Short-beaked common dolphin

Appendix 6: Comparison of dolphin landing to the four main target orders of fishing fleet.