STRENGTHENING MONITORING AND CONTROLLING OF ARTISANAL FISHERIES USING PELAGIC DATA SYSTEM IN LIBERIA: CASE OF MONTSERRADO, GRAND BASSA AND GRAND CAPE MOUNT

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ABSTRACT

This paper aims to strengthen monitoring and control of the artisanal fisheries using pelagic data system in Liberia through case analysis of Montserrado, Grand Bassa and Grand Cape Mount. The main objective of this study was to analyze the viability of equipping artisanal vessels with the Vessel Monitoring System (VMS). The work examines the potential for the artisanal fisheries using the Pelagic Data System (PDS) to be integrated into the Automatic Information System (AIS) in order to monitor artisanal canoes at sea. The cases were analyzed using descriptive analysis to conduct a simple cost-benefit scenario with the PDS analysis of fleet segment within the IEZ and deep-sea fisheries. The calculation of the Pelagic Data System (PDS) was done in three scenarios in other to evaluate the total anticipated costs of the PDS activities to the total expected benefits, in order to determine whether the implementation of the PDS is economically viable for sustainable fisheries management in Liberia, and whether if offers any alternative cost reduction. The study concluded that the Pelagic Data System would be of better management for the artisanal fisheries in order to incorporate, the artisanal fisheries into monitoring programs through NGO, industry and government interventions .The study highlights several important issues of high relevance to the artisanal fisheries of Liberia.

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ACRONYMS

EEZ : Exclusive Economic Zone
EPA : Environmental Protection Agency
FIMS : Fisheries Information Management System
GRT : Gross Tonnage
HF : High Frequency
IEZ : Inshore Exclusive Zone
IMO : International Maritime Organization
IPOA : International Plan of Action
IUU : Illegal Unregulated Unreported
LMA : Liberia Maritime Authority
MCS : Monitoring Control Surveillance
MCSCC Monitoring Control Surveillance Coordinate Committee
MOA : Ministry of Agricultural
MOJ Ministry of Justice
MOU : Memorandum of Understanding
MTU : Mobile Transceiver Unit
NaFAA :National Fisheries and Aquaculture Authority
NPA : National Port Authority
PDS : Pelagic Data System
SAR : Search and Rescue
SOPs : Standard Operating Procedures
TURF : Territorial Use Rights Fisheries
UNCLOS United Nation Convention Law of the Sea
VHF : Very High Frequency
VMS : Vessel Monitoring System
WARFP:West Africa Regional Fisheries Program
AIS : Automatic Information System
BNF : Bureau of National Fisheries
CCRP :Code Conduct Responsible Fisheries

1 INTRODUCTION

The fisheries sector is an important part of the Liberian economy, and fisheries provide a major source of livelihood for coastal communities. The marine fisheries consist of artisanal and industrial fisheries. Approximately 86 % of the total capture fisheries production in Liberia is from the marine fishery while the remaining 14% of fisheries occur inland. In 2018, the fisheries employed 33,000 fisher folks, and the contribution of the fisheries sector to the national economy was 10% of GDP (NaFAA, 2018).

In 1960, there were only 44 canoes registered to fish along the coastline of Liberia. By 1980s the artisanal fishery had expanded with the Kru of Liberian ancestry, the Fanti and Ewe of Ghanaian ancestry and the Pohop of Togolese ancestry. Following several years of a success in the fisheries sector, the Liberia civil crisis in the early 1990s affected the country in all aspects, including its infrastructure and human resource development, resulting in several major governance frameworks including the fisheries regulations, becoming outdated. During this period illegal fishing in Liberia consisted primarily of foreign vessels which plundered potential revenue from the resources, destroying habitats and the ecosystem.

In recent times the Bureau of National Fisheries (BNF) aimed to improve its governance mechanisms by putting in place Monitoring Control and Surveillance (MCS) systems that have resulted in better management of the Liberian Fisheries. In 2010, the MCS was set up for the implementation of agreed policies, plans and enforcement of the fisheries laws, ensuring of proper practice, which resulted to 40 vessels fined for infraction in the Liberia waters.

1.1 Problem Statement

VMS does not presently cover the artisanal fisheries. No information exists regarding where artisanal fishermen operate. The management of the artisanal fisheries is limited, for instance in case of accidents at sea. Sometimes industrial vessels destroy nets of the artisanal fishermen, which is a serious problem and loss for the fishermen.

The monitoring of artisanal fisheries may be an option to strengthen data collection of the artisanal vessels. This system could provide reliable and accurate location of the canoes, their speed, during anchoring and length of time they are fishing (Caddy, 1995).

Equipping the artisanal vessels with the Pelagic Data System (PDS) would make it possible to obtain information on their locations, speed when they are on sea. This could give better information on the migrations of the stocks, fishing efforts and catch composition at different locations. Better information will make it possible to address potential conflicts and collisions at sea between vessels in the artisanal fleets and the industrial fleet, which lead to gear loss for the artisanal fishermen.

This study explores the potential to utilize need vessel monitoring system (VMS) for the artisanal sector to move towards more effective management through strengthened Liberian MCS.

Potential benefits of incorporating VMS into the Liberian artisanal sector include:

- Improved registration of vessels, proper data collection on the catch composition from each vessel;
- Enhance monitoring for the artisanal sector, with better information about where they fish, their fleets, and location of stocks
- Safety at sea; for better information on how to carry out investigation, and to strengthen Search and Rescue (SAR) if there is any incident

1.2 The Objective of the Study

The overall objective is to analyze the viability of equipping artisanal vessels in Liberia with a Vessel Monitoring System (VMS). Creating a standard monitoring of the Artisanal fisheries activities at sea and fishing grounds would ensure safety and provide a step towards proper management for the artisanal sector.

1.1 Specific objectives

This study will review the basic understanding of the real situation of the artisanal fisheries in order to adjust the fishing capacity and economics productivity in the fisheries. More specifically, the study aims to conduct a survey of artisanal fishermen which will be used to create a simple analysis of the costs and benefits of equipping the artisanal fleet with PDS.

2 LITERATURE REVIEW

2.1 Liberian Fisheries

Liberia has a coastline of 570 km, with a continental shelf extending about 34km into the Atlantic Ocean. The country has a population of almost 4.8 million people, with more than half of the population living in the nine counties (out of 15) on the coast. The capital, Monrovia, is located on the coast and other major cities are the ports of Harper and Buchanan. Liberia affords an area of fishing ground within 3 to 6 nm, with an extended 200 nautical mile of Exclusive Economic Zone (EEZ), approx.18, 400km^2 (Figure 1).

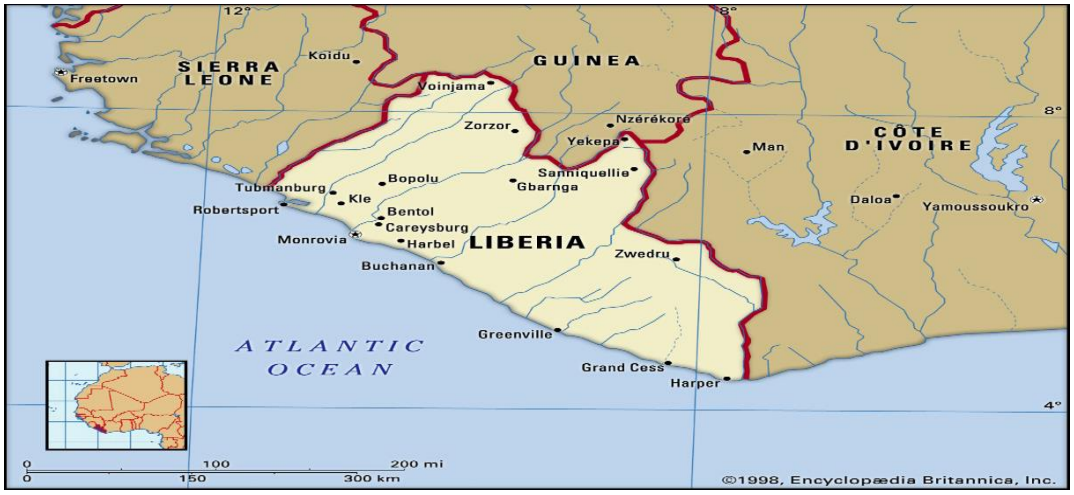


Figure 1. Map of Liberia

2.2 The importance of Liberian fisheries

The estimated maximum sustainable yield of the continental shelf of Liberia before 1989 was about 180,000 and about 40,000 tons from fresh waters tons per annum respectively (BNF, Annual Report, 2013). Seasonal populations of small pelagics including flying fish and herring are the most occurrence to the artisanal fisheries.

The fisheries over the years has shown good potential and has made significant contribution to the economic revitalization, including socio economic development that has impacted the reduction of poverty (NaFAA, 2018). Most of the fish harvested are either consumed locally by the fishers' families or sold in the local markets. Figure 2 shows the production trend of artisanal fisheries from 2010 to 2018 (NaFAA, 2018). Though fluctuating, the landings have been relatively increasing over the years contributing more to meeting the protein need of the population. The production of fish by the artisanal fisheries, has fluctuated between 9,700 tons in 2010 to 13,201 tons in 2018, reaching a peak of 13.914 tons in 2016.

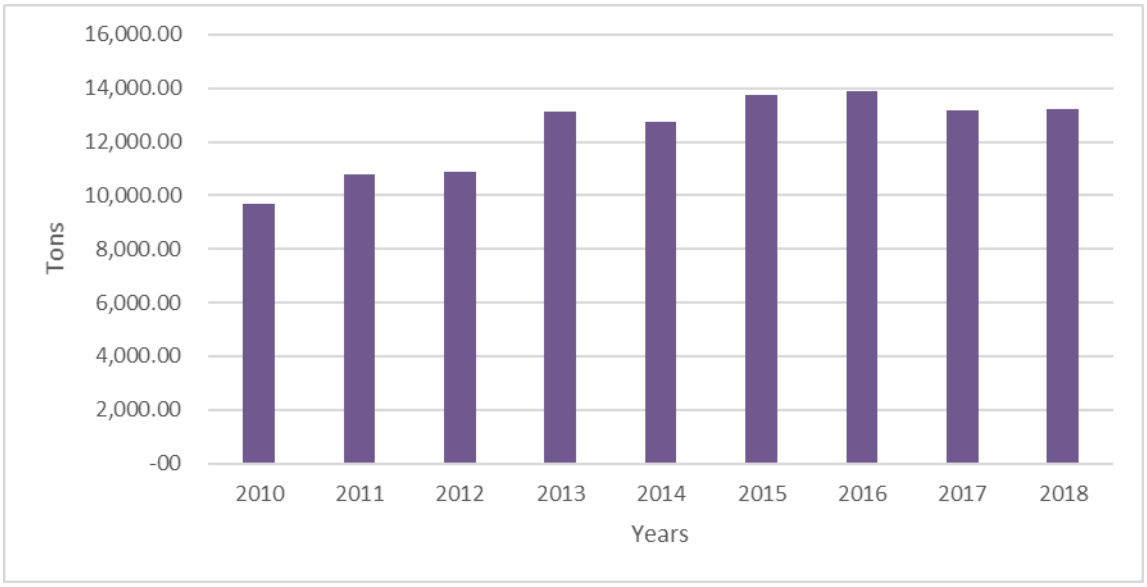


Figure 2. Total production of Liberian small scale (artisanal) sector from 2010 to 2018 (NaFAA, 2018)

Bonny (*Sardinella Spp.*) and porjoe (*Chloroscombrus Chrysurus*) are the most important species harvested by the artisanal fleet and accounted for half of total catches in 2017/2018 (Figure 3). The former species is mainly harvested by Fanti and later by Kru.

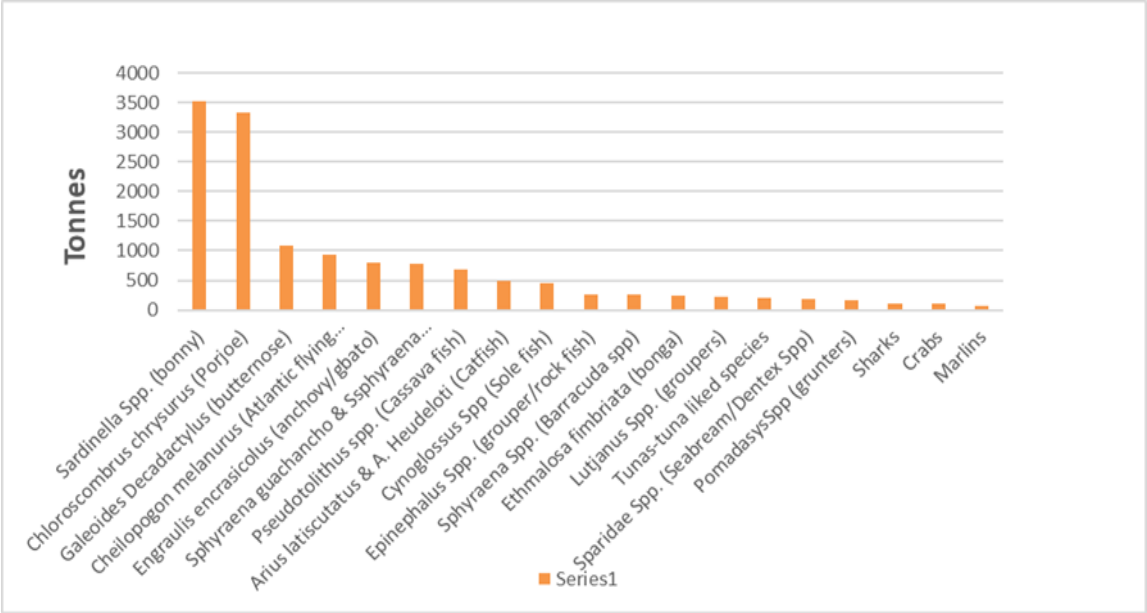


Figure 3. Total catch of species 2017/2018 (NaFAA, 2018)

This is a multi-species fishery, where resources are classified as small pelagic, medium pelagic, large pelagic, shallow water demersal, deep demersal, and crustaceans. Small pelagics are the major species caught, followed by shallow demersal. Figure 4 shows the trend of the different species. The landings from the large pelagic have increased in recent years due to the increase in industrial catches.

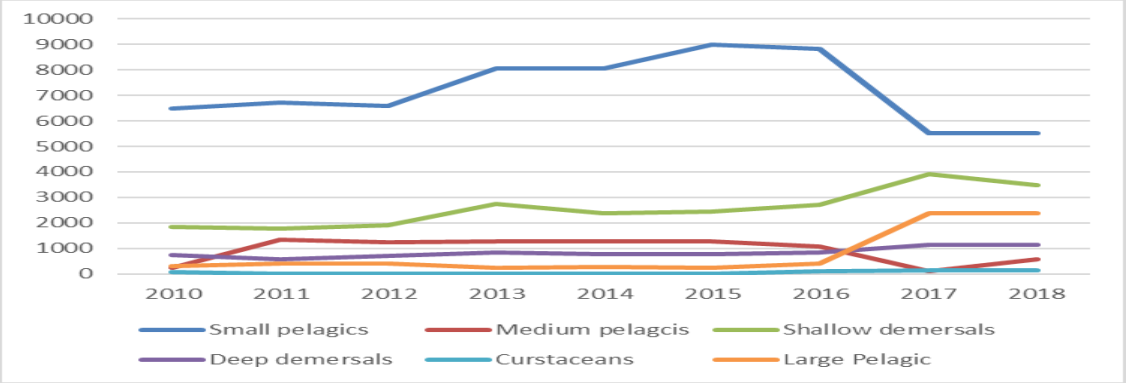


Figure 4. Catch trends of fisheries type in Liberia from 2010 to 2018

2.3 Artisanal Fisheries in Liberia

The artisanal fleet dominates the fishing industry of Liberia. It provides livelihood for about 33,000 full time fishers operating from 114 landing site within the nine coastal counties (Grand Cape Mount, Bomi, Montserrado, Margibi, Grand Bassa, Rivercess, Sinoe, Grand Kru and Maryland). About 80% of those working in the sector are Liberians, and 60% are women to the code of the chain values (NaFAA, 2018).

The largest craft are motorized semi-industrial vessels that target mainly small pelagic species and some larger pelagic species using ring-nets, driftnets, set-nets, gillnets and hook and line. There are 1,083 of these canoes registered to fish in Liberia, which are the Kru, Fanti (Ghanaians) and Pohop. These boats are crafted and constructed with a combination of different types of logs and planks. The Kru fleets comprises indigenous Kru that are about 6m long with the depth of 60cm, with 1 to 3 crew, and the standard canoe (medium) use larger dug-out canoes with 3 to 5 crew. Fanti canoes are operated or owned by mostly Ghanaian or fishermen of Ghana ancestry. They used dug-out planked with outboard engines about 10-15 HP and operate with 12 crew members which allow them to fish in deep sea. Pohops operate beach seines (200–800 m long) using dugout canoes, usually with a 1 or 2 person crew to deploy the net which is pulled to shore by a team of up to 20 men (FAO, 1986).

The value chain for the artisanal fishery is very short, and in most cases, there is little or no value addition at all. There is no use of ice or chillers for post-harvest fresh fish preservation. According to reports of the Bureau of National Fisheries (BNF), most of the catch of this sub sector are processed locally through salting, drying and smoking. Fish is typically marketed as soon as it is landed on shore. The fish is first washed with seawater and then gutted (for small sized fish) and for larger fish, decapitated and dismembered, before being smoke dried using firewood. Metal drums are mostly used for smoking in all coastal communities.

Earlier research has revealed that the Fanti fish further out than the Kru (see Table 1). Almost 43% of the Fanti operate more than 6 nm from the shore, while the corresponding rate of Kru

is 10%. Just over half of the Fanti (53%) operate at fishing grounds 4-6 nm from shore and 37% of the Kru, with 10% of the Fanti and 37% of the Kru covering distances shorter than 4 nm. As mentioned above, the canoes of the Fanti are larger and more powerful and can employ more sophisticated gears and equipment and travel longer distances than the Kru. (Dumbar, 2017).

Table 1. Distance travelled by Canoes. Source (Dumbar, 2017)

	Kru		Fanti			
Sea distance	Frequency	Percent	Frequency	Percent	Overall Freq.	Overall%
0 -3 NM	30	37%	23	10%	53	17.5%
4 – 6 NM	43	37%	77	53%	120	39.60%
7 – 8 NM	8	10%	104	47%	112	37%
Above 8NM	0	0%	18	8%	18	5.90%
Total	81	100%	222	100%	303	100%

2.4 Industrial Fisheries in Liberia

The marine industrial fisheries can be divided into a trawl fishery for shrimp and demersal finfish. The industrial fleet targets shrimps and demersal, finfish (croakers, grunts, threadfins, seabreams, sea perches) by trawling, which they provide frozen fish and shrimps.

This sector is composed of vessels owned by foreigners or vessels registered under the flag of Liberia. In 2009, there were eight industrial fishing companies, mainly foreign owned, operating 35 rigged side and stern trawlers registered in both fishing and shrimping operations. The industrial fleet is quite heterogeneous in size and level of mechanization. The vessels ranged in size from 60 GRT Chinese pair trawlers (ice carriers) to 251 GRT trawlers with on-board freezing, processing and storage facilities.

Industrial fishing trips last for a maximum of 21 days, of which two days are for steaming to the fishing ground back to port. Each vessel makes four hauls per day, and each haul lasts for about 2 hours. The total production from large pelagic fishery mainly tuna and tuna like species were 2,878.19 tons and 10,640.15 tons in 2016 and 2017, respectively. There were no industrial small pelagic vessels for the period under review.

The industrial fisheries operate beyond the 6nm, and most instances of IUU (illegal unregulated unreported) activities occur at night, when industrial vessels sometimes enter the IEZ to fish illegally. Their actions have been a great challenge for the new fisheries regimes of the BNF. However, in 2011, there was a memorandum of understanding (MOU) on fisheries MCS was signed by stakeholders in the maritime domain, during the inauguration of the Monitoring Control and Surveillance Coordination Committee (MCSCC).This resulted led to a decrease in the number of industrial fishing vessels, giving the artisanal fleet improved access to the fisheries (Sheriff, 2012). However, in recent years the number of industrial fishing vessels has risen again and catches from the sector have increased significantly from 2016 (Figure 6).

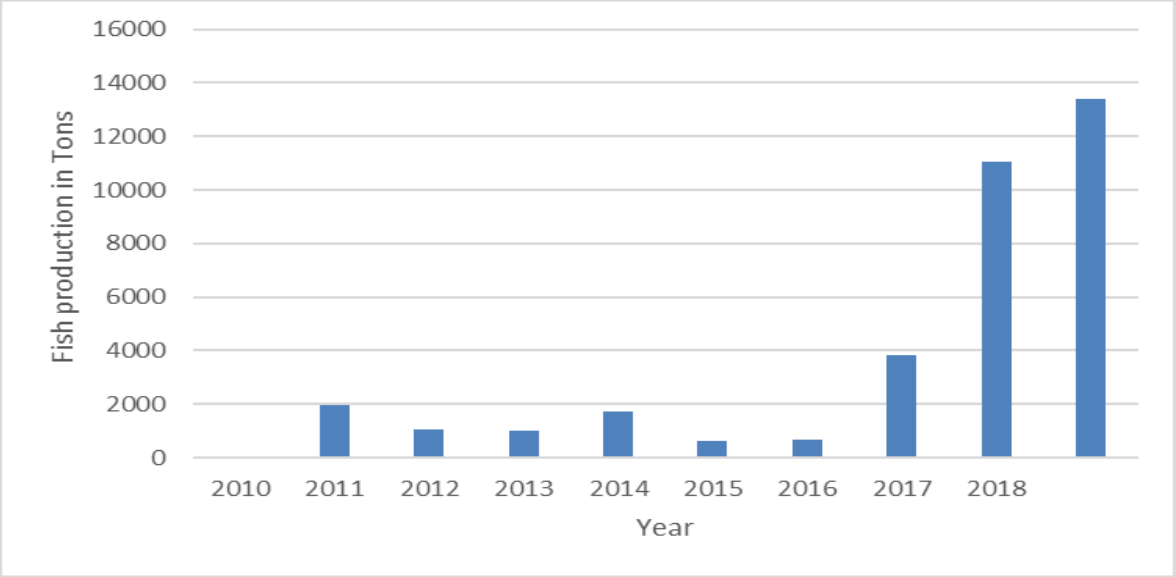


Figure 5. Marine Industrial fish production in tons from 2010-2018 (NaFAA, 2018)

2.5 Fisheries Management in Liberia

In 1956, the Bureau of National Fisheries was established through an act of legislation within the Ministry of Agricultural (MoA). The bureau is charged with oversight of the management and conservation of the fisheries resource of Liberia, which included regular statics for the marine resources. The Liberian waters were open to exploitation, and there was record of vessels and catches. In 1973, through assistance of the FAO, the government of Liberia revised the legal framework, which provided regulations for various fishing activities. The Bureau of National Fisheries (BNF) over the years has institutionalized in its capacity the governance of fisheries. In 1982, the United Nation Convention on the Law of the Sea (UNCLOS) was adopted, covering all aspects and uses of the sea. Additionally, some elements from the FAO Code of Conduct for Responsible Fisheries (CCRF) were adopted by the Ministry of Agricultural in 2008.

During the period between 1956 and 2010, the fisheries sector several serious challenges. These included

- Limited institutional capacity in the Bureau of National Fisheries (BNF),
- Increased damage to coastal ecosystems and fish spawning and nursing grounds.
- Reports of high levels of illegal fishing (some estimates of 60 to 100 illegal vessels fishing in the Liberian waters).
- Deep poverty and a high level of social fragmentation in fishing communities. As a result, no legal fish was exported from the country in those years.

The 2010, the West Africa Regional Fisheries Program (WARFP) replaced the outdated natural resource law of 1956, and since, there has been a new fisheries regulation, and a Memorandum of Understanding (MOU) on fisheries MCS. The basic aim of the WARFP project in Liberia was to strengthen the MCS capacity of the activities of the industrial fisheries, and to established Territorial Use Rights Fisheries (TURF) through a co-management initiative for the artisanal fisheries.

The actual management practice is based on a licensing scheme for all large vessels and the registration of canoes. To fish in Liberian waters, all industrial vessels should obtain a license and proper registration, but many in artisanal fleet go about fishing without registration. All registered industrial vessels have on board fisheries observers to monitor the fishing activities, and the catch of the vessels. Observers monitor and record catches and number of hauls per day, species, and by-catch. There are also inspectors at the landing sites at the Freeport of Monrovia. Artisanal landings are recorded at selected landing sites (Drammeh, 2007).

Another potential management strategy could be monitoring the artisanal fishery for the possibility of the future implementation of an individual or community-based quota system. Such systems commonly involve an allocation of quota to fishers or communities that can prove historical participation in the fishery.

A fisheries act is being drafted to support the management of fisheries in the country, with the consideration to the coordination of activities in the maritime domain. The new fisheries regulations have incorporated significant aspects and provisions of major international agreements and framework including the code of conduct for responsible fisheries, IMO and other conventions, International plan of Action (IPOA) to conduct IUU fishing and protocols addressing fisheries (Sheriff, 2012).

2.6 The Legislative Framework of other related sectors

The fisheries management in Liberia considers the legislative framework of other sectors that are partners in making sure that those laws are put in place.

i. *Liberia National Policy on Decentralization and Local Governance* (2010) – decentralizing government is a key governance strategy that is relevant for artisanal fisheries, particularly inland fisheries;
ii. *Maritime Act* (2010) – establishes the Liberia Maritime Authority (LiMA) as a corporate body and highlights the need for cooperation between agencies and departments;
iii. *National Defense Act* (2008)– establishes the role of the Liberian Coast Guard including in respect to maritime regions and its relationship with the Bureau of National Fisheries;
iv. *Environmental Protection Agency Act* (2003) – establishes a monitoring, coordinating and supervisory authority that is to provide an inter-ministerial mechanism for addressing and coordinating responses to Liberia's environmental problems
v. *Executive Order # 39 of 2012* (2012) – delimits Liberia maritime zones and embeds the1982 UNCLOS in domestic law;
vi. *National Capacity Development Strategy* (2010) – provides a vision for capacity development to be sustainable, inclusive, results-oriented, and aligned with the broader development agenda of the country;
vii. *National Food Security and Nutritional Strategy* (2008) – makes the provision of access to food in order to live an active and healthy life, a right of Liberian citizens;
viii. *National Adaptation Program of Action* (2008) – guides government in relation to adapting to climate change induced impacts and notes that fisheries are a key area of concern; and
ix. *Liberia Agriculture Sector Investment Program* (2010) – aims to empower women and youth and increase the fishery sector contribution to food and nutrition security and GDP through improving capacity of the BNF; instituting good governance and

sustainable management of fisheries; and reducing illegal, unreported, and unregulated fishing.

2.7 Monitoring Controlling and Surveillance (MCS)

Generally, the fisheries sector is important to the development of a state in managing all marine resources as fish is renewable resource in the territorial water and exclusive zone. The role of fisheries management is to maximize the benefits and economics opportunities from the state's territorial waters within sustainable harvesting limits, considering strong and cost-effective MCS (Doulman, 1981).

In most basic form, Monitoring, Controlling and Surveillance is an integrated information gathering, rules making, and enforcement system used to manage fisheries (FAO, 2005). An expert consultation defines MCS in a most common means to all fisheries personnel as follows:

a) Monitoring – the measurement and analyzing for fishing activity, including catch, species composition, fishing effort, by catch discard and area of operations. The monitoring component should receive, integrate and verify information from the licensing unit, sea going units(sighting inspections),observers, vessel monitoring system(VMS) and satellite imagery, radar, port inspection, dockside monitoring of landing, fishery logbook, vessel identification activity and location. This information are primary data that fisheries managers used to arrive at management decision.

b) Control – the regulatory and enforcement terms and condition under which resources can be harvested. This pattern is normally contained in national fisheries legislation and other arrangement that might be nationally, subregionally, or regionally agreed.

c) Surveillance – involves the regulation and supervision of ensuring that national legislation and terms, condition of access, and management measures are observed on fishing activity. The surveillance component of MCS will require fisheries personnel to communicate and educate stakeholders that are involved in participation conservation activities (FAO, 2005).

2.8 Monitoring Control and Surveillance in Liberia

Since the establishment of Bureau of National Fisheries (BNF) in 1956 and the revision of the Natural Resource Law of 1973, there was no MCS in Liberia. The MCS was established within the WARFP in 2010, as a strategic tool in reducing IUU fishing in Liberia. The newly-established unit was headed by a Focal Person who was a part of the management team including an international MCS consultant. Supervised by this team, WARFP established the fisheries monitoring centre (FMC) in 2010, which was commissioned in early 2011 to serve as the monitoring and surveillance arm.

Four personnel were recruited in the monitoring activities of licensed and unlicensed fishing and fishing related vessels in Liberia waters. Fisheries inspectors and observers were also trained along to enhance their skills in the execution of their duties. Fisheries sea and aerial patrols were also conducted to keep surveillance and enforce the fisheries laws and regulations. Standard Operating Procedures (SOPs) were drafted to guide the implementations of various duties associated with the MCS Department.

2.8.1 Institutional Arrangements

The Ministry of Agricultural through the Bureau of National fisheries (BNF) oversaw the overall management of the fisheries in Liberia. BNF became autonomous entity in 2017 as National Fisheries and Aquaculture Authority (NaFAA), as it continues to collaborate with other institutions and stakeholders such as Ministry of Finance, National Port Authority, Environment Protection Unit, Ministry of Justice, Liberia Maritime Authority, and the Coast Guard of the Liberian Army. A steering committee is charged with the responsibility to coordinate the activities of all stakeholders and partners which is chaired by the Ministry of Agriculture and co-chaired by the Liberia Maritime Authority.

2.8.2 The Fisheries Monitoring Center (FMC)

The Fisheries Monitoring Center (FMC) in Liberia was set up in 2011 and has the main function of monitoring and recording all vessels in the territorial waters and nearby international waters. The FMC monitors fishing vessels and fishing-related vessels, such as reefers, as well as transshipments. These are registered and mounted with Mobile Transceiver Unit (MTU) for all vessels greater than 299 gross tones (GRT).

The center is equipped with the following software and supplies;

- Automatic Identification System (AIS),
- Vessels Monitoring System (VMS),
- Faria Watchdog, all satellite based,
- Shore-based equipment cell phone,
- Very High Frequency (VHF) radio
- High Frequency (HF) radio.

In Liberia, the FMC is responsible for collecting and storing data from the earth station, *Satcomms* in Australia, and is computerized. In addition, the staff are to carry out 24/7 monitoring, and sea patrol two times every month.

2.9 The VMS System

VMS is a satellite-based fishing vessel monitoring system providing data of the fishing activities of a vessels interval on the location and course of speed of vessels (Magnuson, 2020). This application is specific for commercial fishing boats. The transmitter or transceiver, a device that is used in a circuit or equipment to boost signal strength to reach farther or receive from a distance automatically fixes positions and calculates the speed and course of the vessel. In the case of the operations of VMS systems, the transceiver is most often referred to as a Mobile Transceiver Unit (MTU) otherwise known as the black box (Elbert, 1999). The Global Positioning System (GPS) is a component of the VMS unit that has a separate antenna for transmission of signals. The VMS system is capable of being programmed to send position reports hourly, date and time, latitude and longitude, speed (MPH) and heading. The Bureau of National Fisheries operates an approved Faria Watchdog 750VMS for the Liberian VMS (Elbert, 1999).

2.10 The Pelagic Data System

The Pelagic Data System (PDS) was designed to provide reliable data collection in Liberian waters. PDS is a tracking device that can be used to establish locations in which fish are caught and landed. These data can serve as part of a digital record of seafood provenance. (Figure 6).

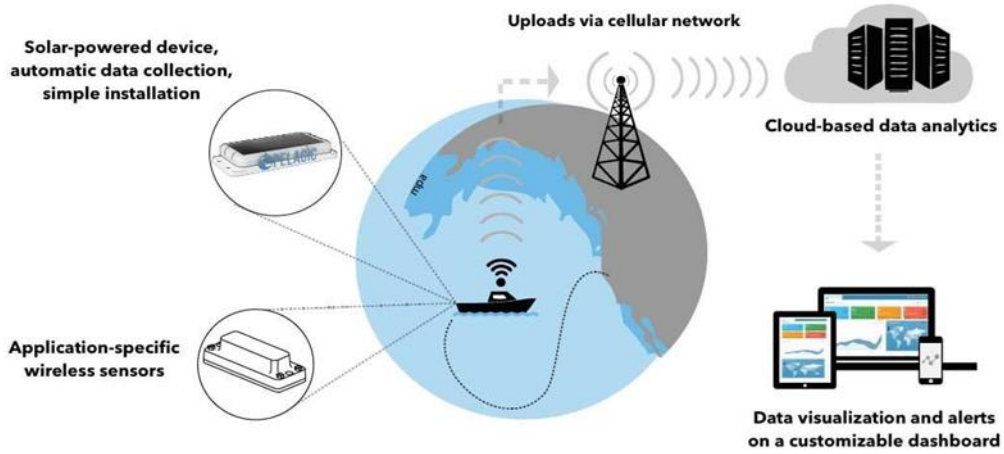


Figure 6. The system of the Pelagic Data System(PDS) (Pelagic Data System, 2014)

This system is also used for specific fields of application, such as monitoring, tracking fleet locations, activity, catch methods, and vessel to vessel interactions. The PDS system is rugged, waterproof, fully sealed, and durable. It logs data continuously regardless of network coverage through a wireless sensor by creating encrypted network on each boat. The system is solar powered, with quick uploads and is enabled with hundred times higher-resolution tracking compared with satellite-based technologies (Pelagic Data System, 2014). System specifications are detailed in Table 2, below.

Table 2. Show the technology architecture of the Pelagic Data System. (Pelagic Data System, 2014)

The system	**How it works**
Device	Location of vessel (600 locations per hrs.)
Cellular Network	It is simple in storing the data
Data	Compressed and encrypted prior transmission To keep it secure that there is plenty of room to Store data on board.
Database	Send receipt confirmation.
IT Support	Is fully provided by PDS users
Catch Reporting	Can integrate through a wide variety of methods Ranging from API to Webform or paper records.
Full Language Support	Offer 8 different languages

The Pelagic Data system benefits the fishermen by;

a. Providing precise information on location at all times.
b. Helping fishermen avoid areas of high bycatch.
c. Make it easier for fishermen to comply with fishing rules and regulations.
d. Help fishermen fish most efficiently and effectively.
e. Allow fishermen to better market their catches as traceable and transparently sourced.

3 METHODOLOGY

A scoping study was carried out with 6 trained research assistants and a research guide who were all familiar with the study area. A checklist was prepared in the form of social-ecological system inventory to establish preliminary information on the objectives of the study. This survey was administered by the enumerators from the research and statistics department, NaFAA. All together, 126 fishermen were included in the sample. The survey took place from January 6th -16th 2020. Participants were asked about the fishing in the previous year (2019), and various questions about the canoe used and gear, fishing grounds, length of trip, size of fishing crew and method of manoeuvre.

The study was conducted in three coastal counties, Grand Cape Mount, Montserrado and Grand Bassa county, which constitute Liberia's most important fishing communities. Two major fish landing sites were sampled from each county and twenty-one fishermen from each fishing segment (i.e. Fanti and Kru) were questioned at each landing site (Figure 7).

The study was a case study and a survey. The survey was conducted by representatives from

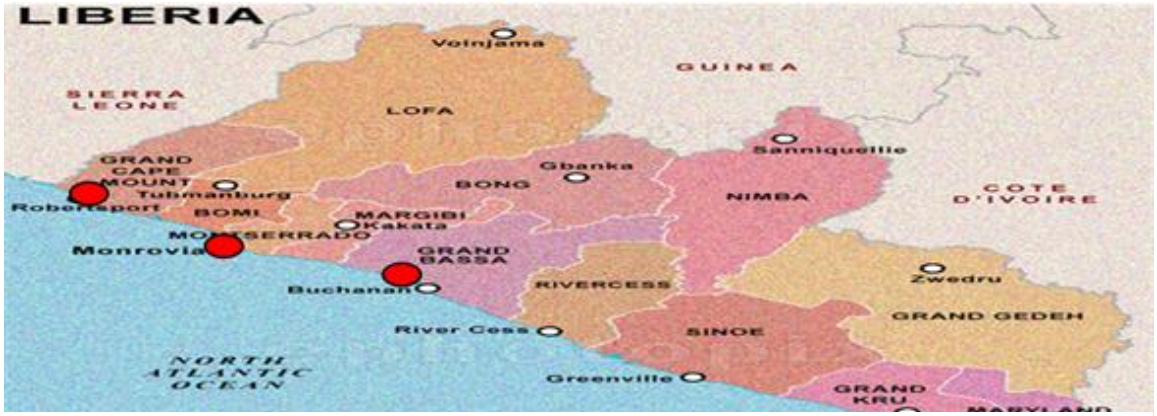


Figure 7. Map of Liberia showing the study area (Red dots)

NaFAA who decided whom to interview and where. Both qualitative and quantitative data were collected using the primary sources. An in-depth analysis of the socio-ecological system of the artisanal fisherman was conducted, as well as a comprehensive discussion regarding the utilization of fisheries resources in the study area.

4 RESULTS AND DISCUSSION

As shown in Figure 8, the number of Fanti and Kru fishermen is similar in Montserrado and Grand Bassa, but in Grand Cape Mount county there are more Kru than Fanti. Very few other fishermen are active in these counties.

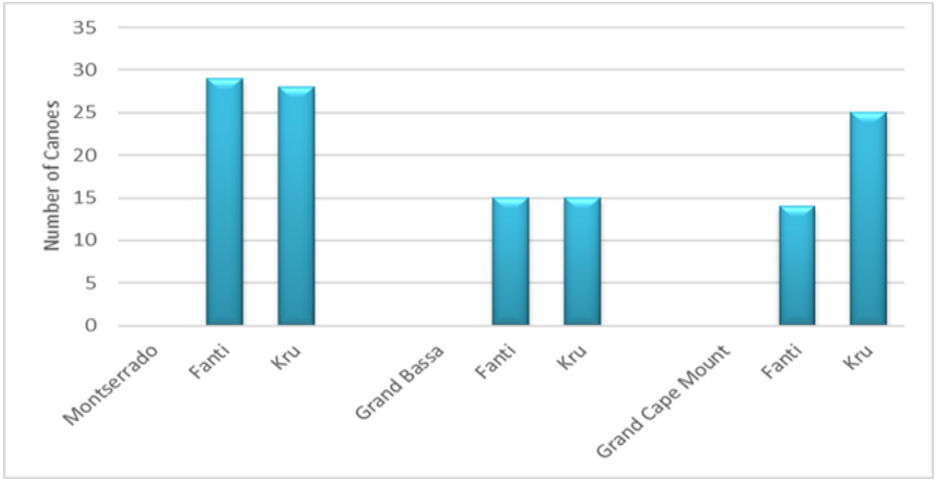


Figure 8. Landing sites of the three counties (Fanti & Kru)

4.1 Vessels Characteristics

The Fanti and Kru operating in the artisanal fishery use motorized and non-motorized canoes. All the motorized canoes, 66, are operate by Fanti, but the 60 non-motorized canoes are used by the Kru. Horsepower of the Fanti vessels in the survey as outlined in Figure 9, below. The survey clearly reveals that the Fanti canoes are more sophisticated than the Kru canoes. This

has implications for the possibility of employing PDS, as the Fanti canoes can go further out and may therefore have more use of the PDS.

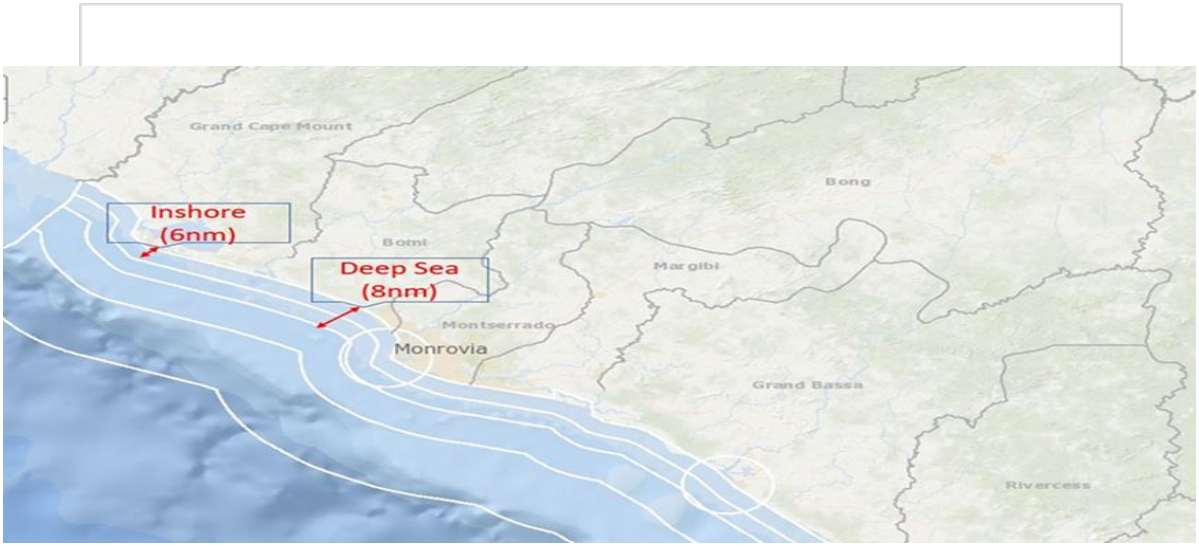


Figure 9. Total number of motorized canoes by horsepower categories sampled from six fish landing sites.

4.2 Gears used

The Fanti and Kru use very different gear. As shown in Figure 10, the Fanti employ nets, either set nets (31 vessels), ring nets (18), gillnets (12) or bottom gillnet (5), while the Kru employ mostly hook and line (29).

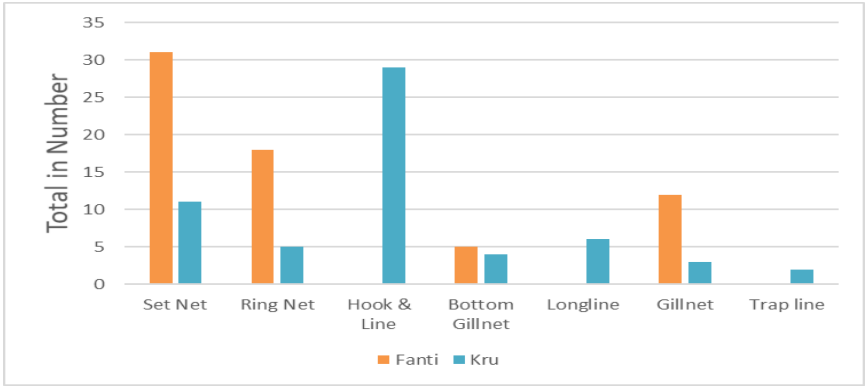


Figure 10. Total sampled number of fishing gears by category use by the two groups of canoes within the marine artisanal sector across six(6) sampled fish landing sites in Liberia.

4.3 Fishing Ground

The fishing grounds were categorized by two locations, inshore and deep sea, where inshore is defined as all fishing grounds within the 6 nm inshore exclusive zone (IEZ), while the deep sea refers to all fishing grounds further out. As shown in Figure 11 , the Fanti canoes all fish

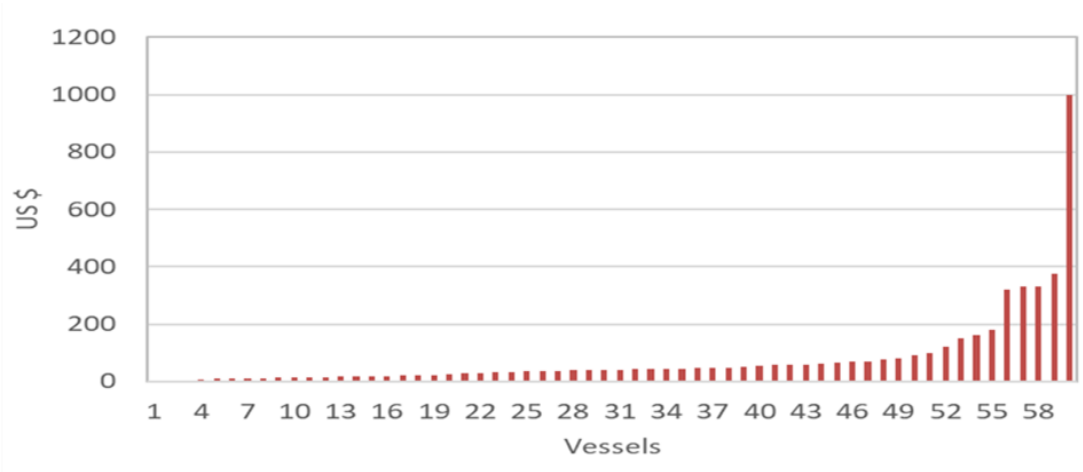
in the deep sea beyond the IEZ, while the Kru fish within the (IEZ). Thus, out of 126 canoe, 26 fished at undefined locations in the deep sea, and other 40 at Anny (19 vessels), Bukan (12), Roysville (5) and Sat PAA 4. All the other fishing grounds are located within the IEZ.

Figure 11. Snap from the Vessel Monitoring system (VMS), showing the demarcation within the EEZ as to where the Fanti and Kru fish.

4.4 The Revenue of the Inshore and Deep sea

Figure 12 and 13 reveal the distribution of income per day of the canoe fishing inshore and further out in the deep sea. Canoes fishing inshore reported on average revenue of 80.5 USD, while those fishing in deep waters had average revenue of 205.8 USD. The median value for canoes fishing inshore was 40.00 usd, and the median value of revenue for the canoes fishing in the deep sea was 150.00 USD.

Figure 12. Revenue from inshore fisheries



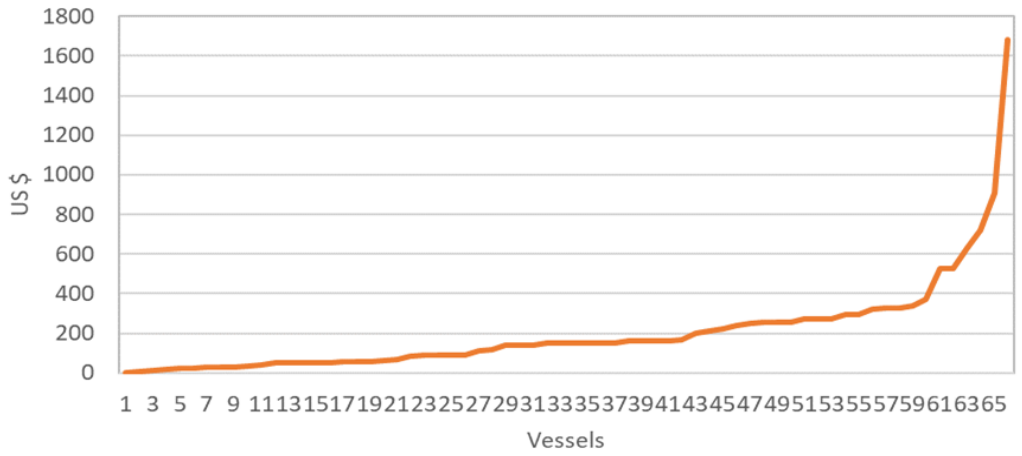


Figure 13. Revenue for Deep sea.

4.5 Gears used by the Artisanal Fisheries

Marine artisanal fisheries in Liberia takes place widely in the coastal seas, both within the IEZ which is from shore up to 6nm, and further out of the IEZ, up to 8nm. Most of the canoes are motorized and non-motorized. Motorized canoes with large crew, fishing further out and stay longer time at sea, so they used more advanced gears and huge quantity. Table 3 shows the gears that are mostly used by those fleets and in fishing efforts

Table 3. The contributions of gears types to the total fishing effort

Fishing Gear Type	Contribution to the fishing effort
Set Net	47%
Ring Net	27%
Gillnets	18%
Bottom Gillnets	8%
Hook &Line	0%
Longline	0%
Trap Line	0%

4.6 Accidents

Most accidents were caused by the natural elements such as rough sea, strong wind, water force, etc. Machine failure and too heavy catches may also contribute to accidents. However, in some cases other vessels are to blame, i.e. paddles may break because there are used to fend off intruders, and nets may be charged by other boats. As shown in Figure 14, accidents follow a seasonal pattern, and are more likely to occur during the ending of the dry season throughout the raining season (April-October).

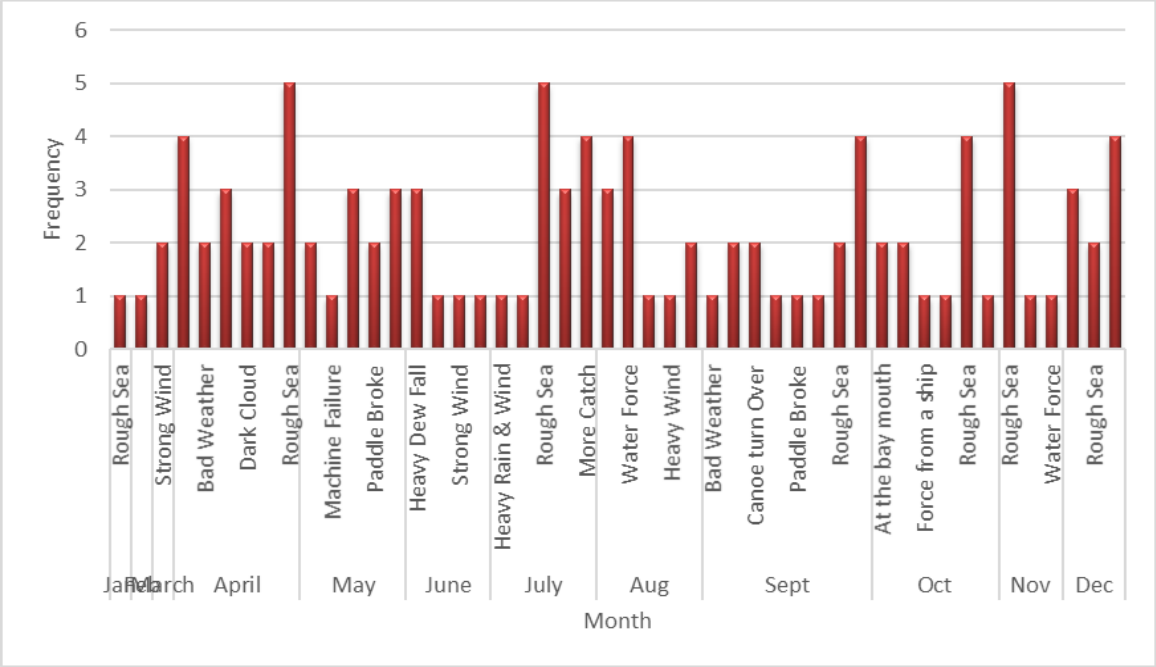


Figure 14. Accidents by type and month in 2019.

In some cases, lives may be lost at sea. In 2014-2016, there are five records of accidents of fatal accidents which together claimed the lives of 17 persons, identified in Table 5 below.

Table 5. Accidents and death at sea.

NO	VESSEL NAME	YEAR	CAUSE OF ACCIDENTS	NO. OF DEATH
1	GOD IS ONE -4	July 2014	Lack of early warning on ocean condition	8 PERSONS
2	LOVE THE WORLD NO. 1	APRIL 2015	Inability to withstand the wave during the rainy seasons	1 PERSON
3	GREAT EMMANUEL N0. 3	JUNE 2015	No GPS on board local vessels on fishing trips	4 PERSONS
4	AMAZING GRACE NO. 2	AUGUST 2015	Improper reflective gears for safety	2 PERSONS
5	GREAT MESSIAH	APRIL 2016	Canoe demission	2 PERSONS

4.7 Implementing PDS in the artisanal sector

The survey undertaken clearly revealed that data is currently not available that would allow for a comprehensive cost-benefit analysis of introducing a PDS into the artisanal pelagic fishery. Instead the focus here is on providing an estimate of the cost associated with implementing the PDS and outlining the main benefits.

For vessel owners, the costs of a PDS can be broken down into purchase costs of the unit (USD 368) and annual subscription charge (USD 300). As shown in Table 6, the cost associated with putting PDS on all canoes is USD 723 thousand in the first year and USD 2 million over a five years period, i.e. the installation year and subsequent four years. Installing the PDS only on Fanti canoes, would cost USD 434 thousand in the first year and USD 1.2 million in all five years, and installing the PDS on 10% of the artisanal fleet would call for a cost of USD 72 thousand in the first year, and USD 200 thousand over the five years period.

Table 6. The cost of installing the PDS under three different scenarios.

Scenarios	No of canoes	Unit cost of PDS (Data excl.)	Annual Data Charge	First Year	5 Years	10 Years
All registered canoes	1083	368	300	723,444	2,023,044	3,647,544
Only Fanti boats	650	368	300	434,200	1,214,200	2,189,200
10% of all canoes	108	368	300	72,144	201,744	363,744

4.8 Average Revenue

As discussed above, the average revenue per day of Kru fishermen was USD 84 and that of Fanti fishermen was USD 150. Assuming the survey results are representative for the artisanal fleet, it is possible to extrapolate those revenue figures for the fleet. This is done in Table 7. Assuming 100 fishing days per year and the Kru average, the revenue in the first year is put at USD 9.1 million. The figure is even higher for the Fanti boats, as their revenue per day is much higher than that of the Kru. Assuming 100 fishing days per year, the Fanti fleet is projected to have revenue of USD 9.8 million in the first year. The costs associated with installing the PDS and paying for the subscription in the first year, are thus only 8% of projected total revenue for all the artisanal fleet and 4% of total revenue for the Fanti fleet.

Table 7. Average revenue of canoes in the three scenarios

Scenarios	No of canoes	Fishing days in the year	Average revenue per boat per day ($)	First Year Revenue($)	Five (5) Year Revenue($)
All registered canoes	1083	100	84	9,097,200.00	45,486,000.00
Only Fanti boats	650	100	150	9,750,000.00	48,750,000.00
10% of all canoes	108	100	84	907,200.00	4,536,000.00

4.9 The benefits for having the pelagic data system (PDS)

The implementation of PDS is expected to have both social and ecological benefit through improved fisheries management with the used of the PDS. Basically, the excesses of the problem of the commons are expected to be reduced. Based on the survey, the benefits were categorized into a dashboard table indicating low, medium and high level of benefits with a color code, for better visual illustration

Table 8 below shows that there are several high positive benefits and sentimental values in terms of ecological and social benefits through a good fishery management. It is important to denote that implementation of the PDS also contribute to the conservation of the ecosystem, such as biodiversity and maintaining of ecosystem services, reduction of pollution in marine ecosystems and maintaining the regenerating function of fish species (fish stocks). Factors such as its contribution to national food and nutritional security, as well as providing several livelihood opportunities for coastal communities and their wellbeing are also significant, even though these benefits are yet to be quantified.

Table 8. The benefits of having the PDS

The Benefits of the PDS	Inshore	Deep sea
Ecological benefits		
Conservation of eco system: biodiversity and eco system services		
Target fishing through resource mapping and utilizing resources in a sustainable manner		
Reduction of marine pollution by fishing activities		
Increase regeneration and fish stocks		
Increase the production with low harvesting efforts		
Social benefits		
Food and nutritional security		
Enhancing the wellbeing of coastal communities		
Effective demarcation of fishing areas and reduction in user conflicts		
Sea-safety		
Stabilization of catch per boat and income		
Reputation of good fishery management and ethical values		

Benefit level	Low	Medium	High
Color indicator			

5 CONCLUSION

Artisanal fisheries lack the VMS in order to monitor them when they are at sea. The fanti canoes are more industrial, they travel long distances, carry more crews and they are fishing with more sophisticated gears and they catch more fish. The pelagic data system would probably lead towards better management for the artisanal fisheries in order to incorporate them into the monitoring programs through NGO, industry and government interventions. The Pelagic Data system would be of more benefit for those canoes that goes fishing out of the IEZ, to reduce collision that will caused the loss of their gears which in some ways will be of benefit from the PDS.

6 RECOMMENDATION

Although this research paper highlighted several important issues of high relevance to the artisanal fisheries of Liberia, it is important to make key recommendations that will strengthen the use and operationalization of VMS (pelagic data system) for the sustainable management of fisheries in the country. Specific actions will include:

- Encourage the integration of activities of MCS functions to provide support to VMS operations for the monitoring and control of commercial fishing canoes with PDS mounted on them. These activities will include platforms and mechanisms put in place to monitor and reporting from sea and landing sites in order to validate VMS data from the FMC and enumerators.
- In order to apply better and more successful measures for the artisanal fisheries, their protection should be put into place, constant monitoring of their fleets, safety at sea and assessment of the impact of fishing gears.
- Keep the FMC running and operational 24 /7 a day-365 day a year.

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APPENDIX

National Fisheries and Aquaculture Authority
Artisanal Catch and Efforts form

Date	Enumerator Name

County	Town/Area	Landing site

Canoe Details Number of Crew canoe registered

Motorized? Yes, No If yes # of HP

Fishing Segment: Fanti: Kru: Other Specify_____

Fishing Location/Ground	Registration # Canoe

Hours Fish	Trip duration(day)	Number of Trips per day

Number of Accident: If Yes ,How/Where /When

Gears used		Cost of Gear			Cost of Gear
Trap Line			Bottom Gillnet		
Long line			Hook and Line		
Set line			Other		

Species Caught

Species FAO Code	**Catch Unit (bag/buckets/pieces)**	**Number of Units**	**Total catch Weight (Kg)**	**Price per Catch unit**