UNIVERSITY OF CAPE COAST

ASSESSMENT OF THE IMPACT OF FISHING AND SOCIO-ECONOMIC DRIVERS ON CETACEAN EXPLOITATION IN GHANAIAN WATERS

BY

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DECEMBER 2022

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this University or elsewhere.

Candidate's Signature ………………………… Date…………

Name: ……………………………………………………………………..

Supervisor's Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature……………………… Date…………

Name: ……………………………………………………………………

Co-Supervisor's Signature ……………….…………… Date…………

Name: ……………………………………………………………………

ABSTRACT

The study aimed at assessing the fishing impact and socio-economic drivers of cetacean exploitation in four coastal communities (Axim, Shama, Dixcove, and Apam). Data was collected from April – October, 2022 using field data and questionnaires from fishers and fish processors. A total of 55 animals were recorded throughout the study. The highest catch landings were with the drift gillnet in August and September with the Purse seine net [Ali-Poli-Watsa (APW)] recording the least. The majority of cetaceans landed were at Dixcove with *Stenella attenuata* (pantropical spotted dolphin) being the most dominant. The values obtained for species diversity, evenness, and richness show that the species are diverse and almost evenly distributed off the coast of Ghana. When the stomachs of cetaceans were examined, cephalopods were the main prey items found followed by small pelagic fishes. Fishers utilized small-sized (up to 3 m) by-caught and targeted cetaceans as bait for the shark fishery while larger sizes (4 – 10 m) were sold to fish processors to be smoked or salted. Fishers showed a high dependence on fishing as their main source of livelihood thus, the decline in small pelagic fish stocks in synergy with high cost of fuel has increased the use of cetaceans as bait in the shark fishery to make profits due to the high price of shark fins. The majority of fishers admittedly had no idea of the laws protecting marine mammals nor marine mammal meat containing persistent organic pollutants. Also, there was an interrelation between sharks and cetaceans where proper management of the shark fishery will concomitantly reduce cetacean use as bait.

KEYWORDS

Bait

By-catch

Marine bush meat

Marine mammals

Sharks

Threats

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DEDICATION

To my family: Juliana, Daniel, Owusu, Alice, Solomon, and Asante

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CHAPTER ONE

INTRODUCTION

Globally, there is growing concern that many species of marine mammals are at an increased risk of extinction due to a number of threats including overfishing, climate change, coastal development, and invasive species with by-catch (directed harvesting and accidental), pollution (plastic and noise), boat strikes, and entanglement with the fishing gear being the major threats (Lusher et al., 2018; Mintzer et al., 2018; Ofori-Danson et al., 2019; Campbell et al., 2020; Honda & Suzuki, 2020; Nelms et al., 2021). Studies have been carried out on the identification, characterization and Catch per Unit Effort (CPUE) of cetaceans (dolphins, whales, and porpoises) landed as by-catch in selected coastal communities such as Axim, Apam and Dixcove, over the years (Debrah, 2000; Debrah et al., 2010; Van Waerebeek et al., 2014; Ofori-Danson et al., 2019). The studies provided important information on species diversity, CPUE, fishing gears utilized in their capture and fish species landed together with the marine mammals, however, attention has not been focused on determining how cetacean prey influences their capture and the socio-economic drivers that promote the exploitation of cetaceans as a source of food also referred to as "marine bush meat".

1.1 Background to the Study

Marine mammals are species that depend on the aquatic environment for their survival. They are dispersed throughout the world's coasts, oceans and riverine systems, although, some species are endemic to particular regions. Marine mammals are a polyphyletic group of three orders; Cetacea (dolphins, whale, and porpoise), Sirenia (manatees and dugongs), and

Carnivora (pinnipeds, otters, and polar bears) that have 130 living species (Berta et al., 2015). The order Cetacea is made up of two suborders namely the Odontocetes (toothed whales) and the mysticetes (baleen whales) which constitute 94 living species (Jefferson et al., 2015; Fordyce, 2018; Carwardine, 2020). Cetaceans (whales, dolphins, and porpoises) are one of the five groups of marine mammals with the others being pinnipeds (seals, sea lions, and walruses), sirenians (manatees and dugongs) and marine and sea otters and spolar bears (Jefferson et al., 2015). Marine mammals play a crucial role in structuring the marine ecosystem and ensuring that the system is healthy and productive, thus, they are referred to as "ecosystem engineers" (Roman et al., 2017). The bodies of large cetaceans serve as a stable repository for carbon and upon death their carcasses contribute to biodiversity and carbon sequestration on the ocean floor. They also help in nutrient recycling and bioturbation (Roman et al., 2017). The faecal plumes they release near the surface are rich in iron and nitrogen, therefore, making deep ocean nutrients readily available to surface-dwelling species (Roman et al., 2017; Nelms et al., 2021;Weelden et al., 2021).

Yet, these mammals are faced with several human-induced factors that negatively impact on their population abundance and biodiversity. Such threats include fisheries by-catch, climate change, and pollution (Nelms et al., 2021). Chemical pollutants released into the environment bio-accumulate and/or biomagnify from prey to predator through the food chain (Law & Deaville, 2019) affecting the reproduction and survival of cetaceans. Other pollutants such as plastics affect feeding, and digestion and may alter some physiological processes (Lusher et al., 2018). Climate change also poses a serious threat to cetaceans, although, the extent to which they are affected is not clearly understood; it might surpass those caused by habitat loss or overexploitation. It may lead to an increased incidence of stranding, reduction in critical habitats, exposure to pathogens, and causing a mismatch between marine mammals and prey abundance which can affect reproduction success and survival (Bryndum-Buchholz et al., 2019; Albouy et al., 2020; Pinsky et al., 2020). Historical exploitation of marine mammals has influenced their present-day abundance and caused some species to become extinct [e.g., Yangtze river dolphin (*Lipotes vexillifer*)] (Carwardine, 2020) and many others vulnerable or threatened.

The exploitation of marine mammals began during the whaling era (1700s – 1950s) where whalers targeted sperm, humpback whales, and other species opportunistically (Weir, 2013). In recent years, interaction between small cetaceans with fishing gears has either resulted in directed takes (deliberate killing of cetaceans to utilize the carcass for subsistence or commercial purposes) or as by-catch (including ghost fishing) and this has become a major source of global concern. Many cetaceans caught by the fishing gear serve as an alternative source of protein or income especially in many developing countries (Mintzer et al., 2018). Several studies have been conducted globally to investigate fisheries-related cetacean mortality, biology, evolution, feeding ecology, migration routes, and effects of pollution on cetacean reproduction success and survival (De Boer et al., 2016; Marçalo et al., 2018; Fordyce, 2018; Moan et al., 2020; Weelden et al., 2021; Kebke et al., 2022).

In Africa, several studies have been conducted on fisheries-related mortality, concentrations of persistent organic pollutants in cetaceans as well as occurrence and biodiversity of cetacean species (Segniagbeto & Van Waerebeek, 2010; Sohou et al., 2013; Sakyi et al., 2019; Mwango'mbe et al., 2021). In Ghana, studies on the identification and quantification of cetaceans caught along selected landing beaches have been conducted. Although, these studies provided information on the various species of cetaceans caught in Ghana, how prey preference and socio-economic drivers influence their capture were lacking (Van Waerebeek & Ofori-Danson, 1999; Van Waerebeek et al., 2009; Debrah et al., 2010; Van Waerebeek et al., 2014). Six species of marine mammals were thought to occur in Ghanaian waters (Van Waerebeek & Ofori-Danson, 1999) although, an updated checklist by Van Waerebeek et al. (2009) confirmed 12 additional species.

Following this information, recent studies conducted covered extensively several landing beaches along the coast of Ghana (Ghana Wildlife Society, 2020). Research work conducted over the years showed that cetaceans accidentally caught as by-catch were used as occasional source of food (Van Waerebeek & Ofori-Danson, 1999). However, this practice has now led to the deliberate capture of cetaceans as "marine bush meat" and as bait for the shark fishery (Van Waerebeek et al., 2014) which might be due to the high price of shark fins. With Ghana's historical decline in the small pelagic fish stocks which supports 92% of fishers (FAO, 2016) in the artisanal fisheries sector, fishers have increased the rate of cetacean exploitation (Debrah et al., 2010), and further exacerbating this situation is the weak fisheries laws and enforcement which fails to protect and conserve small cetaceans. Unfortunately, the fisheries commission of Ghana which is the state agency mandated to collect fisheries landed data does not collect data on cetacean landings, thus, leaving a paucity of information on real-time marine mammal strandings and by-catch incidences.

1.2 Statement of the Problem

The distribution of cetaceans in the Gulf of Guinea is poorly understood. Little is known about the feeding habits of most cetacean species off the coast of Ghana. Capture of cetaceans as "marine bush meat" is on the rise especially in the artisanal fisheries sector due to the decline in small pelagic fish stocks (*Engraulis encrasicolis, Scomber colias, Sardinella aurita* and *S. maderensis*) (Lazar et al., 2017; Lazar et al., 2018a; Lazar et al., 2018b; Lazar et al., 2020). As small pelagic fish stocks are projected to collapse, there is a high likelihood of increase in the rate of cetacean exploitation to offset catch deficit and cost of fishing operation. Currently, the Fisheries Commission does not collect data on cetacean landings thereby undermining the availability of data for any rational conservation/protection efforts.

Although baseline data exists, consistent data on cetacean catch landings over the years has been scarce with no plans for monitoring (Van Waerebeek & Ofori-Danson, 1999; Van Waerebeek et al., 2009; Debrah et al., 2010; Van Waerebeek et al., 2014; Ofori-Danson et al., 2019; Ghana Wildlife Society, 2020). Therefore, comprehensive data on cetacean by-catch landings, gears and mesh sizes used in their capture is crucial to help guide in the formulation and implementation of effective management and conservation strategies. To do this, information on how their population is being impacted on human activities is needed. Ghanaian coastal waters are very productive because of the guinea current which influences the major and minor upwelling seasons. This provides conducive habitats for cetaceans due to the availability of prey (Ghana Wildlife Society, 2020). It is, therefore, imperative to determine how the impact of the continuous decline of Ghana's fish stocks influence fishing and entanglement of cetaceans. Thus, detailed analyses of the composition of prey items consumed by marine mammals are crucial in understanding the link between prey preference and how it renders them susceptible to exploitation.

1.3 Purpose of the Study

This research investigates how cetacean species in Ghanaian coastal waters are impacted by fisheries and fisheries-related interactions especially by artisanal fishermen which make up 92% of fishers (FAO, 2016). The aim of this research was to assess the impact of fishing and fisheries related activities on cetacean populations, and drivers for cetacean exploitation along the coast of Ghana to inform strategies that improve marine mammal conservation.

1.4 Research Objectives

The specific objective of the study was to:

I. Identify, characterize and quantify small cetaceans landed at selected landing beaches of Ghana

II. Assess the impact of fishing and fisheries related interactions on small cetaceans caught in Ghana.

III. Assess the feeding habits of small cetaceans and how it contributes to their exploitation.

IV. Determine the socio-economic drivers of small cetacean exploitation in selected communities along the coast of Ghana.

1.5 Significance of the Study

Information on the biology and ecology of cetaceans is scarce especially in Ghanaian waters. Understanding the prey preferences is very crucial in the conservation of these mammals (Parrish et al., 2002). Ghana is a signatory to several international biodiversity conservation treaties/instruments including the international convention for the regulation of whaling (IWC) and Convention on Biological Diversity (CBD), Convention on the Conservation of Migratory Species of Wild Animals (CMS), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) among others (Mitchell & IEA database Project, 2002). Ghana also has a number of biodiversity/fisheries conservation laws focused on protecting marine mammals and other aquatic biodiversity to which this research significantly contributes to supporting (Fisheries Act 625, 2002; Fisheries Management Plan of Ghana, 2015). Information on their feeding will help to better understand which gear deployment leads to their capture (Marçalo et al., 2018) to help in the formulation and implementation of effective management and conservation policies to prevent some species from unnoticeably declining. Furthermore, information on the socio-economic drivers of cetacean capture will help provide the requisite knowledge on how to better conserve and protect them in accordance with Sustainable Development Goal 14 (Life below water).

1.6 Delimitation

This study focused on identifying species of marine mammals caught in the Central and Western region of Ghana (Axim, Dixcove, Shama and Apam). Investigations on their diet, gears used and socio-economic drivers influencing their capture were also studied. Results from the study might not be applicable to other sites or regions such as the Volta Region of Ghana because cetaceans are deemed to be deities and therefore not exploited or consumed in the region (Ghana Wildlife Soceity, 2020). This research also focused on peculiar variables pertinent to these communities in designing of questionnaires for interviews on socio-economic drivers influencing cetacean exploitation.

1.7 Limitations

Because marine mammals spend their lives at sea, researchers have little opportunity to study their diet directly and as such depend on indirect methods; using stomach contents from stranded or by-caught individuals to predict their diet (Beasley et al., 2019). Sometimes the percentage contribution of some items in the stomach like cephalopod beaks can be overestimated due to their long retention time in stomachs (Glaser et al., 2015). Additionally, because some fishers use cetaceans as bait for the shark fishery at sea or hide their landings, the actual numbers landed might be underrated.

1.8 Definition of Terms

Throughout this document, the author refers to several terms such as “cetaceans”, “by-catch” and “marine bush meat”. Cetaceans are the only marine mammals known to live their entire lives in or around waterbodies. They lack hair or fur but possess a thick layer of blubber for insulation. Cetaceans include whales, dolphins, and porpoises. By-catch is when animals that are not the primary target are captured during routine fishing operation. Marine bush meat refers to when marine wildlife is commercially exploited as a source of food. Given that the practise is illegal, it is prevalent especially in coastal developing countries.

1.9 Organization of the Study

The thesis is made up of six chapters: the first chapter is introduction, second – literature review, third – materials and methods, fourth – results, fifth – discussion and six – conclusions and recommendations. There is also a reference section and the appendices after chapter six.

Chapter 1: introduces the research work, giving a global and regional overview of the problem that the study seeks to address emphasizing on existing knowledge gaps, the purpose of the study, objectives and significance of the study.

Chapter 2: recaps the study focusing on the theoretical frameworks underpinning it.

Chapter 3: focuses on the research design, study area, population under study, sampling procedures, data collection and analysis.

Chapter 4: the results of the study are presented using descriptive and inferential statistics.

Chapter 5: the findings of the study are interpreted using published reference materials.

Chapter 6: an overview of the project is presented, including conclusions and recommendations derived from the research.

CHAPTER TWO

LITERATURE REVIEW

This chapter reviews literature from blogs and articles published in books and journals relevant to the research topic. The subjects covered include how cetaceans interact with fishing and the threats imposed on them. Characteristics of cetaceans, their importance and identification are discussed in details. Fishing activities, how they impact on marine mammal populations and socio-economic drivers influencing their capture as well as their feeding habits are discussed. International, national policy and legal frameworks relevant to cetacean conservation are also discussed.

2.1 Cetaceans

The order Cetacea (dolphins, whales and porpoise) is distributed from the tropics to the temperate zone and occur from freshwater to the oceanic ecosystems. Cetaceans appeared more than 50 million years ago (Ma). Their evolution is strongly informed by several ecological phenomenon including feeding, predator-prey relationships, habitat shifts and migration routes (Fordyce, 2018). Mysticeti and Odontoceti constitutes the two living clades of cetaceans which appeared and diversified rapidly in about 5 million years ago (Fordyce, 2018). Cetaceans are the most diverse clade of modern marine mammals in terms of species, ecology and range. Mysticetes are made up of four families consisting of 14 species with Balaenopteridae having eight species in two genera, thus, making it the most speciose (Fordyce, 2018). Odontocetes include ten families constituting 76 species with the family Delphinidae being the most diverse with 37 species (Carwardine, 2020).

Mysticetes are cetaceans with tightly packed comb-like structures hanging from their upper jaws called “baleen plates” (Appendix 1) which is used for filter-feeding of small fishes and crustaceans. They have a symmetrical skull with a double blow hole and feed in shallower waters than the Odontocetes. They do not have a melon for echolocation but have a well-developed vocalisation for communication. Most mysticetes are large with the females bigger than the males (Carwardine, 2020). Odontocetes on the other hand have teeth (Appendix 1) and feed on mostly fishes, large crustaceans, marine mammals and squids (Carwardine, 2020). Small cetaceans feed on cephalopods and low-mid trophic fishes while others consume upper trophic predators (Jefferson et al., 2015; Marçalo et al., 2018; Kiszka et al., 2022). They feed at greater depths, have melon for echolocation, an asymmetrical skull and a single crescent-shaped blowhole. Most Odontocetes are small (Up to 3 m) to medium (4 – 10 m) in size [except the sperm whale (*Physeter microcephalus*)] with variable sexual dimorphism (Carwardine, 2020). Eighteen (18) species of marine mammals (17 toothed and 1 baleen whale) are thought to occur in Ghanaian waters including: *Stenella longirostris*, *S. attenuata*, *Orcinus orca*, *S. clymene*, *Tursiops truncatus*, *Kogia sima*, *Feresa attenuata*, *Delphinus capensis capensis*, *Ziphius cavirostris*, *S. frontalis*, *Grampus griseus*, *Lagenodelphis hosei*, *Steno bredanensis*, *Peponocephala electra*, *Globicephala macrorhynchus*, *Pseudorca crassidens*, *Physeter microcephalus and Megaptera novaeangliae* (Van Waerebeek et al., 2009).

Ecological Importance of Marine Mammals

Cetaceans as top and mesopredators play important role in food webs and influence community structure and dynamics (Kiszka et al., 2022). They can cause changes or modify the physical structure of their habitats (e.g., bioturbation) thus giving them the name "ecosystem engineers" (Roman et al., 2017). Bioturbation helps modify water-sediment interface by increasing benthos microbial activities and promoting sediment enrichment through feeding and biodeposition (Kiszka et al., 2022). Marine mammals also help contribute to water mixing especially in well stratified waters through diving activities and promote nutrient cycling and release of faecal plumes near water surfaces which are rich in iron and nitrogen, therefore, making deep ocean nutrients readily available to surface-dwelling species (Roman et al., 2017; Nelms et al., 2021;Weelden et al., 2021; Kiszka et al., 2022). Larger cetaceans serve as a sink for carbon and upon death their carcasses contribute to biodiversity and carbon sequestration on the ocean floor (Roman et al., 2017).

Economic Importance of Marine Mammals

The use of marine mammals for ecotourism has been reported worldwide (O'Connor et al., 2009; Bearzi, 2018; Valdez, 2018). Whale-watching is a very lucrative and fast-growing industry worldwide (average growth rate of 3.7% per year) with a business value of $2.1 billion in 2008; revenue production higher than fisheries and aquaculture combined with the potential to boost local economies and improve the overall growth of several developing countries (O'Connor et al., 2009; Bearzi, 2018; Valdez, 2018). Over the years, there has been a massive increment in the number of whale-watchers worldwide; 31 countries with 4 million people in 1991 to 119 countries with 13 million people in 2008 (Valdez, 2018). In 2008, whale-watching directly employed about 13,200 people, created employment, improved livelihoods and generated income for several people globally

(O'Connor et al., 2009). Some African countries such as The Gambia, Egypt, Namibia, Mozambique, South Africa, Madagascar, Benin, The Gabon, and Mauritius who were engaged in ecotourism earned a direct income of $6,720,353 from whale-watching alone in 2008 (O'Connor et al., 2009). Ghana has the potential to become one of the highest revenue generating ecotourism countries in Africa because of the diversity of marine mammal species found in our waters. The establishment of a whale watching industry will directly create employment and generate revenue for local communities as well as indirectly boost the income of the hospitality industries and livelihoods of people in the country at large.

Cetacean Identification Using Photographs

Cetacean photo-identification is a non-invasive technique used in mark–recapture studies to investigate the social structure, site fidelity, and estimate population (Gibson et al., 2020). It also helps to determine species at risk; where they are most vulnerable and trajectories of their communities and populations for effective conservation and management (Blount et al., 2022). Cetacean identification using photographs help to provide relevant data on the distribution, demographics, and abundance of wide-ranging species. The study of many cetacean species has been made possible by the use of large catalogues of photo identified individuals (Jefferson et al., 2015; Carwardine, 2020; Blount et al., 2022). Photo identification helps to easily identify marine mammals when landed or in their natural environment by observing their behaviour, dorsal fin, specific colour patterns, and dive sequence (Carwardine, 2020) and this is very important especially in developing countries where research on marine mammals is non-existent or sparse.

Threats Faced by Cetaceans

Globally, marine mammals are faced with several threats including pollution, overexploitation, fisheries by-catch and recently, climate change causing at least 25% of the population to be threatened (Vulnerable, Endangered or Critically Endangered) (Kannan et al., 2005; Elliott et al., 2009; Ofori-Danson et al., 2019; Nelms et al., 2021). Climate change impact on cetacean populations immensely and may cause a rise in stranding incidences, exposure to pathogens, reduction in critical habitats, and influence prey abundance which can negatively affect their survival (Bryndum-Buchholz et al., 2019; Albouy et al., 2020; Pinsky et al., 2020). Interaction of cetaceans with fisheries has become one of the biggest threats to conservation. Human interactions continue to affect cetaceans worldwide with overexploitation and entanglement with fishing gear being the major threats (Nelms et al., 2021). Entanglement of cetaceans in fishing gear occurs in most fishing nations. Larger whales might be able to drag the fishing gears and escape whereas smaller cetaceans might be caught. The time frame from entanglement to death may last from several months in larger cetaceans to a few minutes in smaller Odontocetes who easily suffocate or drown when entangled (Dolman & Brakes, 2018). Entanglement with fishing gear may lead to high prevalence of injuries, stress and lethal trauma (Dolman & Brakes, 2018) and possible stranding of marine mammals (Campbell et al., 2020). The impact of fishing on by-caught individuals and their larger social groups are often largely underestimated and the only way to reduce this, is to decrease or eliminate the number of individuals caught in the fishing gears (Dolman & Brakes, 2018).

The demand for fish and fish products is on the rise due to population growth. According to FAO (2020) the global fish consumption has been twice as high as population growth with an estimated per capita protein consumption of 20.5kg. About 59.51 million people are engaged in the primary sector of fisheries and aquaculture and support the livelihoods of more than 10% of the global population (FAO, 2020). Small-scale fisheries play an integral part in the economic growth of several developing countries. It contributes about half of global fish catches and employs more than 90% people with 97% estimated to be living in developing countries (FAO, 2020) with prevalence in Africa, Indo-Pacific and developing regions of South and Central America (Temple et al., 2018). Small-scale fisheries play a vital role in food security and income generation especially in developing countries (Temple et al., 2018; FAO, 2020) nevertheless, because such fisheries are mostly unregulated, it could lead to overexploitation, affect the abundance, distribution, and species diversity of several marine megafauna causing them to become vulnerable (Temple et al., 2018). It may also lead to the decline of these crucial species and distortion of the broader food web which might affect species critical to peoples livelihood (Temple et al., 2018). The gillnet fishery constitutes the largest component of the small-scale fishery of many countries (Temple et al., 2018; Bielli et al., 2020) and often have high by-catch landings of threatened species such as sea turtles, seabird, small cetaceans and sharks (Lowry et al., 2018; Temple et al., 2019; Campbell et al., 2020; O'Keefe et al., 2021). About 71.1% of sharks and rays and 51 – 56% of turtles globally are threatened with extinction (Pacoureau et al., 2021; Rhodin et al., 2021). Entanglement in the fishing gears (gillnets, purse seines, driftnets, trawls and hook and line) poses a major threat to marine mammals (Carwardine, 2020). The gillnet and longline fishery accounts for majority of marine mammal catch (Mintzer et al., 2018; Temple et al., 2018; Temple et al., 2019) because using such fishing gears is inexpensive, very effective and widespread among fishers**.** The diversity of catch for small-scale fisheries (subsistence or artisanal) has the potential to influence several ecosystems (Temple et al., 2019). Data on cetacean catch landing in several countries is lacking and little is known about the extent of interaction between small-scale fisheries and marine mammals especially in developing countries (Temple et al., 2018; FAO, 2020).

2.2 Interaction of Cetaceans with Fisheries

Fish is an important source of protein and accounts for 17% of animal protein consumed globally and 50 – 90% in coastal populations (FAO, 2018a). Fish provides a cheap and nutritious source of protein especially for communities dependent on small-scale and artisanal fisheries (FAO, 2018a). In sub-Saharan Africa fish provides 22% of the total protein intake, however, in West Africa, this number is exceeded because of the historical dependence on fish as a central part of their diet (Béné & Heck, 2005). In Ghana, fish consumed contributes a protein percentage of about 60, making it one of the most important and cheapest sources of animal protein when compared to others like chicken or pork (Odei, 2015). The per capita consumption of protein in Ghana as of 2016 was 25 kg (FAO, 2016) which is higher than that of the worlds (20.5 kg) (FAO, 2020). Fisheries play an important role in food security, poverty alleviation, and support the livelihoods of several Ghanaians. The artisanal fisheries sector plays a crucial role in the socio-economic development of the country (Afoakwah et al., 2018) and contributes over 70%

of the total marine fish production (FAO, 2016). The marine sector employs about 135,000 fishers of which 124,000 (92%) are artisanal fishers (FAO, 2016). Small-scale fisheries support other livelihoods including fish processors, middlemen, boat builders and repairers among others. About 2.5 million fish workers and artisanal fishers in Ghana are dependent on fisheries for their livelihoods (Amadu et al., 2021).

However, due to the historical decline in small pelagic fish stocks (Akpalu et al., 2018) and increase in the number of fishers; the fishing business has not been as profitable as some years prior. In a bid to meet the increase in demand for fish and generate profit, fishers have adopted illegal fishing practices such as using illegal mesh sizes, illegal unregulated and unreported (IUU) fishing, light fishing, use of explosives and chemicals (Afoakwah et al., 2018). IUU fishing exacerbate poverty and threaten the livelihoods of many people living in developing countries (FAO, 2020). This practice in synergy with overcapacity has further contributed to the rapid decline of the dwindling small pelagic fish stocks which is also known as "the backbone of the artisanal fisheries sector" thus, causing many small-scale fishers to be faced with high levels of poverty. According to Daulay et al. (2019) poverty coupled with lack of livelihood alternatives seems to be the major contributing factor driving the decline of the fishery resources; many fishers survive under US $10 per capita each month. The decline of the small-pelagic fishery resource might be a major contributing factor to the exploitation of occasionally by-caught cetaceans as food. However, this practice has now led to the deliberate capture of cetaceans as bush meat and bait for the shark fishery (Debrah, 2000; Debrah et al., 2010; Ofori-Danson et al., 2019) further exacerbating this practice is the weak laws and enforcement.

Utilization of Cetaceans as Bait

Data on cetacean landing (by-catch or targeted) in several African countries (e.g., Morocco, Mauritania, Guinea-Bissau, Liberia, and Sierra Leone) is scarce or scanty (Segniagbeto et al., 2019) except for Ghana where data is available although, not consistent. Marine mammals present in many African countries (e.g. Senegal, Ghana, Côte d'Ivoire, and Togo) to a certain extent are protected by law because most of these countries are signatories to many international treaties including the IWC that seek to conserve and protect cetaceans, however, in many of these countries there are no or few provisions made concerning cetaceans that are found dead, moribund, stranded or salvaged (Segniagbeto et al., 2019) and even when provisions exist, public awareness, monitoring and enforcement are non-existent or non-operational. Fishers utilize by-caught, targeted, or stranded cetaceans as bait for sharks or cephalopods or consumed locally or for medicinal purposes (Segniagbeto et al., 2019). The practice of using cetaceans as bait in the shark fishery has also been reported in Latin American countries such as Ecuador (Castro et al., 2020), Peru (Campbell et al., 2020), Brazil (Barbosa-Filho et al., 2018), Mexico and Venezuela (Mintzer et al., 2018); indo-pacific countries including Philippines and Taiwan (Mintzer et al., 2018) and other African countries including Nigeria, Sernegal and Ghana (Segniagbeto et al., 2019). The use of small cetaceans as bait in the crab and catfish fishery has also been reported in Tierra del Fuego and Peru; although the practice has proven unsustainable and a threat to many marine mammals (Mintzer et al., 2018). Longlines fishers preferred cetacean meat and blubber because it's durable on the longline, does not disintegrate easily and attracts sharks faster because of its strong odour, blubber, and abundant blood (Barbosa-Filho et al., 2018; Mintzer et al., 2018; Segniagbeto et al., 2019; Campbell et al., 2020) low price and availability (Campbell et al., 2020).

The increase in demand for shark fins from oriental countries due to foreign exchange also plays a major role in cetacean exploitation (Mintzer et al., 2018) thus, influencing fishers to develop methods and gears for their capture (Ofori-Danson et al., 2019; Segniagbeto et al., 2019; Campbell et al., 2020) such as the locally made hand-harpoon for hunting cetaceans in Ghana (Debrah, 2000). The use of fat from incidental or targeted cetaceans (by harpooning) as bait for certain freshwater fishes and sharks in Brazil has also been reported by Barbosa-Filho et al. (2018). The practice of using cetaceans as bait to target fish species has received little attention (Mintzer et al., 2018) as compared with the incidental capture of cetaceans in fishing gear which is deemed a major cause of mortality globally (Castro & Van Waerebeek, 2019). The practice of using cetaceans as bait is poorly understood and more information is needed to develop effective conservation strategies (Mintzer et al., 2018). The development of such strategies will reduce the number of cetaceans caught in the fishing gear.

2.3 Utilization of Cetaceans as "Marine Bush Meat"

The market for dolphin meat has been reported in the Indo-pacific regions (e.g. Indonesia) (Mintzer et al., 2018) and several African countries (e.g. Côte d'Ivoire and Gambia) (Segniagbeto et al., 2019). In Ghana, marine mammals have historically been exploited as a source of food "marine bush meat" (Van Waerebeek & Ofori-Danson, 1999; Debrah, 2000; Debrah et al., 2010; Ofori-Danson et al., 2019; Ghana Wildlife Soceity, 2020). The exploitation of cetaceans was first documented in the 1900s (Van Waerebeek & Ofori-Danson, 1999) when by-caught cetaceans were occasionally exploited as food. This practice has currently led to the direct harvesting of cetaceans as food; the rate processed small-cetaceans either as smoked or salted is becoming rampant in several coastal and inland markets.

2.4 Socio-Economic Drivers of Cetacean Exploitation

According to Mintzer et al. (2018) socio-economic conditions are major contributors to the utilization of cheap and effective bait sources to enhance the harvest of marine resources especially in the artisanal fisheries sector. Many studies have shown the inextricable relationship between poverty and the exploitation of small cetaceans especially in developing countries. Some research studies conducted in Peru and Brazil, focused on the use of cetaceans as food and as a bait source at the micro-level (Barbosa-Filho et al., 2018; Campbell et al., 2020), as does this study. However, improving fisheries data will inform management strategies and sustainability of marine mammals and fish species that support the livelihoods of communities dependent on them (FAO, 2020). A designed representation of the conceptualized structure for the socio-economic drivers of cetacean capture in the Central and Western region expressed in Figure 1 enables the examination of why fishermen and fish processors exploit by-caught and targeted marine mammals in Ghana. From the perspective of fishermen, low fish catches coupled with the high cost of fishing expenditure and demand for shark fins are the main factors driving cetacean exploitation. For fish processors, income generated the from the sale of cetacean carcasses as well as market availability drives the cetacean exploitation.

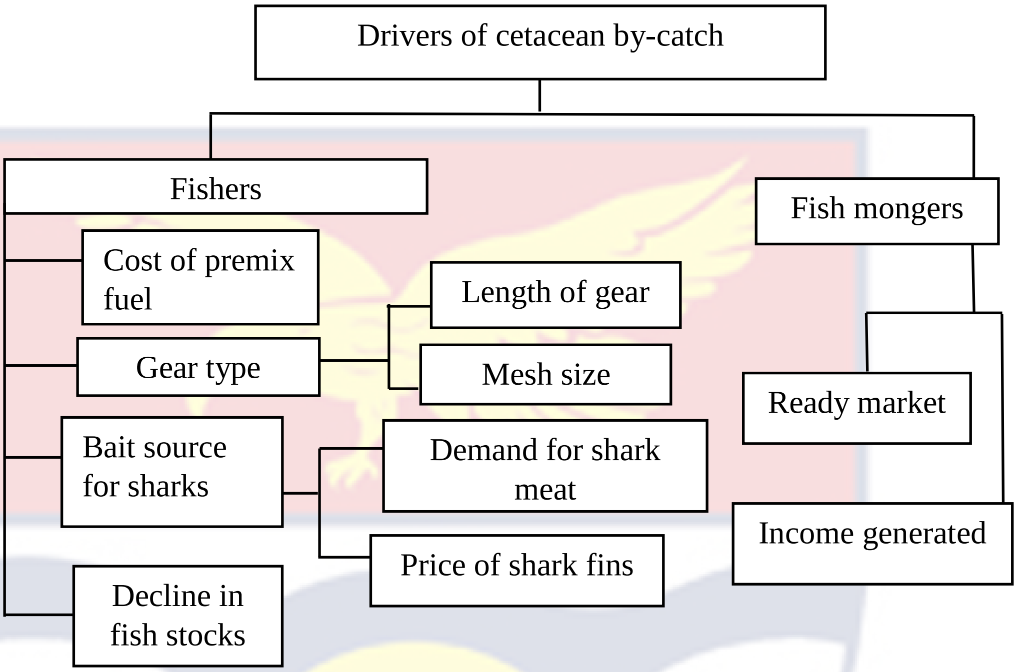

Figure 1: Conceptual framework for socio-economic drivers of cetacean capture in Ghana

2.5 Cetacean Feeding Ecology

Marine mammals depend on the aquatic environment for their survival (Jefferson et al., 2015). They feed on several prey ranging from copepods, krill and other small invertebrates to crustaceans, cephalopods, fishes, and other cetaceans. Because marine mammals spend their lives at sea, researchers have little opportunity to study their diet directly and as such depend on indirect methods; using stomach contents from stranded or by-caught individuals to predict their diet (Beasley et al., 2019). Fish otoliths and cephalopod beaks are the major food items of relative importance found in the stomach of cetaceans. Cephalopods have a major ecological and economic relevance in marine ecosystems around the world, being both predator and prey in food webs (Xavier & Cherel, 2021). They thrive in a wide range of habitats and are crucial in the diet of several predators in the marine food chain. Cephalopods have a beak (chitinous mandibles) that grow throughout the life of the individual without replacement and are widely used in cephalopod studies (Clarke & Kristensen, 1980; Xavier et al., 2011; Xavier & Cherel, 2021). The beaks of cephalopods are characterized by a high resistance to erosion during the digestive process, thus, accumulate in the stomach of a predator and because the beaks of cephalopod are among the few hard structures found in their bodies, they are taxonomically very important.

Studies on cephalopod beaks have led to the development of a specific classification method that permits the identification of cephalopods from their beaks (Wolff, 1984; Xavier & Cherel, 2021). Thus, assessment of cephalopod beaks in guts helps to understand the feeding ecology of predators. Also, to better understand the predator-prey relationship between top predators and cephalopods, several research works have been conducted since the1950s to determine the size of cephalopods worldwide by using their beaks (Xavier & Cherel, 2021). Cephalopods are mainly identified using their chitinized upper and lower beaks which are assumed to be the same in the diet of a predator, however, studies have been more focused on the development of identification keys for the lower beaks which is easily identifiable morphologically because of their more obvious variation between species (Xavier & Cherel, 2021). The ratio of upper to lower beak vary greatly in the diet of predators including whales, seals and fishes, therefore, using only the lower beaks can underestimate the importance of cephalopods in the diet of the predator (Xavier & Cherel, 2021). Cephalopods are found in the diets of many species including sea birds, sharks, whales, seals and other fishes (Wilson &

Hammond, 2019; Xavier & Cherel, 2021). Sometimes the percentage contribution of some items in the stomach like cephalopod beaks can be overestimated due to their long retention time in the stomachs of marine mammals (Glaser et al., 2015).

Most marine mammals from the order Odontocetes are piscivorous and consume large numbers of fish species. Fish otoliths are among the most important structures found in fishes that help in identification especially when observed in the diet of a predator, nevertheless, because otoliths are easily corroded by the digestive enzymes fish identification and estimation of fish weight from otolith size becomes challenging and often leads to underestimation (Byrd et al., 2020). This subsequently affects the estimation of the overall energy contribution of prey species in predator diet (Byrd et al., 2020). The determination of prey in stomachs is very important because it enables researchers to understand how prey preference and target species of fishermen make cetaceans vulnerable to the fishing gear as does this study.

2.6 Cetacean Protection and Conservation

Marine mammals, sharks and turtles although, protected by legislation due to their depleting numbers are still being exploited at alarming rates due to weak law enforcement. About 71.1% of sharks and rays and 51 – 56% of turtles globally are threatened with extinction (Pacoureau et al., 2021; Rhodin et al., 2021), albeit, international treaties such as the IWC, UN CBD, and CITES aimed at their protection and conservation (Mitchell & IEA database Project, 2002). Ghana is a signatory to such conventions and has laws to this effect. The Fisheries Act 625 (2002) clearly states that marine mammals when found in fishing gear are to be released with the least possible harm.

Additionally, the yet-to-be-gazetted fisheries management plan of Ghana (2022) includes provisions aimed at mitigating by-catch of threatened species through improvement in data collection by artisanal fishing vessels especially in drift gillnet (DGN) fishery, gear modification to avoid or reduce by-catch and creating public awareness through education. It is very important that data collection has been added to the Fisheries plan because official national catch records for cetacean data in Ghana are non-existent, thus, the extent of cetacean exploitation is often limited to few landing beaches and even when data exists monitoring is not consistent.

A current by-catch report generated by Ghana Wildlife Soceity (2020) along ten landing beaches gave insights to the extent of marine mammal exploitation in Ghana. Currently, Dixcove is the only community that has been a little consistent in its marine mammal landings over the years (Debrah, 2000; Van Waerebeek & Debrah, 2009; Debrah et al., 2010; Van Waerebeek et al., 2014; Ofori-Danson et al., 2019). Because data collection of marine mammals is limited to only a few communities the extent of exploitation may be underrated. Additionally, because coastal communities especially in developing countries are dependent on fisheries for their protein and income, creating alternative livelihood opportunities for fishers and fish processors will improve income, reduce overdependence on fishing, and alleviate poverty (FAO, 2020). Introducing public education, awareness (Mintzer et al., 2018; Ghana Wildlife Soceity, 2020) and incentives in fishing communities can lead to behavioural change among fishers (Mwango'mbe et al., 2021).

Also, introducing community-based management programmes and ecotourism (dolphin watching activities) will enhance community engagement, provide an alternative source of livelihood for fishers and arouse their interest in engaging in practices that promotes conservation of marine wildlife and their environment rather than hunting them (Hoyt, 2021). Implementing by-catch reduction technologies such as pingers or LED lights can reduce the availability of small cetaceans and its use as bait (Bielli et al., 2020). Also, implementation of stringent laws protecting cetaceans and a ban on shark fishing, trade and exportation of shark products can lead to a decline in the utilization of cetaceans as bait (Ward-Paige, 2017). The establishment of a network comprising of governmental, non-governmental organisations, institutions, researchers and stakeholders in the artisanal fisheries sector will also help improve data collection and protection efforts.

CHAPTER THREE

MATERIALS AND METHODS

This study assessed the impact of fishing and socio-economic drivers of cetacean capture in Ghana using cetacean landing data collected on the field and structured questionnaires. This chapter describes the research design, study area, population, sampling procedure, data collection instrument, data collection procedure, data processing, analysis, and chapter summary. This chapter further explains the research methods used for the analysis, the different research paradigms and research approaches.

3.1 Research Design

Research designs are specific methods for gathering data, analysing and interpreting results based on the research approach adopted (Dawson, 2019). This study was conducted using the positivists research paradigm. Positivism focuses on operationalizing variables and measures to verify experimentation and priori hypotheses by hypothesis testing to inform and advance science. Positivism is a philosophy based on the assumptions that only a single reality exists; one which can be identified, measured and understood. It adheres to the view that only knowledge obtained through observation including measurement is trustworthy. As a result, a researcher's role in positivism studies is limited to data collection and interpretation in an objective way. Quantitative research approach relies on objectivity of the research finding and seeks to determine relationship among variables being tested by the investigator and this stems from the positivism paradigm (Creswell, 2014).

The choice for using quantitative method for this study was because of its ability to address the research problem and objectives. The socio-economic drivers of cetacean exploitation in selected coastal communities could be better assessed using quantitative approach. This was because data collected needed to be statistically analysed and the outcome generalized and this could be achieved by using quantitative approach. For the research design, field reconnaissance and structured questionnaires were conducted using cross-sectional survey design. Cross-sectional survey design is a quantitative method for data collection where data is collected representing the cross section of a population of interest to the researcher to better understand the situation of that population (Creswell & Creswell, 2017). The survey instrument helps to quantify the beliefs, ideas and personal opinions of respondents in order to observe patterns in respondents using verbal and written prompts (Baŝkarada & Koronios, 2018). Using cross-sectional survey design is fast and inexpensive and can help to assess multiple outcomes, it is however, susceptible to biases (Rezigalla, 2020). Cross-sectional survey design was used for this study because it helped to obtain information from a large population thus making the sample very representative (Creswell & Creswell, 2017) also, it gave an in-depth description of the situation in their existing environment or location. As a result, the researcher employed the cross-sectional survey design because she wanted data on cetacean by-catch landing and the opinions of fishermen and fish mongers in the Western and Central regions on the socio-economic drivers of cetacean exploitation.

3.2 Study Area

This study was conducted in Shama, Dixcove, Axim and Apam, respectively (Figure 2) because these areas have the highest cetacean landing (Ghana Wildlife Society, 2020).

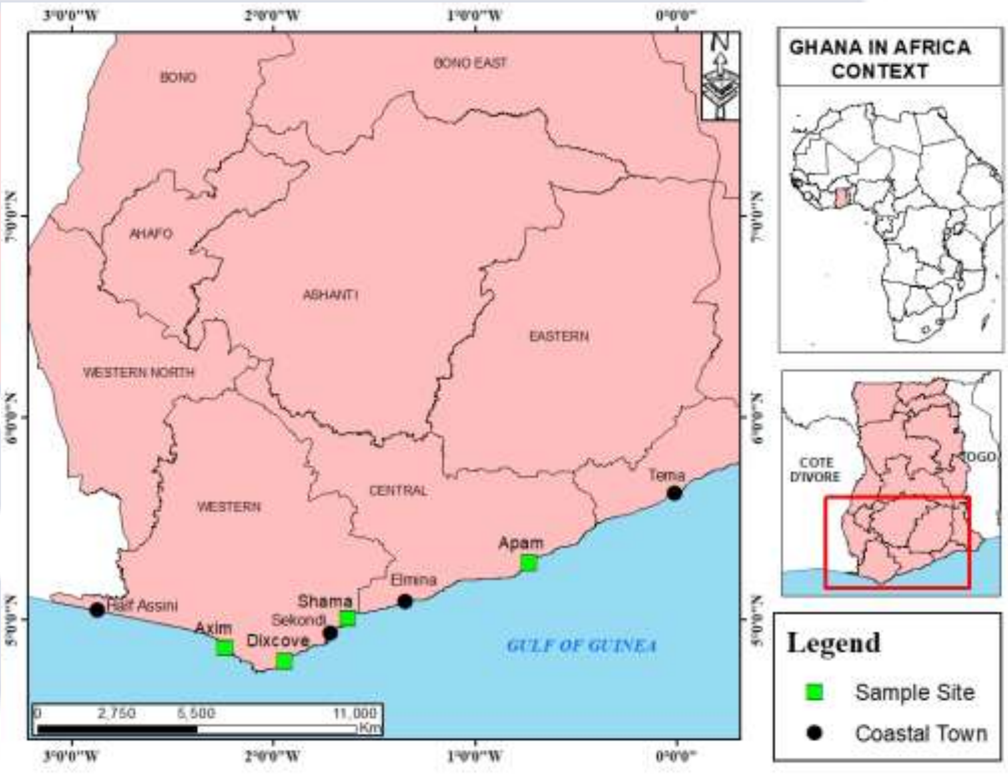

Figure 2: Map of the Western and Central Coast of Ghana showing the Study areas.

Shama is a town located in the Shama district It is characterised by a mixture of hilly and flat landscapes with an estimated shoreline of 27.4 metres. The shore line spans from Shama Apo (which bothers River Pra) through Amena-Ano to Shama Bentsir. Shama Apo is the largest community among the three and is located at the east of Shama Bentsir. The shoreline of Apo is characterized by stone sea walls and gabions (Coastal Resources Center / Friends of the Nation, 2010). Shama was inhabited by 10,062 people as of 2007 with the dominant ethnic group being Fante. Majority of people inhabiting this area are involved in fishing and fish processing. About 2,332 fishers live in this community of which 432 use canoes with drift gillnet being the commonest fishing gear (Coastal Resources Center / Friends of the Nation, 2010; Dovlo et al., 2016).

Dixcove is a commercial town located in the Ahanta West District. It shares boundaries with Busua to the East, Achowa to the west and Sunkoe to the north. The landscape is rocky even on the beaches (Coastal Resources Center / Friends of the Nation, 2010). Dixcove has a population of about 30,000 with the majority being fish mongers and fishermen; about 1,081 fishermen using 233 canoes and drift gillnet as the main fishing gear lives in this community. The dominant ethnic group in this area is Fante (Coastal Resources Center / Friends of the Nation, 2010; Dovlo et al., 2016).

Axim is a coastal town located in the Nzema East District in the Western region of Ghana. It comprises of three communities (Apewosika, Upper Axim and Lower Axim). Apewosika is predominantly a Fante community with few Nzemas. It shares boundaries to the west with Anto-Apewosika, east with Domunli and north with Dr. Beamish. The northern part of the community is relatively hilly with its coastal areas being relatively low. Upper Axim is a large coastal town located in the Nzema East District. It shares boundaries to the east with Lower Axim and Amanfukuma to the west. The topography is a mixture of rocks and sand. Lower Axim is a town that shares boundaries to the north with Boka-kokole, east with Fante-line and west with upper Axim (Sowlo) (Coastal Resources Center / Friends of the Nation, 2010). Axim has a population of about 25,446 people with the men being mostly fishermen and the women involved in fish processing. Axim is made up of 3 main ethnic groups; Nzema, Ga and Simpa (From Winneba in the Central Region). Axim has about 552 canoes and 5,219 fishermen who usually use set net as fishing gear (Dovlo et al., 2016).

Apam is a coastal town and capital of Gomoa West District in the Central Region of Ghana, located approximately 45 km east of the Central regional capital of Cape Coast (Akutse & Samey, 2015). Apam is a community with a population of about 26,466 and a growth rate of 2.5%. Apam has a lot of fishermen (1,437) with the women involved in fish processing since the main occupation in this community is fishing (Akutse & Samey, 2015). About 193 canoes using mostly set nets are operational in this community (Dovlo et al., 2016). Fishing on Tuesday is considered as a taboo in all three communities (Coastal Resources Center / Friends of the Nation, 2010).

Ethical Consideration

The protocols used in this research were reviewed and approved by the University of Cape Coast Institutional review board (UCCIRB). The clearance reference number is (UCCIRB/CANS/2022/21).

3.3 Cetacean Morphometric and Fisheries Interaction

Data on cetacean by-catch landings were collected during a seven-month period (April – October, 2022) by trained field assistants. Photographs of landed specimens were taken, and published manuals were used to identify the animals at the species level (Jefferson et al., 2015; Carwardine, 2020). The length (m) (measured from the tip of the upper jaw to the notch of the fluke) and sex (females have mammary slits while males do not) were determined as well as gears and mesh sizes used in their capture (the mesh sizes used, type and length of gears were obtained from fishermen during cetacean landings and recorded). The number of males and females was determined and expressed as percentages. Cetaceans identified were grouped into three (3) main categories; (1) by-catch (based on marks caused by netting and/or presence of net on the anterior of the fins and flippers or from amputation of the tail (Kuiken, 1994), (2) stranding (beached at shore) and (3) targeted (presence of visible wounds caused by harpoons and other cutting tools). The various fish species and other organisms landed together with the cetaceans at the landing sites were collected to determine the relationship between prey preference and fishes landed.

Diversity of cetaceans was estimated using the Shannon Weiner Index where (H) given as: *(H)* = $\sum pi$ (In pi); *pi* is the proportion of each species. The species evenness was estimated using the Pielou's evenness index (J′) given that: (J′) = $\frac{H'}{(\text{In } s)}$, where *H′* is the number derived from the Shannon Weiner Index and *s* is the number of species in a sample. Margalef's Index (*D*) was used to estimate the species richness where *D* = $\frac{(S-1)}{\text{In (N)}}$; *S* is the number of species in a sample and *N* is the total number of individuals in the sample (Margalef, 1958; Hill, 1973). The percentage composition of each species was also estimated. The Catch Per Unit Effort (CPUE) was estimated as number of cetaceans caught per active fishing canoes (Temple et al., 2019; Ghana Wildlife Soceity, 2020) monthly for each site.

3.4 Cetacean Stomach Content Analysis

In the field, whole stomachs of identified cetaceans were removed, and the content collected and stored in polyethylene bags frozen at -20 °C for transport to the laboratory. Stomach contents were examined in the Fisheries and Coastal Research Laboratory at the Department of Fisheries and Aquatic Sciences at the University of Cape Coast. Frozen stomachs were thawed at the laboratory, opened with a scalpel blade and washed through a 0.5 mm mesh sieve. Stomachs were analysed for fish, crustaceans and beaks using published materials (Tuset et al., 2008; Lin et al., 2020; Aggrey-Fynn, 2020; Xavier & Cherel, 2021). The number of food items present in each stomach was estimated using the numerical method by Hyslop (1980). Prey items that were whole were measured and stored in 5% formalin. Cephalopod beaks recovered from the stomach were stored in 70% ethanol while otoliths were stored dry. Each otolith was equated to half a fish thus; the number of fish species were determined by half the number of otoliths while the highest number of upper or lower beaks were used to estimate the number of cephalopods. Only undamaged otoliths were used to avoid errors due to reduction in size or erosion caused by gastric juices (Silva, 1999).

3.5 Sampling Procedure for Socio-Economic Drivers

Sample size for fishermen was estimated from data provided by Dovlo et al. (2016) and administered using simple random sampling to ensure that every fisherman has an equal chance of being selected. Close-ended and open-ended questionnaires were used for both fishermen and fish processors. Linear snowballing sampling technique was used for fish processors because their actual numbers were unknown.

Snowballing was used to recruit new participants into the study who share similar characteristics which are relevant to the study. The questionnaire was administered to better understand how socio-economic drivers contributes to cetacean exploitation at the study sites. Fishermen and fish processors from the four study sites were interviewed from 5th to 30th August, 2022. Before commencement of data collection field assistants were trained for a day to ensure that they understood the questions and were able to interpret it effectively in the local dialect of the survey participants. The survey lasted for about 30 minutes or a little longer and participation was voluntary. Participants were assured of their confidentiality and anonymity. Although most fishermen were curious about the survey, some were agitated because of an insufficient supply of premix fuel and fatigue from several surveys in which they had previously participated. The sample size for fishers was computed from Cochran's (1977) formula at a confidence level (CI) of 95% as shown in Equation 1. This implies that the results obtained will reflect 95% of the true situation of the population.

The sample size formula for a finite population

$$SS = \frac{Z^2 * (P) * (1 - P)}{C^2} \qquad \text{Equation 1}$$

SS = Required Sample size

Z= z value corresponding with CI (e.g., 1.96 for 95% CI)

P= Expected prevalence expressed as a decimal (0.5 used for sample size)

C= Confidence Interval (Margin of error or precision) expressed as a decimal (e.g., 0.05= ± 5).

Calculation:

$$SS = \frac{Z^2 * (P) * (1-P)}{C^2} = \frac{(1.96)^2 * (0.5) * (1-0.5)}{(0.05)^2} = 384.16 \sim 384$$

Number of fishermen for Dixcove = 1,081, Shama = 2,332, Axim = 5,219 and Apam = 1,437

When the population size of each community is taken into account, proportions are shown as:

1,081+2,332+ 5,219 +1,437 = 10,069.

For Dixcove: $\frac{1081}{10,069} \times 384 = 41.22$~41 and this represent 10.7%

For Shama: $\frac{2332}{10,069} \times 384 = 88.94$~89 and this represent 23.2%

For Axim: $\frac{5219}{10,069} \times 384 = 199.04$~199 and this represent 51.8%

For Apam: $\frac{1437}{10,069} \times 384 = 54.80$~55 and this represent 14.3%

Data collection instrument

The survey instrument used for fishermen comprised of questions on the different thematic areas including, information on drivers of cetacean exploitation and knowledge of cetacean protection and persistent organic pollutant in cetacean meat, while that of the fish processors constituted questions on financial information on cetacean (Appendix 2). Using structured questionnaire makes answering questions easier, quicker and very timely, however, some information might be lacking because it does not give respondents the choice to give a detailed response of their opinion. The questionnaires used in the four coastal communities were not pre-tested before administration.

3.6 Data Processing and Analysis

Excel and Minitab statistical software were used for the data analysis. Cetacean data collected were tested for normality using the Kolmogórov–Smirnov test. The length of each cetacean species caught within the four study areas was compared using a one-way analysis of variance (ANOVA). The percentage composition, lengths, and catch trends of each species were calculated and expressed as graphs and tables. The fishing gears deployed in the capture of marine mammals and CPUE were calculated and expressed as graphs.

The stomach content of each prey item was examined to the lowest taxon and then expressed as graphs. The food items found in the stomachs were compared with the catch landings of the DGN to determine whether the prey preference of marine mammals makes them vulnerable to fishing gear.

Socio-Economic Drivers

In the identification of socio-economic drivers influencing marine mammal exploitation, structured interviews were coded into the KoBo collect toolbox and data was analysed using descriptive statistics. The results obtained were expressed as tables and graphs.

CHAPTER FOUR

RESULTS

This chapter shows the finding of the study by presenting the outputs of the data analysis in figures and tables in accordance with the research objectives.

4.1 Identification, Characterization and Quantification of Cetaceans Landed at Axim, Shama, Dixcove and Apam.

Catch Composition and Size Range of Cetaceans

A total of eleven (11) marine mammals (Figure 3 - 6) belonging to the family Delphinidae and one belonging to family the Physeteridae were recorded (Table 1). The species recorded belonged to the family Delphinidae except one which belonged to family the Physeteridae. The most dominant species were the Pantropical spotted dolphin (*Stenella attenuata*) (25.5%), Fraser's dolphin (*Lagenodelphis hosei*) (14.6%) and Clymene dolphin (*Stenella clymene*) (10.9%).

Figure 3: A sperm whale (*Physeter microcephalus*) captured in Axim during the study

Figure 4: Some cetaceans landed during the study (A) Long-snouted spinner dolphin (*Stenella longirostris*), (B) Common dolphin (*Delphinus delphis*), (C) Short-finned pilot whale (Globicephala macrorhynchus), and (D) Rough-toothed whale (*Steno bredanensis*)

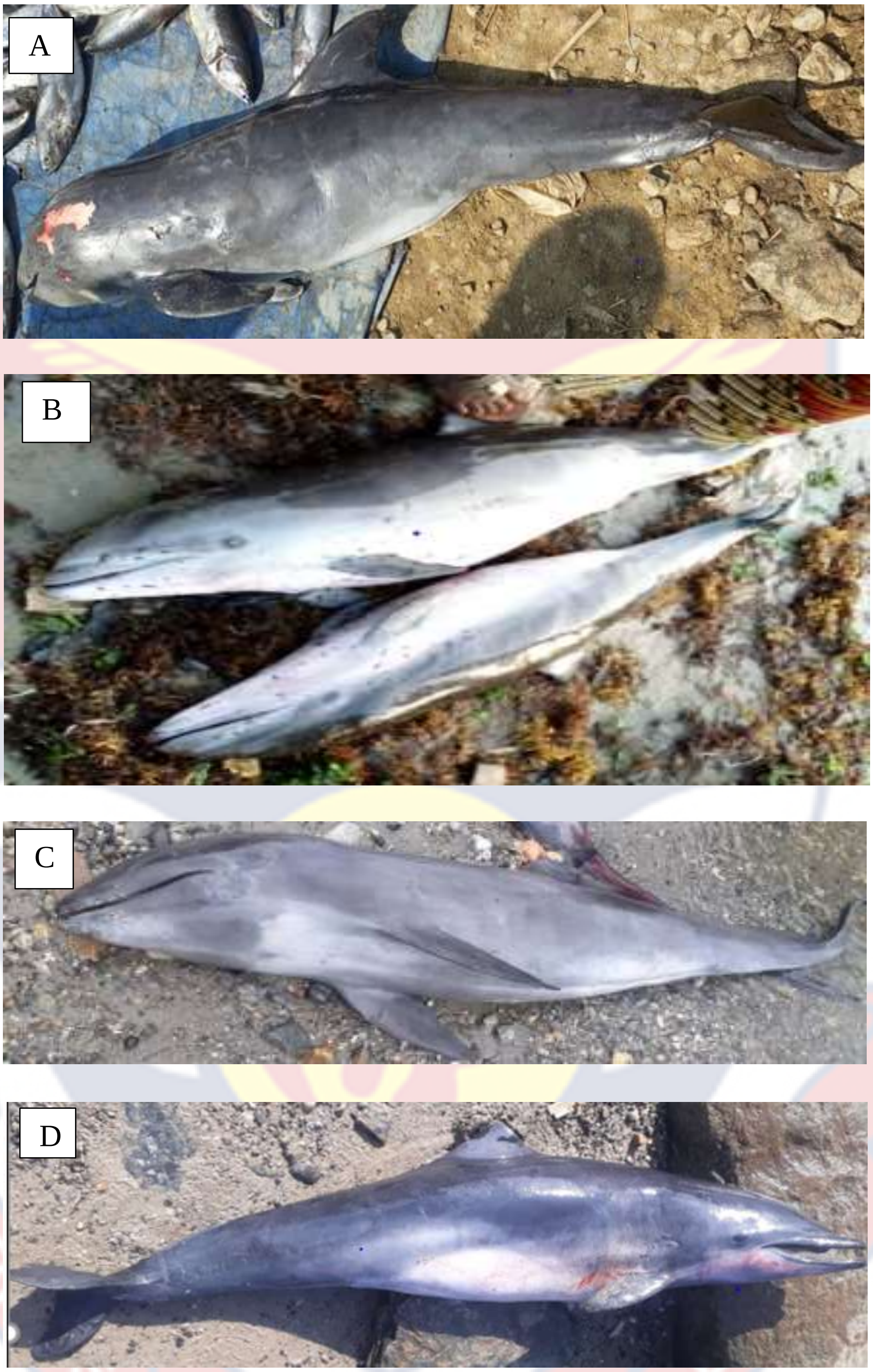

Figure 5: Species of landed cetaceans (A) Pygmy killer whale (*Feresa attenuata*), (B) Fraser's dolphin (*Lagenodelphis hosei*), (C) Melon-headed whale (*Peponocephala electra*), and (D) Clymene dolphin (*Stenella clymene*)

Figure 6: Some landed cetacean species (A) Risso's dolphin (*Grampus griseus*) and (B) Pantropical spotted dolphin (*Stenella attenuata*)

Table 1: *Size range of species landed (m)*

Species	No. landed	Min. size	Max. size	Percentage composition (%)
Lagenodelphis hosei	8	1.06	2.41	14.60
Steno bredanensis	3	1.60	2.44	5.50
Globicephala macrorhynchus	5	1.60	3.54	9.10
Tursiops truncatus	4	1.20	2.64	7.30
Stenella longirostris	6	0.96	1.98	9.10
Stenella attenuata	14	1.06	1.91	25.50
Stenella clymene	5	0.95	1.85	10.90
Peponocephala electra	4	1.50	1.90	7.30
Delphinus delphis	3	1.49	1.83	5.50
Grampus griseus	2	2.388	2.69	3.60
Feresa attenuata	1	-	-	1.80
Physeter macrocephalus	1	-	-	1.80

The Short-finned pilot whale (*Globicephala macrorhynchus*), Long-snouted spinner dolphin (*Stenella longirostris*) and Melon-headed whale (*Peponocephala electra*) each made up less than 10% of the landings while the Common dolphin (*Delphinus delphis*), Rough-toothed whale (*Steno bredanensis*), Risso's dolphin (*Grampus griseus*), Pygmy killer whale (*Feresa attenuata*) and Sperm whale (*Physeter microcephalus*) each constituted less than 6% (Figure 7).

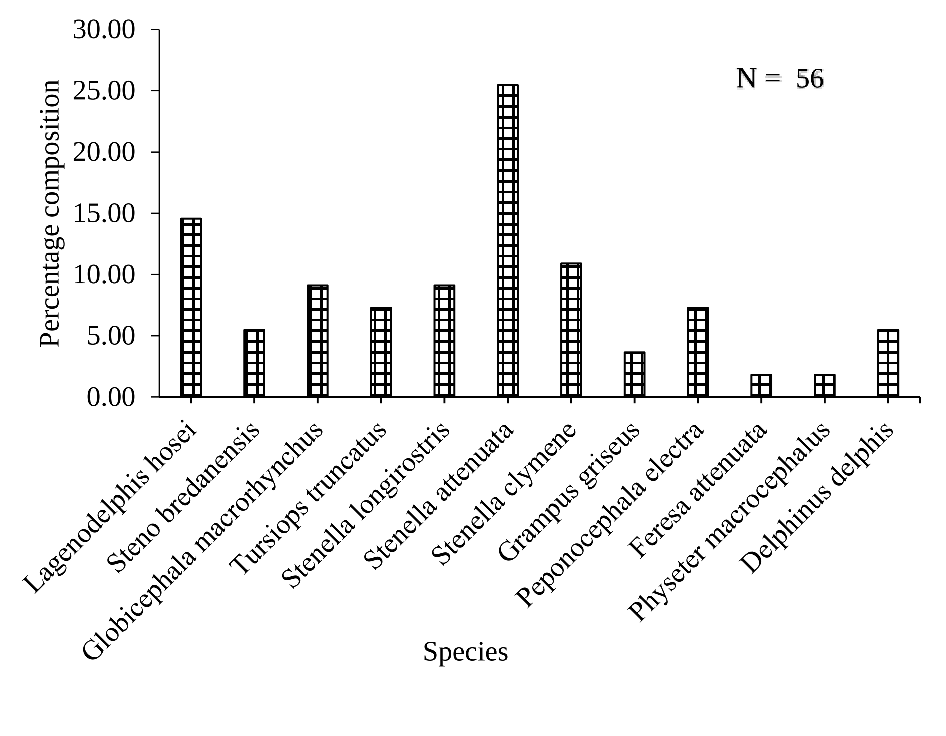

Figure 7: Percentage frequency of cetaceans caught during the study period (April – October, 2022)

The mean size range of species landed are presented in Figure 8. The largest sizes recorded was for sperm (4.3 m) and short-finned pilot whale (1.6 – 3.5 m) which are generally large in size. None of the species occurred in all four study sites, however, some species occurred in three of the study sites: *Stenella longirostris*, *Stenella attenuata* and *Steno bredanensis* were reported in all the communities except Shama. *Lagenodelphis hosei* and *Globicephala* *macrorhynchus* were reported at all sites except Apam and Dixcove, respectively (Figure 9). Most of the species obtained were from Dixcove (54.5%) with Shama recording the lowest percentage (5.5%). During the sampling period the highest cetacean landings were recorded in August and September with June recording the lowest (Figure 10). The species diversity (H), evenness (J′), and species richness (D) were 2.7, 0.91 and 2.5 respectively. There was no significant difference between lengths recorded for *L. hosei* (*df* = 6, *p-value* = 0.73, *f-value* = 0.35), *G. macrorhynchus* (*df* = 4, *p-value* = 0.37, *f-value* = 1.71) and *S. attenuata* (*df* = 15, *p-value* = 0.50, *f-value* = 0.73) in the communities when a one-way ANOVA was used ($p > 0.05$).

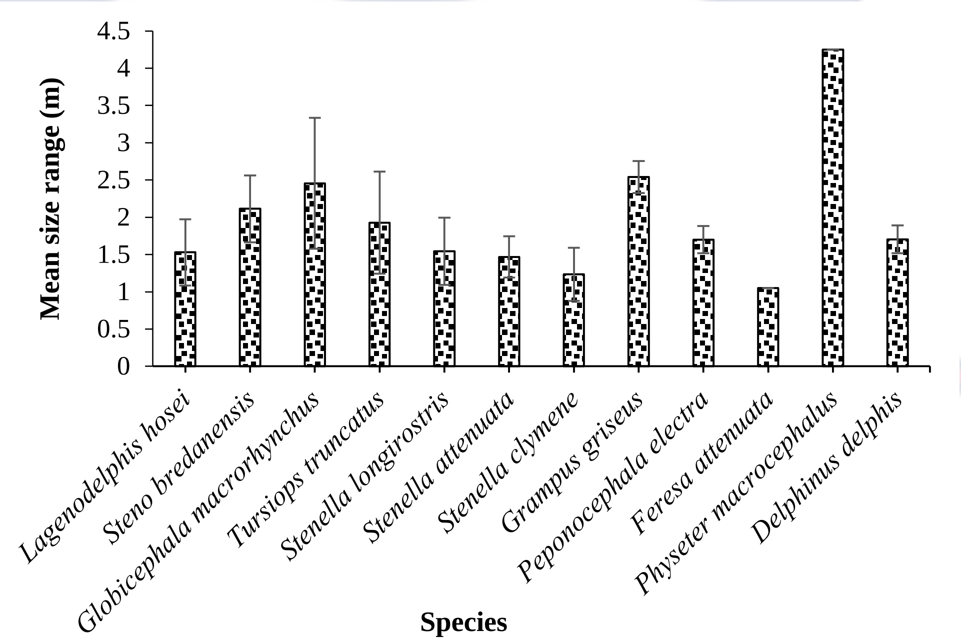

Figure 8: Mean size range of species landed during sampling period (April – October, 2022)

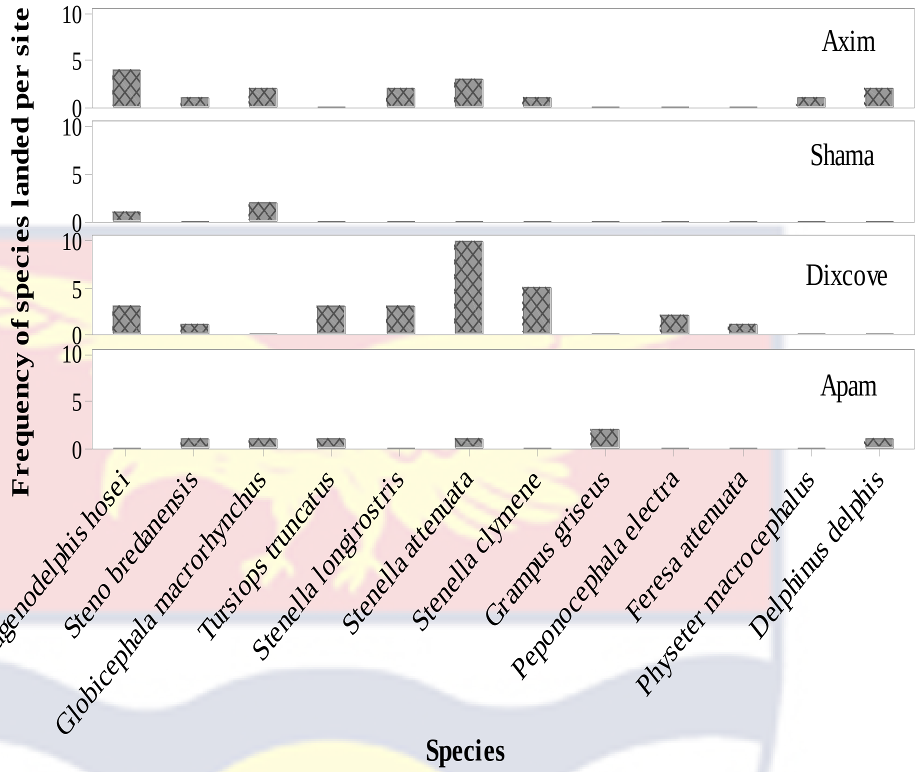

Figure 9: Frequency of landings of species per site

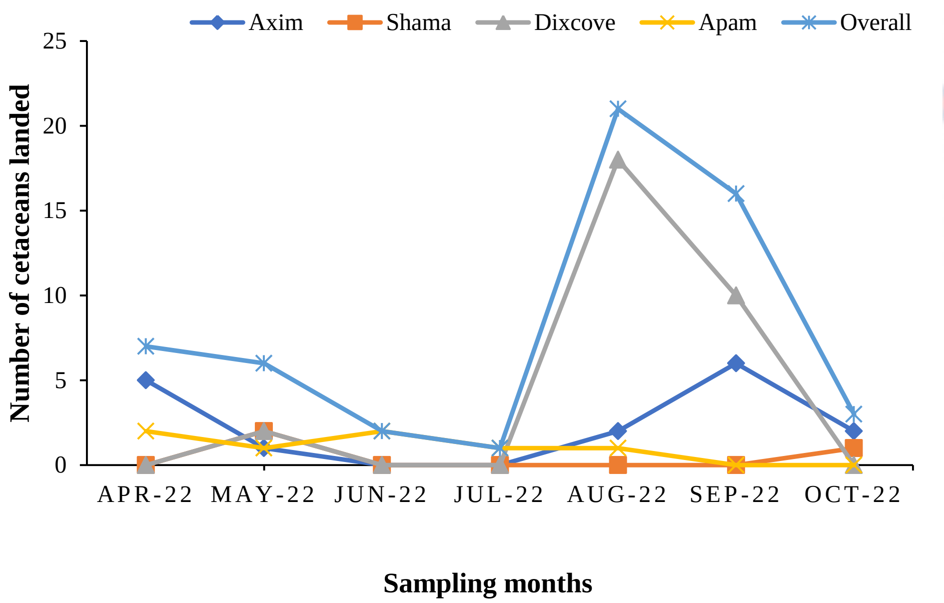

Figure 10: Monthly variations of cetaceans landed per month in Axim, Shama, Dixcove and Apam

4.2 Catch Trend of Cetaceans

From the four study sites, a total of 56 cetaceans were landed of which by-caught and targeted cetaceans comprised 49.0% each respectively with the remaining 2.0% being stranded animals. Dixcove was the community with the highest cetacean landings during the study period (Figure 11). Cetaceans caught during the study were mostly females (77.4%) with the majority (45.5%) being adults, followed by juveniles (34.5%) and calves (Figure 12).

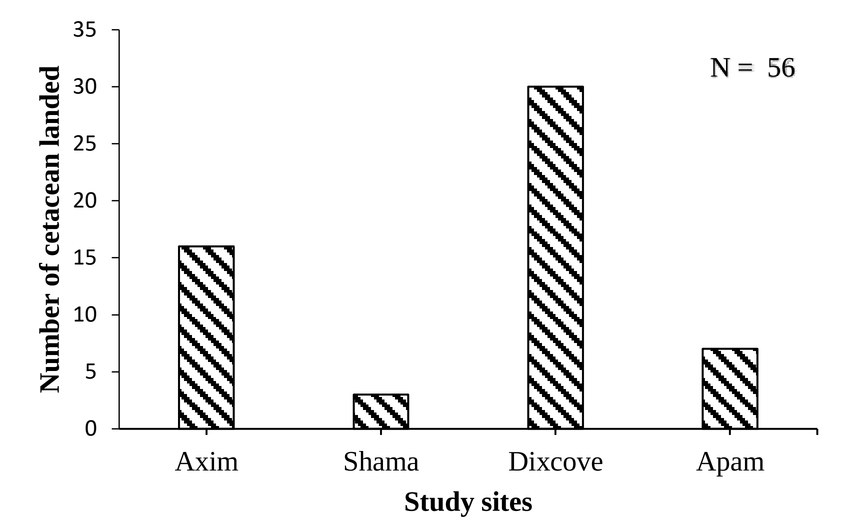

Figure 11: Number of cetaceans landed per study site

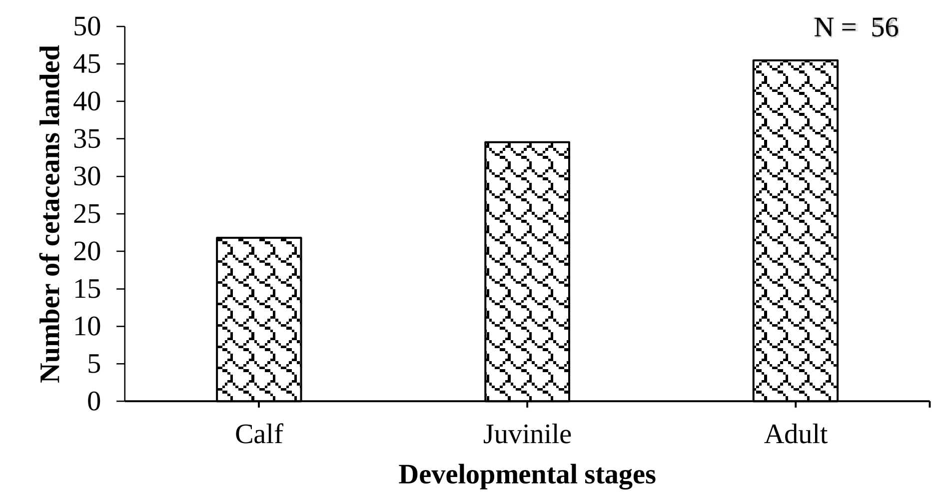

Figure 12: Developmental stages of cetaceans caught during the study period

4.3 Assessing the Impact of Fishing and Fisheries Related Interactions on Cetaceans

Fishing Gears and Mesh Sizes Utilized in Marine Mammal Exploitation

During the study period the Drift gillnet (DGN) had the highest marine mammal landings (95.1%) with Purse seine (APW) recording the least (4.9%) (Figure 13). The lengths of DGN used for the capture of cetaceans ranged from 1600 m – 2800 m (2293.5 ± 341.5) with mesh sizes ranging from 7.62 – 12.7 cm. The highest number of marine mammals were caught with DGN at Dixcove followed by Axim, Apam and Shama with APW only recorded at Apam (Figure 14).

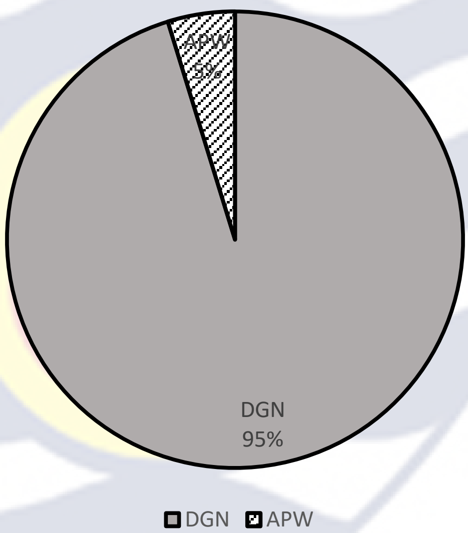

Figure 13: Percentage composition of the fishing gears used in cetacean capture

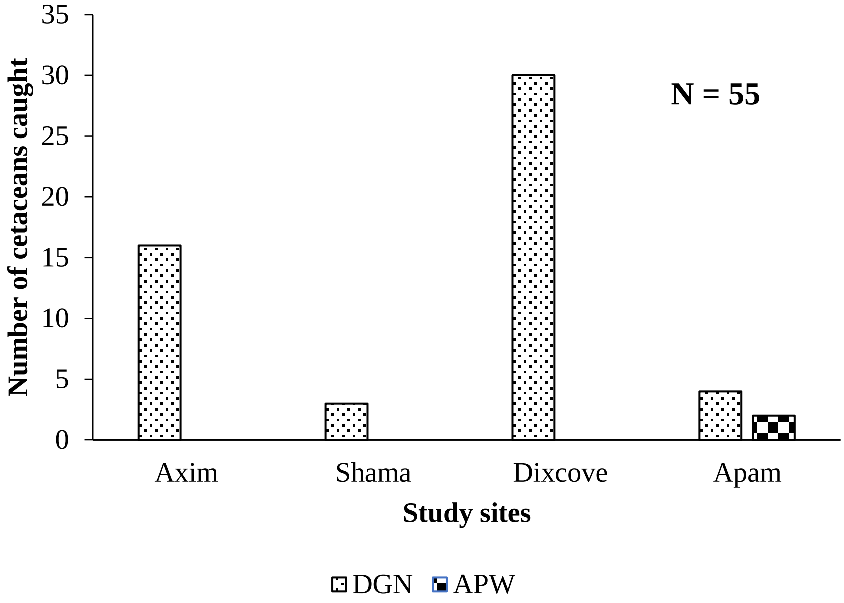

Figure 14: Number of cetaceans caught per fishing gear at various study sites

Monthly Catch per Unit Effort of Marine Mammals

The catch per unit effort (CPUE) for September was the highest (1.6 animal landed/canoe), followed by August (1.4 animal landed/canoe) with May, June, and October recording the lowest value (1.0 animal landed/canoe). There was no CPUE recorded for July because it was a closed season (Figure 15). See Appendix 3 for the CPUE data collected.

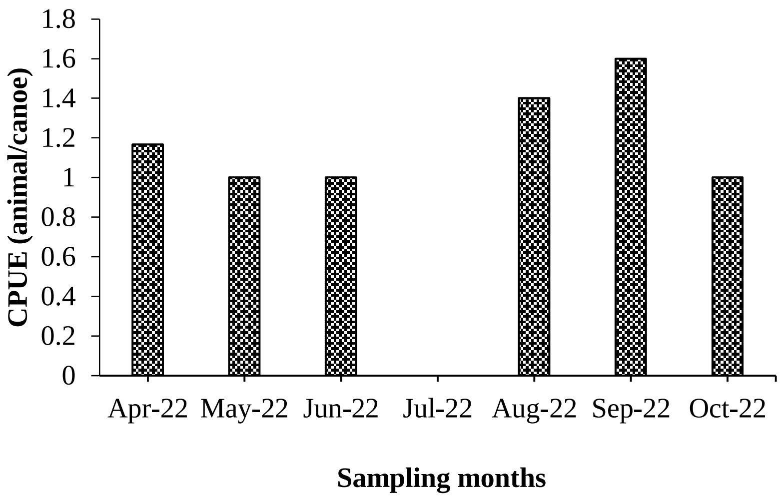

Figure 15: Catch per unit effort (CPUE) values recorded for the sampling months

4.4 Assessing the Feeding Habits of Cetaceans and its Relation to Exploitation

Feeding Habits of Marine Mammals

Throughout the study although 59 animals were recorded getting stomachs were sometimes difficult, thus, only 29 stomachs were obtained and examined (irrespective of species); 11 were empty while 18 contained prey items: 2 stomachs contained 4 shrimps, 11 contained 102 fish otoliths, 1 contained Thunidae head (Tuna), 1 contained a *Caranx* spp. Head (Jacks and pompanos), 3 contained 35 *Cheilopogon melanurus* (Atlantic flying fish), 1 contained 9 whole cephalopods (Orangeback flying squid) and 13 contained 218 cephalopod beaks.

The cephalopod beaks found were identified as *Sthenoteuthis pteropus* (Orangeback flying squid) (82.5%), *Chitoteuthis* spp. (Whip-lash squid) (2.6%) and *Onychoteuthis banksia* (Common clubhook squid) (1.8%) and unidentified (13.2%).

Fish species were identified from otoliths and their numerical percentage composition determined (Figure 16). The total percentage composition of food items present in the stomachs is also presented in Figure 17. Some nematode parasites were also observed in some stomachs.

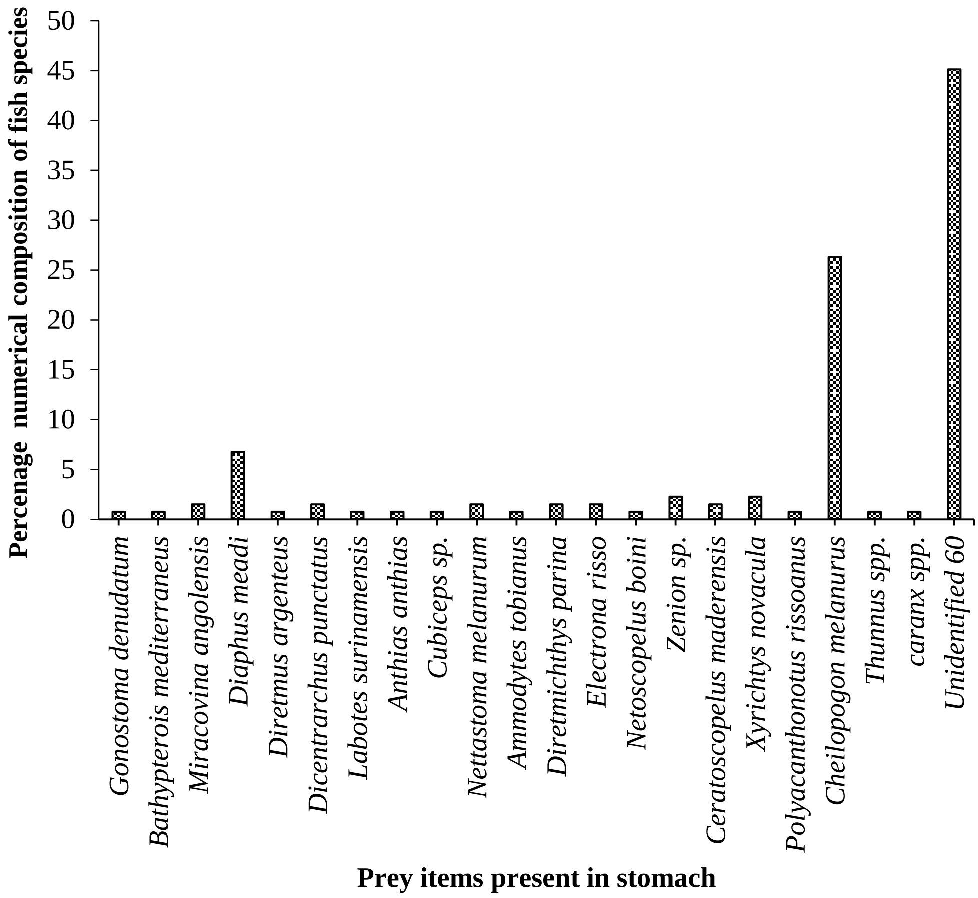

Figure 16: Percentage numerical composition of fish prey items found in cetacean stomachs

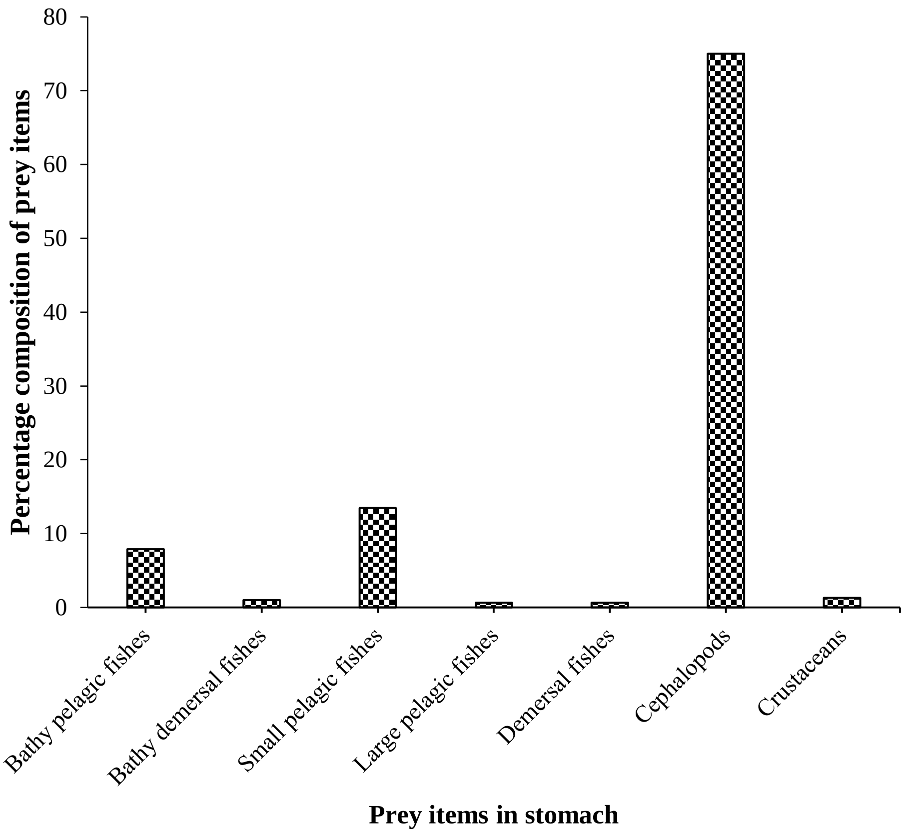

Figure 17: Categories of prey items found in the stomach

4.5 Determination of Socio-Economic Drivers of Cetacean Exploitation

From the four fishing communities, a total of 389 surveys were completed for fishermen (Axim: *n* = 199, Dixcove: *n* = 44, Shama: *n* = 91 and Apam: *n* = 55). A total of 55 surveys were completed for fish processors (Axim: *n* = 5, Dixcove: n = 32, Shama: n = 5 and Apam: *n* = 13).

Demographic Details of Fishermen

Fishermen who participated in the survey were between the ages of 17 – 80 (average age of 41 years), with an average number of dependents of 6 (SD = 4 persons), have stayed in the community an average of 28 years (SD = 15.6) and had a working experience of 26 years. Fishermen from the four communities had different levels of education; the highest being "No formal education" with secondary education being the least (Table 2). Most of the participants in the survey were married (74.3%) and 12.9% had a secondary source of livelihood.

Table 2: *Number of fishermen surveyed and their demographic information*

		Level of education				
Site	Number surveyed	No education (%)	Primary (%)	Secondary (%)	Number of dependants	Fishing experience in (years)
Axim	199	61.8	29.6	8.5	6.2 ± 3.9	27.2 ± 11.7
Dixcove	44	31.8	65.9	2.3	4.5 ± 3.4	20.9 ± 12.0
Shama	91	47.3	45.1	7.7	6.3 ± 3.7	24.8 ± 12.8
Apam	55	50.9	47.3	1.8	5.1 ± 4.7	21.3 ± 12.6

Gears Deployed and Target Species of Fishermen

Participating fishermen used various fishing gears for fishing but the most common gear used in all the communities was the DGN (Table 3). Fishermen in the four communities used an average three different meshes for fishing (SD = 1). Participants used various mesh sizes (cm) for fishing: DGN fishermen (7.62 – 13.97), Bottom set net fishermen (1.59 – 12.7), Purse seine net (2.54 – 5.12), and Set gillnet (0.64 –10.16). DGN fishermen deployed a mesh size greater or equal to 7.62 cm (100%, n = 381) which is later sold to set and gillnet fishermen when old.

Table 3: *Interviewed fishermen and the types of gear deployed*

Sites	DGN (%)	Bottom set net (%)	Purse seine net (%)	Hook and line (%)	Set gill net (%)
Apam	25.5	14.5	36.4	10.9	12.7
Axim	60.8	2.0	30.7	1.5	10
Dixcove	95.5	4.5	0	0	0
Shama	83.5	11	4.4	0	1

Participating fishers used fishing gears with lengths measuring 300 – 4500 m (average 1600 ± 400 m, *n* = 371). Fishers spent 1 – 8 days (average 4 ± 1 day) during each fishing trip while others spent 3 – 24 hours (average 14 ± 4.3 hours). Most fishers targeted large pelagic fishes (65.8%), while others targeted small pelagic fishes (30%), demersal fishes (7.5%), and crustaceans (0.8%).

Interaction with Marine Mammals on Fishing Grounds

Most respondents confirmed having sighted cetaceans during fishing (Figure 18). Participating fishers also reported that cetaceans were frequently sighted during certain months (January, February, June, July, August, September, and December) but frequently landed during the full moon, colder months (December and January) and August, and September. The most frequently sighted cetaceans according to fishers were the Long-snouted spinner dolphin (*Stenella longirostris*) (65.2%), Snout-snouted spinner dolphin (*Stenella clymene*) (55.3%), Short-finned pilot whale (*Globicephala macrorhynchus)* (11%), Atlantic spotted dolphin (*Stenella frontalis*) (9.3%), Fraser's dolphin (*Lagenodelphis hosei*) (8.0%), Rough toothed whale (*Steno bredanensis*) (3.3%), Pantropical spotted dolphin (*Stenella attenuate*) (1.9%), Common bottlenose dolphin (*Tursiops truncatus)* (1.6%), and the Melon-headed whale (*Peponocephala electra*) (1.4%).

Most fishers reported that cetacean landings over the years had been decreasing (69.9%), some reported an increase in landing (23.7%) while others claimed they had observed no changes in landings over the years (6.4%). For those who claimed an increase in cetacean landings (35%), they attributed it to the decline in small pelagic fish stocks, others claimed the increase in cetacean landings was not because of the decline in the small pelagic fish stocks (51.9%) while (12.9%) had no idea. Most fishers confirmed that they had captured marine mammal during fishing (Table 4).

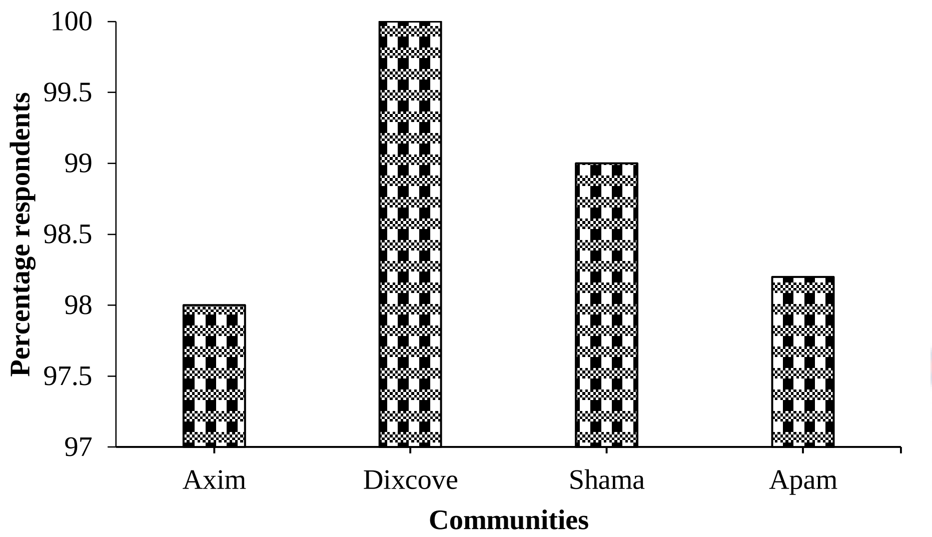

Figure 18: Fishers that have sighed marine mammals during fishing

Table 4: *Confirmation of cetacean capture during fishing*

Site	N	% Incidental	% Targeted	% Incidental and targeted
Apam	32	81.3	18.75	0
Axim	165	89.1	3.6	7.3
Dixcove	37	56.8	2.7	40.5
Shama	77	76.6	0	23.4

Fishermen reported capturing several cetaceans over a one-year period but claimed it was incidental (87.4%) however Dixcove and Apam fishermen had the highest catches (Table 5).

Table 5: *Gears deployed and number of cetaceans caught per site in a year (June 2021- June 2022)*

			Cetaceans caught in a year			
Site	Number surveyed	Fishery	Mean	range	% incidental	% targeted
Axim	113	DGN	6 ± 10	1 - 100	90.0	31.2
	30	Purse seine net	7 ± 20	1 - 100	93.9	26.8
	4	Set gill net	2 ± 2	1 - 5	100	0.0
	1	Hook and line	4	4	100	0.0
Dixcove	35	DGN	27 ± 50	1 - 200	73.4	55.7
	67	DGN	12 ± 16	1 - 100	91.6	33.1
Shama	2	Purse seine net	21 ± 33	3 - 70	100	0.0
	6	Bottom set net	12 ± 16	1 - 25	85.5	43.5
Apam	11	DGN	14 ± 56	1 - 200	85.7	39.3
	15	Purse seine net	7 ± 15	1 - 50	93.3	30.0
	2	Set gill net	1.5 ± 0.7	1 - 2	100	0.0
	1	Bottom set net	3	3	100	0.0
	1	Hook and line	1	1	100	0.0

Fate of by-Caught and Targeted Cetaceans

Most fishermen from Apam and Shama said that by-caught cetaceans were used as bait for the shark fishery (76.3% and 88.9%), following the "use as bait for shark fishery", the most frequent responses were the sale of by-caught cetaceans at the shore (22.3% and 9.3%). Fishermen from Axim and Dixcove reported that by-caught cetaceans were sold at the shore (80.2% and

62.8%) following “brought to shore and sold”, the most frequent response was the use of cetaceans as bait (11.1% and 12.1%). Followed by selling and consumption of cetaceans, consumption at home and discarding at sea being the least response (Table 6).

Table 6: *Fate of by-caught cetaceans in a year (June 2021 – June 2022)*

			Fate of by-caught cetaceans				
Sites	Number of respondents	Cetaceans caught in a year	Left at sea	Sold at shore	Used as bait	Used at home	Sold and rest eaten
Axim	143	948	1	760	105	8	74
Dixcove	34	931	0	585	336	10	0
Shama	74	917	9	85	815	2	6
Apam	30	575	5	128	439	2	1

When fishermen were asked the reason for using cetaceans as bait, the majority of the responses were because of their effectiveness (Figure 19). When fishermen were asked whether there were any species of cetaceans usually preferred as bait, more than half (67.1%) mentioned that they do not have a preference.

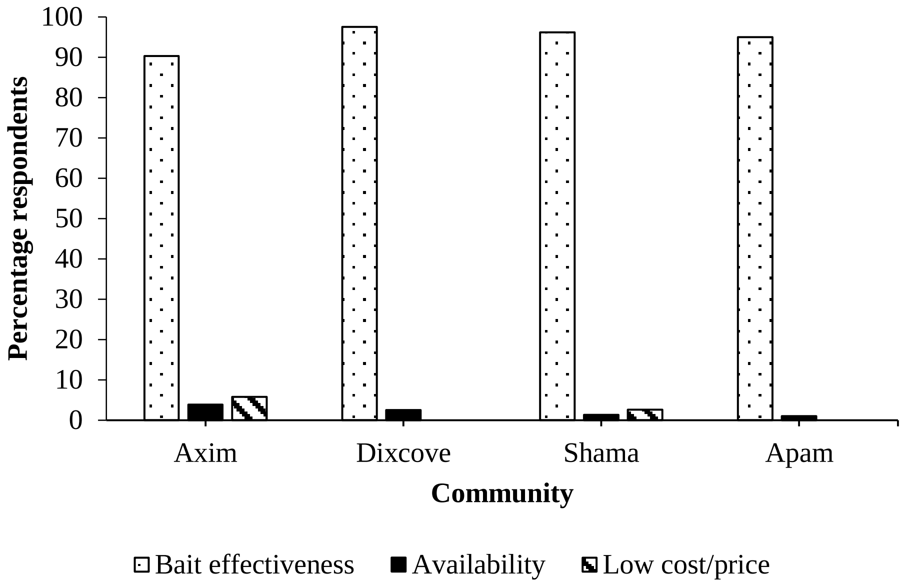

Figure 19: Reasons why fishermen utilize cetaceans as bait for sharks

From those fishers who responded that they had a preference (n = 95), two species were mentioned as the most preferred species, Stenella clymene (n = 40) and Stenella longirostris (n = 38). Some fishers mentioned that the least preferred species for bait was the pilot whale (Globicephala macrorhynchus) because of its huge blubber reserve. Majority of fishermen mentioned that apart from certain body parts (bones, head, and flippers), the skin, blubber and muscles were all used as bait (97.9%, n = 286). Participating fishermen also reported that cetaceans brought to shore were mostly sold to market women (47.8%), women who finance the fishing trip (fish mommies) (32.4 %), and other DGN fishers (19.9%).

Alternative Bait Sources Used for Shark Fishing

Fishermen mentioned that apart from cetacean meat other species used as bait were tuna (*Thunnus* spp. and *Katsuwonus* spp.), mackerel (*Scomber colias*) Cuttlefish (*Sepia officinalis*), Sardine (*Sardinella* spp.), beef, pork, flying gurnard (*Dactylopterus* spp.), cassava fish (*Pseudotolithus* *senegalensis*), and swordfish (*Xiphiidae* spp.) were used. However, cassava fish was only used at Axim (0.7%) and Shama (1.3%) while sword fish was used in three communities (Axim: 0.7%, Dixcove: 2.7% and Shama: 17.1%) (Table 7)

Table 7: *Alternative bait sources for the shark fishery*

Site	n	% Tuna	% Beef	% Sardine	% Mackerel	% Pork	% Cephalopod	% flying gurnard
Apam	19	94.7	21.1	5.3	15.8	5.3	5.3	0
Axim	142	95.1	45.1	1.4	1.4	2.8	2.1	2.8
Dixcove	37	70.3	35.1	10.8	2.7	5.4	0	13.5
Shama	76	48.7	19.7	0	47.4	5.3	5.3	10.5

Preference for Cetacean Meat as Bait for Sharks

When fishers were asked why cetaceans were used as bait when there were other alternative bait sources, they indicated that cetacean meat was bloody, oily and firm: making them last for several days in the water without disintegrating and its bloody and fatty nature attracts sharks easily (Axim: 100%, Dixcove: 100%, Shama: 100% and Apam: 100%).

Prices of the Cetacean Carcass

Fishermen were shown pictures containing different species of cetaceans and then asked how much they were averagely sold for. Some of the interviewed fishermen (38.5%) had no idea how much cetaceans were sold for. From those fishermen who knew the prices (Axim: *n* = 126, Dixcove: *n* = 22, Shama: *n* = 31 and Apam: *n* = 13) they explained that cetaceans brought to shore were not sold per kilo gram (kg). Rather, prices were estimated according to their sizes (small, medium, large) species and market demand; at an exchange rate of 1 dollar to 14 Cedis (Table 8).

Table 8: *Price of cetaceans at the various sites*

		Price of cetacean when landed (Cedis)		
Species	Site	Small	Medium	Large
Stenella frontalis	Axim	238.8 ± 148.6	537.0 ± 360	955.9 ± 596.0
	Dixcove	345.0 ± 225.4	633.3 ± 389.7	1044.4 ± 515.1
	Shama	255.0 ± 94.6	668.3 ± 370.4	1221.7 ± 456.1
	Apam	200	375 ± 35.4	700 ± 141.4
Tursiops truncatus	Axim	362.5 ± 245.1	729.2 ± 369.6	1383.3 ± 605.8
	Dixcove	500	800	1500
	Shama	214.4 ± 57.0	411.1 ± 108.3	777.8 ± 402.4
	Apam	0	0	0
Globicephala macrorhynchus	Axim	417.4 ± 267.7	905.3 ± 429.5	1889.1 ±1625
	Dixcove	461.0 ± 202.0	930.0 ± 311.4	1645 ± 367.7
	Shama	526.7 ± 346.5	1187.5 ± 531.8	2258.3 ± 1051.0
	Apam	221.3 ± 73.0	650.0 ± 307.1	1425 ± 627.4
Stenella clymene	Axim	286.6 ± 157.4	626.7 ± 271.5	1021.8 ± 430.9
	Dixcove	373.5 ± 239.2	764.7 ± 267.4	1179.4 ± 541.1
	Shama	305 ± 101.2	621 ± 232.9	1035.2 ± 473.5
	Apam	258.3 ± 135.7	608.3 ± 272.8	1083.3 ± 444.6
Feresa attenuata	Axim	637.5 ± 255.1	976 ± 219.5	1468.4 ±366.7
	Dixcove	722.2 ± 277.4	1188.9 ± 261.9	1788.9 ± 231.5
	Shama	525 ± 231.8	983.3 ± 256.3	1600 ± 126.5
	Apam	500	1000	1200

Table 8 Cont'd: *Price of different species of cetaceans in study areas*

Lagenodelphis	Axim	368.8 ± 294.3	621.9 ± 431.6	1053.1 ± 658.7
hosei	Dixcove	450.0 ± 185.2	775.0 ± 242.0	1162.5 ± 315.9
	Shama	193.3 ± 130.0	733.3 ± 121.1	1266.7 ± 196.6
	Apam	200	500	1000
Stenella	Axim	280.4 ±169.7	610.8 ± 309.2	1006 ± 410.9
attenuata	Dixcove	491.7 ± 228.9	775.0 ± 223.0	1400.0 ± 429.0
	Shama	200.0 ± 147.2	462.5 ± 286.9	1375 ± 629.2
	Apam	150	500	1000
Peponocephala	Axim	263.1 ± 223.3	594.2 ± 343.3	994.2 ± 380.6
electra	Dixcove	485.7 ± 167.6	907.1 ± 117.0	1528 ± 262.8
	Shama	183.3 ± 28.9	566.7 ± 152.8	966.7 ± 251.7
	Apam	100	500	1000
Stenella	Axim	375.5 ± 195.8	759.1 ± 262.9	1242.5 ± 357.9
longirostris	Dixcove	432.5 ± 194.2	950.0 ± 363.5	1550 ± 508.4
	Shama	353.6 ± 173.9	776.0 ± 330.0	1245.5 ± 475.8
	Apam	257.1 ± 136.7	550 ± 236.3	928.6 ± 309.4
Steno	Axim	276.3 ± 156.6	655 ± 290.8	1200 ± 495.5
bredanensis	Dixcove	645 ± 404.5	1105.0 ± 481.0	1845.5 ± 484.5
	Shama	220.0 ± 108.52	470.0 ± 241.8	800.0 ± 390.9
	Apam	400	800	1200
Pseudorca	Axim	354.2 ± 261.2	831.3 ± 472.7	1352.1 ± 629.3
crassidens	Dixcove	525 ± 207.2	1090 ± 299.8	1770 ± 402.9
	Shama	330.0 ± 216.8	840.0 ± 296.6	1320.0 ± 327.1
	Apam	260	700	1200

Monthly Income Generated from the Sale of Shark Fins and Marine Mammal Carcasses by Fishermen and Fish Processors

When fishermen were asked how much they earned monthly from selling cetacean meat, most of them explained that cetaceans landed were sold by the canoe owners and the money was used for repairs and other expenses on the fishing vessel, however, some (17.5% of total respondents, *n* = 68) indicated that they earned 40 – 5000 Cedis (average 751.6 Cedis, SD = 796.3 Cedis) monthly. DGN fishers were asked how much they averagely sold a kilogram of shark fins. Fishers from Axim reported 224.8 Cedis (SD = 132.5 Cedis, *n* = 72), Dixcove: 160.8 Cedis (SD = 84.5 Cedis, *n* = 13), Shama: 174.7 Cedis (SD = 93.2 Cedis, *n* = 36), and Apam: 400 Cedis (*n* = 1). Participating DGN fishermen were asked how much they earned monthly from the sale of shark fins. More than half (77% of DGN participants) could not answer the question. They explained that the shark fins solely belonged to the canoe owners and as such they had no share in the money generated from the sale of the fins. Some fishermen who were also canoe owners (*n* = 88) mentioned that they earned 20 – 5000 Cedis monthly (average 836.7 Cedis, SD = 897.5 Cedis). When fishermen were asked whether cetacean carcass was in high demand, almost all fishermen said “yes” (Figure 20).

Many fish processors also reported that they earned 30 – 250 cedi’s (average 155.20 cedi’s, SD = 58.7 Cedis; *n* = 42) with few others earned 280 – 500 Cedis (average 390.8 Cedis, SD = 66.6 Cedis; *n* = 13) monthly from the sale of cetacean meat.

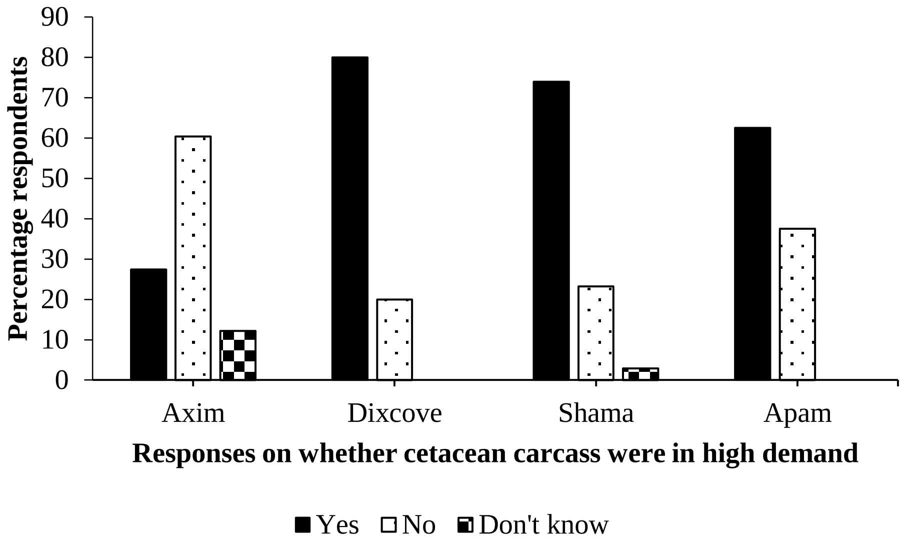

Figure 20: Fishermen responses on whether cetacean carcass was in high demand

Interaction Between Premix Fuel and Fishing

When fishermen were asked whether premix fuel (government subsidized fuel for fishermen) influenced their fishing activities, majority (93.1%, n = 362) strongly agreed and explained that they do not often get fuel for fishing (99.2%, n = 386) and that 5 liters of premix fuel averagely cost between 5 – 17 Cedis (average 8.5 Cedis, SD = 2.0 Cedis). Fishermen further reported that because they hardly get premix fuel for some time now, they had to resort to buying vehicle fuel and premix fuel that has been hoarded by certain members of the community that are not fishermen. They explained that buying such fuel was very expensive (78.9%, n = 306) because they cost between 10 – 35 Cedis to purchase 5 liters (average 35 Cedis, SD = 2 Cedis). Fishermen bought several liters of fuel for fishing and this was dependent on the types of gear used as well as the number of fishing days however, DGN fishers had the highest fuel consumption because the number of days spent fishing (Table 9). Fishermen emphasized that because they do not get enough catch during fishing and the cost of fuel is high, they sometimes make losses and the only way to ensure that they make a profit or break even is to use cetacean meat as bait to get sharks or sell cetaceans to fish processors or other DGN fishermen.

Table 9: *Gears used and quantity of fuel bought per fishing trip*

Site	n	Gear	Number of liters bought per fishing trip
Axim	121	DGN	515.5 ± 99.5
	4	Bottom set net	31.3 ± 28.3
	3	Hook and line	533.5 ± 160.5
	61	Purse seine net	376.5 ± 146.5
	10	Set gill net	354.5 ± 271.0
Dixcove	42	DGN	565.0 ± 94.0
	2	Bottom set net	45.0 ± 14.0
Shama	76	DGN	838.5 ± 268.0
	10	Bottom set net	16.6.0 ± 14.0
	4	Purse seine net	659.0 ± 584.5
	1	Set gill net	15.0
Apam	14	DGN	762.0 ± 304.0
	8	Bottom set net	55.5 ± 20.0
	6	Hook and line	168.5 ± 53.0
	20	Purse seine net	308.0 ± 229.0
	7	Set gill net	105.0 ± 90.5

4.6 Income Generated from Each Fishing Trip

Majority of fishers (71%, *n* = 275) earned 10 – 500 (average 275.2 Cedis, SD = 132.0 Cedis) while other fishers (mostly canoe owners) earned

600 – 15000 Cedis (average 3036.3 Cedis, SD = 2366.5 Cedis). Many respondents (86%, n = 336) also reported that when the catch was low, they sometimes made losses or earned 2 – 500 Cedis (average 100.4 Cedis, SD = 118.0 Cedis) with other fishers earning 600 – 3000 Cedis (average 119.3 Cedis, SD = 548.7 Cedis).

Interaction Between the High Price of Premix Fuel and Exploitation of Cetaceans

Fishermen were asked if the high cost of premix fuel has contributed to the exploitation of cetaceans to offset the cost. Many fishermen (70%) said "yes" and explained that getting sharks especially the higher qualities including great white sharks (*Carcharodon carcharias*), and hammerhead sharks (*Sphyrna* spp.), ensures that they earn a profit. Other fishers also said "no" and explained that cetaceans were not their target species, not found within their fishing grounds, difficult to catch and also illegal.

Knowledge of Laws Protecting Marine Mammal

Participating fishermen were asked if they knew about the National Fisheries Management Plan of Ghana. The majority of fishers (62%, n = 241) said "no" while a few answered "yes". For those fishermen who answered "yes" they were further asked if knew about the provisions concerning marine mammals. Many fishermen reported that they knew of the provisions (58%, n = 86) however, other fishers also said "no" (42%, n = 62). Many interviewed fishers (78%, n = 305) explained that they do not think fishermen can stop using cetaceans as bait because of several reasons (1) fuel is expensive so the cost of financing a fishing trip is high (2) using cetaceans as bait lasts longer in the water column and easily attracts sharks because of its strong odour (3) cetacean meat is less expensive (4) fish catch is low (5) cetaceans are usually found dead in nets and it will a waste not to use it. Other fishermen also reported it was possible to stop using cetaceans as bait when the laws are enforced and fishers are educated about the importance of cetaceans and the need to use alternative bait sources (e.g., tuna, beef and pork).

Protection of Marine Mammals and Strategies to Reduce by-Catch

Most fishermen said that gear modification will help minimize cetacean by-catch, however, few fishermen did not want cetacean by-catch to reduce (Figure 21). More than half (Axim: 72.9%, Dixcove: 68.2% and Apam: 56.4%) of fishermen in all the communities except Shama (39.7%) thought that protecting cetaceans was not important. They explained that cetaceans destroy their fishing nets, and feed on their catches and their protection will lead to a decline in the shark fishery, which will not enable them to offset fuel costs. Some fishers also stated that they do not see any importance in cetaceans and that cetaceans are also “fishes” and very palatable. Some fishermen (Axim: 27.1%, Dixcove: 31.8%, Shama: 60.4% and Apam: 43.6%) also thought protecting cetaceans was important because they can be used for ecotourism, they behave like humans, helps to locate schools of fishes, they deserve to live, helps in direction and provide shelter for other fishes. Many fishermen interviewed agreed that public education and incentives (Axim: 70.9%, Dixcove: 89%, Shama: 67.0% and Apam: 65.5%) should be introduced to strengthened cetacean protection, following “public education and incentives” introducing public education, punishment and incentives (Axim: 7.0%, Dixcove: 9.1%, Shama: 12.1% and Apam: 21.8%).

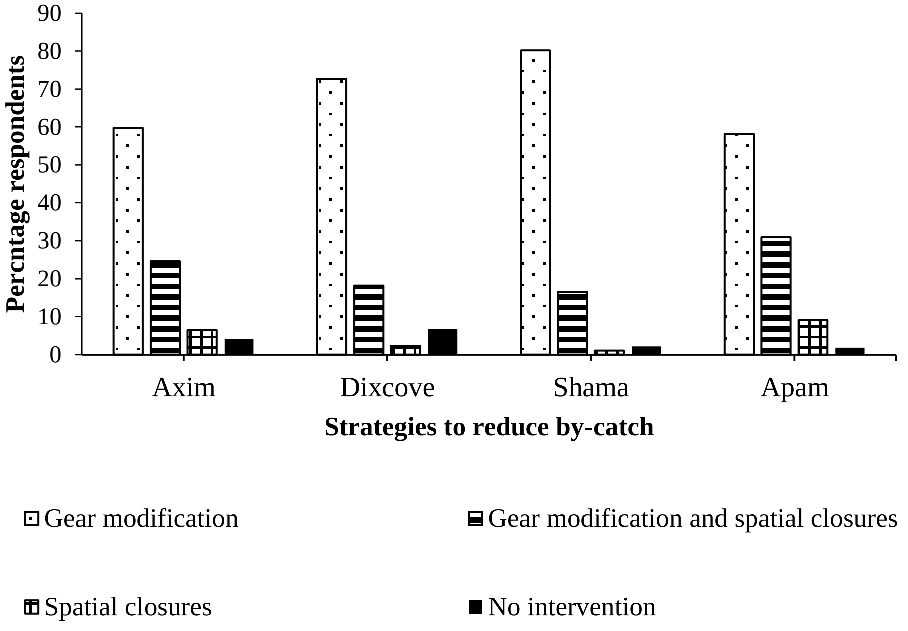

Figure 21: Responses on strategies to reduce cetacean by-catch by fishermen

Knowledge of Cetacean Meat Containing Persistent Organic Pollutants

Almost all fishermen (Axim: 86.4%, Dixcove: 86.4%, Shama: 93.4% and Apam: 90.9%) had no idea that cetacean meat contained persistent organic pollutants. Majority of fishermen (Axim: 78.9%, Dixcove: 65.9%, Shama: 73.6% and Apam: 80%) said that they will stop consuming cetacean meat after they were educated on the dangers associated with consuming cetacean meat including cardiovascular diseases, cancers, diabetes and disruption of the immune and endocrine system (Guo et al., 2019). Some also had mixed feelings after they were educated (Axim: 4.5%, Dixcove: 6.8%, Shama: 13.2% and Apam: 9.1%) however, few fishermen said they will still consume cetacean meat even after being educated (Axim: 16.6%, Dixcove: 27.3%, Shama: 13.2% and Apam: 10.9%).

Demographic Details of Fish Processors

The fish processors surveyed in the study were between 20 – 76 years of age (average 43 years), had an average of 23 years of fish processing experience, had been living in the community for an average of 34 years with an average number of dependents of 5 (SD = 0 persons). Many fish processors from Shama and Apam had no formal education whereas those from Axim and Dixcove had Primary education (Table 10). Few fish processors had a secondary source of livelihood (16.4%) with the majority being married women (61%).

Table 10: *Number of fish processors surveyed and level of education for each site*

	Level of education				
Community	No education (%)	Primary (%)	Secondary (%)	Number of dependants	Fish processing experience in (years)
Axim	20	80	0	25	38.0 ± 14.40
Dixcove	9.4	62.5	28.1	115	16.6 ± 12.41
Shama	80	20	0	48	27.4 ± 9.53
Apam	76.9	15.4	7.7	70	31.0 ± 11.96

Fate of Cetacean Carcass

Fish processors confirmed that cetaceans were landed almost all year round (n = 37) but catches were high during July, August and January (n = 18). Fish processors at Axim, Dixcove and Shama smoked cetacean carcasses bought (100%, 100% and 100%, respectively) while Apam had a mixture of fish processors, who smoked or salted cetacean meat (61.5% smoked, 38.5% salted). Fish processors reported that they bought an average of 4 animals (SD = 3 animals) weekly for processing. At Axim the cost of one animal was 200 – 1200 Cedis (average 660 Cedis, SD = 498 Cedis; n = 5), at Dixcove, the price was 50 – 3000 Cedis (average 910.9 Cedis, SD = 736.1 Cedis; *n* = 32), and 350 – 600 Cedis (average 440 Cedis, SD = 108.4 Cedis; *n* = 5) at Shama and Apam 100 – 400 Cedis (average 257.7 Cedis, SD = 76 Cedis; *n* = 13) (Table 11).

Table 11: *Responses from fish processors on the use of cetacean meat*

Site	Number of fish smokers	Number of salted fish processors	Number of cetaceans bought weekly	Cost of one animal (Cedis)	Price per piece of smoked meat
Axim	5	0	9.6 ± 6.2	660 ± 498.0	4.8 ± 0.4
Dixcove	32	0	4.0 ± 1.8	910.9 ± 736.1	5.1 ± 1.7
Shama	5	0	1.2 ± 0.4	440 ± 108.4	4.8 ± 0.8
Apam	8	5	1.7 ± 1.1	257.7 ± 76.0	5.6 ± 0.5

Price and Market of Cetacean Meat

Participating fish processors reported that a piece of smoked (0.72 kg) cetacean meat was sold at 2 – 9 Cedis (average 5 Cedis, SD = 1.40 Cedis) and the salted meat was sold at 50 Cedis (SD = 0 Cedis). Because these pieces of cetacean meat were not weighed but cut using the eye it varied from one fish processor to the other. Some fish processors reported that cetacean meat was in high demand (32%, *n* = 17) because of several reasons (1) it is cheaper than other fish species sold on the market, (2) it is palatable and tasty, (3) fleshy and very fatty, (4) tastes like goat meat, (5) DGN fishermen buy and use as bait.

CHAPTER FIVE

DISCUSSION

This chapter discusses the results in chapter four using relevant literature. This chapter reports on the different species of cetaceans, their lengths, gears used in their capture, their feeding, socio-economic drivers for their capture and knowledge of laws protecting marine mammals.

5.1 Catch Composition and Trends

The number of cetaceans recorded during the study period (56) was lower than those reported by Van Waerebeek et al. (2014) at Dixcove over a fourteen-month period where 109 animals were recorded. However, Ofori-Danson et al. (2019) also recorded 57 cetaceans landings at Axim during a four-month period. The low landings observed during the study could be a result of the infrequent supply of government subsidized fuel (premix fuel) which most fishers depend on for fishing and the one-month closed season observed in July. Thus, forcing many fishers to dock their canoes or buy vehicle fuel or premix fuel hoarded by some community members which is usually very expensive. Also, during the interview some fishermen (38%) mentioned that they were aware of the laws prohibiting the capture of marine mammals and this might have led them to hide their catches for fear of being arrested by the Fisheries Enforcement Unit of the Fisheries Commission of Ghana or butchering the mammals at sea, thus, making catch recording difficult. Therefore, the numbers observed in this study might be potentially lower than the actual numbers caught.

Almost all the species caught were from the family Delphinidae which confirms that the family Delphinidae is the most abundant and diverse

(Carwardine, 2020). Cetacean landings at Dixcove were the highest throughout the study period as also reported by Debrah et al. (2010) and Ghana Wildlife Soceity (2020) and this is because the majority of fishermen in this community use DGN together with longlines for fishing. *Stenella attenuata*, *L. hosei*, and *S. clymene* were the most landed species in this study. Debrah et al. (2010) reported *S. clymene*, *S. attenuata*, and *T. truncatus* as the most commonly landed species at Axim, Apam, and Dixcove. Ofori-Danson et al. (2019) also reported *S. attenuata*, *S. clymene*, *L. hosei*, and *S. bredanensis* as the most landed species at Axim while Ghana Wildlife Soceity (2020) reported *S. clymene* and *S. longirostris* as the most abundant. The variability in landings could be an indication that some species are declining in numbers over time. From the current study, fishermen reported a decline in cetacean catch landings over the years (69.9%). Most marine mammal landings were recorded at Dixcove with Shama recording the least numbers. The low numbers recorded were because fishers were unwilling to volunteer information due to recent enforcement that led to the arrest and imposition of a fine on culprits to serve as a deterrence, thereby making the fishermen hide their catches or butcher them at sea.

According to a study by Ghana Wildlife Soceity (2020) Shama was the second community after Dixcove with the highest cetacean landings (26%), which shows the extent of cetacean exploitation in this community. The values obtained for species diversity, evenness and richness show that the species are diverse and almost evenly distributed off the coast of Ghana.

5.2 Fishing Gears, Mesh Sizes Utilized and CPUE Data for Marine Mammal

The gear with the highest cetacean landings was DGN as reported by this and other studies (Van Waerebeek & Ofori-Danson, 1999; Debrah et al., 2010; Van Waerebeek et al., 2014; Ofori-Danson et al., 2019; Ghana Wildlife Soceity, 2020). The catch per unit efforts (CPUE) was highest in August and September which coincides with the upwelling season where small pelagic landings are high. Debrah (2000) also reported August and September as the month with the highest cetacean landings. Cetaceans were usually landed with targeted species of DGN gear such as the yellowfin tuna (*Thunnus albacares*), skipjack tuna (*Katsuwomis pelamis*), Atlantic bigeye tuna (*Thunnus obesus*)], swordfish (*Xiphias gladius*), sailfish (*Istiophorus platypterus*), blue marlin (*Makaira nigricans*), blue shark (*Prionace glauca*), oceanic manta ray (*Manta birostris*) and hammerhead sharks (*Sphyrna* spp.) (Debrah et al., 2010; Ghana Wildlife Soceity, 2020).

Fishermen used varying mesh sizes during fishing; for example, a typical fishing gear had at least 2 to 4 meshes of different mesh sizes to ensure that different fish species can easily be caught by the gear during fishing (opportunistic fishing). The gear and mesh size used in fishing significantly influence the capture of cetaceans as they are vulnerable to mesh sizes above 7.62 cm. Purse seine set fishermen reported that large cetaceans tore huge portions of their nets during their escape, thus, they hardly capture them as compared to DGN where they are usually vulnerable. The small-scale fisheries of many countries are comprised mainly of gillnet fishers (Temple et al., 2018; Bielli et al., 2020). This fishery often has high by-catch landings of threatened species such as sharks, sea birds, sea turtles and small cetaceans (Lowry et al., 2018; Temple et al., 2019; Campbell et al., 2020; O'Keefe et al.,2021).

Globally, the gillnet fishery is a major threat to cetacean conservation as it is one of the major causes of death as reported in other studies in Asia, Latin America, and Africa (Mintzer et al., 2018; Segniagbeto et al., 2019; Castro et al., 2020; Marina et al., 2021). During the study period some observations were made on the state of cetacean carcasses landed on the beaches. There were visible deathly injuries inflicted by a locally manufactured hand harpoon made of iron rods called "Karma" which was purposefully developed for the deliberate exploitation of small-sized cetaceans (Van Waerebeek et al., 2014; Mintzer et al., 2018; Campbell et al., 2020). Fishers usually claim that cetaceans landed were found dead in fishing gear, however, during the study two pantropical spotted dolphins were brought alive to shore on 5th August, 2022 in Axim and butchered. Illegal Unregulated and Unreported (IUU) fishing could be one of the major contributing factors to cetacean by-catch (FAO, 2018b) because of its negative impact on the food security and livelihood of several people worldwide (FAO, 2020).

5.3 Feeding Habits of Cetaceans and its Influence on Their Exploitation

The stomachs of the cetaceans were examined to ascertain whether their diet (prey preference) overlaps with the target species of fishermen, thus, making them vulnerable to the fishing gear. The stomachs examined showed presence of Atlantic flying fish (*Cheilopogon melanurus*), Tuna (*Thunnus* spp.), Jacks and pompanos (*Caranx* spp.), Atlantic tripletail (*Labotes surinamnsis*), Parin's spinyfish (*Diretmichchthys parina*) and cephalopods with the majority being Orangeback flying squid (*Sthenoteuthis pteropus*) which constitute the main landings of DGN fishers. These findings show that there is an overlap between prey preference of cetaceans and target species of fishermen especially on fishing grounds. Fishermen confirmed during an interview that the Atlantic flying fish was used as an alternative bait source for sharks, thus, their presence in the diet might not necessarily mean they are a preferred prey item for cetaceans.

Previous studies showed the presence of tuna species but no cephalopods in DGN landings because fishers share cephalopods caught among themselves and are sold separately from the main landings (Debrah et al., 2010; Van Waerebeek et al., 2014; Ghana Wildlife Soceity, 2020). This is because money generated from the sale of cephalopods belongs solely to crew members and not the canoe owners, thus, cephalopod landings are hidden and not accounted for. This practice downplays the contribution of cephalopods to the DGN fishery because the actual numbers caught are not reported (Van Waerebeek et al., 2014; Ofori-Danson et al., 2019; Ghana Wildlife Soceity, 2020).

5.4 Demographic Information, Gears Deployed by Fishers and Income Generated from Catch Landing

Fishers in the survey used various fishing gear such as DGN, purse seine net, bottom set net, set gill net, and hook and line (Ghana Wildlife Soceity, 2020). Most fishers were married men who had primary or no formal education with an average of 6 (SD = 4) dependents as also observed by Eshun et al. (2019), Ghana Wildlife Soceity (2020) and Maulidah and Setiawan (2022) in Indonesia. The number of dependants influences household expenditure and financial burden and might lead to poverty (Maulidah & Setiawan, 2022).

Fishermen from this and other studies show their heavy dependence on fishing as their main source of livelihood (Eshun et al., 2019; Amadu et al., 2021; Maulidah & Setiawan, 2022). The majority of fishers earned between 10 – 500 Cedis when the catch is high with some making losses or earning between 2 – 500 Cedis when the catch is low, which shows that most fishers are living in poverty (Daulay et al., 2019; FAO, 2020; Maulidah & Setiawan, 2022).

5.5 Interaction Between Fishers and Cetaceans on Fishing Grounds

Fishermen from the four communities (98.5%) reported seeing cetaceans during fishing activities (Ghana Wildlife Soceity, 2020) and mostly during January, February, June, July, August, September, and December with the most frequently sighted species being *Stenella longirostris* and *Stenella clymene* which corresponds to those reported by other studies (Debrah et al., 2010; Ofori-Danson et al., 2019). Fishermen confirmed that cetaceans were mostly landed during August, September, December, and January although, Debrah (2000) reported August and September as the months with the highest landing of cetaceans.

Cetacean landings over the years were reported to be declining and this might be a result of a decrease in their population abundance due to anthropogenic factors and climate change (Afoakwah et al., 2018; Nelms et al., 2021). The decrease in catch might also be due to arrests made by the Fisheries Enforcement Unit of the Fisheries Commission of Ghana on fishers who were caught with cetaceans at the various landing beaches and Axim during the stranding of the school of *Peponocephala electra* (Groves, 2021; Ofori-Danson et al., 2022). Majority of fishermen in this study have captured cetaceans during fishing, however, they reported that it was mostly incidental (Mintzer et al., 2018). A study by Castro and Van Waerebeek (2019) showed that the capture of cetaceans incidentally in fishing gear is a major cause of mortality globally. Field data collection of cetaceans during this study, showed physical injuries caused by harpoon indicating that some were targeted (Mintzer et al., 2018). Because the capture of cetaceans is illegal (Segniagbeto et al., 2019) it is possible that fishers claimed catches as incidental, utilized carcasses as bait at sea and discarded evidence of harvest in fear of being arrested. The illegal nature of the practice makes studies and reporting difficult often leading to underreporting (Mintzer et al., 2018) because fishers are unwilling to voluntary information.

Fate of by-Caught and Targeted Cetaceans

The results from the study show that the use of dolphins as bait was very prevalent among DGN fishermen who engage in shark fishery even though there is legislation prohibiting the capture or landing of by-caught cetaceans (Fisheries Act 625, 2002). Temple et al. (2018) report that the gillnet and longline fishery account for the majority of cetacean catch because is inexpensive simple, very effective and widespread among fishers. The practice of using cetaceans as bait in the shark fishery has also been reported in Latin American countries such as Ecuador (Castro et al., 2020), Peru (Campbell et al., 2020), Brazil (Barbosa-Filho et al., 2018), Mexico and Venezuela (Mintzer et al., 2018); indo-pacific countries including Philippines and Taiwan (Mintzer et al., 2018) and other African countries including

Nigeria, Senegal and Ghana (Segniagbeto et al., 2019). The use of small cetaceans as bait in the crab and catfish fishery has also been reported in Tierra del Fuego and Peru, although, the practice has proven unsustainable and a threat to many marine mammals (Mintzer et al., 2018).

In Ghana, the use of cetaceans as bait in some coastal communities including Apam has been reported since the 1900s (Van Waerebeek & Ofori-Danson, 1999). The use of dolphins as bait might also be widespread in other fishing communities where dolphins are caught as by-catch as reported by this and other studies (Debrah, 2000; Debrah et al., 2010; Ofori-Danson et al., 2019; Ghana Wildlife Soceity, 2020). The study showed that DGN fishermen who used longlines preferred cetacean meat and blubber as bait because of its effectiveness, low price, and availability as also reported by Campbell et al. (2020). Fishers reported that cetacean meat when used as bait is durable on the longline, can be used repeatedly without disintegrating and easily attracts sharks because of its strong odour, abundant blood, and fatty nature (Barbosa-Filho et al., 2018; Mintzer et al., 2018; Segniagbeto et al., 2019).

Fishermen used the skin, blubber and muscles of small-sized cetacean as bait in the DGN fishery (Barbosa-Filho et al., 2018), although, there are other alternative bait sources like tuna, mackerel, sardines, pork and beef. Short-snouted and long-snouted spinner dolphin was reported as the most preferred bait source (Mintzer et al., 2018) while the pilot whale was the least preferred bait source. Fishermen used only small-sized cetaceans as bait because they do not fetch much when sold at the shore (Ofori-Danson et al., 2019); the price of a large cetacean equals that of billfishes such as sailfish and marlin (Debrah et al., 2010). Apart from using cetaceans as bait (cutting them at sea or storing them in a fridge for the next fishing trip), some were brought to the shore and sold to fish mummies, fish wives, and market women to be consumed locally (Mintzer et al., 2018; Ghana Wildlife Soceity, 2020) or sold to other DGN fishers for bait. The sale of cetaceans depended on the species, size, and market demand. Canoe owners were the ones who sold and benefited from the sale of cetaceans and shark fins.

5.6 Influence of High Premix Fuel Prices on Utilization of Marine Mammals as Bait

Fishermen complained bitterly that the shortage of premix fuel had negatively influenced their fishing activities and forced them to buy vehicle fuel or premix fuel that has been hoarded by certain members of the community which is almost four times the normal cost. DGN fishermen bought the highest number of fuel during fishing activities which might be a result of the long days spent at sea fishing and their canoe size. DGN fishermen explained the need to break even or earn profits from each fishing trip which has become almost impossible without the use of cetaceans as bait because of the declining fish stocks and the high cost of fuel. A study by Ghana Wildlife Soceity (2020) and Ofori-Danson et al. (2019) showed the dependence of some DGN fishermen on cetaceans as bait especially due to the declining small pelagic fish stock (Akpalu et al., 2018). DGN fishermen explained that catching sharks especially the higher qualities including the great white and hammerhead sharks ensures that they make a profit (fins are more expensive than other sharks) (Ofori-Danson et al., 2019). The demand for shark fins and high-cost fuel has led to the development of effective fishing gears and methods to enable them hunt small cetaceans effectively since the financial incentive is high (Debrah et al., 2010; Mintzer et al., 2018; Ofori-Danson et al., 2019; Segniagbeto et al., 2019; Campbell et al., 2020).

5.7 Knowledge on Laws Protecting Marine Mammal and by-Catch Reduction Strategies

Almost all fishermen (62%) had no idea about the National Fisheries Management Plan of Ghana (Ghana Wildlife Soceity, 2020), although, a few knew of the provisions made concerning marine mammals. Segniagbeto et al. (2019) also reported that fishermen from the Gambia were unaware of the legislation made for protecting marine mammals. This could be due to the high illiteracy rate and lack of public education and awareness of the fisheries management plan. Marine mammals, sharks and turtles although, protected by legislation due to their depleting numbers are still being exploited at alarming rates due to lack of education, weak laws and enforcement. About 71.1% of sharks and rays and 51 – 56% of turtles globally are threatened with extinction (Pacoureau et al., 2021; Rhodin et al., 2021). Marine mammals globally are faced with threats such as habitat loss, overexploitation, fisheries by-catch, pollution, and climate change causing at least 25% of the population to be threatened (Vulnerable, Endangered or Critically Endangered) (Kannan et al., 2005; Elliott et al., 2009; Ofori-Danson et al., 2019; Nelms et al., 2021).

When fishers were asked whether it was possible to stop using cetaceans as bait, majority (78%) thought it was impossible to stop using cetaceans as bait because of their effectiveness, strong odour, hardy and disintegrates slowly, low cost, and the fact that they are mostly found dead in the nets (Mintzer et al., 2018; Segniagbeto et al., 2019; Campbell et al., 2020; Castro et al., 2020). According to fishers, having cetacean carcasses before fishing directs them as to where to start fishing and ensure they don't make losses especially because fuel is very expensive. Some fishers expressed the need to modify the fishing gear and put in place spatial closures to minimize cetacean by-catch while others did not want to minimize cetacean by-catch because they didn't see any importance, despite, their contribution to carbon sequestration, nutrient cycling and bioturbation (Roman et al., 2017). Those who vehemently refused to minimize cetacean by-catch stated that cetaceans destroy their nets, feed on their catches and might lead to the decline and possible collapse of the shark fishery. Fishers claimed the sale of sharks was very lucrative (locally marketed as food) especially their fins because of their high export value due to demand from oriental countries. This has led to an increase in shark fishing efforts and landings (Debrah et al., 2010; Mintzer et al., 2018; Segniagbeto et al., 2019; Ghana Wildlife Soceity 2020).

However, some fishermen thought protecting marine mammals was important because it helps to locate schools of fish (Ghana Wildlife Soceity, 2020), provides direction and is crucial in ecotourism establishment. However, that can only be possible by introducing public education (Mintzer et al., 2018; Ghana Wildlife Soceity, 2020) and incentives which can cause behavioural change among fishers (FAO, 2018b; Mwango'mbe et al., 2021). Introducing dolphin watching activities will enhance community engagement and provide an alternative source of livelihood for fishers. From the interviews conducted, it is clear at the regional and national levels that current monitoring and management practices implemented are insufficient to ensure the sustainability of the artisanal fisheries and the long-term conservation of marine mammals.

Therefore, information on cetacean landings should be prioritised at the regional levels to determine the extent of exploitation.

The results from the survey showed an interrelation between sharks and cetaceans. Better management of the shark fishery or ban on the commercialization of shark fins will not only protect cetaceans but also the target species including the blue shark, great hammerhead, oceanic manta ray and shortfin mako sharks which are classified as near threatened, critically endangered, and endangered by IUCN (2019). Interviews with fishers showed their heavy dependence on cetacean as bait for the shark fishery, however, with the decrease in cetacean landings over the years it is likely harpooning of marine mammals may increase. In order to prevent this, public awareness in fisher communities must be increased and fishers motivated to change this practice through community-based management programmes and co-management (Mintzer et al., 2018). Introducing ecotourism can also help educate local communities and arouse their interest in engaging in practices that promote the conservation of marine wildlife and their environment rather than hunting them (Hoyt, 2021).

Strengthening cultural beliefs will also reduce the number of cetaceans used as food and bait (Ghana Wildlife Soceity, 2020). In the Volta region for example, it is a taboo to land small cetaceans and when a large cetacean is incidentally landed or washed ashore libations are poured and the cetacean is buried as they are considered gods, however, those in the Greater Accra, Central and Western regions do not have such taboos so they readily hunt them (Debrah et al., 2010). In the Maldives, banning shark fishing, trade and exportation of shark products led to a decline in the utilization of cetaceans as bait (Ward-Paige, 2017). The use the marine mammals as bait in New Zealand halted due to behavioural change (mass media education) and the implementation of laws protecting marine mammals (Mintzer et al., 2018). Implementing similar measures coupled with stringent laws protecting cetaceans will reduce their catches and subsequent use as bait. Implementing by-catch reduction technologies such as pingers or LED lights can reduce the availability of small cetaceans and their use as bait (Bielli et al., 2020). Also, partnerships between governmental organizations and fishing communities to develop and test by-catch reduction measures will help minimize exploitation levels (FAO, 2018a).

The population of most species of cetacean in West Africa remains unknown, thus, making assessment of the impact of this practice on their populations difficult. During the study, a by-caught sperm whale (*Physeter macrocephalus*) was landed at Axim and this species is considered vulnerable according to IUCN (2019). Fishers have been using small cetaceans as bait for at least 23 years, therefore, making the practice ingrained rather than a conscious practice, nevertheless, proper management of the shark fishery will concomitantly reduce cetaceans use as bait.

5.8 Knowledge of Cetacean Meat Containing Persistent Organic Pollutants

Almost all fishers had no idea about cetacean meat containing persistent organic pollutants (POPs). The majority were reluctant to consume cetacean meat after they were given proper education. Studies show that marine mammals are susceptible to pollution because of their long lifespan (Honda & Suzuki, 2020). These persistent organic pollutants can either bioaccumulate or magnify in their blubber, tissues or liver (Alava et al., 2020). Despite this, dolphins and whales are still caught and consumed locally either as dried, salted or smoked but these consumers are at risk of ingesting POPs accumulated in the dolphins. A study by Guo et al. (2019) showed that exposure to POPs can result in cardiovascular diseases, cancers, diabetes and disruption of the immune and endocrine systems. Another study by Sakyi et al. (2019) found high levels of persistent organic pollutants in *Stenella clymene* caught in Ghanaian waters.

5.9 Demographic Information, Fate of Cetacean Carcass and Income Generated from the Sale of Marine Mammals

Fish processors smoked or salted cetacean meat when available; especially during July, August and January but reverted to smoking tuna and other fishes when there are no cetaceans. Majority of fish processors smoked cetacean meat (90.1%) instead of salting (9.9%) after purchasing carcasses from fishermen (Segniagbeto et al., 2019).

A smoked piece of cetacean meat (0.72 kg) was sold at 5 Cedis (SD = 1.40 Cedis) while the salted version (cut into huge chunks) was sold at 50 Cedis. Fish processors reported that the meat was sold at markets in Sewei, Akroso, Swedru and Mankessim in the Central and Western region of Ghana and the meat was in high demand because it was cheap, palatable, tasty, fleshy, fatty and tastes like "goat" meat. Afoakwah et al. (2018) also reported that cetaceans were considered a delicacy by fishers in the Western region of Ghana, thus, implementing stringent laws and enforcement towards cetacean protection will halt the trade of cetacean meat in several coastal and inland communities.

CHAPTER SIX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

The research aimed at investigating how fishing and socio-economic drivers impacted on cetaceans along the coast of Ghana to help reduce fisheries by-catch and improve conservation strategies. Daily landings of cetaceans, fishing gears used, mesh sizes and lengths were recorded at landing beaches in Axim, Apam, Shama and Dixcove. In determining the socio-economic drivers of cetacean exploitation, structured questionnaires were developed in accordance with the purpose and research objectives of the study and administered using a simple random sampling technique for fishermen and a linear snowball sampling technique used for fish processors. Data on cetacean catch landings, trends, species composition, diversity, richness and feeding habits were provided. The study also provides information on the interaction between fishing and cetacean, the fate of by-caught and targeted cetaceans, finances of fishers and fish processors knowledge of laws protecting marine mammals and the presence of persistent organic pollutants in cetacean carcasses.

6.2 Conclusion

The fishing gear with the highest cetacean landings was the DGN with mesh sizes of 7.62 cm and above. Throughout the sampling period, the highest cetacean landings were recorded during August and September at Dixcove. The majority of the landings were adults from the family Delphinidae. *Stenella attenuata* (Pantropical spotted dolphin), *Lagenodelphis hosei* (Fraser's dolphin) and *Stenella clymene* (Clymene dolphin) were the most abundant species landed. Also, the majority of the landings were females (77.4%). Examination of stomachs collected from the field showed that marine mammals are likely feeding on the same species targeted by DGN fishers thus, resulting in their capture. There was the presence of lethal injuries on cetacean carcasses landed which confirmed the presence of a targeted fishery. Fishers confirmed the utilization of small-sized cetaceans as bait while larger-sized ones were sold as “marine bush meat”, however, they reported a decline in cetacean landings over the years. The sale of the cetacean carcass or use as bait is a very lucrative venture among fishers and drives the continuous exploitation of cetaceans. Fishers reported that the high cost of premix fuel had adversely affected their livelihood and increased the rate of cetacean exploitation as bait for the shark fishery due to the demand and high price of shark fins. Also, the majority of fishers denied knowledge of laws protecting cetaceans and the presence of persistent organic pollutants in cetacean carcasses. The drivers of cetacean exploitation were more economical than social. There is a ready market for fresh, smoked or salted cetacean carcasses either for baiting sharks or consumption at homes. Also, the inexpensive nature of smoked cetacean meat as compared with other smoked fish seems to be the driving force for the high demand for processed cetacean meat.

6.3 Recommendation

This study is the first to report on the influence of cetacean feeding habits and its vulnerability to fishing as well as the socio-economic drivers influencing their capture. Therefore, the following recommendations are drawn from the study:

I. Studies on cephalopods in the Gulf of Guinea are needed to understand cetacean diet.

II. The study showed an interrelation between sharks and cetaceans; thus, research should be conducted to determine the extent of the relationship since both species are threatened or vulnerable.

III. Studies on the implications of by-caught individuals on their larger populations and other important biological parameters should be investigated to determine their distribution in Ghanaian waters.

IV. Collection of national and regional data on cetacean landings is needed to determine the extent of distribution and exploitation.

V. Awareness creation and public education in fishing communities on laws protecting cetaceans will help reduce their exploitation.

VI. Introduction of community-based management programmes such as community-based dolphin ecotourism will advertently protect marine wildlife.

VII. Empowering the fisheries commission and marine police with sufficient financial and human resources will help increase enforcement efforts and compliance.

VIII. Extensive research should be conducted on the value chain of cetacean carcass landed.

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APPENDICES

APPENDIX 1

A picture of the baleen plates of a mysticete

A picture of the teeth of an odontocete

APPENDIX 2

1. QUESTIONNAIRE FOR FISHERMEN

PART 1: DEMOGRAPHIC DETAILS

1.Location, time and date

2. Level of education

a) No formal education

b) Primary

c) Secondary

d) Tertiary

3. Sex

a) Male

b) Female

4. Age …….

5. Marital status

a) Single

b) Married

c) Divorced

d) Widowed

6. Number of dependents………….

7. How long have you stayed in this community in years?

8. What is your main source of livelihood?

a) Fishing

b) Farming

c) Others (Specify) …………….

9. Do you have a secondary source of livelihood?

   a) Yes

   b) No

If yes kindly indicate?...................

PART II: SOCIO-ECONOMIC DATA

10. How long have you worked as a fisherman (in years) …….

11. What type of gear do you use in fishing?..........

12. Number of meshes and mesh sizes used (in cm)?........

13. Length of the fishing gears (in cm)? ………….

14. How many days do you fish within a week?

15. How many hours or days do you spend per fishing trip? ……………..

16. What type of fishes do you usually target?..........

17. Have you ever sighted marine mammals during fishing?

    a) Yes

    b) No

18. What months are marine mammals frequently sighted?

19. Which species are frequently sighted?................

20. What months are marine mammals frequently landed? ……..

21. In your own opinion do you think marine mammal catch over the years is increasing at the landing beaches?

    a) Yes

    b) No

    c) Don't know

22. Do you think the decline in small pelagic fish stocks has increased cetacean capture?

a) Yes

b) No

c) Don't know

PART III: SOCIO-ECONOMIC DRIVERS

23. Have you ever caught a marine mammal before?

a) Yes

b) No

If answer yes answer question 24 - 42

24. Was it incidental or targeted?

a) Incidental

b) Targeted

c) Both

25. How many marine mammals have you caught over a one-year period?

26. What percentage were incidental (by-catch)?.........

27. What percentage were targeted catches?..............

28. What did you use it for?

a) Discarded at sea

b) Used as bait for shark fishery

c) Brought to shore and sold

d) Consumed at home

e) Some sold and the rest consumed at home

29. In your opinion, what do you think is the main reason why fishers use cetacean meat in the shark fishery?

a) Price/cost (cheaper than other bait sources)

b) Availability

c) Bait effectiveness

d) Others …………….

30. Is there any particular species of marine mammals usually preferred as bait?

a) Yes

b) No

31. If yes, which species is that? …………..

32. Which body parts are usually used for baiting sharks?

a) skin

b) blubber

c) muscle

d) All the above

33. Apart from marine mammals which other alternative bait sources do you use for luring sharks? ………………..

34. Why do you use cetacean meat when there are other bait sources available? …………

35. Which people usually buy marine mammal meat?

a) Market women

b) Middle men

c) Others ……………………….

36. Have you sold marine mammal meat before?

a) Yes

b) No

37. How much is marine mammal meat averagely sold per kg?

38. How much do you make a month from selling marine mammal meat?.......

39. How much do you usually sell the different cetacean species caught?

Species	Small	Medium	Large
Long-snouted spinner dolphin *(Stenella longirostris)*			
Short-snouted spinner dolphin *(Stenella clymene)*			
Short-finned pilot whale (*Globicephala macrorhynchus*)			
Melon-headed dolphin (*Peponocephala electra)*			
Rough-toothed dolphin *(Steno bredanensis)*			
Pigmy killer whale *(Feresa attenuata)*			
Atlantic spotted dolphin (*Stenella frontalis)*			
Fraser's dolphin (*Lagenodelphis hosei)*			
Pantropical spotted dolphin (*Stenella attenuata)*			
False killer whale (*Pseudorca crassidens)*			
Common bottlenose dolphin (*Tursiops truncatus*)			

40. How much do you sell shark fins per kg? ………..

41. How much do you averagely make a month from selling shark fins?................

42. Is marine mammal meat in high demand?

a) Yes

b) No

c) Don’t know

43. Do you think premix fuel influences fishing activities?

Strongly Agree (1)	Agree (2)	Neutral (3)	Disagree (4)	Strongly Agree (5)

44. How often do you get premix fuel for fishing activities?

a) Very often

b) Less often

45. How much does a gallon of premix fuel cost averagely?

46. How many gallons do you usually buy for a fishing trip?

47. In your own estimation how much do you make averagely from a fishing trip

a) When catch is high ………….

b) When catch is low…………….

48. In your own opinion do you think the increase in fuel has contributed to the exploitation of cetaceans as by-catch to offset cost?

a) If yes why?.................

b) If no why? ………….

49. If you were to be given an incentive to release cetaceans caught at sea:

i. Will you land them to be sold as bush meat?

a) If yes why?.................

b) If no why?.....................

ii. Will you use them as bait for the shark fishery?

a) If yes why?..................

b) If no why?..................

FISH PROCESSORS

PART 1: DEMOGRAPHIC DETAILS

1. Location, time and date

2. Level of education

a) None

b) Primary

c) Secondary

d) Tertiary

3. Sex

a) Male

b) Female

4. Age (in years) …………

5. Marital status

a) Single

b) Married

c) Divorced

d) Widowed

6. Number of dependents…………

7. How long have you stayed in this community? ……………

8. Main source of livelihood?

a) Fish smoking

b) Others …………….

9. Do you have a secondary source of livelihood?

a) Yes

b) No

- If yes what?

PART II: SOCIO-ECONOMIC DATA AND DRIVERS

10. How long have you been processing fish (in years)?

11. Have you ever bought marine mammal meat?

a) Yes

b) No

12. What did you use it for?

a) Smoked

b) Salted

c) Traditional medicine

d) Others (Specify)

13. Averagely how many marine mammals do you buy each week for processing

14. What is the average cost of one animal?

18. How much do you averagely sell marine mammal meat on the market (per kg)?

- Or a piece of smoked marine mammal meat ……………

15. How much profit do you make a month from selling marine mammal meat?

a) <100 Cedis

b) 100 - 190 Cedis

c) 200 - 290 Cedis

d) 300 – 390 Cedis

e) 400 - 490 Cedis

f) >500 Cedis

16. Is there a specific month where marine mammals are landed in high quantities?

a) Yes

b) No

c) Don't know

17. If yes, in which month?

19. Is marine mammal meat in high demand on the market?

a) Yes

b) No

20. If yes, why do you think it in high demand?

21. In your opinion why do you think people choose to eat marine mammal meat?

KNOWLEDGE ON CETACEAN PROTECTION AND PERSISTENT ORGANIC POLLUTANTS (POP'S)

1. Do you know about the National Fisheries Management Plan of Ghana?

a) Yes

b) No

2. If yes, do you know about the provisions concerning marine mammals?......................

3. Do you think fishers can stop using Cetaceans as bait?

a) Yes

b) No

- If "Yes" reasons why?............
- If "No" reasons why?............

4. What do you think can be done to minimize marine mammal by-catch?

a) Gear modification

b) Spatial closures (Breeding or nursery habitats)

c) Both

d) Others …………….

5. Do you think protecting marine mammals is important?

a) Yes

b) No

If yes, why? ……………………..

If no, why? ……………………..

6. What do you think can be done to strengthen marine mammal protection?

a) Public education

b) Punishment

c) Enforcement

d) Incentives

e) Others …………………

7. Do you know about marine mammal meat containing persistent organic pollutants?

a) Yes

b) No

8. Will you still consume marine mammal even after knowing it contains persistent organic pollutants?

a) Yes

b) No

c) Don't know

9. Is there anything else you would like to say?

APPENDIX 3

Month	No. of cetaceans caught (N)	Canoes landed (C)	CPUE (N/C)
Apr-22	7	6	1.167
May-22	6	6	1
Jun-22	2	2	1
July-22	1	0	0
Aug-22	21	15	1.4
Sep-22	16	10	1.6
Oct-22	3	3	1