Taxonomy, Exploitation and Conservation of Dolphins in the Marine Waters of Ghana.

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DECLARATION

I, Joseph Sefah Debrah do hereby declare that this thesis consists entirely of my own work and that no part of it has been presented for a degree elsewhere.

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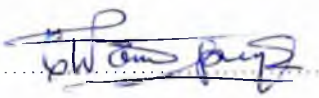

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DEDICATION

This work is dedicated to my late mother, Madam Gladys Abena Somuah, whose motherly care and the discipline she instilled in me has enabled me to attain this level of academic excellence. May her soul rest in perfect peace.

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ABSTRACT

Little is known about dolphins present in Ghanaian coastal waters. Taxonomic status, catch rate, and impact of the fishery on these animals, are areas, which have remained virtually untouched by previous workers. The present study attempts to fill-in these gaps in knowledge. Studies conducted during 1998 –2000 revealed the presence of the following eight species in Ghanaian waters: *Stenella clymene, Stenella attenuata, Steno bredanensis, Tursiops truncatus, Grampus griseus, Lagenodelphis hosei, Globicephala macrorhynchus, and Delphinus capensis*. *S. Chlymene* emerged as the most abundant species. Dolphin catches were low with peak period in August and September. Demand for dolphin meat for human consumption and bait for the shark fishery increased during the period of study. Though laws designed to protect and conserve dolphins exist on the Ghanaian statutes, little effort is made to enforce them. An educational programme, which would sensitize fisherfolk on the issue of conservation, is also absent. Morphological taxonomy proved very useful in discriminating between species of dolphins encountered but no single character was found to be suitable. A combination of morphological characters, however, proved most effective. It was difficult to use biochemical characters possibly because the *Delphinidae* family, exists as polymorphic form of the same species.

CHAPTER ONE

1.0 INTRODUCTION

Dolphins have low reproductive potential: they give birth to one calf at a time after a gestation period of 11 – 16 months. Females attain sexual maturity between 4 – 8 years and males, 6 – 12 years (Tavolga and Essapan, 1957; McBride and Kritzler, 1951; Kleinenberg, 1960; Essapian, 1963; Anderson, 1969). The International Union for Conservation of Nature (IUCN) includes dolphins in the list of animals which need to be protected on account of their low reproductive rate (Jefferson *et al.*, 1997). In the United States of America, dolphins are among 19 marine mammals listed under endangered species (Happold, 1987).

For dolphins to be rationally managed in Ghanaian waters, knowledge of certain aspects of their biology and population parameters is very essential. This study makes contributions in the areas of taxonomy, parasitic infestation (especially, degree to which it contributes to mortality), catch rate, and impact of the commercial fishery on the stocks. Methods of capture as well as the degree of utilization of dolphins as food by Ghanaians were also investigated. Finally, proposals regarding their protection and conservation have been outlined.

1.1 Taxonomy and distribution

1.1.1 World-wide

Dolphins are cetaceans which belong to the richest aquatic mammalian family, *Delphinidae*. The Delphinids are the most abundant and varied of the families belonging

to the Suborder Odontoceti. The family has undergone considerable adaptive radiation resulting in 17 genera and 34 species which are found in various habitats including the high seas, estuaries and tropical rivers (Webb *et al.*, 1979; Corbet and Hill, 1991).

The close taxonomic relationships among different dolphins have, however, been the source of many important taxonomic problems at the population, species and generic levels. For instance, it is more difficult to differentiate between separate dolphin populations than it is for large whales and pinnipeds (FAO, 1978). This, therefore, calls for more attention to be devoted to the study of the taxonomy of dolphins to enhance their management and conservation.

1.1.2 West Africa

A recent review of the species account of cetaceans in West African region from the Strait of Gibraltar to the Congo River indicated that there were 18 species of dolphins in the region (Jefferson *et al.*, 1997). The species included the following: *Orcinus orca, Globicephala melas, Globicephala macrorhynchus, Pseudorca crassidens, Feresa attenuata, Pepnocephala electra, Grampus griseus, Lagenorhynchus acutus, Steno bredanensis, Sousa teuszii*, (an endemic species), *Tursiops truncatus, Stenella attenuata, Stenella frontalis, Stenella longirostris, Stenella clyymene, Stenella coeruleoalba, Delphinus species* and *Lagenodelphis hosei*.

Apart from Senegal the identity of species of dolphins in the waters of most other countries in West Africa remain unknown (Van Waerebeek and De Smet, 1996). This unfortunate situation has been brought about by the fact that earlier workers in West Africa, most of whom were French scientists concentrated their research efforts in French speaking West African countries. Consequently, there is little account in the literature, on

catch rates, and biology of dolphins in marine waters of English speaking West African countries (Cadenat, 1959; Duguy, 1976; Maigret et al., 1986; Maul and Seargeant, 1977). Other factors, which have compounded the problem, have stemmed from difficulty in obtaining representative samples of carcasses, difficulty of studying dolphins at sea, paucity of local researchers, and limited resources for research work on dolphins in the sub-region (Van Waerebeek and De Smet, 1996; Perrin and Reilly, 1984).

Identification of species by early French researchers was based on only morphological and meristic characters. Owing to overlap and plastic nature of these characters, confusion still exists in the literature on the identity of a number of species (Jefferson *et al*., 1997). In the circumstances, it was considered worthwhile to explore for other methods in addition to the morphological characters, which could assist in improving the identification process. In this respect, the method, which was given due trial, was the use of starch gel electrophoresis (a biochemical method).

1.1.3 Ghana

The taxonomic status, as well as the distribution of dolphins in Ghanaian waters is not known even though researchers have indicated that there are dolphins in Ghanaian waters (Irvine, 1947; Ofori-Adu, 1987; Ofori-Danson and Agbogbah, 1995; Ofori-Danson and Odei, 1997). The occurrence of these aquatic mammals in our local waters is buttressed by the fact that local fishermen know them and have given them some local names such as *Adanseke, Etui, Fumelokploui and Atakpe,* whilst there have been reported cases of dolphins as by-catches and direct catches in drift gillnets and purse seines (Ofori-Danson and Odei, 1977; Maigret, 1994).

General lack of information on the taxonomic status, distribution and biological characteristics of dolphins in Ghanaian waters, could be attributed to lack of locally trained cetologists to identify the various species. The situation needs to be addressed to enable Ghanaian scientists to contribute to the present global effort aimed at conservation of these mammals (Van Waerebeek *et al.*, 2000).

1.2 Economic importance

The economic importance of the species includes the following: (i) their products such as oil are used for medicine and other products (FAO, 1978); (ii) few populations are the basis of large fisheries providing essential meat for local consumption (FAO, 1978), (iii) they form a significant element in marine ecosystems in all regions, both in terms of their biomass and their contribution to the secondary productivity of the oceans (FAO, 1978); (iv) they are excellent indicators of the presence of contaminants in the sea since they are at the top of the aquatic food chain (FAO, 1978) and (v) since dolphins are carnivores which feed on mainly large molluscs (mostly octopus and squid) and fishes (mostly tuna, salmon and herring), their presence in an area in the sea serves as a good indication of the presence of these prey organisms. In the eastern tropical Pacific for instance, local fisheries exploit this relationship to locate target species (Van Waerebeek and Reyes, 1994a). (vi) The high level of intelligence exhibited by dolphins has made it possible for them to be trained for man's own benefit and pleasure (FAO, 1978). They have been trained to work for man in several ways including (a) participation in military activities (for instance: Bottlenose dolphins have been trained to locate and recover personnel and equipment lost at sea during military operations) and (b) they can entertain people with their admirable diving and swimming skills and their aerial displays. These

attributes which are the source of considerable pleasure to man have tended to attract tourists to their site, thus contributing substantially to the development of ecotourism (FAO, 1978).

1.3 Conservation of dolphins

1.3.1 World-wide

The Bonn Convention on the Migratory Species of Wild Animals (CMS), which aims at conserving terrestrial, marine and avian migratory species throughout their range was the latest international convention to be signed by many nations to protect migratory species (including dolphins) within their range. Countries that are signatories to this Convention are required to protect dolphins within their territorial waters.

To ensure effective management and conservation of a resource, Mcneely *et al.*, (1990) and Pimm (1991) recommended a multi-disciplinary approach in collaboration with the exploiters. For dolphin conservation, such a program would mean the inclusion of the dolphin fishers in the overall management plan. Unfortunately, however, this has not been the case, as they are normally excluded in such plans. The result is that exploiters do not see the need to conserve these valuable animals.

1.3.2 West Africa

In West Africa, some countries such as Cote d'Ivoire, The Gambia and Ghana have enacted various legislations designed to protect dolphins as well as other marine mammals. These laws are however, not strongly enforced (Jefferson *et al.*, 1997).

In Senegal, the Ministry of Fisheries Decree No. 97-1044 of 18 August 1987 declares that cetaceans of all species and sizes are protected. Consequently, mere

possession of the cetacean carcass is even unlawful. This has also prevented biologists from obtaining data on mortalities of dolphins and other cetaceans caught accidentally as the fishermen try to hide such animals or refuse to give any information about them. In The Gambia, there is currently no specific legislation regarding the conservation of cetaceans. However, the 1977 Fisheries Act requires that license for fishing within the 200 nautical miles (nm) is obtained. Further, the license should specify the species to be fished, the equipment to be used and the method of exploitation to be adopted (Van Waerebeek, 1998). Even though this is to ensure that all the living resources within the 200 nm are protected, the law is too general to protect dolphins and other cetaceans.

1.3.3 Ghana

In Ghana, dolphins as well as other marine mammals are protected under the Wildlife Conservation Regulation 1971 (Legislative Instrument (L.I.) 685). This L.I., which has been enacted to embrace all marine mammals, does not adequately protect dolphins in particular, from wanton exploitation. Another weak point in this L I., so far as dolphin conservation is concerned, is the unclear usage of the term, "wildlife" Two governmental agencies, Fisheries Department and Game and Wildlife Department, one of whose responsibility it would have been to see to the implementation of the provision, interpret the term differently. The Fisheries Department cannot see their way clear in implementing a provision, which comes under wildlife (for that matter, under Game and Wildlife Department) in the ocean. The consequence is that, though a party to the Bonn Convention, Ghana has not been protecting some of the migratory species of wild animals (including dolphins) in its territorial waters as terms of the Convention stipulate.

1.4 Exploitation of Dolphins

1.4.1 Worldwide

Exploitation of dolphins is common worldwide; dolphins are intentionally or accidentally captured (Jefferson *et al.*, 1997; IWC, 1994; Northridge, 1984; Van Waerebeek and Reyes, 1994b). Notwithstanding this, mortality estimates have been determined for only a few geographical areas. These include the eastern tropical Pacific (FAO, 1978) and some southern American countries, such as Peru, Chile and Ecuador (Van Waerebeek and Reyes, 1990; Van Waerebeek, 1994; IWC, 1994; Aguayo, 1975; Bello, 1997; Felix and Samaniego, 1994). Even though a ban has been imposed on the exploitation of dolphins and other cetaceans in these countries, the exploitation of the cetaceans has not completely stopped. There is evidence that people are still clandestinely catching and trading in dolphins (Van Waerebeek and Reyes, 1994b). For example: The Peruvian Ministry of Fisheries estimated that in 1985 around 10,000 dolphins and porpoises were killed (IWC, 1994; Read *et al*, 1988; Van Waerebeek and Reyes, 1994b).

In Ecuador, it was estimated that 227 Bottlenose dolphins, *Tursiops truncatus* representing 9% of the resident population were annually caught (Bello, 1997).

Overall, little effort is globally put into conservation of dolphins even though organizations like United Nations Environment Program (UNEP) in collaboration with Centre for Migratory Species of Wild Animals has been creating much awareness on the issue.

Culture has played a significant role in the conservation of dolphins. In countries, where there are taboos against capture or consumption, people normally avoid catching dolphins and thus indirectly help in their conservation. For instance, the Bijagos and

Balante ethnic groups in Guinea-Bissau consider dolphins as sacred and thus would not eat them (Tous, 1977). On the other hand, in some countries where it is believed that dolphin meat has some therapeutic qualities or its eating confers certain spiritual powers on an individual, their exploitation rate is high. For example: In Japan it is believed that a dolphin eyeball contains some memory-enhancing, properties; consequently a single eyeball sells for as much as 40 US dollars. This high economic value has tended to considerably enhance the exploitation rate of the species in Japanese territorial waters (Mirror (Gh), August 29,1998).

1.4.2 West Africa

In West Africa, rate of exploitation of fin-fish has been outpacing growth in human population. To close the gap, there has been increasing demand for other marine animals hitherto little used for food (Maigret, 1994; IWC, 1994). Among these are dolphins, which are now captured in places where they were formerly little targeted for by fishers (IWC, 1994).

Though dolphins are commonly consumed as a source of mammalian protein in many West Africa countries, there are unfortunately no mortality estimates available in any of these countries, and there is scanty data on cetaceans and the fishery impact on cetaceans in the Gulf of Guinea (Mitchell, 1975 and Northridge, 1984). Furthermore, Maigret (1994) in his review of records of dolphin captures in Ghana, Togo, Benin, Nigeria, Cameroun, Equatorial Guinea, Sao Tome and Principe, Gabon and Congo-Brazzaville observed that there were no details of possible dolphin captures. The earlier French biologists who worked in West Africa, gave indication of the presence of dolphins and other marine mammals and their exploitation by local people for food (Cadenat,

1959; Dupuy and Maigret, 1976; Maigret *et al.*, 1976; Maul and Seargeant, 1977; Maigret, 1986). They also indicated that some were caught for research work while others were involved in strandings. They, however, did not give details of the numbers involved in this fishery (Cadenat, 1959; Dupuy and Maigret, 1976; Maigret *et al.*, 1976; Maul and Seargeant, 1977; Maigret, 1986).

1.4.3 Ghana

In Ghana, though evidence exists that culture has influence on the conservation of dolphins, this has not been thoroughly studied. Among the Ewes, it is a taboo to eat or land dolphins and offenders are seriously punished (pers comm. with local fishermen in Anloga and Keta). This measure helps to conserve dolphins.

1.5 Objectives

The general lack of published information on small cetaceans including dolphins in West Africa, has prompted a collaborative research between Marine Education and Research (MER) of United Kingdom and the United Nations Environment Programme (UNEP) Centre for Migratory Species of wild animals (CMS) with headquarters in Bonn, Germany. This collaboration is popularly known as UNEP/CMS-WAF Project. Its primary objective is to improve the management, scientific knowledge and conservation of cetaceans in the West African sub-region. The project also aims at training local biologists that will help in collecting information on small cetaceans, especially dolphins. Unfortunately, as of now, Ghana is not included in this project. There is, therefore, the need for her to conduct her own local research on dolphins as well as other cetaceans to enhance their effective management and conservation.

Following from the above, this study has been designed with the primary objective of providing baseline information on taxonomy, distribution and some aspects of biology of dolphins in Ghanaian coastal waters.

Specific objectives of this study include:

I Determination of the taxonomic status of dolphins in the Ghanaian waters.

II Assessment of the catch rates of dolphins in two selected coastal towns, Apam and Shama, which are well known for dolphin capture and marketing of dolphin meat.

III Identification of the various methods of capture.

IV Determination of the extent of utilization of dolphin meat.

V Assessment of the preference for dolphin meat.

VI Investigation into some aspects of the biology including the peak periods of dolphin capture and their common parasitic infestations.

VII Identification of the extent of awareness of the need to protect and conserve dolphins by the local fishermen.

CHAPTER TWO

2.0 METHODOLOGY

2.1 Study area

Three coastal towns, Kpone in the Greater Accra Region, Apam in the Central Region, and Shama in the Western Region (Fig.1) were selected as sampling sites. The selection was made after the preliminary survey of the coastal towns revealed that these towns had history of dolphin catches. Apam and Kpone also had the added advantage of being closer to Accra and would consequently reduce time and cost that might be involved in transporting field samples to the Water Research Institute of Council for Scientific and industrial Research (CSIR) in Accra for studies. Apart from these towns, information on dolphins such as species account, pictures of dolphins caught and numbers caught were also collected from towns like Dixcove and Axim in the Western Region.

2.2 Interview with local fishermen on dolphin exploitation and conservation.

Forty people were randomly selected from each of the three coastal towns: Apam, Shama and Kpone. These included ten women (dolphin processors) and thirty fishermen. This was based on preliminary survey, which reflected the relative numbers of men and women involved in catching and processing of dolphins respectively.

Appendix I shows the questionnaire used in conducting the interview.

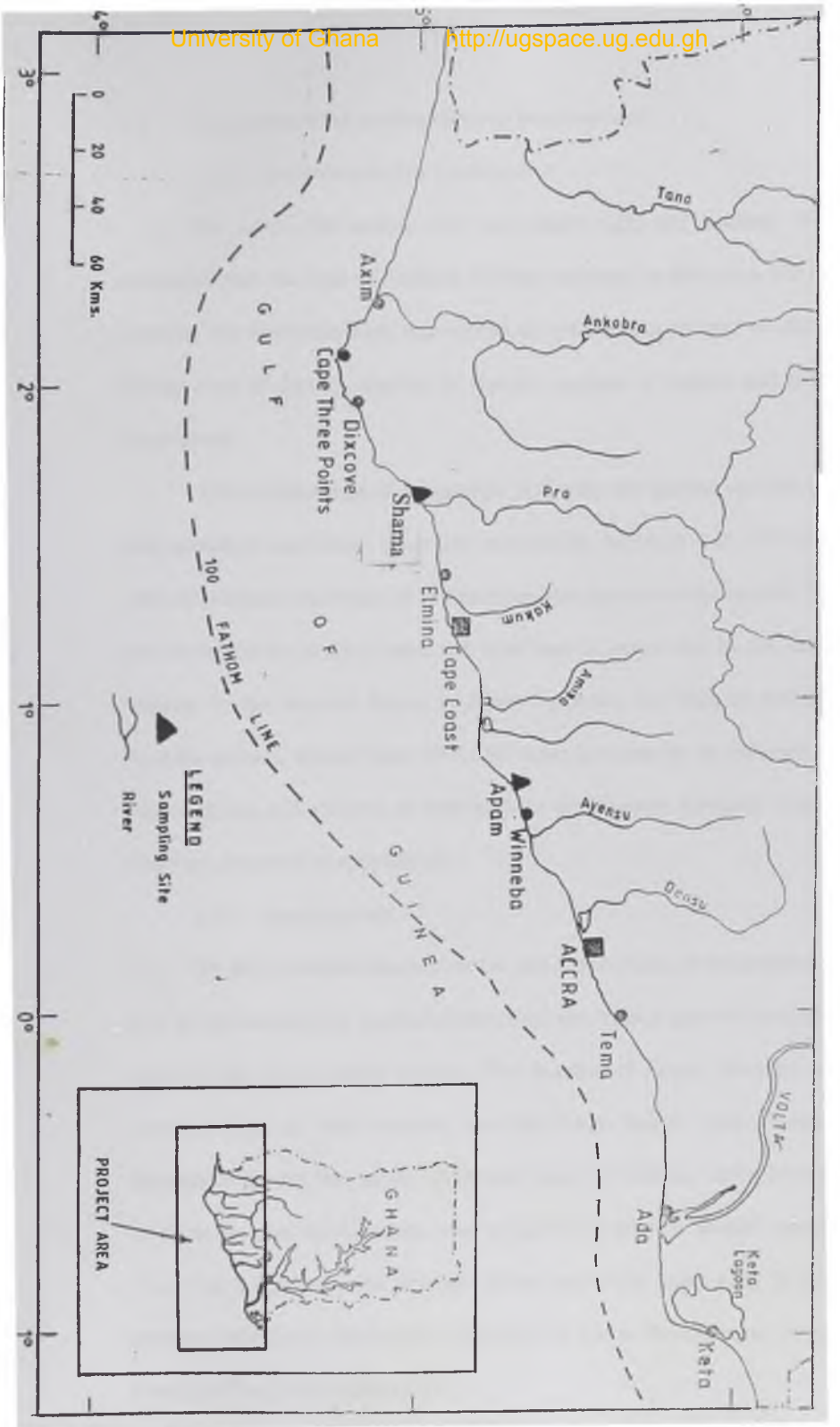


Figure 1. Coastal map of Ghana showing sampling towns.

2.3 Monitoring of fish landing sites and beach surveys

2.3.1 Monitoring at fish landing sites

The Apam fish-landing site was visited daily and landings of dolphins monitored with the help of Fisheries Officers stationed in this town. On landing of dolphins, the fishermen were interviewed for information on time of departure for fishing, time of capture, method of capture, location of capture and time animals were landed.

The dolphins were also examined to identify the species, sex and numbers of each species in each canoe using keys provided by Jefferson *et al.*,(1993) as well as with my personal experience of certain taxonomic features of the species. Data were then compiled on monthly basis and later used to assess the annual catch rate of dolphins by the artisanal fishery in Apam (Appendix II). Data on dolphin catches from the artisanal fishery, from 1995-1997 were provided by the Fisheries officers at Apam, Shama and Dixcove as well as from the Fisheries Research Unit at Tema. These are presented in appendix III.

2.3.2 Beach surveys

To aid in the determination of the taxonomic status of the dolphins as well as give an indication of the level of exploitation, the skeletal parts of the dolphins were searched for, during beach surveys. The beaches of Apam, Winneba and Kpone were surveyed at three monthly intervals (i.e.in March, June, September and December). During the survey, all skeletal parts of dolphins, either from strandings or those captured by fishermen were sought for. Distances usually covered ranged from 2 to 5 km along the beaches. These were done either early in the morning between 0600 hours GMT and 1000 hours or late in the afternoon between 1500 hours GMT and 1800 hours GMT.

2.4 Identification, collection and preservation of samples

Complete carcasses of dolphins landed at Apam were measured for total length in centimetres. Thereafter, for identification purposes, pictures of whole animals, dorsal and lateral aspects were taken. The specimens were then initially identified using skin colour patterns, the general body shape as well as shape of the snout, position and relative size of dorsal fin and flippers (Perrin *et al.*, 1981). The meristic character used for identification was tooth counts (the number of teeth per row in both the upper and lower jaws). In difficult cases, keys provided by Jefferson *et al.*,(1993) was consulted.

Fresh dolphin heads and stomachs were bought from the local fishermen and preserved in a deep freezer at Apam for about a week. They were later transferred to the Water Research Institute (WRI) of the Council for Scientific and Industrial Research (CSIR) where they were further kept in a deep freezer and later studied in the laboratory for cranial measurements, meristics (tooth counts). Allozyme studies on muscular tissues were also done. For the allozyme studies, about 10 g of the muscle from the back of the head of each specimen was removed and kept in vials to be homogenised later for the gel electrophoresis (allozyme studies).

2.5 Preparation of skulls

The skin (blubber) and most of the other tissues around the head that could be removed were all removed from it with the help of a kitchen knife. The brain tissues were scooped out of the skull with the help of a spoon. The head, at this stage, was exposed to air to allow houseflies to lay their eggs on it for about three hours. The head was then kept in a partially perforated polythene sack (to allow air in) and buried for 14 days to ensure that all remaining tissues on the skull were eaten

up by the larvae from the houseflies or were completely decomposed. The skulls were then exhumed, washed thoroughly with water and dried in the sun for three hours or more depending on the intensity of the sun. The dried skulls, lower jaws and the teeth of the individual specimens were labelled and stored in polythene sacks; camphor was added to help reduce odours that might be associated with the skulls. The skulls were then kept in open shelves in a storeroom for cranial measurements and other morphological observations.

2.6 Morphological Taxonomy

2.6.1 *Cranial measurements*

30 cranial measurements per one skull were taken in millimetres with the help of a measuring tape and dial callipers to the nearest 0.5 mm accuracy following the method of Schnell *et al.*,(1982). Measurements taken included the following: Condylobasal length (CBL), Rostrum length (RL), Rostrum width at base (RWB), Rostrum width at 6 cm from the base (RW6B), Rostrum width at 1/4 length from the base (RW1/4L), Rostrum width at 1/2 length from base of rostrum (RW 1/2 L), Rostrum width at 3/4 length from base (RW 3/4 L), Premaxillary width at 1/2 length from the base (PREW 1/2 L), Tip of rostrum to internal nares (TRIN), Tip of rostrum to external nares (TREN), Temporal fossa length (TFL), Temporal fossa width (TFW), Orbit length (ORL), Antorbital process length (AOPL), length of upper tooth-row (LUTR), length of lower tooth-row (LLTR), Preorbital width (PROW), Post-orbital width (POW) , Zygomatic width (ZYGW), Parietal width (PAW), Greatest width of premaxillaries (GWPMX), Width of internal nares (WINTN), Width of external nares (WEXN), Ramus length (RAML), Ramus height (RAMH), Height of braincase (HBRC), Length of braincase (LBRC), Maximum

width of palatines (MWP), Maximum span of occipital condyles (MSOC) and the Maximum width of nasals (MWNAS). Figure 2 shows a sketch of some of the cranial measurements taken.

2.7 Cranial maturity

Cranial maturity of the specimens were also determined to separate juvenile skulls from the matured ones so as to avoid including data on juveniles in the general data for analysis; this examination also helped to assess the relative ages of the dolphins caught. Here the fusion of the various elements or sutures of the skull were considered. The fusion of the sutures were based on a three point scale of zero (0), one (1) and two (2) after Van Waerebeek (1993) and Robineau *et al.*(1994), as follows:

0 implies there was no fusion between the bones or elements concerned and the individual cranial bones can be moved more freely.

1 implies there was limited fusion and suture line was clearly visible at all points.

2 implies there was advanced fusion of the suture with at least partial obliteration of suture line.

Skull fusions that were considered included the premaxillary and maxillary fusion (PRMX-MX), the mandibular symphysis (SYM), pterygoid-basoccipital (PT-BAS), frontal-occipital, the zygomatic elements, pterygoid-palatine and lacrymal. The overall assessment of a cranially mature specimen was based on the advanced fusion (scale 2) of the frontal-supraoccipital suture or advanced fusion (scale 2) in at least two of the seven defined cranial sutures after Van Waerebeek (1994).

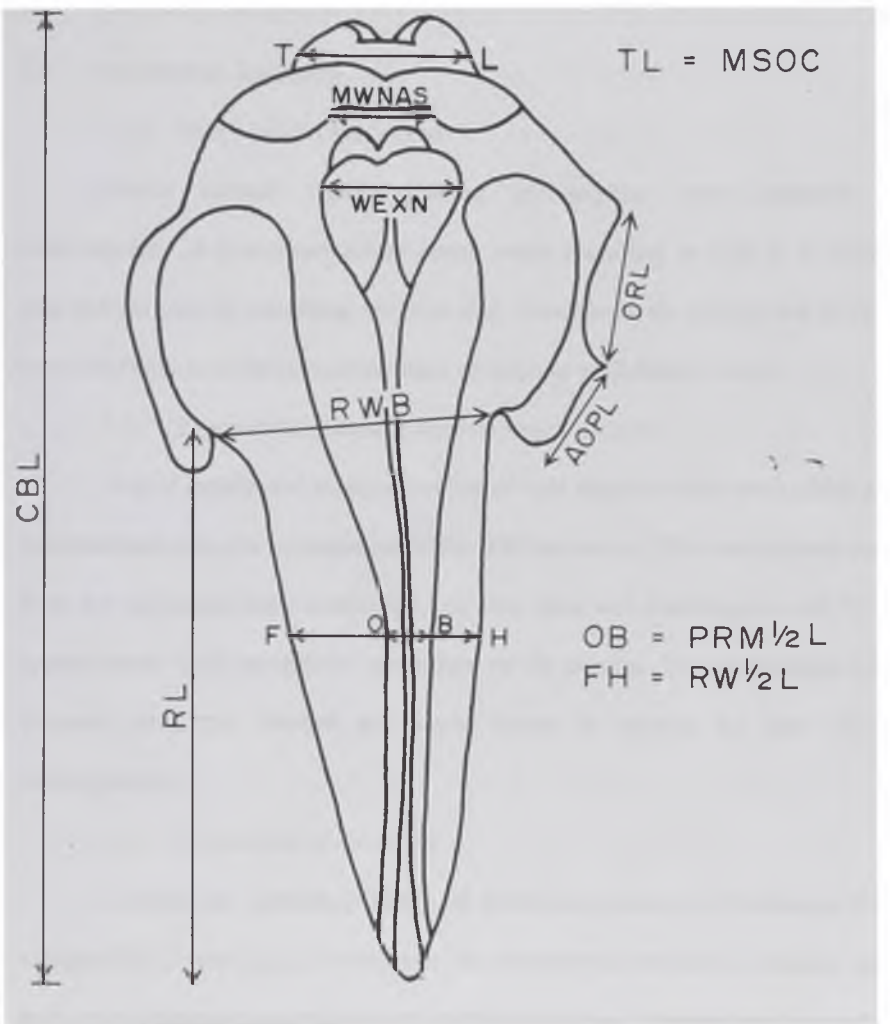


Fig. 2 A SKETCH OF SOME CRANIAL MEASUREMENTS

2.8 Meristics

Tooth counts were made using the number of alveoli (sockets where teeth fit in jaws). Counts were made for the number of alveoli in the upper left (NAUL), upper right (NAUR), in the lower right (NALR) and in the lower left (NALL) after Perrin *et al.*(1981).

2.9 Biochemical Taxonomy

2.9.1 Starch gel electrophoresis

Soluble skeletal muscle proteins of dolphins were subjected to electrophoresis in hydrolysed potato starch media according to Falk *et al.*,(1996) with the purpose of identifying loci that may discriminate the species and provide some information on the taxonomic status of dolphins in Ghanaian waters.

2.9.2 Preparation of soluble skeletal muscle proteins

10 g of muscle and an equal volume of cold distilled water were added and homogenized using the homogenizer of the WRI laboratory. The homogenized paste from the specimens were transferred into test tubes and centrifuged at 40 ^{0}C at approximately 4000 revolutions per minute for 30 minutes. The supernatants were decanted into vials, labelled and stored frozen as samples for later use in electrophoresis.

2.9.3 Preparation of starch gel

A single gel containing 12.5% of hydrolysed potato in Continuous-Tris-Citrate (CTC) buffer, pH 8.0 was used. The mixture was heated in a Buchner flask held over a bunsen burner flame with continous swirling. Heating was stopped as soon as the first big bubble appeared at the bottom of the flask. The gel was then quickly degassed using a vacuum pump, and poured into a mould previously set, and

covered with a glass plate. The gel was allowed to set and cooled at room temperature between 3-4 hours after which it was incubated in a refrigerator for 3-12 hours.

2.9.4 Loading of the gel

A horizontal incision, of about 4.0 cm from the lower end of the gel was made. The supernatants (from different specimens) were adsorbed on strips of 0.33 mm Whatman chromatography paper and arranged along the upper cut surface of the gel. Specimens of known proximate protein mobilities were included on new gels to indicate relative positions of new samples on gel. The cut surfaces of the gel were then pushed into place (with the samples between them). A spacer was pushed into the gel former together with the samples to ensure very close contact of samples to gel. The 'loader" gel was placed over a buffer tray containing an electrode buffer (Continuous-Tris-Citrate (CTC) pH 8.0). A wick was stretched gently over each end of the gel with enough of it immersed in the tray buffer. A thin polythene film was stretched over the gel to prevent dehydration of the gel during electrophoresis and a glass plate was placed over it. Iced packs were then positioned on the glass plate as coolants.

2.9.5 Electrophoresis

Buffer tray (with contents) was placed in a refrigerator and the terminals of tray were connected to a power supply unit (negative terminal relatively nearer to the samples). The Ammeter and Voltmeter were adjusted to about 50 amps and 160-200 volts DC respectively. The amperage and voltage readings were checked after 20 minutes to ensure that set values were constant. The duration for electrophoresis ranged between 5 to 6 hours depending on the power supply conditions.

2.9.6 Slicing of gel After the electrophoresis, the gel was trimmed, and the anode end of on the side of the 'specimen 1'cut off to indicate orientation of specimen prior to slicing. A Buchler gel slicer with a gauge of 2 mm was used to horizontally slice the gel into 2 mm slices.

2.9.7 Staining of gel

A staining mixture produces bands on this principle: a substrate (in the mixture) forms a colourless product with enzyme (in the gel from the tissue sample). This colourless product then couples with a salt (also in the mixture) to give out coloured bands at positions where the enzyme(s) being stained for have migrated during the electrophoresis of the samples. Staining recipes that were used were similar to those used by Shaw and Prasad (1970). The slice of gel (cut surface up) was placed in a staining tray and the staining solution poured on them. The staining trays (containing the gel) were placed in a warm-air incubator at 37^0C for enzymes to stain. The stain was washed off with tap water when the staining solution (yellowish in colour) began to turn black or when the bands could be read on the gel, and a fixing solution was then added.

2.9.8 The enzymes studied

The 12 enzymes studied were Alcohol dehydrogenase (ADH), Lactate dehydrogenase (LDH), Malate dehydrogenase (MDH), Octanol dehydrogenase (ODH), Sorbitol dehydrogenase (SDH), Glycerol-6-phosphate dehydrogenase (G6PDH), Xanthine dehydrogenase (XDH), Malic enzyme (ME), α-Glucose-phosphate dehydrogenase (α-GPDH), 6-Phosphoglucose dehydrogenase (6PGDH), Isomerase dehydrogenase (IDH), and Esterase (EST).

The following are abbreviations for these compounds in the staining recipes:

NAD- Beta-nicotinamide adenine dinucleotide

MTT- 3- (4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazoliumbromide

PMS- N-methyldibenzopyrazine methylsulphate salt, phenazine methosulphate

EDTA-Ethylenediamine tetra-acetic acid.

2.9.9 Staining recipes for the enzymes studied

Table 1 shows staining recipes for the enzymes studied.

Table 1. Staining recipes for the enzymes studied.

6PGDH		**ODH**	
6-Phosphogluconic acid	10 mg	NAD	15 mg
NADP	5 mg	MTT	6 mg
MTT	5 mg	Octanol	0.75 mls
Tris-Hcl PH 8.0	40 mls	Tris HCl 0.2M, PH 9	30 mls
PMS	Trace	PMS	Trace
EST		**MDH**	
Fast blue RR(BB)	20 mg	L-Malic	150 mg
α-naphthyle acetate	2 mls	MTT	6 mg
Tris maleate PH 5.3 (Incubate gel in it for 30 minutes)	30 mls	NAD	10 mg
		Tris	600 mg
α-GPDH		PMS	Trace
NAD		Water	30 mls
MTT		**ME**	
α-Glycerophosphate		DL Malic acid	60 mg
EDTA	15 mg	NADP	10 mg
PMS	7 mg	$MgCl_2$	10 mg

Tris-HCl PH 8.0	20 mg	MTT	7 mg
IDH		PMS	Trace
Sodium isocitric acid	50 mg	Tris-HCl	30 mls
Magnesium chloride	10 mg		
NADP	4 mg	**LDH**	
MTT	7 mg	NAD	15 mg
PMS	Trace	MTT	7 mg
Tris-HCl	30 mls	Sodium lactate	1 ml
SH		PMS	Trace
NAD	15 mg	Tris-HCl	30 mls
MTT	7 mg	**XDH**	
D-Sorbitol, Sigma	150 mg	Hypoxanthine	20 mg
$MgCl_2$ $6H_2O$, Merck	10 mg	NAD	15 mg
PMS	10 mg	MTT	7 mg
0.2M Tris-HCl PH 8.0	30 mls	PMS	Trace
G6PDH		Tris-HCl PH 8 0	30 mls
Glucose-Phosphate	10 mg		
EDTA	10 mg		
NADP	7 mg		
MTT	7 mg		
PMS	Trace		
Tris-HCl PH 7.1	3.3 mls		
Water	30 mls		

2.9.10 Recording of allozymic data

Since stained bands fade with time, the record patterns of allozymes produced after electrophoresis and staining were recorded diagrammatically for later analysis.

2.10 Examination of parasitic infestation in guts of dolphins

Ten stomachs of three species of dolphins caught were dissected and examined for possible internal parasites. There were 8 guts for *Stenella clymene,* 1 for *Steno bredanensis*, and 1 for *Grampus griseus.* Each of the guts studied was divided into three portions: (i.) the stomach, (ii.) the small intestine and (iii) the large intestine. The contents of each section were washed with distilled water into a 250 ml beaker. The parasites were identified using the guidelines provided by Price (1932), Baer (1954), Yamaguti (1958), Skrjabin (1961) and Arnold (1973) as well as with the help of experts from the Water Research Institute of CSIR, Accra.

2.11 Treatment of data

2.11.1 Methods of capture and gears used in dolphin capture

Data on gears used and methods of capture from sampling stations were carefully collated from answers from the interviews conducted as well as those from personal observation in the field.

2.11.2 Catch data

Catch data for the study period were used to plot a graph to reflect monthly distribution of dolphin catches as well as calculate total annual catches for the sampling stations and the relative abundance of dolphin species encountered are presented in Figure 4.

2.11.3 Craniometric data and meristics

Means, ranges and standard errors of cranial measurements and meristics (tooth counts) of individual species were calculated and presented in Tables 3, 4, 5 and 6. Values obtained were compared with those of the same species from Senegal in West Africa and Peru in South America. This was done to check whether values obtained from the same species in Ghana fall within the range of values obtained in another West African state as well as those from other continents. This would help to confirm the presence of the same species in Ghana or to determine whether there was any geographic variation in the species concerned.

2.11.4 Cranial proportion variables

Means, ranges and standard deviations of 8 cranial proportion variables of each of the species were calculated to check whether they could be used to discriminate species. These proportion variables included the following: (i) RL/LBRC, (ii) HBRC/RL, (iii) RWB/CBL (iv) RL/CBL (v) WEXN/LBRC (vi)WINTN/LBRC (vii) HBRC/CBL (viii) RL/ZYGW. In addition to these the ratio of all measurements taken were calculated as a percentage of the condylobasal length (CBL) after Perrin *et al.*,(1981) and Perrin and Mead (1994). Comparisons of the values of the means and ranges of the different species were made to identify which variables could be used as discriminatory characters among the species.

2.11.5 Allozymic data

(a) Allelic frequency obtained from results of various enzyme loci were used to estimate the genetic differences between species.

The frequency of an allele was estimated by the formula:

(2H+He) / 2N (Ferguson,1980),

Where: H= Number of Homozygotes for that allele, He= Number of heterozygotes for that allele and N= Number of individuals examined.

(b)The band patterns of the enzymes at the various loci were also used to discriminate the various species as well as establish phenetic relationships among species.

CHAPTER THREE

3.0 RESULTS

3.1 Interviews with local Fishermen

Table 2 shows the results of the interview conducted.

Table 2.
Interviews with local fishermen and their responses.

Question	Response
Species of dolphins seen:	65%: 2 species, 20%: 3 species and 15%: 4 species.
Local names of species of dolphins:	*"Etui eko"* (Parrot-like beaked dolphin), *"Etui papa"*(Real dolphin), *"Etui Sebo"* (Spotted dolphin). *"Fumelokploui"* is the general name for dolphin in *Ewe* and *"Adanseke"* general name for dolphins by the *Gas*.
Taboos associated with capture and eating of dolphins:	There are no taboos associated with the capture and eating of dolphins by the *Gas* and *Fantes* but a taboo by the *Ewes*.
Gears for dolphin capture:	The commonest gear is the drift gillnet (DGN). Implements such as swords, wooden bars and cutlasses are used in weakening captured dolphins before retrieving them from nets on landing.
Incidental capture of dolphins with target species:	Dolphins are usually captured with target species such as sharks, sardinella, tunas and swordfishes.
Seasonality of dolphin capture:	The capture is seasonal and coincides with the *Sardinella* season. The capture occurs throughout the year with peak captures starting from June and reaching the peak in September or in October. This also depends on the presence of fishermen to fish and capture the dolphins
Processing of dolphin meat:	It is cut into pieces and smoked for human consumption or salted and used as baits for sharks and other fishes.
Estimates of dolphins landed per canoe per year:	20-30 by 30% of respondents, 6-13 by 65% of respondents and about 50 by 5% of respondents.
Estimates of dolphins caught during peak season:	2-8 by 70% of respondents, 5-10 by 15% of respondents and 10-15 by another 15% of the respondents.
Preference for dolphin meat:	It varied from one locality to another. 35-60% of respondents liked the meat. Preference was lower at Kpone (35%) and highest at Shama (60%).
How costly was a complete fresh dolphin:	The market value varied from one locality to the other. The most expensive dolphin in Apam and Kpone with a total length of 300 cm or more could be sold for not more than 200,000 cedis. Dolphin of the same size could be sold for 300,000 cedis or more at Shama

Prices of dolphins compared to fishes of the same weight or size such as sharks and swordfishes:	85-90% of respondents in Apam and Kpone said they were cheaper than other fishes of the same size or weight. 10-15% said they were comparable with other fishes. In Shama, 60% of respondents claimed they were cheaper than other fishes whilst 40% said they were of moderate price.
Towns where smoked dolphin meat is marketed:	The smoked meat was marketed in major fish marketing centres along the coast such as Mankessim, Takoradi and Accra and in the hinterlands such as Kumasi, Bibiani, Asamankese, Akim Oda and Akim Swedru.
Awareness of need for dolphin protection and conservation:	Low awareness to protect and conserve dolphins among coastal fishing communities.
Enforcement of laws to protect dolphins:	Laws were not being enforced. No arrests were being made of people who caught dolphins or trade in dolphin meat.

3.2 Species composition and relative abundance

3.2.1 Species composition

Five species of dolphins were identifed in Ghanaian waters between 1998-1999 at Apam. Three other species were also identified at Dixcove and Axim in the year 2000. Thus, between 1998-2000, eight species of dolphins were encountered. None of these species has been identified before in Ghanaian waters. All the species belong to 1 family, *Delphinidae* and 7 different genera (Table 3 and Plates A-H).

Table 3. The genera and species of dolphins encountered in Ghanaian Waters during the 1998-2000 study period.

Genus	Species	Common name
Stenella	*clymene* (Gray,1850),	Clymene dolphin,
Stenella	*attenuata* (Gray, 1846)	Pantropical spotted dolphin.
Tursiops	*truncatus* (Montagu,1821)	Bottlenose dolphin.
Steno	*bredanensis* (Lesson, 1828)	Rough-toothed dolphin.
Grampus	*griseus* (Cuvier, 1812)	Risso's dolphin.
Globicephala	*macrorhynchus* (Gray,1846)	Short-finned pilot whale.
Delphinus	*capensis* (Gray, 1828)	Common dolphin.
Lagenodelphis	*hosei*(Fraser,1956)	Fraser's dolphin
Total: 7	8	

Plates A-H show the pictures of the 8 dolphin species encountered.

Plate A. *Stenella attenuata* (Pantropical spotted dolphin) caught in Apam waters on 25th September, 1998.

Dorso-lateral view

Lateral View

x 7/100

Plate B. *Tursiops truncatus* (Bottlenose dolphin) caught in Apam waters on 25th September, 1998.

Lateral View

Latero-Ventral View

x 3/100

Plate C. *Stenella clymene* (Clymene dolphin) caught in Apam waters on 4th August, 1999.

Dorso-Lateral View

x 1/10

Plate D. *Steno bredanensis* (Rough-toothed dolphin) caught in Apam waters on the 17th October, 1999.

Dorso-Lateral View

x 1/50

Plate E. *Grampus griseus* (Risso's dolphin) caught in Apam waters on 4th November, 1999.

Ventral View

x 1/25

Plate F. *Globicephala macrorhynchus* (Short-finned pilot whale) caught in Dixcove waters on the 15th August, 2000.

Ventral View

Plate G. *Delphinus capensis* (Common dolphin) caught in Axim waters on 8th September, 2000.

Dorso-Lateral View

38x x 3/50

Plate H. *Lagenodelphis hosei* (Fraser's dolphin) caught in Axim waters on 10th September, 2000.

Dorso-Lateral View

x30x

x 3/50

3.2.2 Relative abundance

Figure 3 is a pie chart showing the relative abundance of dolphin species encountered in the Apam waters in the 1998-1999 study period. From the pie chart, *S. clymene* is the most dominant species caught (68.5%). This is followed by *S. attenuata* and *Steno bredanensis* each with 11% relative abundance. In all 19 dolphins were caught made up of 13 *S. clyymene*, 2 *S. attenuata*, 2 *Steno bredanensis*, 1 *Tursiopsp truncatus* and 1 *Grampus griseus*.

3.3 Seasonal pattern of dolphin catches

Figure 4 shows pattern of dolphin catches in both Apam and Shama.

Data on the dolphin catches during the study period can be found in Appendix II.

Dolphin catches appeared to be seasonal. Catches started in August in Apam in 1998 and 1999 and reached a peak in September 1998 and November 1999 respectively. In Shama, catches started in March 1998 and January 1999 and reached the peak in December 1998 and March 1999 respectively. In both towns catches were made occasionally after the peak period till the year ended.

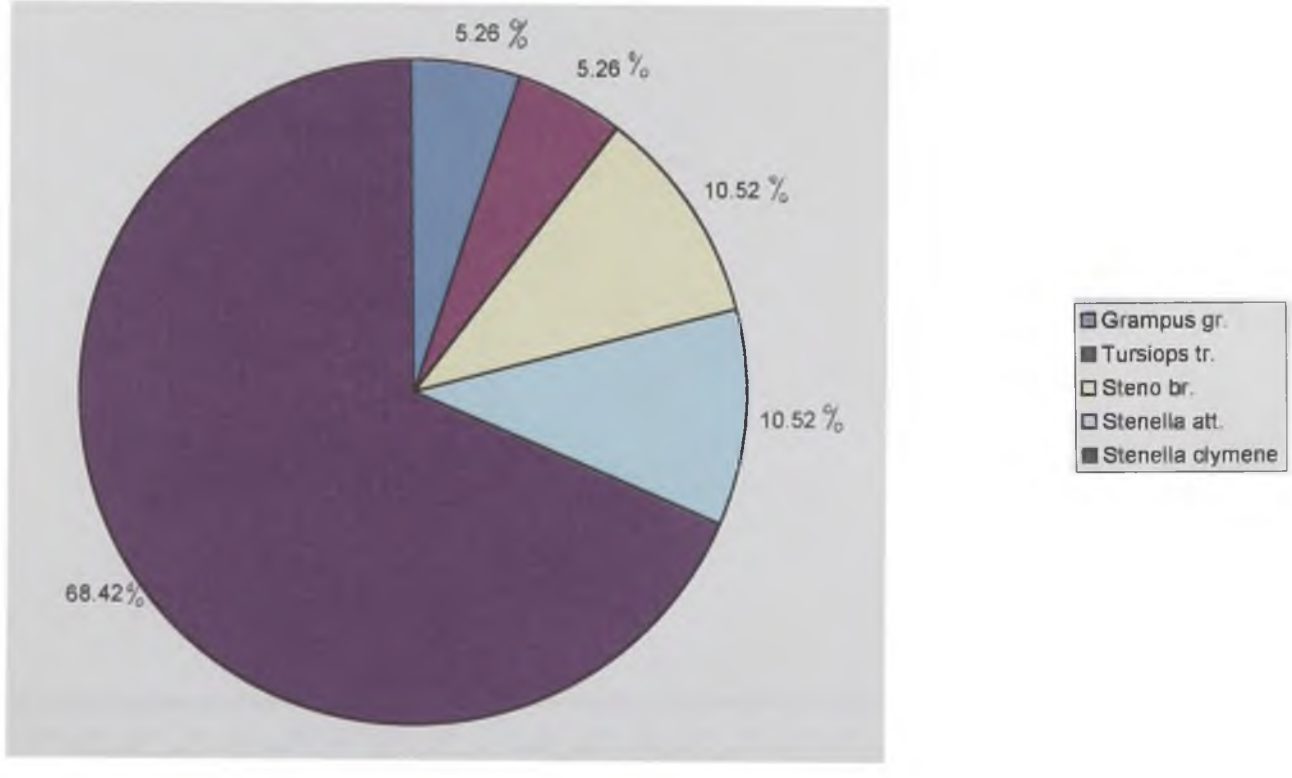
Drift gillnet (DGN) was the commonest gear used in dolphin capture but other implements such as spears, cutlasses and wooden bars were normally used in weakening the dolphins so that they can be removed from the net more easily before bringing them ashore to be processed for market and local consumption.

3.4 Beach surveys

No skeletal parts of dolphins were found on the beaches of Apam, Shama and Kpone throughout the period of this study.

Figure 3.

A pie chart showing relative abundance of 5 dolphin species encountered in Apam waters during 1998-1999 study period.



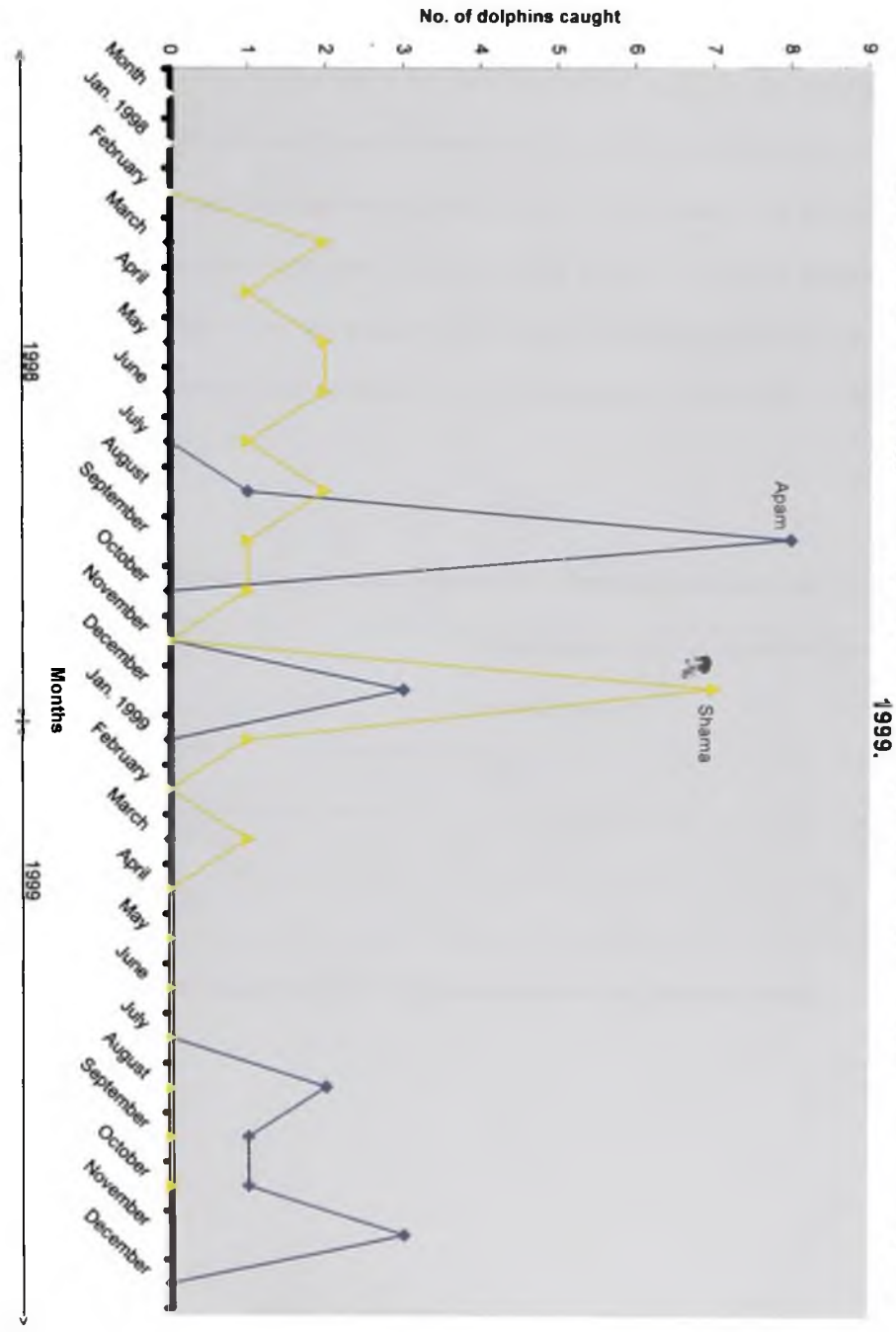


Figure 4.
A graph showing (monthly) seasonal pattern of dolphin catches in Apam and Shama during 1998-1999.

3.5 Parasitic infestation in guts

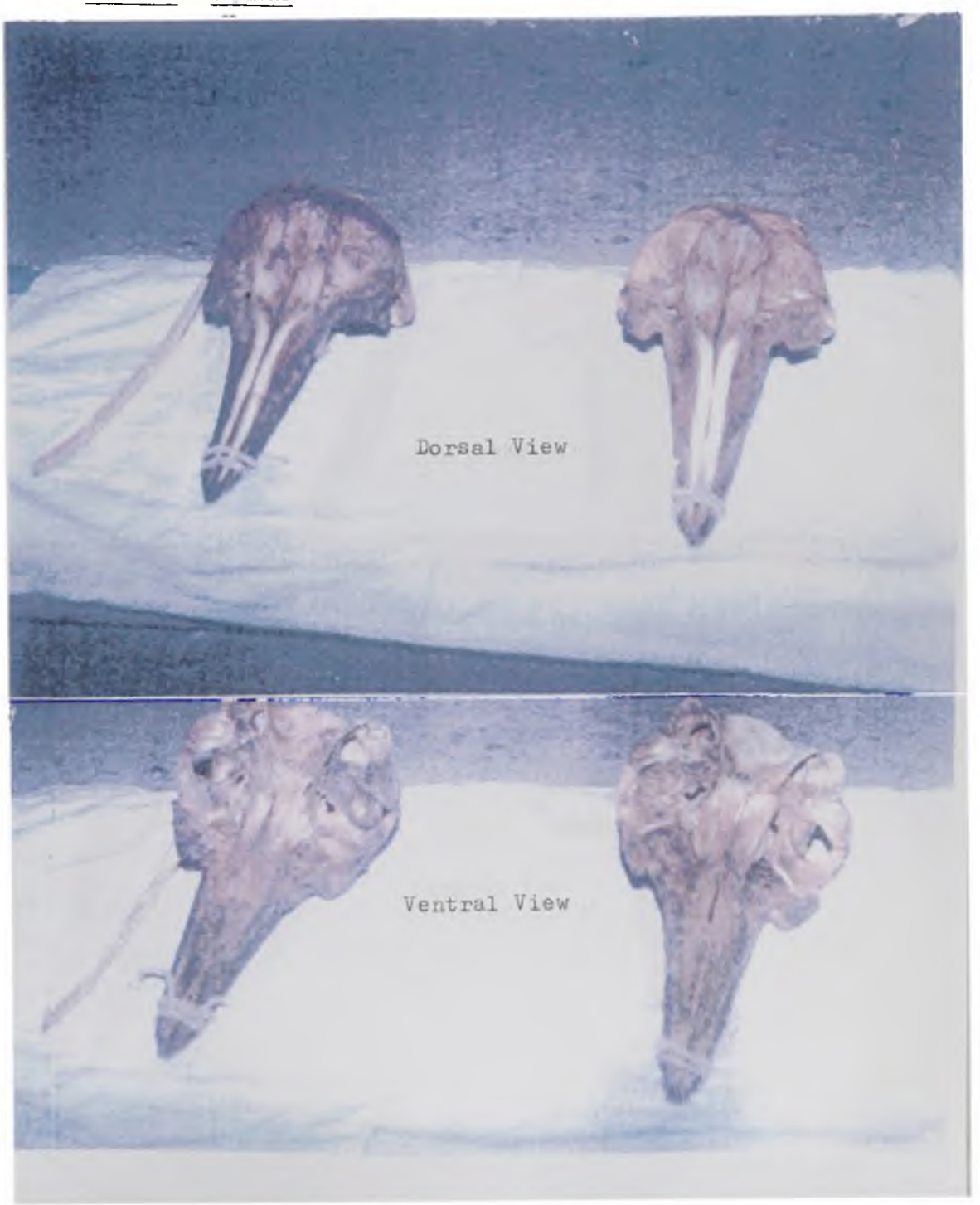
Out of 5 guts (3 for *S. clymene*, 1 for *Steno bredanensis* and 1 for *Grampus griseus*) only two from *S. clymene* were found infested with 213 and 40 nematodes respectively. These were identified as belonging to the genus: *Anisakis*. The parasitic load between these two dolphin species was compared to show which species was more susceptible to the nematode (Table 4). All the parasites were found in the fore-stomachs of the guts. This study, thus, showed low parasitic load in the dolphins encountered in the waters of Ghana.

Table 4. A table showing the parasitic load of 3 dolphin species examined for parasites.

Species	Total number of the parasites found in each species.
S. Clymene	253
Steno bredanensis	0
Grampus griseus	0

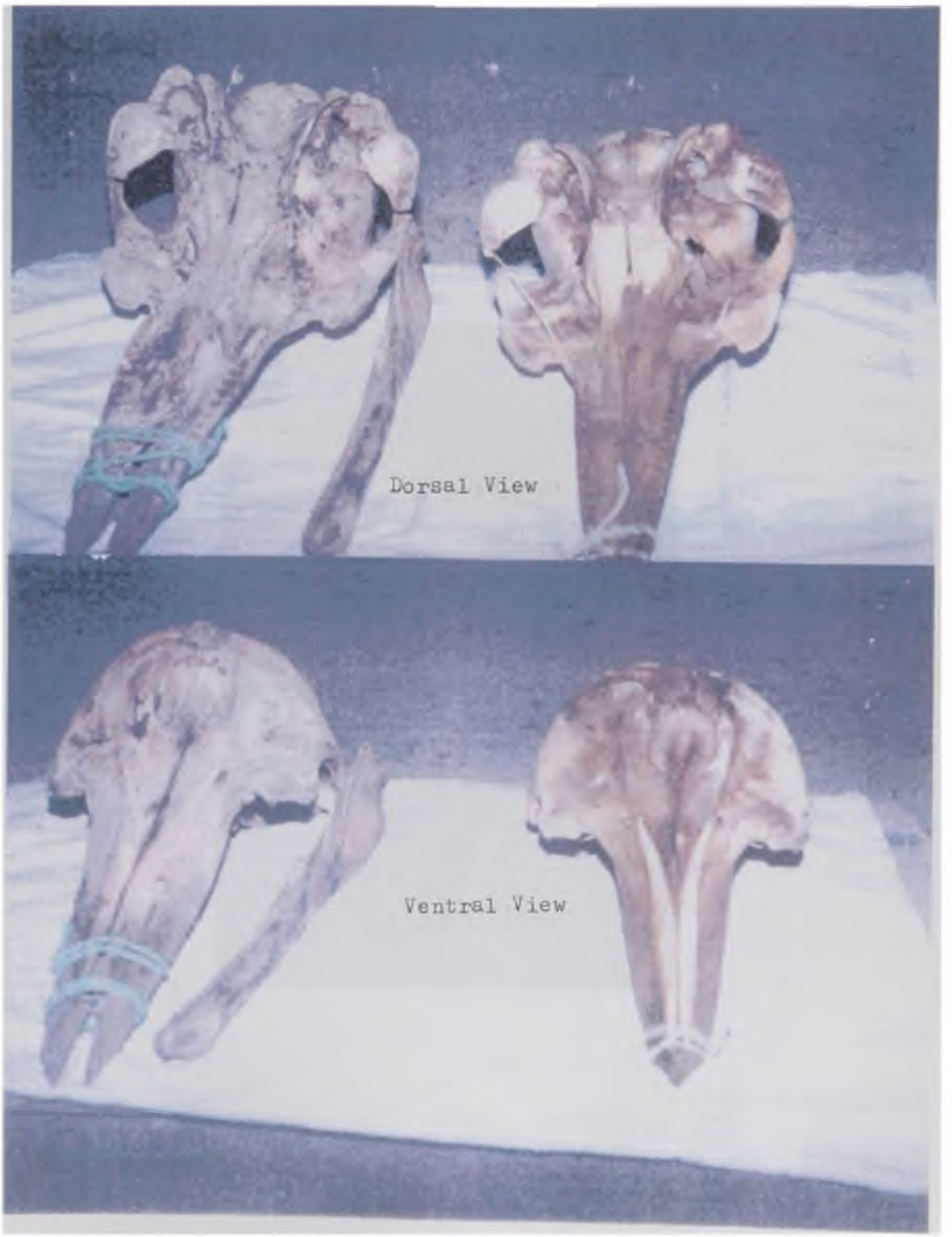
Plates I-M show typical skulls of dolphins encountered in Ghanaian waters.

Plate I. Picture of the skull of Stenella clymene



x 1/5

Plate J. Picture of the skull of Tursiops truncatus



xxxx

x 1/50

Plate K. Picture of the skull of Grampus griseus

Dorsal View

~~4x 5~~ x

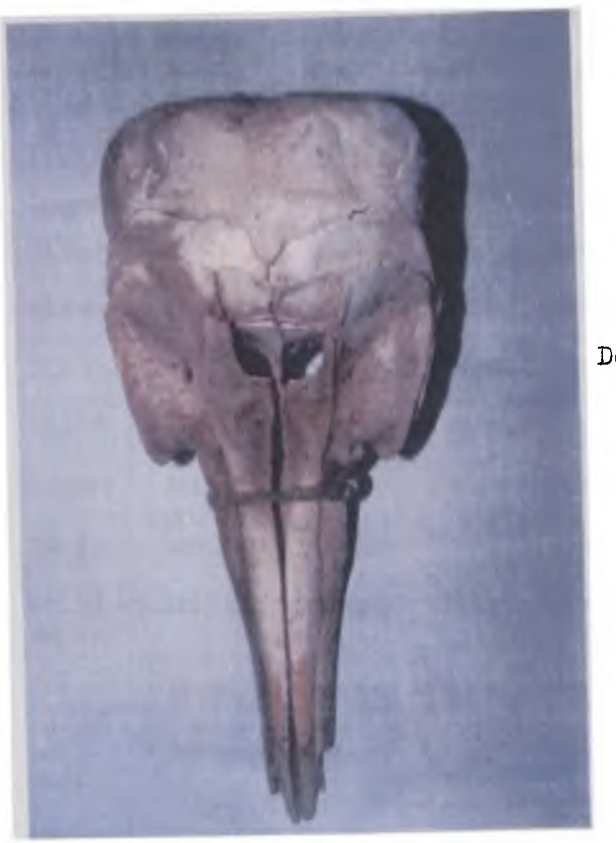
x 3/100

Plate L. Picture of the skull of Stenella attenuata

Dorsal View

x 3/100

Plate M. Picture of the skull of *Steno bredanensis*



Dorsal View

x 3/100

3.6 Morphological taxonomy

3.6.1 Cranial measurements

Table 5. Cranial measurements of dolphin species found in Ghanaian waters in 1998-1999 study period.

Species / Measurement (mm)	*Stenella Clymene* Mean(sd) n=10	Range	*Tursiops truncatus* Mean (sd) n =2	Range	*Steno bredanensis* **	*S. attenuata* **	*Grampus griseus* **
CBL	**366.7 (15.87)**	**347-386**	**505 (53.74)**	**467-543**	**395***	**383**	**416***
RL	**214.7 (11.21)**	**200-234**	**297.5 (36.06)**	**272-323**	**216***	**229**	**211***
RWB	**89.6(6.47)**	**81-102.7**	**135.8 (11.03)**	**128-143.6**	**81.5***	**84.5**	**148.4***
RW6B	**61.0(4.53)**	**53-65.8**	**99.1 (15.49)**	**88.1-110**	**65.1***	**56.4**	**117.5***
RW1/4L	**62.6(5.13)**	**52.1-67.9**	**93.6(11.46)**	**85.5-101.8**	**67.6***	**59.3**	**126.2***
RW1/2L	**50.2 (3.59)**	**42.6-54.6**	**78.35(9.40)**	**71.7-85.0**	**47.5***	**40**	**88.1***
RW3/4L	**38.2(3.39)**	**31.8-42.1**	**59.15(6.58)**	**54.5-63.8**	**31.9***	**30.3**	**66.2***
PRM1/2L	**25.4(3.13)**	**19-29.5**	**41.5(4.95)**	**38-45**	**30.8***	**22.7**	**61.1***
TREN	**261.8 (13.13)**	**242-281**	**348.5 (37.48)**	**322-375**	**251***	**274**	**281***
TRIN	**256.6 (10.75)**	**244-276**	**349(36.77)**	**323-375**	**260***	**274**	**264***
PROW	**156.7 (7.72)**	**145.3-169.5**	**222(11.31)**	**214-230**	**147.2***	**149.3**	**232***
POW	**177.5**		**253.5(6.36)**	**249-258**	**174***	**172.8**	**254***
ZYGW	**173.6 (7.45)**	**160.7-181.9**	**254.5(6.24)**	**245-264**	**170.2***	**172.2**	**255***
PAW	**141.1 (3.38)**	**134.7-145.2**	**181.8(7.35)**	**176.6-187**	**164.2***	**139.2**	**190.2***
GWPRM	**66.9(3.51)**	**64-74.2**	**90.6(2.12)**	**89.1-92.1**	**169.7***	**70.6**	**102.5***
WEXN	**41.2(1.99)**	**38.1-44.1**	**61.25(4.88)**	**57.8-64.7**	**46.9**	**41.4**	**54.4***

WINTN	**50.2(3.04)**	**44.3-54.5**	**67.9(5.73)**	**63.8-71.9**	**73.4***	**45.5**	**74.4***
TFL	**54.6(5.76)**	**46.1-62.8**	**110.1(7.21)**	**105-115.2**	**97.2***	**66.8**	**104***
TFW	**36.1(2.68)**	**31.7-38.9**	**83.9(4.81)**	**80.5-87.3**	**70.7***	**47.3**	**39.9***
ORL	**47.9(2.23)**	**45.1-51.6**	**64.05(3.89)**		**59.2***	**49.9**	**64.2***
AOPL	**43.1(2.74)**	**39.1-47.0**	**52.1(0.71)**	**51.6-52.6**	**27.3***	**38.6**	**37.6***
LUTR	**180.29 (10.96)**	**170-199**	**245(21.21)**	**230-260**	**176***	**190**	**58.2***
LLTR	**184.8 (5.03)**	**177.8-191**	**242.5 (24.75)**	**225-260**	**-**	**189**	
RAML	**314.3 (10.29)**	**300-330**	**341(97.58)**	**272-410**	**332***	**328**	**334***
RAMH	**57.8(2.30)**	**55.6-60.4**	**89.35(2.19)**	**87.8-90.9)**	**63.6**	**-**	**-**
HBRC	**104.9 (5.62)**	**94.1-110.6**	**220.25 (92.98)**	**154.5-286**	**132.4***	**107.7**	**158.7***
LBRC	**106.2 (4.38)**	**100.5 113.2**	**156.3 (17.96)**	**143.6-169**	**153***	**113.6**	**149.3***
MWPAL	**43.3(6.02)**	**33.9-55.9**	**53.9(6.08)**	**49.6-58.2**	**69***	**35.4**	**80***
MSOC	**78.2 (6.22)**	**63.3-86.7**	**96.4 (3.11)**	**94.2-98.6**	**102.1***	**77.1**	**80.4***

Legend: * cranially immature values. ** Single specimen measured (n=1).

Table 5 shows *Tursiops truncatus* as having the highest values for most of the measurements taken such as the condylobassal length (CBL), maximum width of nasals, length of rostrum etc. whilst *Stenella clymene* has the lowest in most of the measurements taken such as those of the condylobasal length, rostral length and maximum width of nasals. The small sample sizes of all the species could permit minimum statistical analysis such as mean and standard deviation on the various measurements. From Table 5, the measurement with the highest values for all the species was the CBL and it ranged from 366.7 mm in *S. clymene* to 505 mm in *Tursiops truncatus* whilst the measurement with the lowest values was the maximum width of the nasals (MWNAS) and it ranged from 33.91 mm in *S. clymene* to 60.9 mm in *Grampus griseus.* Even though the means for the measurements for the different species did not overlap, yet a lot of overlaps were observed in the ranges of different species for the same measurements. Differences were also observed in the means and ranges of values of particular measurements among the various species that could be used to discriminate the various species. For instance, in Table 5, the mean CBL of the 5 species could be used in discriminating them (366 mm for *S. clymene*, 383 mm for *S. attenuata*, 395 mm for *Steno bredanensis*, 416 mm for *Grampus griseus* and 505 mm for *Tursiops truncatus*).

Cranial measurements of dolphin species in Ghanaian coastal waters were also compared with those from other areas such as Senegal (West Africa), other localities in the Atlantic, Peru and Chile (South-east Pacific) where data were available Tables 6 and 7 show comparison between cranial measurements of dolphin species in Ghana with those in other geographical areas.

Table 6.Comparison of cranial measurements and meristics (tooth counts) of dolphin species in Ghanaian waters to those in other waters.

Species	*S. clymene (Ghana)		**S. clymene (Senegal)		***S. clymene (Atlantic)		Steno bredanensis *(Gh)	Steno bredanensis ****(Ch.)
Measurement (mm)	Mean(sd) n=10	Range	Mean N =5	Range	Mean	Range (n)	Mean n=1	Mean n=1
CBL	366.7 (15.87)	347-386	368.5	357-380(4)	390	376-409 (14)	395#	492
RL	214.7 (11.21)	200-234	215	203-224(4)	233	218-250 (14)	216#	
RWB	89.6 (6.47)	81-102.7	87.5	84-91(4)	89.4	80-90(14)	81.5#	
RW6B	61 (4.53)	53-65.8	63	61-64(3)	-	-	65.1#	
RW1/4L	62.6 (5.13)	52.1-67.9	-	-	-	-	67.6#	77
RW1/2L	50.2 (3.59)	42.6-54.6	52	51-53 (2)	52.4	49-58 (14)	47.5#	48
RW3/4L	38.2 (3.39)	31.8-42.1	38	-	39.7	3644 (14)	31.9#	37
PRM1/2L	25.4 (3.13)	19-29.5	23	-	25.3	21-29(14)	30.8#	39
TREN	261.8 (13.13)	242-281	-	-	-	-	251#	-
TRIN	256.6 (10.75)	244-276	259.3	253-263(3)	-	-	260#	-
PROW	156.7 (7.72)	145.3-169.5	160.5	154-166(4)	164.1	156-171 (14)	147.2#	-
POW	177.5 (7.92)	164.2-187.7	177	171-184(3)	181.6	171-190 (14)	174#	214
ZYGW	173.6 (7.45)	160.7-181.9	177.7	174-108.4 (3)	179.1	167-189 (14)	170.2#	224
PAW	141.1	134.7-	141.7	137-	140.6	135-146	164.2#	164

	(3.38)	145.2		146(4)		(14)		
GWPRM	66.9 (3.51)	64-74.2	66.3	66-67(3)	69.3	62-74(14)	169.7#	78
WEXN	41.2 (1.99)	38.1-44.1	-	-	-	-	46.9#	48
WINTN	50.2 (3.04)	44.3-54.5	-	-	50.4	47-55(14)	73.4#	-
TFL	54.6 (5.76)	46.1-62.8	50.25	47-53(4)	51.3	45-56(14)	97.2#	99
TFW	36.1 (2.68)	31.7-38.9	39.75	37-41(4)	39.2	32-44(14)	70.7#	84
ORL	47.9 (2.23)	45.1-51.6	-	-	46.2	44-48(13)	59.2#	-
LUTR	180.29 (10.96)	170-199	185	-	198.1	183-210 (14)	176#	-
LLTR	184.8 (5.03)	177.8-191	193	-	-	-	-	-
RAML	314.3 (10.29)	300-330	325.5	324-327(2)	330.9	316-347 (13)	332#	436

Sources of data: * Present study, **Robineau *et al* (1994), ***Perrin *et al.* (1981), Van Waerebeek and Guerra (1988).

Legend: **# Cranially immature values.**
***(Gh.) ……..Ghana**
*** **(Ch)……Chile**

Table 7. Comparison of cranial measurements and meristics of *Tursiops truncatus* in Ghanaian waters to those in the South Pacific (Peru).

Species Measurement (mm)	**Tursiops truncatus*(Ghana) Mean(sd) (n=2)	Range	***Tursiops truncatus*(Peru) Means(n=15)	Range
CBL	505(53.74)	467-543	521.1	494-542
RL	297.5(36.06)	272-323	291.8	278-311
RWB	135.8(11.03)	128-143.6	144.3	132-158
RW6B	99.1(15.49)	88.1-110	-	-
RW1/4L	93.6(11.46)	85.5-101.8	107.1	98-114
RW1/2L	78.35(9.40)	71.7-85.0	87.5	82-95
RW3/4L	59.15(6.58)	54.5-63.8	64.5	62-74
PRM1/2L	41.5(4.95)	38-45	51.0	45-59
TREN	348.5(37.48)	322-375	-	-
TRIN	349(36.77)	323-375	-	-
PROW	222(11.31)	214-230	246.1	231-264
POW	253.5(6.36)	249-258	273.1	257-288
ZYGW	254.5(6.24)	245-264	276.3	263-294
PAW	181.8(7.35)	176.6-187	191.3	181-207
GPRM	90.6(2.12)	89.1-92.1	101.0	88-110
WEXN	61.25(4.88)	57.8-64.7	61.3	58-67
WINTN	67.9(5.73)	63.8-71.9	80.9	72-89
TFL	110.1(7.21)	105-115.2	117.7	107-126
TFW	83.9(4.81)	80.5-87.3	82.5	73-96
ORL	64.05(3.89)	61.3-66.3	71.6	65-78
AOPL	52.1(0.71)	51.6-52.6	62.9	58-67
LUTR	245(21.21)	230-260	246.9	233-264
LLTR	242.5(24.75)	225-260	240.7	219-265
RAML	341(97.58)	272-410	447.4	423-465
RAMH	89.35(2.19)	87.8-90.	96.6	92-101
HBRC	220.25(92.98)	154.5-286	152.4	137-170
LBRC	156.3(17.96)	143.6-169	165.1	151-182
MWPAL	53.9(6.08)	49.6-58.2	62.7	55.2-69.3
MSOC	96.4(3.11)	94.2-98.6	-	-
MWNAS	57.4(4.67)	54.1-60.7	-	-

Source: **Van Waerebeek *et al.* (1990).
*Present study.

Tables 6 and 7 shows that most of the measurements from Ghana fell within the ranges of those from other areas. However, the minimum values for Ghana were lower than those from other geographical areas, especially South-east Pacific. For instance: Table 6 shows that the minimum CBL of *S. clymene* in Ghana was 347 mm compared to 376 mm from an unknown locality in the Atlantic and 357 mm from Senegalese waters. For the zygomatic width, (ZYGW) the minimum for *S. clymene* in Ghana was 160.7 mm, 174 mm from Senegal and 167 mm from an unknown locality in the Atlantic. In *Tursiops truncatus* a similar observation was made. The minimum value for the CBL from Ghanaian waters was 467 mm and that from Peru (South-east Pacific) was 494 mm. In ZYGW, the minimum value from Ghana was 245 mm and that from Peru was 263 mm. For the rostrum length (RL), the minimum from Ghana was 272 mm whilst it was 278 mm from Peru (Table 7). The mean for the CBL of *S. clymene* was 366.7 mm for Ghana and it was 368.5 mm from Senegal and 390 mm from unknown localities in the Atlantic (Table 7). The mean for RL was 214.7 mm for Ghana and 215 mm for Senegal and 233 mm for unknown localities in the Atlantic. Consequently, most of the values for the measurements from Ghana and Senegal were closer in terms of the means and ranges but were wider when compared to those from the unknown localities in the Atlantic. Comparison of values for *Steno bredanensis* from Ghana with other geographical areas was not made because the specimens for Ghana were cranially immature. No values were available from other geographical areas for species such as *Stenella attenuata* and *Grampus griseus* to enable comparison to be made. The measurements, therefore, could be considered baseline data.

Cranial measurements were calculated as percentage of the CBL of the various species. These percentages (values) are shown in Table 8.

Table 8. Mean cranial measurements as a percentage of the condylobasal length

Species	***Stenella clymene***	*Stenella attenuata*	*Steno bredanensis*	***Tursiops truncatus***	***Grampus griseus***
Measurement/ CBL x 100	**% (sd) (n=10)**	**% (sd) (n=2)**	**% (n=1)**	**% (sd) (n=2)**	**% (sd) (n=1)**
RL	**58.5 (1.01)**	**59.2**	**54.7**	**58.9 (0.87)**	**50.7**
RWB	**24.4 (1.19)**	**23.3**	**20.6**	**26.9 (0.68)**	**35.7**
RW6B	**16.6 (0.76)**	**14.9**	**16.5**	**19.6 (0.99)**	**28.3**
RW1/4L	**17.1 (1.00)**	**15.5**	**17.1**	**18.5 (0.29)**	**30.3**
RW1/2L	**13.7 (0.67)**	**11.1**	**12.0**	**15.5 (0.21)**	**21.2**
RW3/4L	**10.4 (0.73)**	**7.9**	**8.1**	**11.7 (0.06)**	**15.9**
PRM1/2L	**6.94 (0.73)**	**6.4**	**7.8**	**8.2 (0.11)**	**14.7**
TREN	**71.4 (1.25)**	**71.5**	**63.5**	**69.0 (0.69)**	**67.6**
TRIN	**70.4 (3.07)**	**73.2**	**65.8**	**69.1 (0.07)**	**63.5**
PROW	**42.8 (1.43)**	**38.6**	**37.3**	**44.1 (2.45)**	**55.8**
POW	**48.4 (1.27)**	**44.1**	**44.1**	**50.4 (4.11)**	**61.1**
ZYGW	**47.3 (1.23)**	**45.0**	**43.1**	**50.5 (2.72)**	**61.3**
PAW	**38.5 (1.13)**	**36.9**	**41.6**	**36.2 (5.40)**	**45.7**
GWPRM	**18.3 (0.74)**	**17.9**	**43.0**	**18.0 (1.50)**	**24.6**
WEXN	**11.3 (0.67)**	**11.0**	**11.9**	**12.1 (0.34)**	**13.1**
WINTN	**13.7 (0.66)**	**12.9**	**12.2**	**13.5 (0.30)**	**17.9**
TFL	**14.9 (1.52)**	**18.9**	**24.6**	**21.9 (0.90)**	**25.0**
TFW	**9.8 (0.65)**	**11.9**	**21.0**	**16.7 (0.82)**	**9.6**
ORL	**13.1 (0.61)**	**13.0**	**15.0**	**12.8 (2.13)**	**15.4**
AOPL	**11.8 (0.73)**	**9.0**	**6.9**	**10.4 (0.97)**	**9.0**
LUTR	**49.2 (1.86)**	**50.0**	**44.6**	**48.6 (0.97)**	**14.0**
LLTR	**50.3 (1.59)**	**49.9**	**49.4**	**48.0 (0.21)**	**-**

RAML	**85.4 (1.67)**	**85.8**	**84.1**	**68.9 (26.66)**	**80.3**
RAMH	**15.8 (2.18)**	**-**	**16.1**	**17.8 (1.46)**	**19.6**
HBRC	**28.6 (0.51)**	**28.4**	**33.5**	**42.9 (13.85)**	**38.2**
LBR	**29.0 (0.58)**	**30.5**	**3.8**	**309 (0.26)**	**35.9**
MWPAL	**11.9 (1.07)**	**9.2**	**13.5**	**10.8 (2.35)**	**19.2**
MSOC	**20.7 (1.96)**	**20.6**	**19.9**	**19.2 (1.43)**	**19.3**
MWNAS	**9.3 (1.31)**	**12.0**	**14.8**	**11.4 (0.28)**	**14.6**

From Table 8, *Tursiops truncatus* and *Stenella clymene* had means which were wider apart and therefore could be used to discriminate the two species even though their ranges overlapped to some extent. For instance, in the zygomatic width, means for *S. clymene* was 47.3% whilst that for *Tursiops truncatus* was 50.5% and for the height of the braincase *S. clymene* had a mean value of 28.6% whilst *Tursiops truncatus* had 42.9%. Other measurements such as ramus length and ramus height had variable means between the two species, which could be used as discriminating tools for these species even though their ranges overlapped to some extent.

Apart from the ratio between the cranial measurements and the condylobasal length, six other cranial proportion variables were considered which are presented in Table 9.

Table 9. Other cranial proportion variables of the dolphin species in Ghanaian waters.

Species / Proportion variable	*Stenella Clymene* Means (sd) n=10	Range	*Stenella attenuata* Mean (sd) n=2	Range	*Steno bredanensis* Mean (sd) n=2	Range	*Tursiops truncatus* Mean (sd) n=2	*Grampus griseus* Mean N=1
HBRC/RL	**0.49 (0.46)**	**0.47-0.63**	**0.48 (0.01)**	**0.47-0.49**	**0.61**	**-**	**0.73 (0.23)**	**0.75**
WEXN/LBRC	**0.39 (0.22)**	**0.36-0.43**	**0.36 (0)**	**-**	**0.34 (0.01)**	**0.33-0.35**	**0.30 (0.14)**	**0.36**
WINTN/LBRC	**0.47 (0.03)**	**0.44-0.52**	**0.42 (0.03)**	**0.40-0.44**	**0.42 (0.09)**	**0.36-0.48**	**0.44 (0.01)**	**0.49**
MWPAL/RWB	**0.49 (0.09)**	**0.37-0.69**	**0.40 (0.04)**	**0.37-0.42**	**0.66**	**-**	**0.40 (0.07)**	**0.53**
LLTR/RAML	**0.58 (0.02)**	**0.56-0.61**	**0.59 (0.01)**	**0.58-0.59**	**0.59**	**-**	**0.76 (0.29)**	**-**
PRM1/2 / RW1/2L	**0.50**	**(0.04)**	**0.58 (0.01)**	**0.57-0.59**	**0.65**	**-**	**0.53**	**-**

From Table 9, overlaps in the ranges were observed among species but means of the variables were enough to discriminate even closely related species. Wider differences were observed among species that were morphologically different such as *Tursiops truncatus* and *Stenella clymene;* and *Steno bredanensis* and *Tursiops truncatus.* Mean values were closer for species that looked morphologically similar such as *S. clymene* and *S. attenuata.* For instance, the HBRC/RL ratio mean values for *S. clymene* and *S. attenuata* were closer (0.49 and 0.48 respectively) compared to *Steno bredanensis and Tursiops truncatus* (0.61 and 0.73 respectively). A similar trend was observed in the LLTR/RAML ratio: *S. clymene* (0.58) and *S. attenuata* (0.59), *Steno bredanensis* (0.59) and *Tursiops truncatus* (0.76). The values were closer for *S. clymene* and *S. attenuata* and the same for *S. attenuata* and *Steno*

bredanensis (overlap) but wider between the two *Stenella* species (0.58- 0.59) and *Tursiops truncatus* (0.76)

3 7 Meristics (tooth counts)

Tooth counts on both the lower and upper left jaws of five species of dolphins in Ghanaian waters and their ranges are presented in Table 10.

Table 10.

Tooth counts of 5 dolphin species found in the waters of Ghana.

Species	***Stenella clymene***		***Stenella attenuata***		***Steno Bredanenss***	***Tursiops truncatus***		***Grampus griseus***
Tooth counts	**Means (sd) n=10**	**Range**	**Means (sd) n=2**	**Range**	**Means *** n=1**	**Means (sd) n=2**	**Range**	**Means *** n=1**
No. of teeth in the upper left jaw.	**39.8 (2.6)**	**36-44**	**39 (1.41)**	**38-40**	**20**	**24 (1.41)**	**23-25**	**0**
No. of teeth in the lower left jaw.	**40.8 (2.6)**	**37-46**	**38.5 (2.12)**	**37-40**	**22**	**22.5 (0.71)**	**22-23**	**2**

Table 10 shows that the number of teeth in the upper jaws for the 5 dolphin species ranged from a mean of 39.8 in *S. clymene* to 0 in *Grampus griseus*. In the lower jaw, the means ranged from 40.89 in *S. clymene* to 2 in *Grampus griseus* (the lowest). Variations exist in both the mean number of teeth in the upper and lower

jaws of the different species. Close values exist between *S. clymene* and *S. attenuata* (39.8 and 39 for the upper jaw and 40.89 and 38.5 for the lower jaw respectively) and also between *Steno bredanensis* and *Tursiops truncatus* (20 and 24 in the upper jaw and 22 and 22.5 in the lower jaw respectively) suggesting close taxonomic relationship between these groups. The extremely low number of teeth in both the lower and upper jaws of *Grampus griseus* (2 and 0 respectively) seemed to separate it from the other four species. Overlaps were also observed in the ranges of tooth counts in both the upper and lower jaws of *S. clymene* and *S. attenuata* and also between *Steno bredanensis* and *Tursiops truncatus*.

3.8 Biochemical Taxonomy

The 12 enzymes studied under starch gel electrophoresis and the electrophoretic pattern shown by the enzymes are presented in Table 11.

Table 11. The electrophoretic pattern of 12 enzymes studied under starch gel electrophoresis for 4 dolphin species in the Ghanaian waters.

Enzyme	*Stenella attenuata*	*Stenella clymene*	*Steno bredanensis*	*Grampus griseus*
MDH-1		-	-	-
IDH-1	-	-	-	-
LDH-1	-	-		
LDH-2	-	-	-	-
ME-1	-	-	-	-
ADH				
ODH				
SDH				
G6PDH				
XDH				
α-GPDH				
ME				
EST				

Legend for Table 11: - Electrophoretic score of an enzyme at a given locus.

Blank space indicate no score for the enzyme at a given locus.

From Table 11, only 4 of the 12 enzymes considered showed bands on the starch gel. These four enzymes were Malate dehydrogenase (MDH), Isomerase dehydrogenase (IDH), Lactase dehydrogenase (LDH) and Malic enzyme (ME). Only LDH out of the four enzymes showed bands on 2 loci (LDH-1 and LDH-2) for all the species. MDH, IDH and ME all scored one locus for all the species. The scores for the 4 enzymes were the same for all the species at all the loci scored for the starch gel electrophoresis.

CHAPTER FOUR

4.0 DISCUSSION

4.1 Interview with local fishermen and dolphin processors

Responses from the interaction with the coastal communities (Table 2) clearly indicate that generally, they are aware of the presence of dolphins in Ghanaian waters and have at one time or the other observed dolphins landed by the artisanal fishermen. This is contrary to the views of those outside the fishing communities (response from 20 interviewees). Again, the fact that respondents claimed they had seen one or more species of dolphins and had even gone to the extent of giving them local names, indicate that they are very familiar with these animals.

There were variations in the preference for dolphin meat by the coastal communities. This shows variations in the general reaction of human beings towards a particular food product, especially if it is new. Here, the very curious ones taste it and devise the best methods of processing it to make it acceptable to them. This was the case in all the towns where interviews were conducted. Since most people in Kpone were less skillful in cooking fresh dolphin meat thus making it less acceptable for consumption compared to those from Apam, Shama and Kpone. This might explain why preference for dolphin meat was low at Kpone and high at Apam or Shama where more dolphin landings occur.

The high price of dolphin meat at Apam and Shama compared to the low value at Kpone reflects the differential preference for dolphin meat at those places.

Since dolphin meat is smoked and mixed with that of fishes (from my personal observation) such as sharks and tunas and sent to the marketing centres, it

is likely that some consumers may buy and consume the meat without being aware that they are eating dolphin meat.

Considering the low level of awareness of the presence of dolphins in the Ghanaian waters (sampled opinion of people interviewed) and the fact that they are protected animals, there is the need to embark on intensive campaign to educate Ghanaians to protect and conserve this useful resource. For instance, people must be educated to be able to enable them identify dolphin meat and avoid buying it at the market place to help discourage those who trade in it and by so doing help to reduce their explopitation..

The laws on protection of marine mammals (L.I. 685) have not been enforced but to ensure that dolphins are protected and conserved, these laws should be strictly enforced to ensure that meaningful impact is made.

4.2 Species composition

Since five species of dolphins were identified in Ghanaian waters from January 1998 to December 1999 and three more in the year 2000 (Section 3.2.1), there is the likelihood that more species might be present in our waters considering that 18 known species have been reported to occur in West African waters (Jefferson *et al.*, 1997). This belief is reinforced by the following factors: (I) the short period used for this study, (ii) logistic problems (iii) limitation of samples to captures by only artisanal fishery which operate in offshore waters with drift-gillnets and (iv) differential vulnerability to the fishing gears by some dolphin species.

Thus, there is the need for more monitoring to be done at the beaches especially Apam, kpone, Shama, Axim and other places where drift-gillnet fishery operates in order to confirm or deny the fact that there are still unidentified species in our

waters. Eight species of dolphins were identified from Ghanaian waters in this study. However, at the time of binding this thesis, 14 out of the 18 dolphin species in the West African sub-region have been shown to occur in Ghanaian waters (Ofori-Danson pers. communication).

4.3 Relative abundance of the dolphin species encountered in Apam waters.

S. clymene was the most abundant dolphin species found in Ghanaian waters during the study period. The wide difference observed in the abundance of *S. clymene* (68.4%) and the rest of the species (*S. attenuata* 10.5% and *Steno bredanensis* 10.5%), clearly demonstrates how dominant *S. clymene* is in Ghanaian waters. This result confirms the findings of Robineau *et al.* (1994) that there might be more *S. clymene* in the African waters than is known. Since *S. clymene* is not very common worldwide and is limited to the tropical areas of the Atlantic Ocean (Robineau *et al.*, 1994), every effort must be made to protect this species in our waters.

4.4 Gears used for dolphin capture

It is worthy of note that the decline in the annual catches of fishes in West Africa (Armah *et al.*, 1996) has led to the evolution of more efficient types of fishing gears. The drift-gillnet (DGN) is one of the most recently developed gears designed to capture sharks, swordfishes, tunas and other large pelagic fishes. The operation of this gear has led to the incidental catches of dolphins. Even though these small cetaceans are considered as "by-catch" the current addition of other implements such as metallic swords, cutlasses and wooden bars to enhance capture raises eyebrows and seems to suggest that dolphin capture is developing into a special fishery. There is also a growing demand for dolphin meat in Ghana. It is

used as bait for catching sharks whose fins are valuable and are exported for foreign exchange. There is also ready market for the dolphin carcasses which are processed and sold to both suspecting and unsuspecting consumers at the various marketing centers in Ghana. This indicates a bleak future for dolphin conservation in Ghanaian waters. It is very likely that in future if steps are not taken to curb this practice, more aggressive gears and strategies would be developed to exploit more dolphins.

4.5 Seasonal pattern of dolphin catches

Catch data collected from Shama and Apam seem to indicate seasonal abundance in the catches (Figure 4) (even though catches occur throughout the year). For instance in 1998, dolphin catches started in May in Shama with 2 dolphins caught and reached the peak in December with 7 dolphins, whilst those in Apam started in August, with 1 dolphin caught and reached the peak in September with 8 dolphins caught. In these two instances, catches declined after December. A similar pattern was observed in 1999 dolphin catches at both stations.

In 1999, dolphin catches in Apam started again in August (2 dolphins) and reached a peak in November (3 dolphins) Figure 4. This indicated that dolphin catches probably started earlier at the beginning of the year in Shama than in Apam even though the available data were inadequate for any reasonable conclusion to be drawn. A possible explanation for this seasonal trend in abundance of catch might be a link between dolphin capture and *Sardinella* fishery. This is because dolphins are usually found in association with *Sardinella* and other small pelagics; as they prey on these animals they are incidentally caught with them (Maigret, 1994; Jefferson *et al*,1997). Consequently, trend in abundance in dolphins, follows closely

that of *Sardinella* and other small pelagics which peak in abundfance in August-September (period of upwelling).

The dolphin catches were generally lower in 1999 than in 1998 in the two coastal towns, Apam and Shama. This could be attributed to the low catches of *Sardinellas* experienced by the artisanal fishermen in the two coastal towns (pers comm., Fisheries Officers in Apam and Shama) during 1999.

Comparing dolphin catches of 1998 and 1999 in Apam and Shama to catches compiled by Ofori-Adu (1998) from 1995-1997 (Appendix III) the following observations could be made on the catch trend: catches were gradually shifting from the early part of the year (January, February) to the later part around August in Apam but those in Shama had remained almost the same (January, February, and March). Total annual catches dropped from an average of 18 dolphins in Apam from 1996-1997 (Appendix III) to 8.5 dolphins in 1998-1999 (Appendix II). The low catches experienced could be attributed to the general fall in catches of *Sardinellas*, tunas and other species (Pers comm,; Fisheries Officers in Apam and Shama) or to overexploitation of dolphins. Another possible explanation could be that with time, the dolphins became "wiser" and thus avoided the nets resulting in fewer catches. Another factor might be the level of activity of the migrant fishermen in a particular year. It was observed that fishermen operating DGN were usually migrant ones and their presence at a particular town determined effort put into dolphin capture; thus their absence in a particular town for any given period meant no dolphins would be caught in that locality. This might explain why dolphin catches were low in 1999 at Shama since their operations were very low in that town in that year. The fishermen moved away from Shama because they were getting low catches of sharks and other fishes (Pers Comm. Fisheries Officers at Shama). Also higher dolphin catches were

experienced in the Western part of the coast than in the eastern end probably because more DGN operators were found in the west of the coast, especially Apam, Shama, Axim and Dixcove (findings made during the interaction with the fishermen).

4.6 Beach surveys

Skeletal parts of caught or stranded dolphins could not be obtained along the beaches surveyed. This confirms the observations made by Ofori-Danson and Van Waerebeek (1999) to the effect that in Ghana, dolphins caught were butchered into pieces (with the bones attached) and carried home to be processed. Consequently, no skeletal parts could be obtained at the beaches. Fishermen interviewed indicated that juvenile dolphins that were not landed were used as baits for hooking sharks and therefore their skeletal parts could not be found at the beaches.

It is therefore expected that beach surveys in Ghana for skeletal remains may not yield the expected information that could help in assessing the level of dolphin mortality or species composition. The best strategy then is to concentrate on dolphins caught and landed as well as those monitored at sea.

4.7 Parasitic infestation

The low parasitic infestations observed in this study cannot be conclusive, since stomach samples were obtained from only one locality (Apam) and sample sizes were too small to permit adequate statistical analysis and drawing of appropriate conclusions. Three samples of *S. clymene*, 1 sample of *Grampus griseus* and 1 sample of *Steno bredanensis* were examined. Out of the 3 *S. clymene* stomachs examined two of them were infested with parasites in the fore-stomachs,

whilst stomachs from *Grampus griseus* and *Steno bredanensis* did not have any parasites in them. The numbers of nematodes (*Anisakis sp.*) found in the stomachs of the *S. clymene* were variable (Section 3.5). This might probably be due to chance because *Anisakis sp.* is not species specific and has been found in bottlenose dolphins (Van Waerebeek *et al.*, 1990).

4.8 Cranial measurements

There were some wide interspecific and intraspecific variations in certain cranial measurements with overlaps in the ranges of some values (Tables 5). For instance the condylobassal length in *S. clymene* ranges from 347-386 mm whilst in *Tursiops truncatus* it ranges from 467-543 mm. Values for condylobassal for *S. attenuata* (383 mm) overlaps those for *S. clymene*. This confirms the observations made by Ferguson (1980) that morphological variations are plastic and subject to environmental conditions, hence, might not be very useful for discriminating between species. However, some measurements such as the condylobasal length, zygomatic width and rostrum width at base proved very useful in discriminating between certain species which are genetically wide apart. For instance, the means and ranges of the condylobasal length of *S. clymene* (366.7 mm and 347-386 mm) could easily separate them from *Tursiops truncatus* (505 mm and 467-543 mm), *Grampus griseus* (416 mm), *S. attenuata* (383 mm) and *Steno bredanensis* (395 mm). The overlaps observed in species of the same genus such as *S. clymene* and *S. attenuata*, were not surprising since they looked morphologically similar in many respects. The overlaps could be due to the fact that closely related species may share a lot of common characteristics that might have originated from their common ancestors. The means and ranges of the individual species when compared to values

from other locations such as South Pacific (Perrin *et al.*, 1981) and other West African countries (Robineau *et al.*, 1994) suggest that values obtained from dolphins in the Ghanaian waters were lower. For instance, cranial measurements for the zygomatic width (ZYGW) of *S. clymene* (173.6 mm and 160.7-181.9 mm) when compared with the values of Robineau *et al.* (1994) in West Africa for the same species (177.7 mm and 174-184 mm) and those from the unknown location in the Atlantic (179.1 mm and 167-189 mm) indicate that some of the values of *S. clymene* fall within the range recorded by Robineau *et al.* (1994) but most of them were smaller than the Robineau *et al.* (1994) values. In Table 6 for instance, *S. clymene* in Ghana had a wider range and the lower limit of its range was mostly lower than those Robineau *et al.* (1994). The Robineau *et al.* (1994) values were closer to those of Ghana than those from other distant locations. In *Tursiops truncatus*, the mean CBL for Ghana was 505 mm and the range was 467-543 mm whilst the mean for Peru was 521.1 mm and the range was 494-542 mm (Table 7). The differences could be explained by geographical variation in the sizes of the dolphin skulls. The closer the distance is the closer the characteristics. Differences in geographical variation were observed in the skulls of dusky dolphins, *Lagenorhynchus obscurus* from four geographic areas namely, Chile, New Zealand, Peru and South-Western Africa (Van Waerebeek, 1993). Differences were more prominent when *S. clymene* and other species from Ghana and those from southern-Pacific and the Atlantic were compared for cranial values. Those from Ghana were relatively low and this could be attributed to inter-population differences as well as geographical variation or distance.

4.9 Cranial proportion variables

The mean values of various cranial proportion variables for the different species (Table 8) seemed to vary more clearly in some cases among different species than those observed in the cranial measurements whilst at the same time no overlaps were observed in the cranial proportion variables compared to the cranial measurements. The differences observed were however closer in species, which were genetically closer together such as *S. clymene* and *S. attenuata*. For instance RWB/CBL for *S. clymene* was 24.43% whilst that of *S. attenuata* was 23.27% but when compared to *Grampus griseus* (35.67%), *Tursiops truncatus* (26.93%) and *Steno bredanensis* (20.63%) the differences were wider. From these values it seemed *Tursiops truncatus* and *Steno bredanensis* were also genetically closer together. The clear differences observed in the ratios among different species demonstrated that the ratios could be better discriminants of species than the cranial measurements. This observation should, however, be treated with caution, because the small sample sizes obtained allowed only limited statistical comparison to be made between different species. This could be confirmed in future when adequate sample sizes become available. When considering ranges of values for the various ratios such as RL/CBL and HBRC/RL, overlaps were mostly observed between species that were morphologically identical and therefore could be closely related genetically. For instance, a lot of overlaps were observed between *S.clymene* and *S. attenuata* and also between *Tursiops truncatus* and *Steno bredanensis* (Table 9). The morphological closeness observed in these dolphin species seemed to establish the close taxonomic relationship found in these delphinids. It has been found that hybridization occurs in dolphins that have been kept in captivity and in the wild. For instance, *Tursiops truncatus* is known to crossbreed with *Steno bredanensis*.

Pseudorca crassidens, Globicephala macrorhynchus and Grampus griseus whilst in captivity (Anderson, 1969; FAO, 1978; , Sydney Anderson and Knox Jones Jr., 1984) and in the wild with *Grampus griseus* (Sydney Anderson and Knox Jones Jr., 1984). Fraser (1940) described 3 anomalous dolphins from Ireland that seemed to be crosses between *Tursiops* and *Grampus* species. It must be noted that though overlaps may be observed in morphological characters in certain situations, a combination of several characters as well as cranial proportion variables could still be useful in discriminating between various species of dolphins in Ghana. This could be applicable to dolphins in West Africa and the world at large since no single character or morphological factor may be good enough.

4.10 Meristics

The differences and overlaps observed in tooth counts of the five species of dolphins (Table 10), could be good criteria in discriminating between certain species. In the case of *S. clymene* and *S. attenuata* overlaps in tooth counts were noted in both the upper and lower jaws. This could also be explained by the close taxonomic relationship between the two species. Jefferson *et al.*(1997) reported overlaps in values of tooth counts of some dolphin species in West Africa. This has revealed that overlaps are common in certain species in the family *Delphinidae*. Hence tooth counts cannot be used exclusively to discriminate between closely related species such as *S.clymene* and *S. attenuata* or *Steno bredanensis* and *Tursiops truncatus* (Table 10) but under such circumstances, shape, structure and nature of teeth could help in discriminating between them. For instance, overlaps in tooth counts could be observed in *Steno bredanensis* and *Tursiops truncatus* (Table 10), but the former has rough surface on the crown whilst the latter has smooth

surface and the top of the crown may be seen wearing off especially in the older ones. From the observation made on both meristic and morphological taxonomy, it was realized that no single factor could be good enough to discriminate between all the species. It is therefore necessary that a combination of morphological as well as the meristic characters be combined to obtain best results in determining the taxonomic status of dolphins in any geographic area.

4.11 Biochemical taxonomy

The results from the starch gel electrophoresis could not discriminate between species since all the enzymes showed similar results for all the species. Only 4 enzymes out of the 12 studied in the muscle tissue showed bands on the starch gel (Table 11). These were the Lactase dehydrogenase (LDH), Malate dehydrogenase (MDH), Isomerase dehydrogenase (IDH) and Malic enzyme (ME). The other enzymes ADH, ODH, SDH, G6PDH, XDH, α-GPDH and EST were absent from the results. The absence of the bands of these enzymes from the starch gel could be attributed to the absence of these enzymes in the muscle tissue. These enzymes may be found in other tissues and it will therefore be advisable if in future other tissues such as blood, liver and heart are also used in this study. Further, the 4 enzymes that showed bands on the starch gel could not discriminate between the species since they showed the same bands at any given locus for all the 4 species. In addition only one (LDH) out of the four showed two loci. The same scores shown by all the four enzymes for the 4 different species indicate that there might not be significant genetic differences among the 4 dolphin species hence the same genes were responsible for producing the same enzymes in different species. This might be the case because they were really not species at the biochemical (protein) level

but may be polymorphic forms of the same species. The hybrid forms observed in these delphinids evidence this. This might also explain why a lot of overlaps were observed in the morphological characters. The two loci scored by LDH, might be because the production of LDH in the four species of delphinids is controlled by alternative alleles, which have the same gene frequencies at the two loci, LDH-1 and LDH-2. Polymorphic genes could be responsible for this, and in that case the enzymes might have not been produced by one specific gene but rather polygenes, and hence the proteins were not species specific. It is noteworthy that the results obtained from this study might not be conclusive enough due to the very few samples obtained. The results also confirm the findings of Sharp (1975) when he used red blood cells and serum proteins to discriminate between species of dolphins in starch gel electrophoresis. In his investigation to distinguish several races of *Stenella*, *Delphinus*, *Steno*, *Orcinus* and *Tursiops* from the eastern Pacific, Sharp (1975) using the red blood cells and serum proteins found that, all the species showed the same bands in the starch gel electrophoresis for enzymes such as LDH and ADH. However, when he examined glutamate oxalocetate transaminase (GOT), tetrazolium oxidase and a serum globin in these species by non-specific protein staining recipes during starch gel electrophoresis, they were adequate for discriminating between species of *Orcinus orca, Steno bredanensis, Delphinus delphis, Globicephalus species, Tursiops gilli, Stenella attenuata, Stenella longirosris* and other species. This suggests that, perhaps more studies will have to be done on more enzymes possibly using a non-specific protein-staining recipe till the appropriate one for discriminating between is found. Arnason (1960), described the C- and G-band karyotypes of *S. clymene*, and found them to be strikingly similar to those of white beaked dolphin, *Lagenorhynchus albirostris* and the harbor

porpoise, *Phoecoena phocoena*; they were all found to have 2n=44 chromosomes. He, again, did not find any significant differences between the G- banded karyotypes of *S. clymene*, *S. plagiodon* and *T. truncatus*; he only found minor differences between their C-banded karyotypes, this indicates a high degree of karyotypic conservatism in the *Delphinidae*.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The results from fishery-dolphin interaction on coastal communities have revealed low level of awareness on the need to protect and conserve dolphins in the Ghanaian waters. Unfortunately, no conscious effort is currently being made to salvage these marine mammals by enforcing laws ensuring their protection in our waters. Furthermore, more people are getting involved in the consumption of dolphins consciously or unconsciously due to strategies adopted by dolphin processors in marketing the meat together with fishes. There is, therefore, the tendency for more aggressive methods to be employed in the capture of dolphins for consumption. Already there is evidence that more aggressive implements such as spears and cutlasses are used to weaken dolphins after capture in the fishing nets. The capture is gradually changing from being an incidental catch to a directed one. Every effort must be made to stop this upward trend. Another impetus that may increase the exploitation of dolphins is their use as bait in the capture of sharks due to the increase in demand for shark fins for export and therefore sharks' high commercial value compared to dolphins.

Eight species of dolphins belonging to 7 genera were encountered in Ghanaian waters and more species may be found in the near future if continuous monitoring is done.

A relatively high abundance of clymene dolphins were found in Ghanaian waters contrary to the views of most scientists who had sampled the West African waters.

Seasonality of abundance in the dolphin catches were observed since catches were recorded throughout the year with peak periods usually observed between August and September. This could be linked with the *Sardinella* season and its related upwelling period. However, migration of drift-gillnet artisanal fishermen may not allow this peak period in a particular area to be realized since they will not be there to catch the dolphins.

Strandings of dolphins seemed to be rare in Ghana and no evidence of strandings was observed during the period of study.

Parasitic infestations of guts of dolphins encountered showed low levels of occurence and therefore may not be so much of a threat to the survival of dolphins.

Morphological taxonomy proved very useful in discriminating between species of dolphins encountered but no one single character was found to be suitable for discriminating between all the species. A combination of morphological characters such as, cranial measurements and meristic characters (tooth counts), have, however, been very useful in discriminating between all the species. It was difficult to use biochemical characters for discriminating between the dolphin species because perhaps the *Delphinidae* family, exist as polymorphic forms of the same species.

5.2 Recommendations

The following recommendations are made based on the current study on dolphins in Ghanaian waters:

(i) More concerted efforts should be directed towards promoting dolphin watching and its conservation. This could be done by inviting experts to train Ghanaians locally on dolphin watching and its management or sending people outside the

country to learn this skill and individuals or government providing the necessary infrastructure for this venture.

(ii) Education on dolphin conservation should be done extensively especially among the coastal communities.

(iii) Laws protecting dolphins should be strongly enforced to discourage people from catching dolphins for their economic gains.

(iv) Continuous monitoring for at least five years should be undertaken on dolphin capture and species identification.

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APPENDIX I

UNIVERSITY OF GHANA, LEGON

DEPARTMENT OF OCEANOGRAPHY AND FISHERIES

A SURVEY OF THE OCCURRENCE AND CONSERVATION OF

DOLPHINS IN THE MARINE WATERS OF GHANA.

QUESTIONNAIRE

Introduction:

This is a survey aimed at providing information on dolphins caught in the coastal waters of Ghana, for my post-graduate thesis. I will be very happy if you could help to provide information on the following questions.

Name of respondent:----------Age--------- Sex-------

Location:----------Occupation----------Tribe/Ethnic group-

1. How long have you been staying in this area?---------yrs.

2a. Have you seen a dolphin before? Yes / No.

2b. If yes, how many types have you seen?----------

2c. Can you give their local names:----------

3. Are there any taboos associated with the capture or eating of dolphins in your tribe/ethnic group?

4. By what methods are they caught? Hooks / Gill nets / Purse seines / Harpoons (Spears) / Any other.

5. How are dolphins processed for market? Smoking / salting / sold fresh / any other.

6. How frequently do you catch dolphins in a year?----------

7. Can you give me estimate of how many dolphins that are caught at your beach per week or Month.----------per week /----------per month.

8. What is your preference for dolphin meat? I like it / I don't like it / Indifferent.

9. Do you sell the dolphin meat if you catch it? Yes / No.

10. If yes where are they sent for sale ?----------

11a. How valuable is dolphin meat ? Costly / Cheap / Moderate price.

11b. Give the economic importance/ uses of dolphins in Ghana.

12a. Do you know dolphins are protected? Yes / No.

12b. If yes, who gave you that information? A friend / another fisherman / Game and wild life

staff/ any other person or group.

13. Has somebody been caught selling dolphin meat in this area? Yes / No.

14. Do people intentionally go for dolphins at sea? Yes / No.

15a. Are there any types of fishes that are normally associated with dolphins during your fishing expedition ? Yes / No.

15b. If yes, then name the type of fishes.

16. During what periods of the year are dolphins usually caught? Rainy season /dry season / cold weather /hot weather.

Thank you.

APPENDIX II

Dolphin catches in coastal waters off Apam and Shama during 1998-1999 study period.

Apam			Shama	
Month	1998	1999	1998	1999
January	0	0	0	1
February	0	0	0	0
March	0	0	2	1
April	0	0	1	0
May	0	0	2	0
June	0	0	2	0
July	0	0	1	0
August	1	2	2	0
September	8	1	1	0
October	0	1	1	0
November	0	3	0	0
December	3	0	7	0
Total	12	7	19	2

APPENDIX III

Catch data from Apam 1995-997 (Ofori-Adu, 1998).

Month	1995	1996	1997
January	1	5	2
February	2	2	6
March	0	2	0
April;	1	2	0
May	1	3	0
June	1	2	0
July	2	1	0
August	0	0	7
September	0	0	1
October	0	0	2
November	0	1	0
December	4	0	0
Total	12	18	18