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DEPARTEMENT DE BIOLOGIE ANIMALE
DEPARTMENT OF ANIMAL BIOLOGY

OPTION : Ecologie et Gestion de la Faune Sauvage
OPTION: Ecology and Wildlife Management

ACTIVITY CENTER, HABITAT USE AND CONSERVATION OF THE WEST AFRICAN MANATEE (*Trichechus senegalensis* Link, 1795) IN THE DOUALA-EDEA AND LAKE OSSA WILDLIFE RESERVES

A Thesis Submitted to the Faculty of Sciences of the University of Dschang In Partial Fulfillments of the Requirements for the Award of the Master of Science (M.Sc) Degree in Animal Biology.

By

TAKOUKAM KAMLA ARISTIDE

CM04-07SCI1437

Co-supervised by

CARYN SELF-SULLIVAN (Ph D)

Supervised by

THEODORE MAYAKA BILENG (Ph D)

Academic Year/ 2010-2011

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CORRECTION CERTIFICATE

This is to certify that the dissertation entitled: "**Activity center, habitat use and conservation of the West African manatee (*Trichechus senegalensis* Link, 1795) in the Douala-Edea and Lake Ossa Wildlife Reserves**", submitted to the Department of Animal Biology, Faculty of Science, University of Dschang, in partial fulfillment of the requirements for the award of the Master of Science (M.Sc.) degree in Animal Biology is authentic and has been corrected according to the recommendations of the jury board and the actual Department rules.

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17/02/12

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REPUBLIQUE DU CAMEROUN FACULTE DES SCIENCES DEPARTEMENT DE BIOLOGIE ANIMALE LE CHEF DE DEPARTEMENT UNIVERSITE DE DSCHANG

Chef de département (Dr. KHAN PAYNE)
V. KHAN PAYNE PhD
22 FEB. 2012

PREFACE

A Masters programme is a two-year study at the end of which each student is expected to present and defend a research thesis which topic is chosen by him and/or his supervisor(s). As a masterôs student, I had to defend a thesis and for this purpose, my curiosity pushed me into the marine fauna. This was coupled with the fact that not only had I studied the background of some aquatic animals as part of a course in the academic syllabus, but also, there were very few scientists who had devoted themselves to exploring this field of research in Cameroon. After consulting my supervisor (Dr. Mayaka), we both agreed to explore the world of manatees which are listed among animals whose background I had already studied, and which are counted among endangered species in the world. Having set my mind to embark on this field of research, the next challenge was finding an organisation which would frame the work and finance it as much as possible. It took us a couple of months to have the approval of CWCS and WTG that accepted me as intern in their institutions.

As intern at CWCS, I was exposed to the realities of field work: I was not very familiar with the wildlife milieu and I had few documents on this domain as it is not well developed in Cameroon. I overcame this difficulty with the help of CWCS staff who made it possible for me to obtain a grant awarded by the Earthwatch Institute (UK) to attend a workshop on manatee conservation in Ghana. At the workshop, I was opportune to learn more about manatee sampling techniques and met many specialists in the domain, among which was Dr Self-Sullivan, who later agreed to co-supervise my thesis. This request was granted by the university administration and from that moment, she and Dr Mayaka (my supervisor) became the pillars of this piece of work and the reason behind the choice of the language I am using, even though it is not my first language.

Having acquired knowledge on manatee sampling techniques and with the support of my supervisors, I set myself to work and went about doing daylight and night surveys by boat. This was the most tedious part of the research; it was not easy staying for long hours in the middle of the night or under a harsh sun to scan for manatees. Nevertheless, I stood firm till the end, braving mosquitoes and other insect bites.

At the end of this work, I feel delighted with all the findings I made. I am however convinced that much is still to be done and that with the employment of more resources in terms of equipment and finance, the conservation of manatees in Cameroon and in the world as a whole will experience a substantial improvement.

ACKNOWLEDGEMENT

- I thank The University of Dschang for accepting me as an MSc student and for providing me with the academic requirements for this work.

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- I equally thank my supervisor, Dr. Mayaka, for the constant support, patience, advice and availability granted to me. The efforts he put into the completion of this thesis were remarkable.

- My Co-supervisor Dr. Self-Sullivan willfully offered her expertise in the realization of this work and in the molding of the dissertation. I am very grateful and thank her for the precious time she always granted me in spite of her many occupations.

- Lucy Keith Diagne: thanks so much for the information and advice you have always been providing to me.

- Robert Bob Bonde: Iôm grateful for the time and effort you put in reviewing and editing this work.

- I thank the coordinator of CWCS for the logistical support he provided me. I am grateful that he facilitated my admission in the manatee workshop in Ghana.

- I am grateful to the Coordinator of WTG, Mr. Chi Napoleon, for providing logistical and financial support to this study. Also, I thank him particularly for the field capacity he built in me.

- Many thanks to the coordinator of field activities at WTG, Mr Justin Chekoua for leading me and providing me field work facilities. You have been a good field teacher for me. Through you, I have learned how to write projects, plan activities and implement them.

- I thank the responsible field activity staff of CWCS, Mr. Dihuke Eugene for leading me and providing me field work facilities

- I thank my pilot during the boat survey, Mr Mbonya François. Without you this work would not have been completed by now.

- NCRC and EARTHWATCH INSTITUTE UK for granting me the opportunity and facility to build my capacity in manatee conservation.

- Iôm grateful to the MINFOF agent of Douala Edea Wildlife Reserve and Lake Ossa Wildlife Reserve for giving me space and authorization to work in these protected areas. Special thanks to Mr Tieubou Joseph from MINFOF (DFAP) who provide me with key information related to Cameroon fauna.

- I acknowledge the collaboration of traditional chiefs of each village where we conducted interview surveys. They have provided good communication channels between the researcher and the local population.

- I acknowledge the contribution of local fishermen who did not spare their energy and time when providing me with information needed for this study.

- Without Papa Takoundjou Philip and Mama Rose who brought me up to this stage of life, this work would not have been possible. I am ever grateful to them for their love and their constant financial and moral support

- The work on manatees required substantial financial support and I thank my uncle and aunt, Takoukam David and Aunty Christine, for their provisions and the care they showed through out the research period.

- My pastors, Tangi Maurice, Votio Laurent, Ngwomeh Babisco, and my brothers and sisters of the Full Gospel Mission were of great spiritual and moral support to me especially in times of hardships. Many thanks to them.

- For the love, care and moral assistance, I am grateful to my friend Kangmo Lapa Eliette on whom I leaned all through the research. She always encouraged me and assisted me as much as she could.

- My promotionals for the solidarity that exists amongst us for the assistance we gave each other during the years spent together.

- Mr. Nasser Tchania for the accommodation support in Douala.

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ABREVIATIONS

ANOVA: Analysis of Variance

AIC: Akaike information criterion

CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora

CMS: Convention on Migratory Species

CWCS: Cameroon Wildlife Conservation Society

DEWR: Douala Edea Wildlife Reserve

GLM: Generalized Linear Model

IUCN: World Conservation Union

LOWR: Lake Ossa Wildlife Reserve

MINFOF: Ministry of Forest and Wildlife

MoU: Memorandum of Understanding

NGO: Non Governmental Organization

NCRC: Nature Conservation Research Centre, Accra, Ghana

RRA: Rapid Rural Appraisal

SAFACAM : Société africaine forestière et agricole du Cameroun

SOCAPALM: Societé Camerounaise de Palmeraies

TEK: Traditional Ecological Knowledge

UNEP: United Nations Environment Programme

WATCH: Western African Talks on Cetaceans and their Habitats

WTG: Watershed Task Group

ABSTRACT

The West African manatee (*Trichechus senegalensis* Link, 1795) is the least biologically studied species of all living sirenians. Studies conducted between 1980 and 1981, and later between 1986 and 1995 indicate that within the Sanaga drainage, manatees are present in the Sanaga River below the Edea dam to the coastal zone, in the River Nyong, in Lake Ossa, and in Lake Tissongo (Nishiwaki, 1982; Grigoine, 1996; Powell, 1996).

Our recent interviews, conducted among fishermen near the Douala-Edea Wildlife Reserve (DEWR) and Lake Ossa Wildlife Reserve (LOWR) confirmed the presence of manatees in the Sanaga River, River Nyong, the coastal zone, Lake Ossa and Lake Tissongo. The same study revealed that the lower reaches of River Sanaga around Malimba village may have the highest density of manatees and the highest manatee number of manatee carcass report in the drainage. Main cause of death is attributed to illegal hunting. Lake Ossa appears to provide a refuge for manatees in the Sanaga watershed during the dry season. Fisherman-manatee conflicts in DEWR and LOWR are evident. Fishermen proposed compensation for their torn nets as a solution to end the conflicts. Fishermen in DEWR and LOWR have a good and clear understanding of manatee life, behavior and habitat. Their perception might vary from one habitat to the other, reflecting the difference in the status of the manatee across the various habitats.

Boat surveys conducted in Lake Ossa indicated that the Lake Mevia site within the Lake Ossa complex provide the highest probability of sighting manatees during the dry season, with 0500-1000 hours being the best period of the day for sighting a manatee in this site, and 1800-2200 hours the best period for sighting them in the other sites of the lake. Indeed, the Lindema-Mevia canal might be the most important manatee feeding area in Lake Ossa during the dry season. Manatees are continuously hunted in Lake Ossa. Entanglement in nets and Chinese bamboos placed underwater by fishermen is another threat to manatees in Lake Ossa.

This study underscores the importance of promoting collaborative management of natural resources that will enable fishermen to be involved in the decision making and implementation process of conservation activities. As a result of my investigation, I recommend the following conservation strategy: Designating Lake Mevia as a manatee sanctuary with the promotion of eco-tourism as an alternative livelihood for local fishermen during the dry season, and extending the limits of the reserve in such a way to encompass most of the current distribution area for manatees in the Sanaga drainage basin.

RESUME

Le lamantin Ouest Africain (*Trichechus senegalensis*), de lôordre des Sireniens, est le moins connu biologiquement des mammifères aquatiques. Les informations existantes provenant de la littérature et des résultats des enquêtes et des études effectuées entre 1980 et 1981, puis entre 1986 et 1995 sur la distribution et la biologie de *Trichechus senegalensis* ont montré que dans le bassin versant de la Sanaga, les lamantins sont présents depuis le barrage hydroélectrique dôEdea jusqu'à la côte, dans la Rivière Nyong, le Lac Ossa et le Lac Tissongo (Nishiwaki, 1982; Grigoine, 1996; Powell, 1996).

Les enquêtes dôopinion menées auprès des pêcheurs de la Reserve de Faune de Douala-Edéa et la Réserve de Faune du Lac Ossa confirment la présence du lamantin Ouest Africain dans la Sanaga, le Nyong, la zone costale, le Lac Ossa et le Lac Tissongo. Lôétude révèle aussi dans la partie basse de la Sanaga, à Malimba, la plus forte densité de lamantins mais aussi le taux de mortalité le plus élévé. Le braconnage est la cause principale de décès. Le Lac Ossa quant à lui constitue un refuge pour les lamantins de la Sanaga pendant la saison sèche. Il existe un conflit permanent entre lamantins et pêcheurs. Ces derniers proposent comme solution au conflit une compensation de leurs filets endommagés par le lamantin. Les pêcheurs de la Reserve de Faune de Douala Edéa font preuve dôune connaissance assez claire de la biologie et du comportement du lamantin, et de son habitat. Cependant, leurs perceptions varient dôun habitat à lôautre, montrant ainsi que les lamantins ont un statut différent pour chaque type dôhabitat.

Dôautre part, les séries de scannages à lôï il nu effectués à partir dôune pirogue dans le Lac Ossa, ont montré que pendant la saison sèche le lac Mevia représente le site du complexe Lac Ossa où il est plus probable dôobserver un lamantin et, le temps le plus probable dôobservation dans ce site étant situé entre 5h et 10 h du matin et 18h à 22h sur dôautres sites. Le Canal Lindema-Mevia, serait le site pâture du lamantin le plus important pendant la saison sèche dans le Lac Ossa. Les lamantins sont chassés à la dérobée dans Lac Ossa. Les filets à lamantin et les bambous de Chine (*Bambusa* sp) plantés sous les eaux par les pêcheurs constituent une menace pour la population de lamantin du Lac Ossa.

Cette étude souligne lôimportance de promouvoir une gestion collaborative des ressources naturelles afin de permettre au pêcheur de participer au processus de prise de décision et à la mise en î uvre des activités de conservation. Le Lac Mevia devrait être établit comme sanctuaire pour lamantins où lôécotourisme devrait être encouragé et développé comme stratégie de conservation des lamantins. Enfin, il serait important dôétendre les limites de la Reserve de Faune de Douala-Edea et la Reserve de Faune du Lac Ossa enfin de couvrir tout lôaire de repartions de lôespèce au sein du bassin de la Sanaga.

Chapter I: INTRODUCION

In Cameroon, the Lake Ossa Wildlife Reserve (LOWR) was established in 1948 at Dizangué by the colonial administration for the protection of manatees that use this habitat as a refuge. There, the Government is strongly interested in having a research and conservation project (Powell 1996). Land and boat surveys conducted from June to August 1989 by Grigione (1996) revealed manatee abundance around the region of Korup, Mamfe and Edea. No manatee presence was reported in the Kribi area. Like other protected areas of the country, the conservation of wildlife in the Douala-Edea Wildlife Reserve (DEWR) and LOWR is ensured to a certain extent by the State. Conservation benefits from the support of local NGOs, organized bodies dedicated to the protection of wildlife populations. However, support remains insufficient to guarantee a promising future for the reserves or the manatee population.

I. Background

A. Taxonomy and distribution

There are three extant species of manatee in the Order Sirenia: the Amazonian manatee, *Trichechus inunguis* Natterer in von Pelzeln, 1883; the West Indian manatee, *Trichechus manatus* Linnaeus, 1758; and the West African manatee, *Trichechus senegalensis* Link, 1795. The West African manatee is an endemic aquatic mammal found in West Africa from southern Mauritania to southern Angola in rivers, along the coastline (Powell 1996) and up to 75 km offshore among the shallow coastal flats and mangrove islands of the Bijagos Archipelago in Gunea-Bissau (Powell 1990). There are insular populations in Lake Volta (Ghana), the upper reaches of River Niger (Mali), the Logone and Chari Rivers (Chad), which are isolated from the sea and conspecifics due to dams. All sirenians are large, fully aquatic, herbivorous mammals. West African manatees can measure up to 4 m long (Powell 1996) and weigh up to 500 kg (Husar 1978) with an average of 360 kg (Stuart and Stuart 1996). Relatively little is known of the West African manatee (Powell 1996) compared to the other species of sirenians; yet it is likely the most threatened of all manatees (Perrin 2001).

Figure 1: Geographical range of *Trichechus senegalensis* in the world from http://www.iucnredlist.org

In Cameroon, manatees are frequently sighted in the Sanaga River at Edea, downstream from the dam (Dekeyser, 1955; Nishiwaki *et al*., 1982 as cited in Powell, 1996). Manatees are also abundant in Lake Ossa, which may provide a sanctuary for manatees during low water periods. Along the Cameroonian coastline there is suitable habitat for manatees (Hat 1934, Powell 1996) and manatees are not rare there (Powell 1996) as suspected by Allen (1942). Manatees are present in Akwayafe, Rio del rey, Ngosso, Andokat, Meme Rivers and in the extensive mangroves. West African manatees are also present in coastal creek of southwestern Cameroon near the Nigerian border (Powell 1996). Manatees have also been found in the Munaya and Cross River, in Wouri River and lower estuary, in the lower reaches of Nyong, Dihende, Dipomba and Ntem River (Grigoine 1996). In Northern Cameroon, manatees are present in the Benue River, from the mouth of the Faro to Lake Léré. They may also be present in Lagdo Lake (see Figure 2).

B. Habitat use, habitat preference and movement

Similar to the West Indian manatee, West African manatees inhabit practically every aquatic habitat that allows them access and meets their thermoregulation requirements of water temperatures greater than 20 degrees Celsius (Hartman 1979; Powell and *al*., 1981; Rathbun *and al*., 1983; Irvine 1983; Powell and Rathbun 1984). West African manatees have been observed or recorded in coastal areas, estuarine lagoons, large rivers that range from brackish to fresh water, freshwater lakes and the extreme upper reaches of rivers above waterfalls (Powell 1996). In general, their habitat requirements appear similar to *T. manatus,* requiring sheltered water with access to food and freshwater (Powell & Rathbun 1984). Three types of habitats are optimal for manatees in the coastal region (Powell, 1996):

- Coastal lagoon: with abundant growth of mangrove, seagrass, or emergent vegetation;

- Estuarine areas with abundant mangrove plant species (*Rhizophora racemosa*) and seagrass in the lower reaches and lined with grass, particularly *Vossia* and *Echinochloa* further upriver;

- Shallow (<3 m depth) and protected coastal areas with fringing mangroves or marine macrophytes, particularly *Ruppia, Halodule or Cymodocea.*

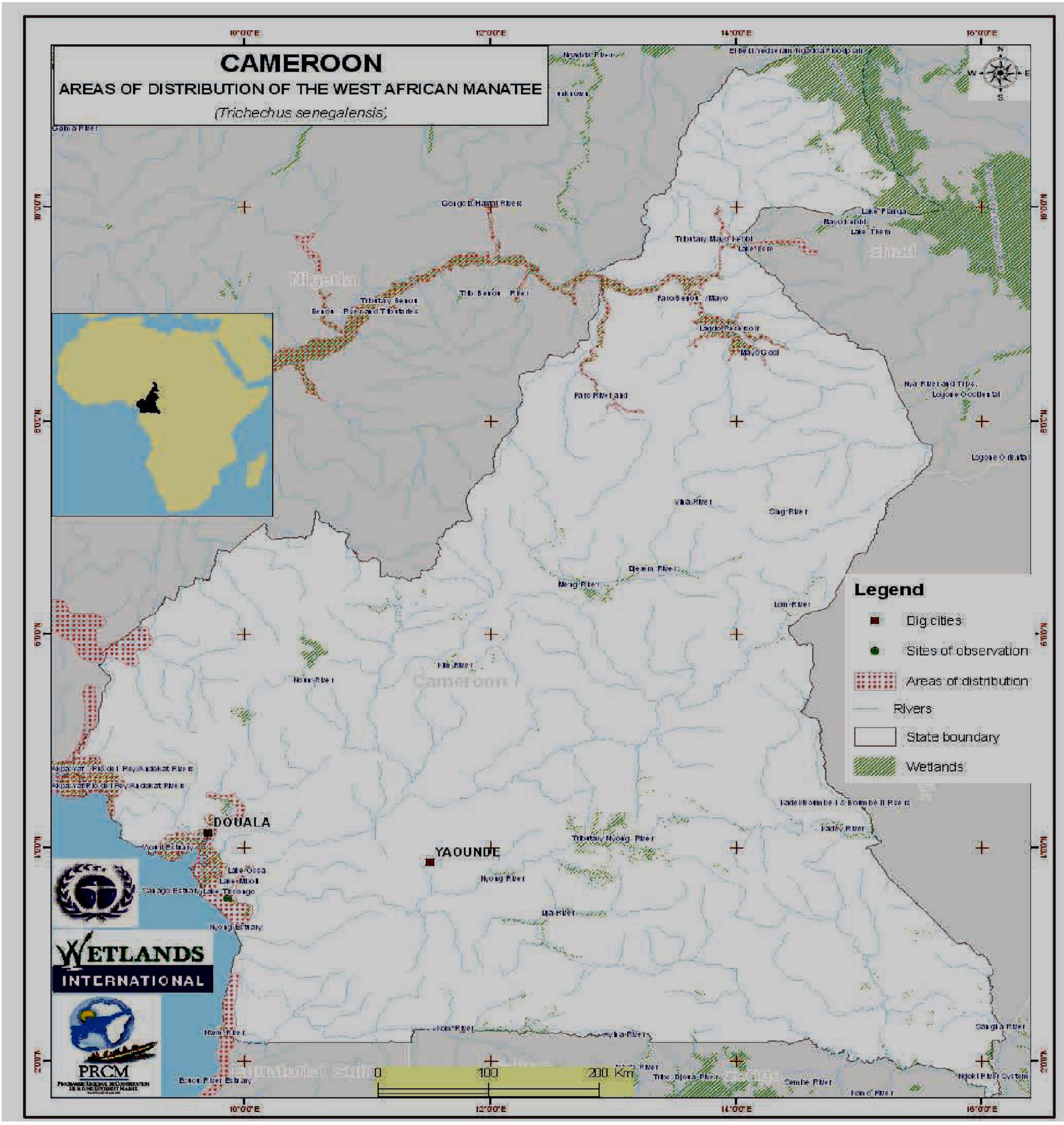


Figure 2: Map of the distribution of West Africa manatee in Cameroon (Source: Wetland International and PRCM (Regional Coastal and Marine Conservation Programme)).

In riverine habitats that have major fluctuations in flow rates and water levels, manatees seem to prefer those areas that have access to deep pools or connecting lakes for refuge during the dry season and seasonally flood into swamp or forest with abundant grass and sedges, particularly *Vossia, Echinochloa and Phragmites*

Manatees in some areas of West Africa have been reported to make movements in response to varying water levels that affect the manateeôs ability to obtain food or osmoregulate (DuChaillu 1860, Bessac & Villiers 1948, Kienta 1982, *cited in* Powell 1996). In general there are two scales of movement exhibited by manatees: seasonal movements and daily movements.

Seasonal movements are related to three factors, which in-turn are related to dry and rainy seasons in West Africa (Powell 1985, 1996): (1) current; (2) salinity variation; and (3) water level changes. Unlike Florida manatees (*Trichechus manatus latirostris*) that live in the temperate zone, seasonal movement towards warmer water during colder seasons has not been observed in tropical manatees in West Africa. In West Africa, daily movements are most likely directed by feeding and resting requirements, and access to fresh water. Based on radio-tracked manatees in Niouniourou River and the Niouzomou lagoon system in the Ivory Coast, manatees rest during the day in preferred areas in the middle of a large river or lagoon (Powell 1996). In the afternoon, at about 17:00 h, manatees begin to slowly move from their resting site, often just drifting with the current and leaving no disturbance on the surface of the water. When reaching their destination, usually a stand of grasses, they stop and begin to feed. Through the night they may move to a number of feeding sites. They usually returned to their resting site before dawn, usually between 03:00-04:00h. Powell also observed an average breathing interval for manatees of 6.2 minutes. The longest interval recorded was 18 minutes.

C. Legal and ecological status

West African manatees have been red listed by the IUCN as Vulnerable (A3cd; C1 ver. 3.1), (IUCN redlist 2011), which means that the species is facing a high risk of extinction in the wild. However, data are limited for the species, which is facing increasing threats, particularly from hunting, incidental catch and habitat destruction. Based on these threats, the IUCN assessment (Powell & Kouadio 2008) suggests a high probability of a 30% or greater reduction in population size within 90 years. The report also suggests that there are fewer than 10,000 manatees in West Africa. Also, *T. senegalensis* is listed on Appendix II of the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES 2009). CITES is an international agreement between governments that aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival. For this purpose, it lists species that are not only currently threatened with extinction but also those that may become so, unless trade is closely controlled. Furthermore, *T. senegalensis* has been listed in appendix II of the Convention of Migratory Species since 2002 (CMS 2011). Appendix II includes migratory species that have an unfavorable conservation status or would benefit significantly from international cooperation organized by tailored agreements. Cameroon has not signed the Memorandum of Understanding (MoU) concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia of 2008 (WATCH II).

Four legislative instruments make up the corner stone of wildlife protection in Cameroon (Djeukam, 2007):

- The Convention on International Trade on Endangered Species of Wild Fauna and Flora, signed on July 05th 1981 and ratified on September 03rd 1981;

- Law No. 94/01 of 20 January 1994 to lay down Forestry, Wildlife and Fisheries Regulations with the view to the general objectives of the forestry, wildlife and fisheries policy within the framework of an integrated management ensuring sustainable conservation and use of the said resources for and of the various resources. Chapter I (Protection of wildlife and biodiversity) in Part IV (Wildlife) of this law in its section 78 states that animal species in the national territory shall, for the purpose of their protection, be classified into three classes: A, B and C; according to conditions laid down by order of the minister of wildlife. Species of class A, in which the West African manatee belongs, shall be completely protected and may on no occasion be killed except as provided for in Sections 82 and 83 of this law;

- Decree No. 95/466/PM of 20 July 1995 laying down the conditions for implementing Wildlife Regulations; and

- Order No. 0648/MINFOF of 18 December 2006 setting the list of animals of classes A, B and C. Thus according to the Article 1 and 2 of this Order, *T. senegalensis* belong to the class A, hence it is totally protected and it is forbidden to kill them; however, any person who wishes to capture or keep them for management purposes or within the framework of scientific research or for reasons of protection of persons and their property must obtain a special authorization issued by the services in charge of wildlife.

D. West African manatee conservation initiatives

In May 2000, the regional initiative for an action plan for the conservation of the West African manatee was launched at the workshop on ñConservation and Management of Small Cetaceans of the Coast of Africaò held in Conakry, Guinea, which led to two resolutions (Resolution 7.7 and 8.5) and one recommendation (Recommendation 7.3) supporting the development of a CMS instrument on West African manatees, as well as the implementation of the action plans. In 2002 and 2005 these recommendation and resolutions were adopted. In October 2007 (at Adeje, Tenerife, Spain), a first negotiation meeting had considered and further elaborated an MoU concerning the conservation of the West African manatee. Finally in October 2008, in Lomé, Togo, the final negotiation and signing of the MoU was completed, including the adoption of the action plan. Fifteen Governmental representatives signed the MoU (UNEP/CMS, 2008) in which they agreed to work closely in the region to foster cooperation, build capacity, and ensure coordinated region-wide actions in order to achieve and maintain a favorable conservation status for manatees and small cetaceans and their habitats and safeguard the associated values of these species for the people of the region. Cameroon doesnôt figure on the list of fifteen signatories of the MoU.

The adopted action plan, aiming at ñsignificantly improving the conservation of the status of the West African manatee across its rangeò was developed on four main objectives, including (UNEP/CMS/WATCH II 2008):

- Improving policies and legislation for manatee protection, and strengthening their implementation;
- Improving understanding of the West African manatee and its ecological and use information for its conservation management;
- Reducing pressures on the West African manatee through the restoration and safeguarding of its habitats; and
- Instilling a wide appreciation of the West African manatee and its ecological and cultural values through targeted communication, education and public awareness.

These objectives were matched by expected outcomes and recommended action. Some of the regionally recommended actions related to the objective of improving understanding of the West African manatee and its ecological and use information for its conservation management include:

- Identifying key sites for manatee conservation, and develop proposals for their designation and management;
- Identifying key habitat requirements for manatees in different areas, and establishing mechanism for preventing the destruction and degradation of these habitats; and
- Determining important areas for manatees, especially at key site.

As regarding Cameroon, the following actions were recommended in the MuO for the improvement of the manatee conservation:

- Develop a participatory approach toward the inclusion of rural communities in the management of manatee populations in Cameroon;
- Determine the status of manatees in the Benue River in northern Cameroon and identify key sites and potential refuges in this area for the species;
- Undertake a development study of ecotourism potential of the species;
- Fight against coastal pollution and degradation of manatee habitat;
- Develop an ecological monitoring system of manatees in the Cameroonian coastal area and beyond with the use of modern identification tools and the control of activities; and
- Incorporate manatee research into regional conservation efforts, so as to improve the chances of conservation success, and to strengthen sustainability of local efforts;

In addition to the CMS, most range states including Cameroon are signatories of other international conventions and agreements promoting the conservation of threatened species, notably, the African Convention on the Conservation of Nature and Natural Resources (Algiers, 1968); the Bonn Convention on the conservation of Migratory Species of Wild Animals (1987); the convention on Wetlands (Ramsar, Iran, 1971); the Convention on Biological Diversity (1992); and the Abidjan Convention for Cooperation in the Protection and Development of the Coastal and Marine Environment of the West and Central African Region (1984).

Despite the technical support brought to the signatory countries, the implementation of these conventions is generally weak, largely due to limited means of government departments (Dodman *et al.,* 2008). For example, in LOWR the Forest and Wildlife office lacks basic material such as boats and life jackets needed to patrol the aquatic component of the reserve. Fishermen and manatee hunters, being aware of this handicap, freely and easily kill manatees (personal observations).

II. Problem Statement

In Cameroon, Lake Ossa and the lower reaches of the River Sanaga provide a dry season sanctuary for manatees within the Sanaga River basin (Powell 1996). In these areas, they face frequent and intensive anthropogenic pressure including hunting, degradation of habitat via deforestation, pollution from industries and agriculture, accidental collision with boats, and entanglement in fishing nets (Powell 1996). The species is of a considerable importance because it contributes to the water quality by grazing on high proliferating floating plant species that prevent light rays from penetrate in the water; as is the case of water hyacinth in the Wouri (Pers. Obs). Furthermore, its meat, skin, oil and bones are of high economic and medicinal value (Kouadio 1997, Kone 2002). In some areas, there may be a positive relationship between the presence of manatees and an increase in fisheries productivity, due to the enrichment of water by manatee dung (Ciofolo and Sadou 1996).

Only few studies have been carried out on manatees in Cameroon, so there is very little information specific to Cameroon. In the course of the literature review we came across only three published scientific articles (namely: Nishiwaki & al. 1982, Grigoine 1996, Powell 1996) addressing directly the manatee in Cameroon. Moreover, some of the existing information is outdated and needs to be reassessed; the result of the latest study being published in 1996 by Powell. These large gaps in the knowledge of the West African manatee heightens the difficulties in determining the appropriate ecological status of the species (Dodman *et al*., 2008), its current distribution area, and particularly its status in the Douala-Edéa and Lake Ossa wildlife reserves; consequently, the development and the implementation of a conservation strategy ī which will be at the same time efficient and sustainable ī is very difficult

In Florida, Australia , Belize, and other countries sirenians are habituated to human presence and highly valued and protected by the tourism industry. However, the ecotourism potential for the West African manatee is eclipsed by the elusiveness of the species and the highly turbid nature of water in most of its distribution area (UNEP/CMS/WATCH 2008; see II-Doc.5 (F)). In Crystal River, Florida, for example, manatees are found seasonally in clear springs where they have become habituated to humans who pay significant fees for an opportunity to snorkel with the gentle giants. Tourists in West Africa are willing to pay great amounts of money just to observe the elusive West African manatees from a boat in their natural habitats; but since manatees are living in poor visibility water habitat, they are more camouflaged and tour operators do not have any idea of where and when they have a better probability of sighting a manatee as it protrudes it snout above the water surface for breathing. This is true because there is very little knowledge available on manatee habitats use. Consequently, the tourism value of the manatee in West Africa is low, as effective conservation of the species remains difficult to implement.

III. Purpose and objectives of the study

This study aims at improving the knowledge of the West African manatee, particularly with respect to the strengthening of conservation strategies. In particular, we will make recommendations specific to the Lake Ossa Wildlife Reserve. To achieve this objective, it is important to: (a) investigate indigenous knowledge and local perception of the species; (b) identify specific areas and periods of the day having high probabilities of encountering manatees; (c) determine habitat factors associated to the occurrence probability of the manatee at any particular point; and (d) observe and document basic behaviors of the manatee living in the lake. These objectives fall into the wide range of regional and Cameroon-specific recommendations for the improvement of the conservation status of the West Africa manatee stated in the regional action plan (UNEP/CMS/WATCH 2008).

In this chapter I, we have introduced the West African manatee and included information on its taxonomy, biology, population status, legal status, and discussed regional and local initiatives for its conservation. We have also presented the issues this study aims to answer.

Chapter II presents the survey results on indigenous knowledge and local perception of the manatee in the Douala-Edea (DEWR) and Lake Ossa (LOWR) wildlife reserves.

Chapter III presents the results of the field survey conducted in LOWR. Here, we describe the spatial and temporal habitat used by manatee in LOWR. Additionally, we strive to discuss factors that may attract or repulse a manatee in a particular site of the Lake.

Chapter IV is addressed mainly to stakeholders and decision makers. Here we tackle issues on potential impacts and application of the results obtained from this study, followed by a series of recommendations to take into consideration for the development and implementation of an action plan for the conservation of the manatee in Cameroon.

CHAPTER II: TRADITIONAL ECOLOGICAL KNOWLEDGE OF MANATEES IN THE DOUALA-EDEA WILDLIFE RESERVE (DEWR) AND LAKE OSSA WILDLIFE RESERVE (LOWR)

I. INTRODUCTION

Until recently, western scientists have typically rejected the traditional knowledge of indigenous peoples, particularly in Africa, as anecdotal, non-quantitative, and unscientific (Sommer 2004). Today, however, conservation researchers are approaching traditional ecological knowledge (TEK) with increased alacrity, recognizing its potential contributions to both the understanding of biological phenomena and the practice of protecting species and ecosystems (Shackeroff 2007). African governments and international development agencies are also recognizing that local-level knowledge and organizations provide the foundation for participatory approaches to development (Warren 1992). TEK with its related term as indigenous knowledge, indigenous science, fisherọs knowledge and local knowledge although they bear some little difference in meaning can be defined basically as the dynamic contribution of any community to problem solving based on their own perception and conceptions, and the way they identify, categorize and classify phenomena important to them (Waldron 1999). The reliability of TEK notion stems from the assumption that ñpeople living within the same community seem to espouse a range of beliefs, use a host of terms that do not overlap in many casesò (Borofsky 1994 *cited in* Waldron 1999) and, many ecological problems are local in nature and require the cooperation of traditional peoples in addressing global issues. This contrasts with scientific knowledge (western knowledge) by its less universal and less empirical nature.

By encompassing the skills - that is, experiences and insights of people - applied to maintain or improve their livelihood, TEK proves to be important in a variety of research and applied fields of conservation. TEK provides the basis for local-level decision-making about many fundamental aspects of day-to-day life of hunting and fishing (ICSU 2002) that plays a significant role in the development of hypotheses, research designs, methods and interpretations employed by scientists as is the case in this study. In fact, in this study, we investigated local population perception about manatees and then developed a hypothesis from the collected indigenous information that would be tested on the basis of data collected from the ecological field survey techniques.

Conservation strategy can be based on traditional knowledge and resource use (Redford and Padoch 1992, Redford and Mansour 1996 *cited in* ICSU 2002). An outstanding role of TEK is the possibility it allows conservationists to integrate their programs with real human needs and practices. Conservation by exclusion and isolation will not be sustained in the face of growing poverty (ICSU 2002); for this reason, we did not only rely on ecological field result to bring out recommendation related to manatee conservation or a management plan, but, we also took in consideration the perception and recommendations from the local population regarding manatee.

TEK can be collected using methods such as traditional survey methodology through questions and informant participation that involve careful observation in the daily lives of the informants for an extended period of time. The optimum strategy appears to be a combination of the two methods (Waldron 1999). In this study both methods were used, though more consideration was given to the questionnaire survey methodology.

The risk in using TEK is the possibility of getting misinformation or invalid data. The reason for misinformation is the sense of mistrust generally observed between the local community and the informant that most of the time stems from the negative impression they have about each other; it could also result from a lack of fluent communication between the researcher and the informant. Another source of misinformation is the issue of ideal versus real that may raise as the local people (informant) provide information based on what they think they should say rather than providing answers that are more truthful or accurate (Waldron, 1999).

In order to combat mistrust, we endeavored to give a good impression and involved ourself in community policies. Involving informants in the editing process, sharing royalties, co-authorship with them, taking on jobs within the community and socializing in the community all helped to reduce the degree of mistrust that people may have had. In addition, we took care in selecting informants, spending a great deal of time with the people, using several informant sources in order to avoid the problem of ideal versus real and omitted information as recommended by Waldron (1999).

The current chapter comprises two parts. The first part describes the study area, namely DEWR (Douala-Edea Wildlife Reserve) and LOWR (Lake Ossa Wildlife Reserve), and the methodology used for TEK data collection. The second part presents the results, interpretation and discussion of the TEK-data analyzing graphs and statistics. A number of suggestions are made and hypotheses formulated for later confirmation by the field ecological survey.

II. Material and Method

A. Human context and description of the study area.

The study was conducted in two protected areas: the Douala-Edea Wildlife Reserve (DEWR) in Mouanko subdivision and the Lake Ossa Wildlife Reserve (LOWR) in Dizangué subdivision. Both areas are included in the Sanaga Maritime division, one of the divisions of the Littoral Region. As a coastal country of Central Africa, Cameroon shares its boundaries with Chad to the north, Nigeria and the Atlantic Ocean to the west, the Central African Republic to the east, and Guinea, Gabon and Republic of Congo to the south. DEWR and LOWR are both situated in the Sanaga drainage basin (Sanaga watershed) with LOWR along the upper Sanaga (down after the Hydro-electrical dam of Edea) and DEWR along the lower Sanaga River closer to where it empties into the sea (see figure 3).

1. Lake Ossa Wildlife Reserve (LOWR)

a) Location and history

Lake Ossa wildlife reserve is situated 13 km from Edea between the 3° 45ô and 3° 52ô latitude north, and between 9° 45ô and 10° 4 ólongitude east with approximately 300m elevation. LOWR covers an estimated area of 4000 ha; however, the limits of the reserve are not well defined. The LOWR was created in 1968 and falls within the 3rd category of protected areas, according to Cameroonös classification. The reserve was created specifically for the protection of the West African manatee (*Trichechus senegalensis)*.

b) Ethnicity and human settlement

Presently, neighboring areas of Lake Ossa are inhabited by Yakalak and Ndonga tribesmen who settled in this region by the end of the 18th century; other ethnic groups found in the area include Ndonga, Pongo, Malimba, Bassa, Bamileke, Toupouries and Yambassa and are distributed in eleven small villages throughout the Reserve. Recently (2008), for a purpose of good resource management, the Lake Ossa water site villages were grouped by the local conservation office and a local NGO named WTG (Watershed Task Group) into six zones and organized as zonal committees responsible for local natural resource management. Daily life in LOWR mainly centers on exploitation of natural resources such as fishing and, to a lesser extent, hunting. Many women and men of this locality are employed by two agro-industrial corporations, namely SOCAPALM (Palm Oil Refinery Company) and SAFACAM (Rubber Company). Sand dredging in the Sanaga River is another activity in the region and is mostly conducted by youths. Subsistence farming is practiced at a lower scale, given that most of the land is occupied by industrial plantations or bodies of water.

2. Douala-Edea Wildlife Reserve

a) Location, limits and surface

The Douala-Edea wildlife reserve is located in the Coastal Province, Department of Sanaga Maritime. Its geographic coordinates lie between 3° 14' and 3°50' N latitude and between 9°34' and 10°03' E longitude. It has an area of about 1,600 km^2. Its limits extend from the Atlantic coast for a distance of 35 km inland, with its eastern boundary along river Dipombé. The reserve consists of two unequal parts: the larger in the south, lies between the mouths of the Sanaga and Nyong north to south, the smaller part extends along the northern coast of the Sanaga up to Souelaba and is limited in the east by Creek Kwa Kwa (see figure 3).

b) Relief and drainage

The reserve is located within a sedimentary low plain of 0-50 m (rarely to 80m) evlevation. This plain is crisscrossed by rivers and marshes that provide the only relief to this very flat topography. Much of the northern area of the reserve is subject to tides. Streams occupy about 1% of the area of the reserve; the largest surface water is Lake Tissongo.

c) Geological and soil characteristics

The sedimentary basin in which the reserve is located is composed of marine sediments whose depth can reach 2,700 m or more. Soils range from very sandy (from the dunes) to sandy-loam farther inland (with combination of alluvial sediments descending from the Sanaga River).

d) Climate

The reserve is located in a transitional climate zone. In the south of the reserve, the region is characterized by a typical equatorial climate with two rainy seasons and two dry seasons per year. The average annual rainfall ranges from 3.000 to 4.000 mm. The months of December and January are also relatively dry (50mm of rain). Starting in February, rains become more abundant with a peak in June followed by a slight decline variable; a new peak in rainfall occurs from August to October. The monthly average temperature varies throughout the year from 24.6° C to 28.7 ° C.

e) Vegetation

The reserve, adjacent to the Atlantic Ocean, is a littoral forest dominated by *Lophira alata* and *Saccoglottis gabonensis*. This type of vegetation covers most of the reserve. The DEWR is characterized by the abundance of both emergent species. Among the dominant species in the canopy is *Coula edulis* (Oleaceae), which is very abundant. Also frequently present in the reserve are the Ebenaceae (*Diospyros spp*), Guittiferae (especially *Garcinia spp*) especially in the wetted areas, Euphorbiaceae (*Protomegabaria stapfiana; Dichostemma glaucescens;* and *Anthonotha aubryanum)*. However, there are several other types of vegetation according to elevation, drainage, topography and soil type (Newbery and Gartlan, 1996).

f) ***Wildlife***

The arboreal monkeys, typical of the African forest, are well represented. Sanaga River is also the southern limit of distribution for some species of West African monkeys *(Cercopithecus nictitans martini erythrotis, C. camerunensis, C. pogonias pogonias)*. The chimpanzee (*Pan troglodytes*) is present but rare. The occurrence of several species of endangered mammals in the reserve is reported. They include some fairly widespread but threatened species such as the African elephant (*Loxodonta africana cyclotis)* and the West African manatee *(Trichechus senegalensis*). In 1980 there was still a large population of elephants, especially in coastal swamp forests. But it is likely that they have been decimated to date (Nembot and Tchanou 1998) The list of endemic and threatened Cameroon fauna in DEWR include *Loxondonta cyclotis africana* (African forest elephant) *Colobus Colobus satanas* (black colobus monkey), *Trichechus senegalensis* (West African manatee), *Cercocebus torquatus* (white collared mangabey) *Cercopithecus cephus* (whiskered monkey), Pan troglodytes (chimpanzee), and *Ostelamus tetraspis* (pygmy crocodile).

g) *Ethnicity and human settlement*

The Douala-Edea Wildlife Reserve (DEWR) is populated by more than 8,000 people. This population includes migrant fishermen from Nigeria, Benin and Ghana, who engage in fishing activities along the entire Atlantic coast (Nembot and Tchanou., 1998). Along the rivers that form natural boundaries of the reserve, particularly the Sanaga, there are large villages, long established and populated by ethnic and Bakoko Malimba. The DEWR human population is mainly active in fishing and collecting of oysters. Subsistence farming constitutes another livelihood means for this population.

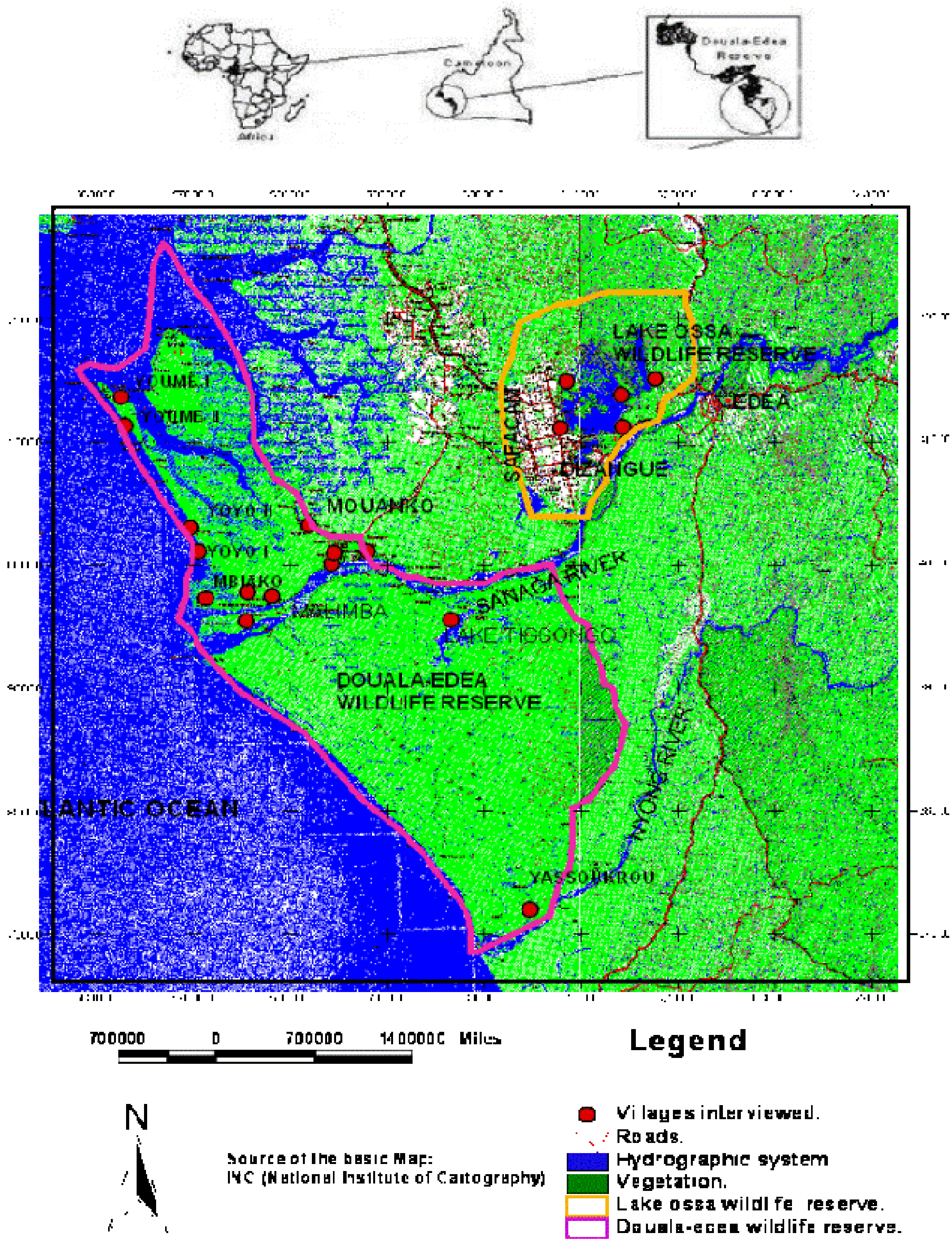


Figure 3: Map of the Geographical location of the study area (DEWR and LOWR) and villages where interviews were conducted.

B. Approaches and justification

Rapid Rural Appraisal (RRA) was the approach used in this study to collect traditional ecological knowledge (TEK) data on the manatee. RRA is an extractive research methodology consisting of systematic and semi-structured activities conducted on-site with the aim of quickly and efficiently acquiring, analyzing and evaluating new information about rural conditions and local knowledge (Cavestro, 2003).

This information was obtained in close cooperation with the local people. The RRA was an important step for the overall study because it provided an overview of the population's perception of manatees. This perception would then help to generate hypotheses and facilitate the general study. It has also helped in orienting field research efforts since we could now define where and when to plan direct observations and which sampling method to use for direct survey. Two methods were used to conduct the RRA: questionnaires survey and the focus group survey.

Questionnaires are particularly suitable tools for approaching certain topics in ecology, including studies of public or stakeholder perceptions in ecological management, large-scale studies and studies of human impacts on wild species (Piran and *al*., 2005). Quantifying public perceptions has become a key component in translating ecology into management. Large-scale ecological studies frequently require high-resolution data for specific areas (Piran and *al.*, 2005). Questionnaires also have the advantage to be less costly compared to other survey methods. This method is commonly used for manatee surveys, especially in Africa. It was used by manatee researcher Nishiwaki in 1982, Powell in 1996, and Grigione in 1996 to survey for West African manatees, including areas in Cameroon.

Focus groups are particularly useful for exploring people's knowledge and experiences and can be used to examine not only what people think but how they think and why they think that way (Kitzinger 1995). Focus group surveys have the advantage of less or even no discrimination against people who cannot read or write. They can also be used to encourage participation from people reluctant to be interviewed individually, or who feel they have nothing to say (Kitzinger 1995). Also, participants can act as checks and balances on one another identifying factual errors or extreme views. The limitations of the focus group are that the responses of each participant are not independent and a few dominant focus group members can skew the session.

Questionnaires were used in both DEWR and LOWR. However, focus groups were only used in LOWR due to limited resources. The fact that LOWR is well structured into zones and the population organized into zonal committee topped by the general managing committee has facilitated the course of the focus group there as we need to gather fishermen in a discussion meeting.

C. Interview survey design

1. Questionnaire survey design

Between June 2009 and September 2009, 143 questionnaires were distributed in DEWR (n=84) and LOWR (n=50). The samples included fishermen with experience in the study area. In DEWR 13 villages were sampled: Yoyo I, Yoyo II, Youme I, Youme II, Mbiako, Tissongo, Kangzog, Yassoukrou, Mulongo, Bolondo, Abee, Elogotot and Lobetal. In LOWR, which is smaller, 5 villages were sampled: Mevia, Lendema, Pongo-Pitti, Koungue-Lac Ossa and Plantation. Study villages were stratified in four habitats: rivers (Lower Sanaga, Lower Nyong); estuaries (Mbiako); the Atlantic coastline (Yoyo, Youme); and lakes (Ossa, Tissongo) (see Table 1). These are the main aquatic habitats within the drainage basin of Sanaga. Each of these habitats presents one or more particular characteristics suitable for *T. senegalensis*. We wanted to investigate whether indigenous perception about *T. senegalensis* differed depending on the habitat considered.

Table I: Distribution of questionnaires according to habitat types and villages.

	HABITAT TYPES								
	Coastline		**Estuaries**		**Rivers**		**Lakes**		
VILLAGES	Youme II	5	Bolondo	7	Abee	3	Koungue-Lac	7	
	Yoyo I	7	Mbiako	12	Kangzog	10	Mevia	12	
	Yoyo II	4			Lobetal	4	Plantation	12	
					Maldjedou	5	Pongo-Pitti	8	
					Mulongo	15	Tissongo	9	
					Yassoukrou	9	Lindema	7	
					Yavi	1			
					Elogotot	6			
TOTAL	**16**		**19**		**53**		**55**		**143**

Formal interviews were conducted based on structured questionnaires. The interview site was chosen according to the type of habitat (coastline, estuary, river or lakes.). The respondents were chosen according to their experience in working aquatic milieu and we targeted fishermen with 5 to 10 years experience or more. The interview was conducted in English or French depending on the spoken language of the interviewee, however there was always a local field assistant and guide to help with translation in case the interviewee was neither French nor English speaking.

We were assisted by two agents from the Ministry of Forests and Wildlife (MINFOF) and one agent from a local NGO: CWCS (Cameroon Wildlife Conservation Society) in DEWR and WTG (Watershed Task Group) in LOWR. On our first visit to a village, we held a meeting with the Chief of the village where we planned to do the survey and some of his people. During the meeting, representatives of MINFOF and the NGO would introduce us to the chief and the whole village. Then, time was given to us to explain the reason for our survey, how it would be conducted and what we expected from them. We tried as much as possible to persuade them to trust us and overcome any fear or mistrust they might have had.

The questionnaire had five sections (Appendix 3). In the first section of the questionnaire, we tried to get the profile of the fisherman (name, age, village, marital status); also, we made sure that the fisherman was familiar with manatees, therefore a test question would be asked such as ñDo you know manatee?ò if yes ñ Please give us a short descriptionò. During the description we asked for more specific details such as approximate length, morphology, skin color, and mouth description. It could happen that the fisherman had never directly sighted a manatee but had sighted direct and indirect signs that indicated the presence of manatees. Hence, if the fisherman could not describe the animal but could describe some of his direct or indirect signs of presence like the water bubbles produced by the manatees as they swim under the water, we would consider his answers. Also to be sure of the reliability of the respondentôs answers, we could ask him ñFor how long have you been fishing in the considered site?ò

The second section of the questionnaire focused on the distribution and abundance of manatees in relation to seasons. Within this section, questions like: ñWhere and how often do you sight manatees?ò were asked. To compare the abundance of manatees in the same site between the rainy season and the dry season, they were asked ñAt which season do you sight most the manatee?ò

The third section was oriented toward manatee mortality. The question ñHow many times and where have you ever seen a dead manatee?ò was asked. In the questionnaire we also used questions that would bring the interviewee to give the most likely cause of death.

The forth section dealt with manatee food. Here, the interviewee would be asked to list what manatees eat; then in order to know whether it was his opinion regarding the food eaten by the manatee or if it was what he had observed the manatee eat, he would be asked ñHow did you know about it?ò

The last section identified fisherman-manatee related conflicts and collected proposed solutions by fishermen. The question ñWhat are the problems manatees cause to you?ò was asked.

Some fishermen could bias the results because they were afraid to be reported or just tried to impress the interviewer. Such biases were avoided by repeating some questions previously asked (5 to 10 minutes earlier) to the fisherman or ask a question bearing a causality link with that question, and then compare whether the two answers would be similar or un-corroborating.

In some situations we could find a group of two or three fishermen. In such conditions it was not easy to get individual answers because, despite explaining that individual answers were needed, they will reply that they are used to fishing together and therefore they have the same knowledge about manatees. In this case, we would consider convergent answers but when their answers were different, we would allow them to discuss among themselves in a focus group survey, and then come out with a final consensual answer.

In some situations, the interview could be informal, that is, the interviewee would give answers to questions not found in the questionnaire but that were good information for the study. The fishermen would occasionally elaborate excessively on details when answering a question.

Each questionnaire was completed within 15 to 20 minutes. Generally, the questionnaire survey was conducted using as guideline the ten recommendations for a best practice in questionnaire-based study by Piran (2005).

2. Focus group survey design

Focus groups were used only in LOWR which is partitioned into six zones. In each zone, there is a management group made up mainly of fishermen. Four groups were created from four of the six management groups present in the reserve. The four groups were respectively made up of 9, 10, 11, 12 fishermen for a total of 42 fishermen aged between 28 and 70 with 9 to 40 years of fishing experience (see Table II). The meeting for each group was organized in their respective village, that is, Plantation, Pongo-Pitti, Koungue-Lake Ossa and Mevia. Letters of invitation were sent one week ahead of the meeting and a day before the meeting, participants were also reminded by phone about the meeting. Each meeting could last 1 to 2 hours. Participants were seated in a circle or an arc; the moderator would stand in the middle of the circle or in front of the arc. The moderator would open the meeting by welcoming the participants, and then he would make them feel free and very comfortable in such a way that they would not be intimidated or reserved in answering questions. He would now explain in detail the aim of the focus group and also guidelines to follow.

Table II: Description of focus group participants including village of residence, age and experience time.

		Number of participants	Age range (year)	Average Age (year)	Experience range (year)	Average experience time (year)
Village focus group	**Mevia**	12	35-65	45	15-40	28
	Pongo-Pitti	10	50-70	58	15-45	30
	Plantation	09	38-58	46	9-40	22
	Koungue-Lac	11	28-61	50	11-51	20
Summary		**42**	**28-70**	**50**	**9-51**	**25**

The moderator would also reassure the participants about the confidentiality and the anonymity of the focus group discussions. The moderator would make them understand that all the answers are important and that nobody should feel excluded or unable to answer questions. Questions were asked in the simplest format using familiar terms and the translation in local language was done for participants who could not understand French. Questions focused on four aspects related to manatees: (1) the various signs, whether direct or indirect, that enable them to recognize manatee presence; (2) the areas, time and season when those signs are most abundant; (3) threats against manatees from man and threats from the manatees against man; (4) proposed solutions for mitigating human-manatee conflicts.

The moderator was aware of participants' energy and concentration levels and providing short breaks when necessary. The moderator would encourage free-flowing discussion around the relevant issue(s), especially when only one or few persons would dominate with their responses. Participants had a response sheet (Appendix 4) where they could write down their answers.

At the end of the meeting, each participant was thanked and we shared a drink together. Two weeks later, data were summarized and we reported a synthesis of all four focus groups to them in a general meeting that we convened some days later. This meeting also aimed at giving the opportunity to the population to amend incorrect information where necessary (see figure 4).

Figure 4: Restitution meeting with fishermen and conservation agent of LOWR

D. Data analysis

Microsoft Excel spreadsheets were used to store the data and cross-tabulated into contingency tables prior to using Chi-square analysis of independence and homogeneity. The statistical software R (R Development Core Team, 2007) was used to analyze the data (with p-value for significance Ò0.05 and Ò0.01 in some cases)

Chi-squared test for either independence or homogeneity was used to see whether responses are independent from habitats. If indeed there did exist a significant habitat effect, we then looked at the frequencies for each separate habitat or group of habitats that are not significantly different. If the Chi-squared test for independence failed to reject null hypothesis (meaning that the responses did not depend on strata or habitat type), we would pool the data of the overall habitats and perform a Chi-squared test to check whether for that particular question the probabilities of the items equal or not (Mayaka, pers.com).

Some data were described using graphs, tables, percentages and frequencies. If need be, this preliminary analysis was followed by a hypothesis test using log-linear models (Agresti, 1990):

either for contingency tables (to assess the association between classification variables) or as ANOVA (to compare a dependent variable among habitats).

The Chi-squared statistic is given as

$$X^2 = \sum_{i=1}^{n} (O_i - E_i)^2 / E_i$$

III. Results

A. Questionnaire survey results

1. Sample characteristics

During a five-month survey (June-October 2009), 143 fishermen were interviewed in 19 villages distributed in four habitat types: coastline (n=16), estuary (n=19), river (n=53) and lake (n=55). The age of interviewees did not differ significantly among habitats and ranged from 19 to 89 with the average age equal to 45 years (see figure 5). Seventy-nine percent of participants had more than 10 years experience (see figure 6).

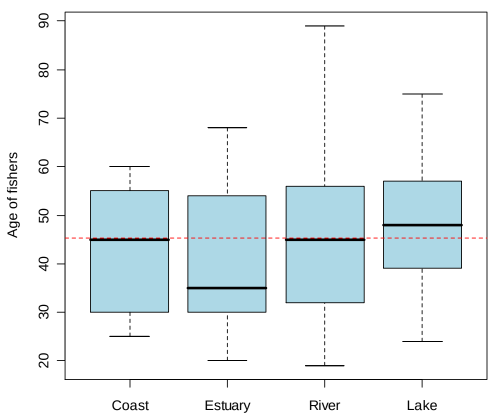


Figure 6: Plot of age of interviewees in relation to their habitat type.

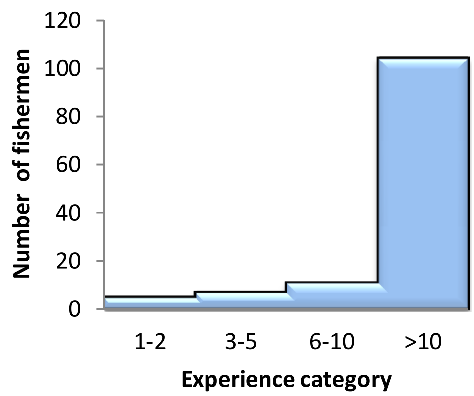


Figure 5: Plot of the distribution of years of experience category within the interviewed fishermen.

The majority of fishermen in the study area were more active only during the dry season (69%), with a few only active in the rainy season (6%), and 22% active during both seasons (see figure 7).

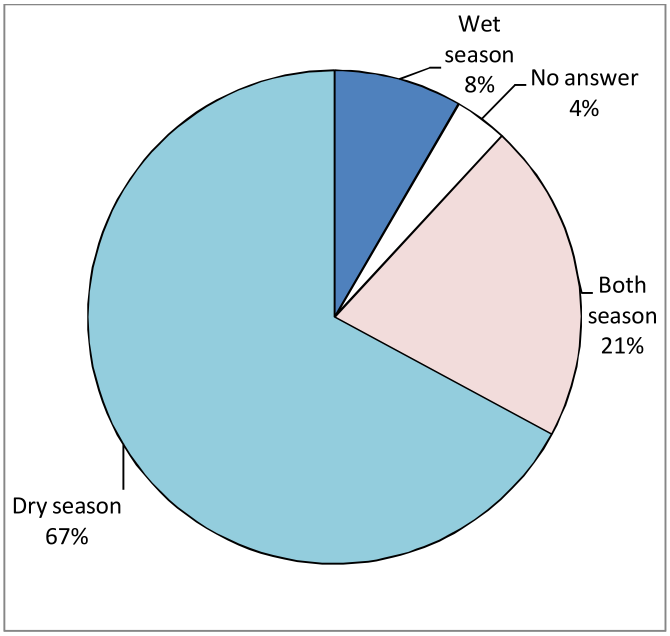


Figure 7: Distribution of interviewees according to their most active fishing season.

2. Distribution and abundance

The answers from interviewees regarding distribution and abundance of manatee in the four different type included in the study area are consigned in the contingency table below.

Table III: Contingency table of fishermenôs responses to questions related to manatee sighting frequency and number of individuals per sighting.

Question	Responses	Coastline	Estuary	River	Lake	Degree of freedom	X2-Value	P-Value	Significance
1-How often do you see manatee?	less than once a month	3	6	6	25	6	24	0.001	S
	once a month	7	6	15	15				
	Twice or more a month	5	6	31	11				
2-How many manatee do you use to sight most at once?	one manatee	2	2	8	4	6	4.5	0,6	NS
	2-3 manatees	10	8	29	22				
	4 manatees or more	4	9	11	11				

Manatee sighting frequency

The proportion of fishermen sighting manatees differs significantly between the 4 habitat types (X^2= 24; df=6; P=0.001). The greatest proportion of fishermen who reported having sighted the manatee on a regular basis, that is, twice or more a month, is highest in the river habitat (59.61%; n=52). In contrast, a strong proportion (49%; n=51) of fishermen in the lake habitat said they sighted the manatee rarely (that is, less than once a month), (see figure 8).

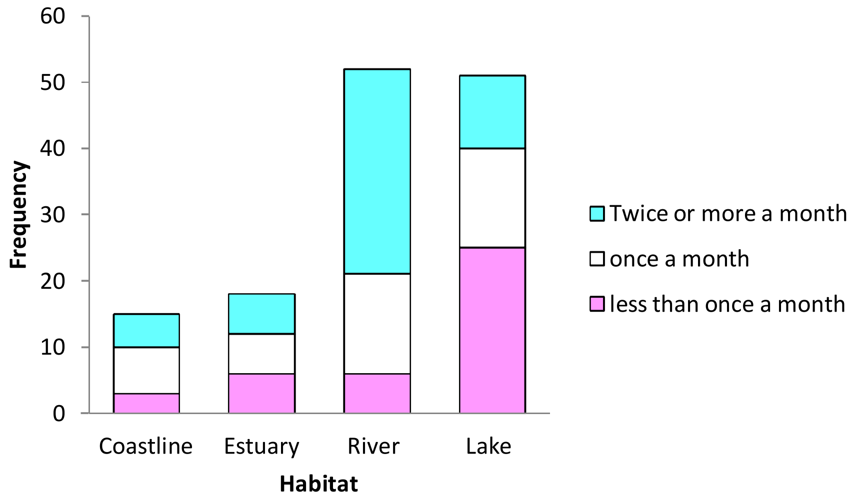


Figure 8: Distribution of fishermen according to habitat type and their monthly frequency of sighting manatees.

The frequencies of manatee group size sighted was independent of habitat type (X^2=4.5; df=6; P=0.6).

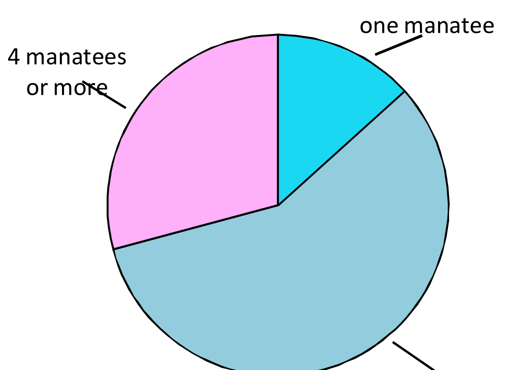


Figure 9: frequency of sighting manatee in different group size.

The frequency of sighting a group of 2-3 manatees is twice that of sighting a group of at least 4 manatees and four times that of sighting a single manatee (X^2= 36.05, df = 2, PÒ0.01), (see figure 9). The frequency of live manatee reported significantly differed according to habitat (X^2=44.370; df=3; PÒ0.01). The proportion (101; N=222) of live report is twice higher in river habitat than in lake and estuary habitat, and 4 times higher than in coastline habitat (see figure 10).

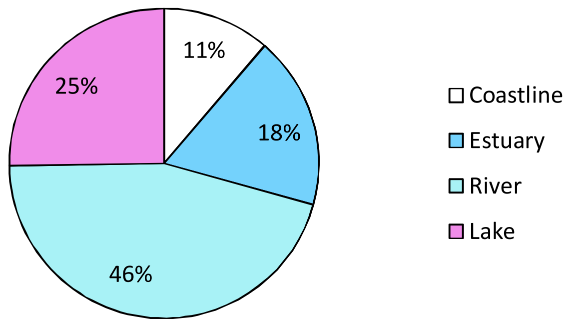


Figure 10: Distribution of live manatee report according to habitat type.

Most of the sightings seem to concentrate at the lower Sanaga River around Malimba (see figure 11), followed by Lake Ossa and then the Estuary around Mbiako; the hotspot of yellow dots are respectively at the Lower Sanaga and Lake Mevia.

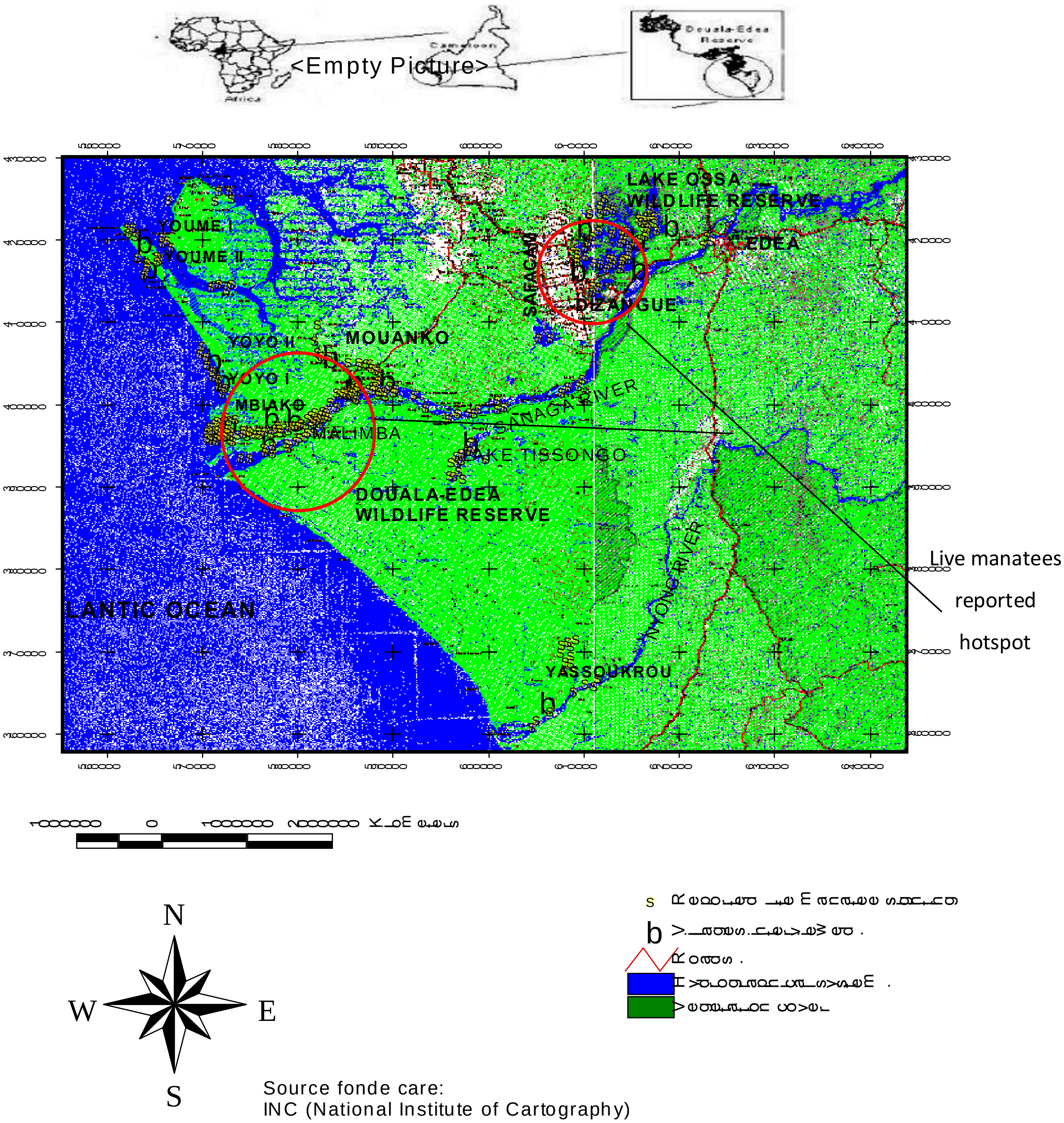


Figure 11: Map of the Distribution of live manatee reporting accross the DEWR and LOWR

3. Habitat use and movements

The perception of interviewees as concerning manatee habitat use and movements is not homogeneous across the four different habitat types (see table IV).

Table IV: Contingency table for statistic of fishermenôs responses related to the season and periods of the day when manatees are sighted most.

Question	Responses	Coastline	Estuary	River	Lake	Degree of freedom	X2-Value	P-Value	Significance
4-During which season do you sight manatee most?	Rainy season	13	4	34	21	6	29	0	S
	Dry sea season	1	10	12	30				
	Both	0	4	7	3				
5-At what time of the day do you see them often?	Morning (0500-1100 hours)	8	3	7	20	9	37	0	S
	Midday/aftern oon(1100-1800 hours)	0	3	3	15				
	Evening (1800-2100)	5	6	35	11				
	Anytime	6	6	14	10				
6-At which water level do you sight manatees most?	Low water level	4	11	4	13	6	22	0	S
	High water level	4	4	22	9				
	Both	6	3	13	3				

- **Manatee occurrence according to habitat types and season**

To the question ñDuring which season do you sight the manatee most?ò the proportion of fishermen that answered that they frequently sighted manatees during the rainy season and dry season is significantly different between habitat (X2=22.6; df=3; $P \leq 0.01$) and season. During the dry season, manatee sighting is higher in Lake and Estuary than during the rainy season. Frequency of manatee sighting during the rainy season is higher than in dry season in the Coastline and River (Figure 12).

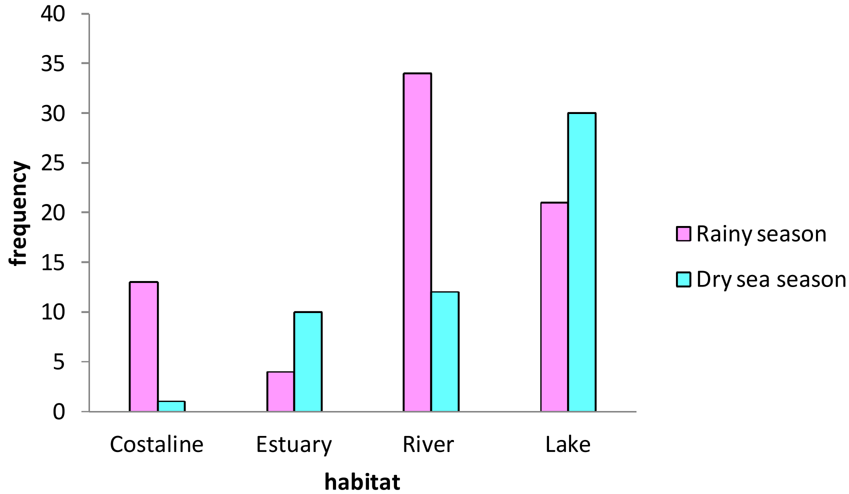


Figure 12: Distribution of interviewees according to seasons they said they sight more manatees.

Manatee occurrence in relation to time of the day and water level

To the question ñAt what time of the day do you sight manatees most?ò fishermen responses significantly differ with coastline/estuary, river and lake habitat (X^2=37.68; df=6; $P \leq 0.01$). From the graph below, it appears that in Coastline/Estuary habitat, the frequency of sighting is not influenced by the time of the day. In the river habitat, manatees are mostly sighted in the evening (between 1800-2100 hours) and in the morning (between 0500 and 1100 hours) in the lake habitat. Sightings at midday or in the afternoon are quite infrequent, except in the lake habitat (see figure 13)

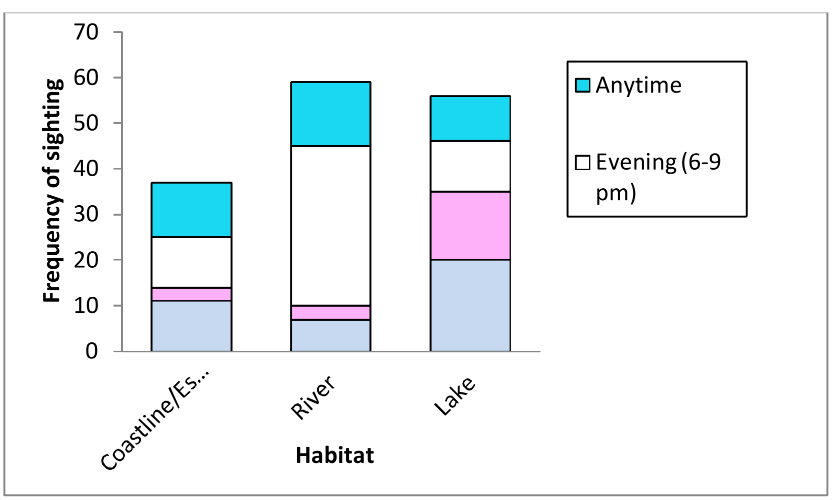


Figure 13: Distribution of fishermen according to habitat and time of the day at which they sight manatees most.

- **Manatee occurrence in relation to water level**

Frequency of sighting at low or high level water is significantly different depending on habitat type (X^2 = 22.45, df = 6, p≤ 0.001). However, this frequency does not differ significantly among the coastline, estuary and river habitat (X2= 6.7, df = 4, p = 0.14). The frequency of sighting a manatee during low water level is twice as much as during low/high water level on coastline, estuary and lake (X2= 7.0526, df = 2, p= 0.029). The frequency of sighting a manatee in River is about 1.29 higher when water level is high than when water level is low (see figure 14).

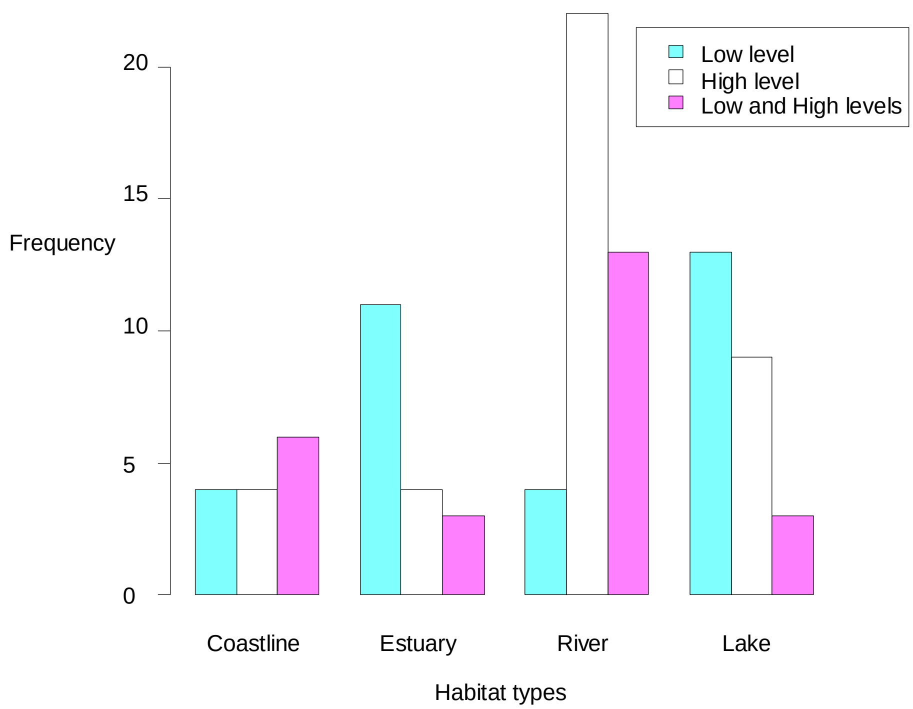


Figure 14: Distribution of respondents in relation to their habitat types and their answer to the water level at which manatees are mostly sighted

4. Threats, trends and mortality

The interviewees also have ideas about manatee threats, trends and mortality that do not always overlap across habitat types (see Table V).

Table V: Contingency table of the fishermenós responses concerning the frequency of dead manatees sighting, number of dead manatees sighted at once, perception of the trend in manatee population, accidental net capture of manatees, and manatee meat consumption and taste.

Question	Responses	Coastline	Estuary	River	Lake	df	X2-Value	P-Value	Significance
7-How many times have you ever seen a dead manatee?	Never	3	6	6	25	6	21	0	S
	Once to thrice	7	6	15	15				
	More than thrice	5	6	27	11				
8-How many dead manatees do you often sight at once?	Only one	12	11	14	18	3	5.5	0.14	NS
	More than one	0	0	2	5				
9-How do manatee populations change in your area?	Increase	5	6	30	44	3	18	0	S
	Decrease/constant /donót know	5	10	15	6				
10-Has your net ever captured a manatee?	Yes	6	2	3	2	3	20.3	0	S
	No	5	11	36	37				
11-How many times have you ever eaten manatee meat?	Never	6	10	5	22	3	21	0	S
	At least once	10	7	47	29				
12-How do like manatee meat?	So good	10	8	45	28	3	0,8	0,86	NS
	Fairly good	0	0	2	1				

To the question ñHow many times have you ever sighted a dead manatee?ò responses differ significantly with habitat (G2= 168.041; df=133; $P \leq 0.01$)

The frequency of fishermen that have never sighted a dead manatee is highest in the lake; whereas the frequency of fishermen that have sighted manatee more than thrice is highest in the river.

The hotspot of dead manatees reported seems to be in the lower River Sanaga around the Malimba village (see figure 15).

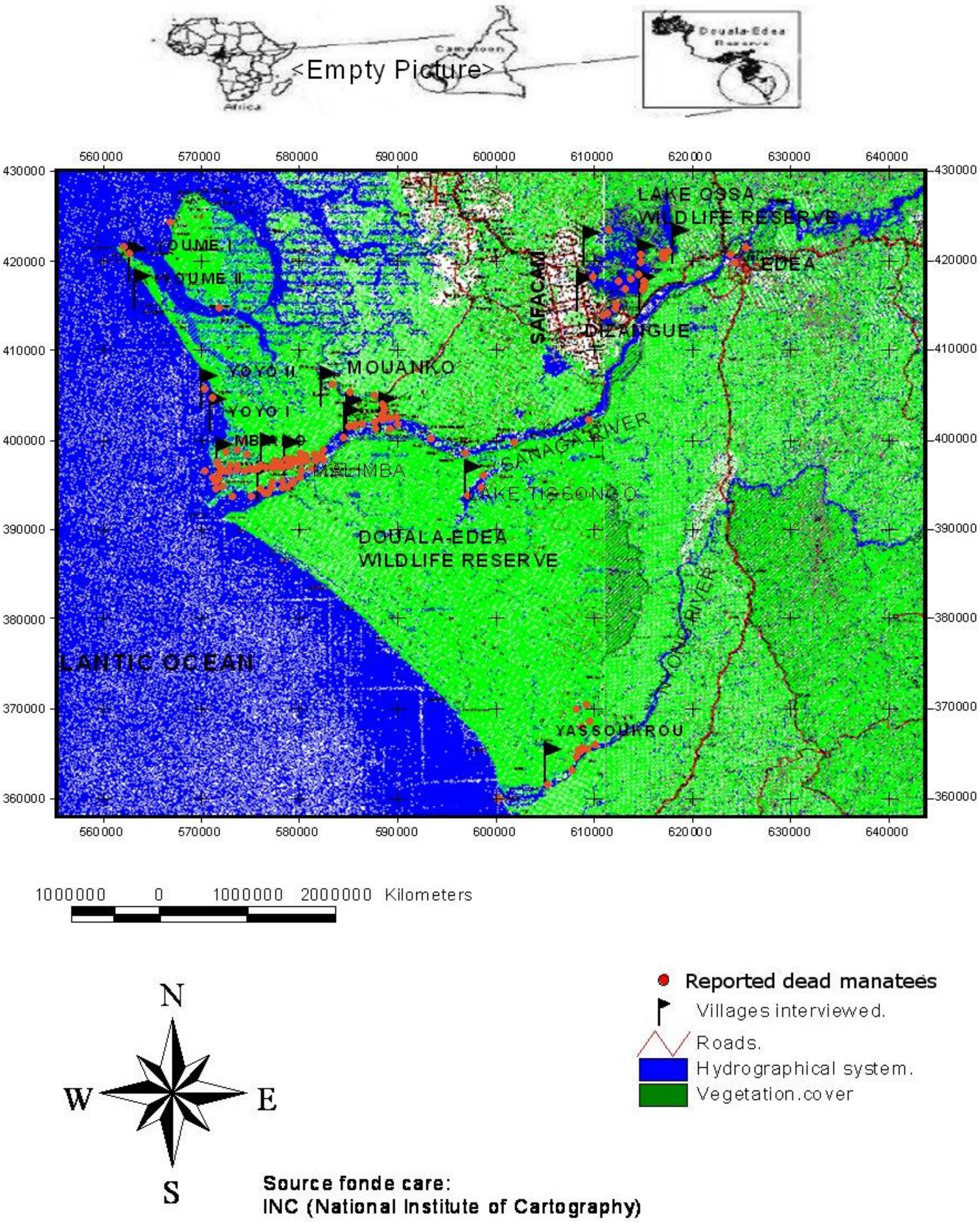


Figure 15: Map of the Distribution of reported dead manatees in DEWR and LOWR

The number of dead manatees (carcasses) sighted at once is significantly higher in river habitat compared to other habitats (X^2=9.106; df=3; p=0.027). Generally, however, the number of dead manatees (carcasses) sighted at once is hardly higher than 1 in any of the habitats (see figure 16).

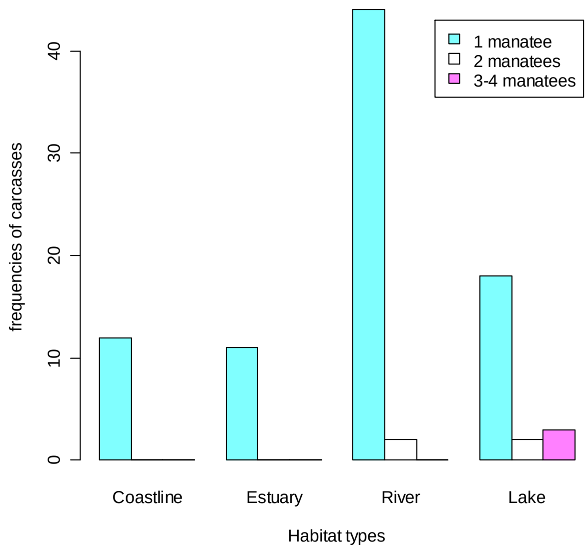


Figure 16: Distribution of the respondents according to the habitat type and their answer to the number of carcasses sighted at once.

The causes of manatee deaths as reported by fishermen differ significantly in their relative frequency (X^2=87.276; df=5; $P \le 0.01$). Cause of death due to hunting is 1.21 times higher than cause of death due to factors other than hunting. Cause of death due to food intoxication (fishermen believe that manatees suffocate when they ingest mollusk s on the hang on grass they feed on), net strangulation or to unknown causes does not differ. Cause of death due to collision with water vessels is quite rare (see figure 17)

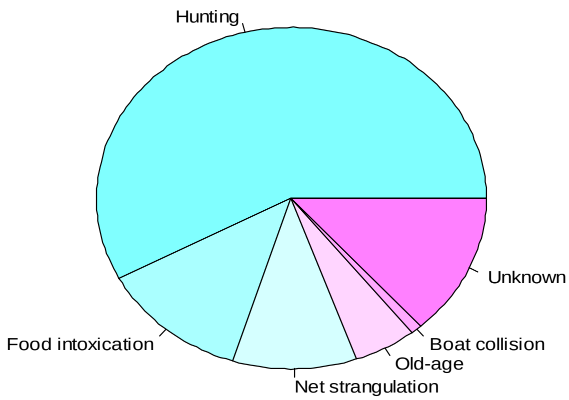


Figure 17: Distribution of respondentsô perception of causes of manatee death.

To the question ñHow many times has your net ever captured a manatee inadvertently?ò the odds of accidental catch is lower in River/Lake than in Coastline/Estuary, (X^2 = 9.664, df = 1, p= 0.001), (see figure 18).

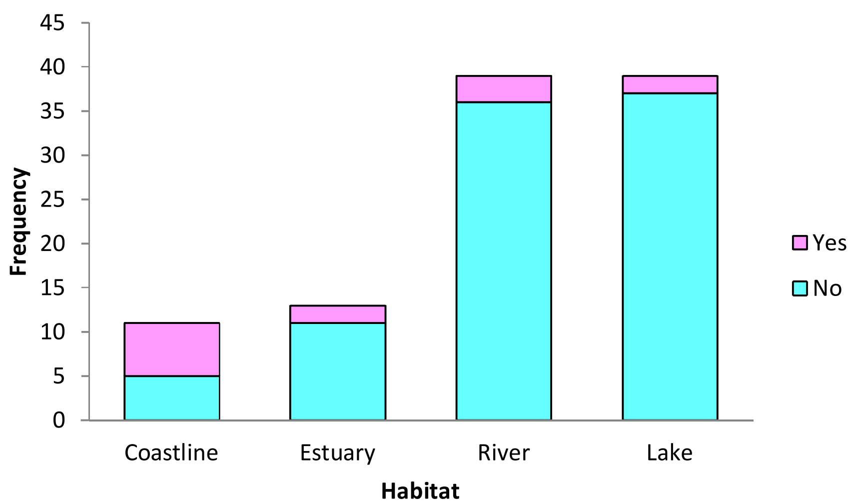


Figure 18: Distribution of fishermen according to habitat and their response to whether their net has ever captured a manatee.

To the question ñHow many time have you ever eaten manatee meat?ò it seems that the frequency of respondents who have eaten manatee meat is at least twice as larger in river habitat than in other habitats (X^2=20.849; df=3; PÒ0.01). Within the latter, the proportion of responses do not differ significantly (X^2=1.744, df=2, P=0.41) and the proportion of those who have eaten manatee is comparable to the proportion of those who have never eaten that meat (see figure 19). Furthermore the frequency ratio in those two groups is not significantly different from 1:1 (X^2 = 0.7619, df = 1, p = 0.382).

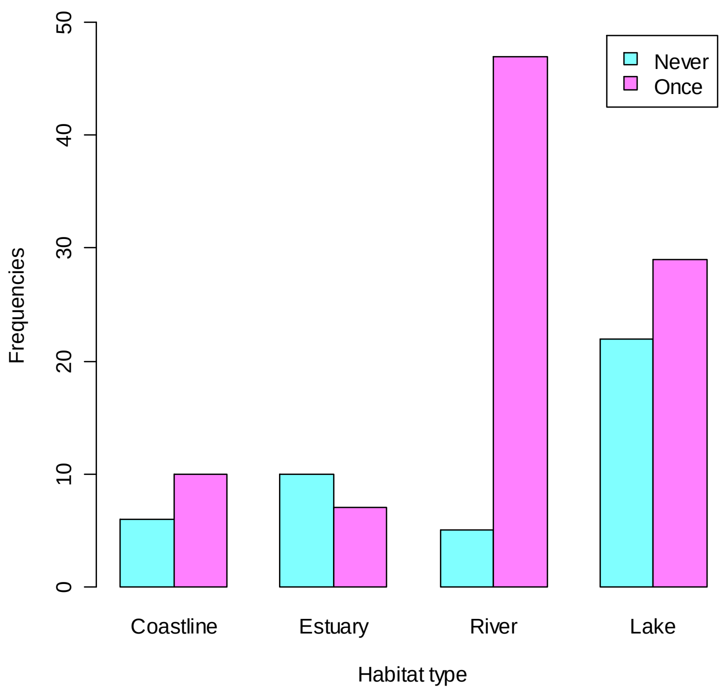


Figure 19: Distribution of respondents according to the habitat type and whether they have ever eaten manatee meat.

Among those who have tasted manatee meat, the proportion of their feeling for the meat do not differ significantly (X^2=0.8; df=3; P=0.86). Nearly all the respondents said that the manatee meat tasted very good (See Table V).

Concerning the question on how fishermen perceive the trend in the manatee population, the majority of respondents saw it as increasing and/or constant (X^2=5.252; df=1; PÒ0.05).

Of the respondents whose nets have inadvertently captured a manatee, 54% said they released the captured live manatee because they are law abiding or because the manatee was too strong for them to kill it. And, 46% said they do not release the captured manatee because it is meat as all other meat (hence there is no crime to kill and eat) or because the manatee was already dead at the time they realized that the manatee was entangled in the fishing net.

Among the respondents saying that manatee population is increasing, 66% of them attributed that increase to reduced hunting pressure on the species; 22% attribute the increase to the high reproduction rate of the species (see figure 20).

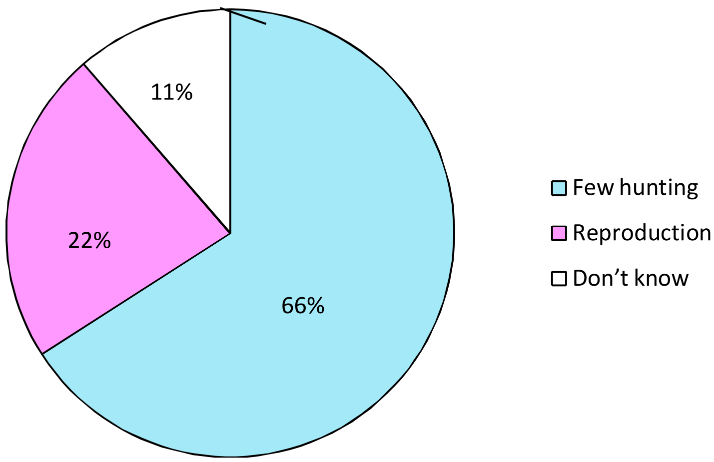


Figure 20: Proportion of respondents and their perception of possible causes for the increase in manatee numbers.

Some fishermen (43) said they were happy to know that manatee population is increasing because the manatee is harmless and it is important to conserve it for future generations. Others (42) are not happy because manatees tear or destroy their nets.

Among the 11 respondents that said that the manatee population decreases, only 2 said that they were happy of seeing the manatee population decreasing because they tear their nets; the other 9 respondents said they were unhappy that the population of manatee is decreasing because the manatee is an important value for future generations and that they are considered to be like spirits.

5. Food and food plant species

The proportion of fishermen who reported that manatees eat grass and those who said they eat fish do not differ significantly (X^2=38; df=6,; P=0.045), (due to values less than 5 in the variable oyster and others it was not included in the X^2 test).

Table VI: Contingency table for the statistic of fishermenôs responses to the question related to manatee food types.

Question	Responses	Costaline	Estuary	River	Lake	Degree of freedom	X2-Value	P-Value	Significance
11-What do manatee eat?	Grass	12	18	53	58	6	38	0.045	S
	Fish	11	12	14	31				
	Oyster & other	4	2	18	0				

Across all categories, the majority of fishermen said that manatees use to eat grass (respectively 32.4%; 56.25%; 70.66%; 65.16% in coastline, estuary, river and lake habitat), (see figure 21)..

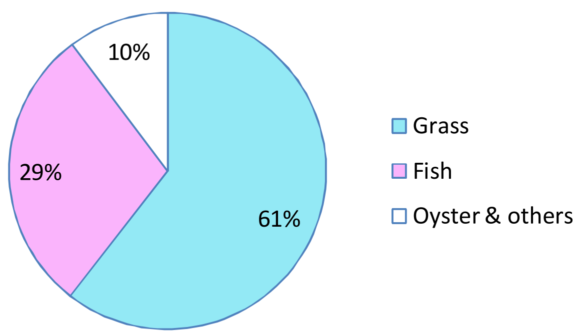


Figure 21: Distribution of fishermen according to the type of food they said manatees eat.

Fishermen listed the following plant species as part of the manatee diet: *Phragmite sp*, Irish potatoeôs leaves (*Ipomea batatas),* cassava leaves (*Manihot esculenta),* cocoyam *Colocasia esculenta,* rotinôs (*Calamus sp)* leaves*, Rhizophora sp* leaves.

6. Fishermen-manatee conflicts

Not only manatees are facing threats from human activities but also manatee activities cause some problems to fishermen. The solutions proposed by fishermen to reduce fishermen-manatee conflicts figure in the table below.

Table VII : Contingency table of fishermenôs responses to questions related to problems they encounter with manatees and the solution they propose to mitigate fishermen-manatee conflicts.

Question	**Responses**	**Coastline**	**Estuary**	**River**	**Lake**	**Degree of freedom**	**X2-Value**	**P-Value**	**Significance**
12-What problems did manatee cause to you?	Capsize boat	1	1	3	3	9	20	0.02	S
	Tear net	10	11	27	50				
	Eat our fishes inside the nets	4	2	1	3				
	No problems	5	4	10	2				
13-What solution do you propose for Fishermen/manatees conflicts?	Compensation	5	5	17	32	6	7	0.32	NS
	Deliver Hunting permit	0	4	11	10				
	Create a manatee sanctuary	1	0	4	3				

From figure 22, it appears that the problem caused by manatees to fishermen in the 4 different habitats is mostly net tearing (71, 53% overall).

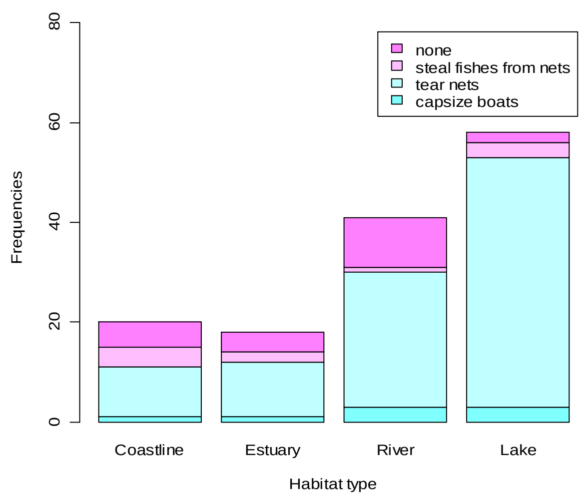


Figure 22: Distribution of respondents according to habitat type and damages caused by manatees.

The proposed solutions by fishermen for mitigating fishermen-manatee conflicts do not differ significantly with habitat types (X^2=7; df=6; P=0.32). Fifty-nine (n=59) respondents of the total respondents (N=92) proposed that fishermen should receive compensation from government for their net destroyed by manatees. Others (n=25) instead proposed that the

Ministry of Wildlife should deliver them hunting permits while a few (n=8) believed that establishing manatee sanctuaries would be a good solution to the conflicts (see figure 23).

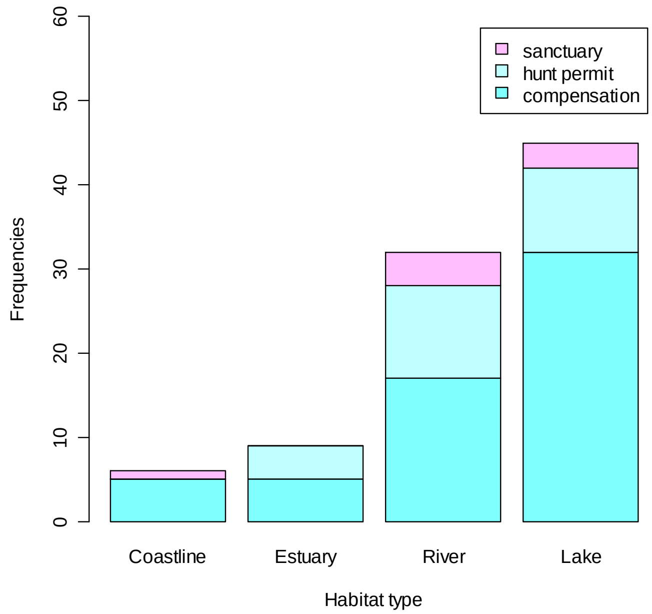


Figure 23: Distribution of respondents in relation to habitat and proposed solution to fishermen-manatee conflict.

B. Focus group survey result

1. Participant characteristics

A total number of 42 fishermen participated in the focus group surveys. They were all aged between 28 and 70 years, with 9 to 51 years of experience (See Table II).

2. Focus group summary data

After discussion during the focus group, the following information was obtained and summarized below:

- Manatee indices of presence include:
    - **Grazed bank vegetation** (grass) at the level of the leaves or the stalk that can be observed mostly in the rainy season by fishermen fishing at Mevia, Pongo and Plantation. It is observed more frequently in dry season than in the rainy season by fishermen of KOUNGUE-LAC (after manatees have finish feeding some pieces of grass leaves can be seen floating at the water surface near the bank grass).

- **Torn net** (Wide piecing hole on fishing nets) caused by manatees can be observed mostly during the rainy season in the morning by fishermen of Mevia; and mostly during dry season in the morning for the fishermen of Pongo.
- **Trails or cloud of mud** that form just after the manatees pass by. For the fishermen of Plantation and Lake Koungue, this occurs mostly in dry season at anytime of the day. However, fishermen from Pongo use to observe it mostly in the dry season, but especially in morning.
- **Dung** green in color with a cylinder form is commonly sighted by the fishermen of Pongo, Plantation and Lake Koungue during the dry season. They observe it at any time, but fishermen from Pongo observe it mostly in the morning.
- **Water bubbles** produced by a manatee as it swims by, is also a sign that is used to indicate the presence of a manatee. Fishermen of Mevia and Lake Koungue observe them mostly during dry season.
- **Jet of water** sprayed out in the air by manatee from their mouth can be observed mostly during the dry season in the afternoon by the fishermen of Mevia and Plantation.
- They sometime **show** their **back** (with the skin similar to the elephant) out of the water surface to warm up. That is observed mostly during the dry season on sunny day by the fishermen of Plantation, especially when it is sunny.

- Concerning threats to manatee,
  - Fishermen of Pongo reported that manatees are sometimes killed in Lake Ossa through **gun hunting** or **captured inside nets**.
  - According to the fishermen of Mevia, manatees also suffer from **food intoxication** when they swallow with their food any type of **snail** species that was attached to the grass.
  - **Pollution** was also mentioned by the fishermen of Mevia as a threat faced by manatees in the Lake Ossa.
  - For fishermen of Plantation and Lake Koungue, manatees in Lake Ossa **do not face any threat.**
- Concerning threats from manatee to human,
  - The fishermen of the four villages agreed on the fact that manatees destroy a large number of **nets.**
  - Fishermen of Koungue-Lac complained about manatee ravaging their **cassava plants they have planted**.

- Concerning how the manatee fishermen conflicts could be solved,
  - Fishermen of the four villages proposed **compensation** for torn nets.
  - Fishermen on Lake Koungue also proposed that a **manatee sanctuary** be set up.
  - **Sensitization** and **alternatives to hunting** were proposed by the fishermen of Pongo.
- Average costs of damages sustained by fishermen per single net destroyed were estimated at:
  - CFAF 50,000 (about US $100) in Mevia and Pongo.
  - CFAF 35,000 (about US $70) in Plantation
  - CFAF 20,000 to 80,000 (about US $40 to $160) at Lake Koungue.

IV. DISCUSSION

Based on the information gathered from the experienced fishermen in the DEWR and LOWR, manatees are present in both areas, usually on the drainage basin of Sanaga. In this coastal region of Cameroon, manatees inhabit four types of ecosystems: coastlines, estuaries, rivers and lakes. Manatees are present in River Sanaga, River Nyong, River Dipombé, River Dihendé, Lake Ossa, Lake Tissongo and the coastal estuary and coastal bay near the Mouanko region. Manatees seem to be more abundant in rivers than any other ecosystem, especially in the lower reaches of River Sanaga. At this location, over half of the fishermen interviewed sight them more than thrice a month. This frequency of sightings was also reported by previous researchers who studied the distribution of manatees in Cameroon (Nishiwaki, 1982). Similarly, there are considerable numbers of manatees in Lake Ossa. Reports of manatees in coastal areas are not as common as in River Sanaga and Lake Ossa. This might be due to the fact that Cameroon coastal areas do not provide good manatee habitat (Powell, 1996) because the coastal areas have rocky bottoms with few grasses and lack access to fresh water. West African manatee habitat requirements are similar to those reported for *T. manatus* and required sheltered water with access to food and fresh water (Powell and Rathbun, 1984) as it is the case of River Sanaga, River Nyong and Lake Ossa. Live manatee reports were relatively frequent at Malimba and Lake Ossa (see figure 11), which are areas of relatively low or stable stream flow; this situation is similar to the observation of Powell (1996) in Gambia where manatees of that area had little preference for area with greatest current flow. Du Chailu (as cited in Powell 1996) also found that manatees preferred areas where water is still and the current not strong. Manatees in DEWR and LOWR are more frequently observed in groups of 2 or 3 individuals than they are observed alone or in groups of more than three. Fishermen believe that these groups represent families with a female, calf and/or male.

There seems to be a seasonal shift in habitat preference for the manatees in the Sanaga drainage basin. Manatees are more frequently seen in Lake Ossa, Lake Tissongo and in the Sanaga estuary during the dry season when water level is low than in the rainy season when water level is high; whereas the opposite is observed in the Sanaga River and the coastal areas. Du Chailu 1860 (as *cited in* Powell 1996) reported similar observations for the central African rivers. This suggests that manatees make regular movements during the wet season, when the water level increases and water salinity reduces, between Lake Ossa, Tissongo and coastal areas passing through River Sanaga. In the dry season when water depth decreases and water salinity increases due to tidal penetration further upriver, manatees prefer areas upriver with deep pools, and low salinity like Lake Ossa. A similar movement in response to water depth and salinity was reported in Gambia River (Powell 1985) where fishermen reported that manatees move up or down the Gambia River in response to seasonal changes that affect water flow, water depth and salinity. Our observations suggest that Lake Ossa provides a dry season sanctuary for the manatees on the Sanaga River as Powell (1996) had conjectured. Moreover fishermen on Lake Ossa and the Sanaga estuary said they sight manatees more frequently during low water level (low tide) than during high water level (high tide) whereas in the Sanaga River manatee sightings were more frequent during the wet season. However, in the Sanaga estuary, fishermen may confuse manatees with dolphins, which also occur in the same area. In fact, during the interviews, some fishermen described the manatee as grey to black in color, about 2 m in length, and that sometimes they spew water from their mouths. Other fishermen said that manatees had yellow dots on their back. These descriptions are more closely aligned with the two species of dolphins that occur in that area (Rice, 1998,Culik, 2004): Cameroon dolphins (*Souza teuszii*) and Atlantic-spotted dolphins (*Stenella frontalis*). The Cameroon dolphin also called Atlantic hump-backed dolphin has a skin color that varies from grey to black as described by fishermen and it size of 2.4 to 2.7 m and weight of 170 to 260 kg; this size is not so different from the average length and weight of the West African manatee. Cameroon dolphins are more abundant in the Cameroon estuary than Atlantic-spotted dolphins, which have yellow spots on their backs. Atlantic-spotted dolphins are more abundant further offshore.

According to fishermen, manatees are sighted more frequently in the morning between 6:00 and 10:00 in the river system (River Sanaga and River Nyong), and between 5:00 and 11:00 in the lake and estuary systems (Lake Ossa, Lake Tissong, Mbiako estuary). Reported sightings at midday and in the afternoon were rare; it might be due to the fact that at this time, manatees might be resting under water agitated by the waves or the wind, with reduced movement of the animal that renders their visibility or detection difficult. However, it is important to note that most fishermen are off the water during midday and afternoon for resting. Therefore, we cannot assume that manatees are not frequent at this period of the day. Observations of tagged and radio-tracked manatees in Cote dôIvoire (Akoi, 2004), suggested that manatees generally feed from 1800-2200 hours, and from 02:00-05:00 hours, and rest generally from 11:00-15:00 hours. This observation is similar to the information provided by fishermen of DEWR and LOWR.

In the course of this study the following plant species were reported by fishermen as manatee food sources: *Phragmite sp.*, Irish potatoe˜s leaves *Ipomea batatas,* cassava leaves *Manihot esculenta, Colocasia esculenta,* rotin˜s leaves (*Calamus sp.), Rhizophora sp*. And *Vossia spp*. Nearly all these plant species cited above were previously known from the *T. senegalensis* food species list provided by Powell (1996) except *Calamus sp and Solanum tuberosum*. The preference of plant species varied with the vegetation characteristics of habitat. For example, in the estuary, which is dominated by mangroves, manatees tend to feed more on the leaves of *Rhizophora sp.* whereas in the River Sanaga and Lake Ossa the dominant aquatic vegetation is *Pragmite sp* and, it is on this plant species that manatees feed most frequently. However, like in The Gambia and Senegal (Powell et al., 2008) fishermen reported that manatee eats fish and oysters. They report that they have seen remains of fish and oyster shells in the manatee stomach. Manatees eating fish were primarily reported in the coastal area; this might be due to lack of grass availability. Manatees as herbivorous, don˜t stalk their prey they are adapted for fixed food such as grass. However, when grasses become scarce, it now rely on fishes that have been caught (or fixed) by the nets. Manatees eating oysters were frequently reported in the Sanaga River especially during the dry season when their ability to obtain food from bank vegetation is reduced because of the low level of water. In general, manatees feed mainly on grass. During the field survey, we observed over 15 manatee feces samples and all appeared to contain fiber from grass (figure 24 and 25).

From the perspective of the fishermen in the Sanaga drainage basin, manatees are not threatened. Instead, they believe manatees are threatening fishermen by tearing nets, capsizing boats and eating fish and oysters from their nets. According to most of these fishermen, manatees reproduce frequently and are hunted at a very low rate. They believe that manatees are proliferating and becoming a nuisance. However other fishermen reported that manatees are threatened by hunting and the progressive decline of water depth due to the hydro-electric dam of Edea.

Reported manatee mortalities rates were highest in the lower reaches of Sanaga River at Malimba (figure 15), which also corresponds to one of the hotspots for live manatees reported in DEWR and LOWR. This can be justified by the fact that the more manatees are abundant in the area the higher the probability to trap one. This high proportion of dead manatees reported in the lower reaches of Sanaga River might also be linked to the water currents or detectabiliy.

Figure 24: Picture of manatee dung collected in Lake Ossa at night

Figure 25: Picture of manatee dung collected at Lake Ossa during day time.

For example, manatee deaths might occur upstream, but the carcass would eventually drift downstream with the current; if this occurs it would offer an alternative cause for high manatee mortality observed in Malimba (lower reaches of Sanaga River). However, itôs important to recall that the primary cause of manatee mortality in Malimba was reported as hunting. Manatee meat is highly coveted and consumed in Malimba (traditional knowledge). Manatees were reportedly captured using large, heavy nets set in manatee feeding areas. Alternatively, hunters would surprise a feeding manatee and strike the animal on the head to death with a sharp machete. In the estuary, hunters set out bag-like nets in the mangroves. During the high tide, manatees would move toward the mangroves to eat, as water would withdraw during the low tide, the animal would be block and stranded out of the water by the bag-like net. In Lake Tissongo hunters would use a gun to shoot the manatee on the head as it raises its nostrils out of the water to breath. Other reported causes of mortality include food intoxication, net entanglement, boat collision, and pollution.

In DEWR and LOWR, fisherman-manatee conflicts are highly evident from the interviews. The majority of fishermen frequently and repeatedly complained about manatees tearing their nets, destroying their cassava farms, and eating their fish and oysters. They also reported that manatees are suffering from constant hunting pressure. Only few are happy about protection of manatees or about the increasing manatee population in their respective habitats. It happens sometimes that a manatee gets entangled in a fishermanõs net; but this occurs rarely. Most of the time, the owner of the net would not release the manatee because the animal was already dead at the time he visited his net or because for them, the captured manatee is a godsend. Some fishermen would release the entangled live manatee because it is stronger than him and difficult to capture or because they are law abiding or because they feel it is important to preserve manatees for future generations.

To put an end to these conflicts the majority of fishermen have proposed compensation for their nets that have been torn by manatees. Others instead proposed that, since there is proliferation of manatees in their habitats, hunting permits should be delivered in order to reduce to the manatee population. Few proposed the creation of manatee sanctuaries, which is an attractive option for at least three reasons:

- There is no guarantee that even the compensation for torn nets would stop the hunting of manatees. New nets are likely to continue to be torn.
- There is no population size estimation of manatees whether in DEWR or in LOWR to be sure that manatee population is far over their minimum viable population (MVP) before attributing hunting permits to reduce the excess number individuals.
- The sanctuary would provide a secured place for manatees and would be out of the fishing ground. Moreover, it would provide opportunities for ecotourism and income among the local human population.

CHAPTER III: SURVEY OF MANATEE IN LAKE OSSA WILDLIFE RESERVE

I. INTRODUCTION

Managing wild animals implies, on top of intervening at policy level, managing at level of the habitat and population with consideration of their behavioral pattern. Most wildlife management is habitat management (Shaw, 1985). Variation of habitat characteristics goes along with the distribution and abundance of species as it is requires for suitable habitat. Suitable habitat requires the availability of components such as: food, cover, water and space that favor feeding, reproduction and protection of that species (Shaw, 1985). Due to pollution, deforestation, human population growth, climatic changes, many species are witnessing the degradation, reduction or lost of their suitable habitat.

Manatees in Lake Ossa, like in other areas of its distribution, face threats such as dam construction, hunting and pollution (Powell, 1996). Manatees tend to aggregate in a clumped distribution pattern in preferred habitats, with no or relatively few disturbances, or areas that best meet their biotic and abiotic requirements. Consequently, due to patchy distribution of food resources and variation in habitat characteristics in Lake Ossa, we would expect to find unequal distribution of the species and various habitat usage (Nomura and Higashi, 2000), which can be revealed by assessing the sighting frequency at different sites in the lake. Activity centers are defined as preferred sites used by manatees for feeding, breeding and resting (Packard and Wetterqvist 1984). Identifying activity centers is an important step toward conservation because these activity centers are hotspots for the species where additional interventions or efforts can be done to protect the habitat and decrease human-manatee conflicts.

However, the notion of suitability may be dynamic, especially for migratory species. Habitat characteristics are subject to daily, seasonally and evolutionary variations. A habitat suitable for a particular species during the day might not be the same at night (Shaw, 1985). Similarly, a habitat suitable during the dry season might not be the same in the rainy season. This phenomenon explains migratory movements observed among some species such as the West African manatee and some bird species. In Gambia, manatees exhibit seasonally movements in response to three factors: currents, salinity and water level changes (Powell 1985; 1996). In Ivory Coast, in the Niouniourou River and the Niouzoumou Lagoon system, radio-tagging reveal that manatees exhibit daily movement between their feeding sites in the night and their resting sites during the day (Powell 1996). In Lake Ossa such movements have not yet been studied. However, Powell (1996) suspected a seasonal movement between Lake Ossa and River Sanaga, with Lake Ossa providing a sanctuary for manatees during periods of low water in the dry season. It is important to understand seasonal movement of manatees in order to determine where and when more conservation efforts and more surveillance have to be implemented for better protection of that species. Additionally, an understanding of daily movement can provide a means for designing a strategic eco-tourism plan in Lake Ossa that would take into consideration the elusive nature of the West African manatee and the low transparency of the water in which they live.

Studying the aquatic fauna of estuaries, lagoons, and turbid lakes and rivers is challenging because of the difficulty of observing animals in murky and muddy waters (Gonzalez-Socoloske 2009). Mildly social, cryptic species, such as manatees, which use these waterways throughout most of their range, are particularly difficult to study because they spend large amounts of time below the surface where they cannot be visually detected (Reynolds and Powell 2002; Gonzalez 2009). And, when they do come at the surface to breathe, they often only briefly expose the tip of their snout. In addition, in areas with traditionally high hunting pressure, manatees may avoid human presence or may exhibit greater nocturnal activity (Rathbun et al. 1983, Gonzalez 2009). It is then challenging to design a survey technique that would go beyond the elusiveness of the species and at same time, be cost and time efficient.

Several survey techniques for marine mammals may be applicable in developing countries: aerial survey, side-scan sonar survey, land-based survey, visual boat survey, stranding networks, capture-mark-recapture methods, etc. The most appropriate survey technique depends on the survey objectives, spatial scale, location, budget and timing, and the availability of logistical support (Aragones, 1997). Hence it is in consideration of our local conditions that the visual non-motorized boat point scan survey (Self-Sullivan *et al.*, 2004; LaCommare *et al.*, 2008; Self-Sullivan, 2008; Bacchus et *al.*, 2009) was chosen for this study. In fact, this survey technique is extremely low cost compared to the alternatives, wand fits with our objectives to determine sighting probability based on presence or absence at specific sites in the Lake. In addition, the study covered a small scale and was located in an enclosed system with only one ingress point. Though more time consuming than its rivals mentioned above, the adopted survey method met the low budget constraint to which we were subjected. Prior to this survey, structured interviews and focus group surveys were held with experienced local fishermen (see Chapter II); this step was important for this study because it has permitted to scope and orientate the field ecological survey. From the focus group, direct and indirect indices that can help in recognizing a manatee presence were hypothetically identified and confirmed during the field surveys. From the interviews, we formulated hypothetical information on the presence of manatees in Lake Ossa and their time of occurrence.

Objective of the study

The objective of this study is to identify activity center and habitat use by the manatee in Lake Ossa. (a) We will compare the probability of sighting a manatee at five (5) different sites of the Lake with different habitat characteristics; (b) we will compare the probability of sighting a manatee at different periods of the day during the dry season; (c) we will determine the habitat use by manatees in each site during the dry season then; (d) we will identify some threats or potential threats to manatees in Lake Ossa.

In the course of this study, a team of journalist from CRTV (Cameroon Radio Television) came to make a documentary film in Lake Ossa and one of their core objectives was to film the manatee in its natural environment. After two days survey in the Lake, they did not have the luck to sight any sign of manatee whether direct or indirect, then one of them concluded that surely manatees were not present in the Lake, that itõs just a myth or legend. Unfortunately their conclusion where biased, because prior to their survey in the Lake, they did not know the signs of manatee presence, neither did they know where and when manatees occur most frequently; in fact, they were surely on the wrong place at the wrong time looking for the wrong indices. Traditional ecological knowledge was essential for the success of this study.

II. MATERIAL AND METHODS

A. Study area

Biophysical milieu

It is estimated that 90% of LOWR surface is aquatic; however, though this estimation is not scientific, its value helps to illustrate the high preponderance of the water over the land relative to the total surface of the reserve (Annual Report Lake Ossa Conservation, 2007). Lake Ossa has a water surface area of about 31 km^2 and lies about 40 km east of the Atlantic coast of the Guinean Gulf, extending from 3°45.7 to 3°53 latitude north and from 9°9 to 10°4.2 longitudes east (Wirrmann and Elouga, 1998). The landscape is made up of littoral and island forest with *Lophira alata* (a tree also known as Azobé or red ironwood) as the dominant species of the area. The natural forest was largely reduced by the implantation of agro-industries like SAFACAM and SOCAPALM that occupy the largest proportion of the reserve. There is no buffer zone between the reserve and SAFACAM. There are sites on the lake where the plantations of SAFACAM are situated at a distance of less than 300 m from the waterôs edge. These agricultural practices have negative impacts on the drainage basin downstream from the lake, which is exposed to erosion and landslides. The rest of the land is used by the local population for subsistence agriculture where they seasonally farm plantain *(Musa spp)*, cassava (*Manihot esculenta),* coco-yam (*Colocasia esculenta),* etc. The LOWR is a rather flat region with 300 m elevation.

The aquatic component of the reserve includes Lake Ossa, which is subdivided into three smaller lakes: Lake Mevia (deepest), Big Lake, and Lake Mwembe (shallowest). Lake Ossa is connected to River Sanaga by a 4 km long canal creek with an average depth of 5 m during the dry season. During the dry season, water flows from Lake Ossa to River Sanaga via this canal creek; the water of the lake is less turbid (more than 1 m visibility measured with a Secchi disk). The lake system has its headwaters in two small rivers that empty at the apex of Lake Mevia and also in creeks located in the northern part of the Lake Ossa complex. This water will then reach the Big Lake through a canal called Bobo (Canal Lindema-Mevia) and then proceed down the entrance located south of the Big Lake, where it finds its way through the canal leading to Sanaga River. Lake Mwembe is also connected to this main canal. The substrate is largely muddy throughout the system, especially in the Lake Mevia. However there are also some sandy bottoms at the banks. The water depth is very shallow (less than 2.5m) during the dry season in most of the lake system, averaging from 2.5 m in the middle to

1.7 m near the bank. However, in the canal creek and near the mouth of the lake, there are depths greater than 5 m. The pH is about 6 at any point of the Lake. The main lake (Big Lake) is relatively calm during the morning and at night, with a sea state of zero on the Beaufort scale. During the afternoons and evenings, between 1400 h and 1900 h, the lake is stirred with a sea state of 2 to 3 on the Beaufort scale (see appendix 1).

During the rainy season, there is a reverse in water circulation with water from the Sanaga River flowing into the Lake Ossa system. Water will flow from Sanaga River to the Big Lake and Lake Mwembe via the narrow canal creek, then from the Big Lake to Lake Mevia. Hence, the water of the lake takes the color of the Sanaga water (brownish), which is very turbid. At the middle of the rainy season, a large proportion of the littoral forest becomes flooded (see Appendix 6).

Water transparency is not equal across all the lakes. The water transparency in Mevia is two fold greater than the transparency in the Big Lake and Lake Mwembe. The banks are mostly covered with invasive weeds and shrubs and in some places with rattan. Some banks have a discontinuity of sand banks that are the preferred sites for the reproduction of soft shell turtles.

B. Survey design

Five permanent sampling points were established at five different sites of the Lake Ossa water surface. Sites were chosen using the same strategy as LaCommare *et al*., 2008, by taking into consideration their different prominent habitats characteristics (vegetation type, bottom substrate, depth, pH, transparency and associated human activity) (See figure 26 and appendix 5 and 6).

Table VIII: Prominent habitat characteristics of each sampling sites

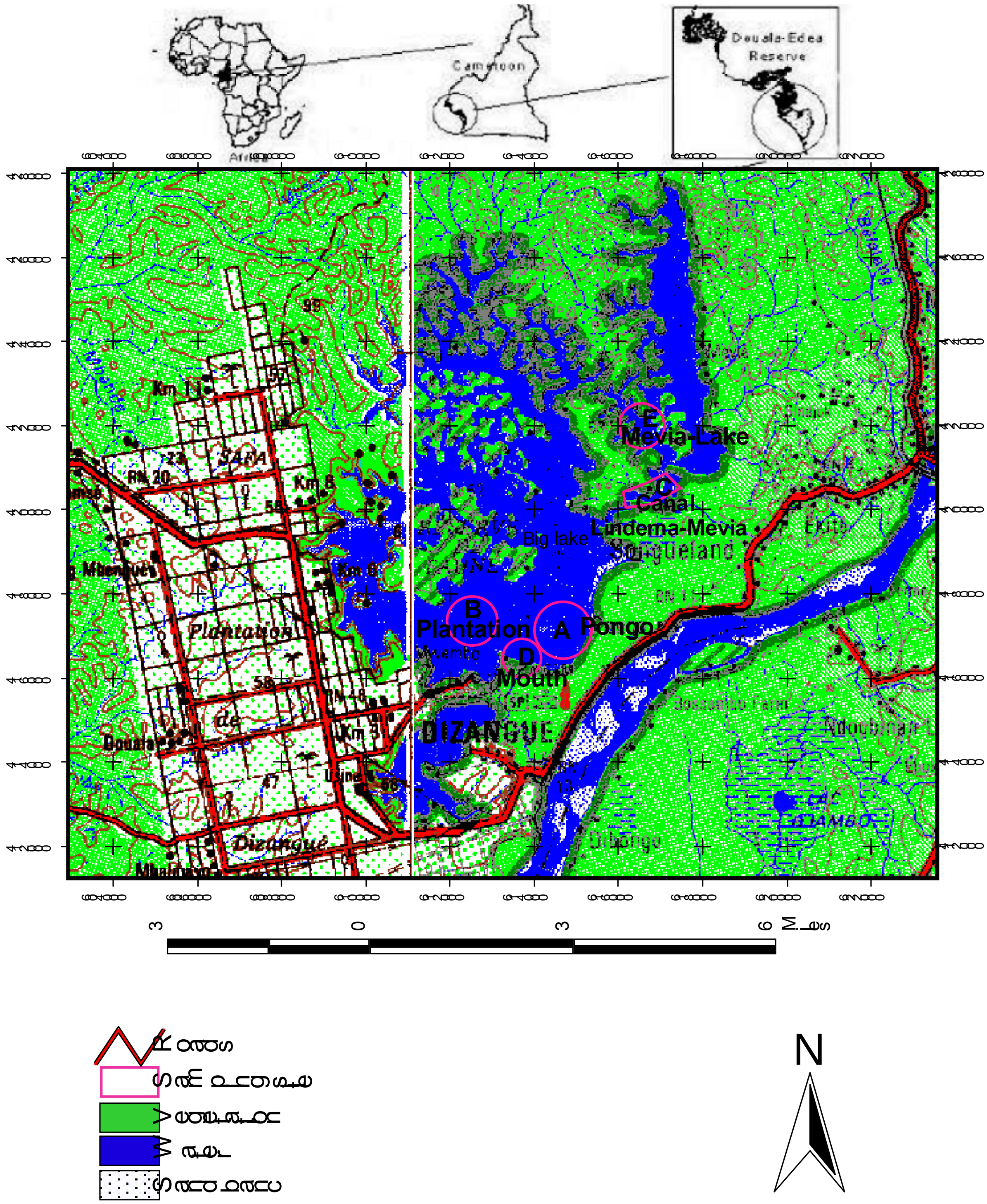
	Site A	**Site B**	**Site C**	**Site D**	**Site E**
Site name	Pongo-Pitti	Plantation	Canal Lindema-Mevia (Bobo)	Mouth	Lake Mevia (Ohe)
position	Off shore of the big Lake	Inshore of the big Lake.	Creek connecting the Big Lake to Lake Mevia	Mouth of the Big Lake	Just after the canal Lindema-Mevia
depth	Shallow water	deep	Relatively shallow	Very deep	deep
Bottom substrate	Sandy and muddy	Muddy and sandy	Muddy and sandy	Muddy and sandy	Exclusively muddy
Landscape	Not surrounded by hills	Partially surrounded with hills	Surrounded with hills	Lightly surrounded by hills	Highly surrounded by hills
Bank vegetation	Abudant and Dominated by *Phragmite sp*	none	Very abundant and dominated by *Phragmite sp* and *Vossiacuspidata*	Abundant and dominated by *Phragmite sp*	Scarce and dominated by *phragmite sp*
Level of exposition to wind	High	Very high	Very low	High	Very low
Canoe trafic level	Low	Low	Very high in the morning and at night	High in morning and at night	Low during the day and high by night
Fishing sticks planted under the water	Very abundant	Few	few	Very abundant	None

Point scans were conducted 9-11 times at each site within the following time periods or intervals:

- Period 1: between 0400 to 0600 hours

- Period 2: between 0600 to 1000 hours
- Period 3: between 1000 to 1400 hours
- Period 4: between 1400 to 1800 hours
- Period 5: between 1800 to 2200 hours

Sampling order for each site was randomized, as period and site were both chosen randomly. We assigned a number from 1 to 5 to each of the five different sites and to each of the 5 different time periods. All possible combinations of the two digits were formed from the two sets of 5 numbers (time and site) with the first digit representing the time period and the second digit the site. Then, each two-digit code was (11, 12, 13é 51, 52é 55) written on a piece of paper that was then twisted and then drawn by lot without replacement. Then, the order of scan (time period and site) was conducted corresponding to the order of draw. Each scan was performed for 30 minutes (Self-Sullivan 2008; LaCommare *et al*., 2008; Bacchus et *al*., 2009) and another 30 to 60 minutes were use to look for indirect signs of manatee presence, such as feces (dung) and grazed vegetation, to observe the behavior of a manatee if sighted, and to collect environmental variables within the habitat.



Base map source: INC (National Institute of Cartography).

Figure 26: Map of Lake Ossa with sampling sites.

Any manatee sightings that occurred outside of the 30-minute scans were recorded as opportunistic sightings. Depending on the weather conditions, we conducted one to three scans a day. To avoid confusion between the effect of the day and the effect of the time period, each site was scanned twice for the same time interval.

Table IX: Distribution of number of scans using time period and site name.

	Time period					
Site name	0400-0600 hours	0600-1000 hours	1000-1400 hours	1400-1800 hours	1800-2200 hours	TOTAL
Canal lindema-mevia	2	2	2	2	3	11
Mevia	2	2	2	2	2	10
Mouth	2	2	2	2	2	10
Plantation	1	2	2	2	2	9
Pongo-pitti	2	3	2	2	2	11
Total	**9**	**11**	**10**	**10**	**11**	**51**

Night scans were conducted using a high intensity torch lamp. However, during the scan the lamp was switched off and we only put it on when we suspected a manatee presence or to look at indirect signs of presence through grazed vegetation and or observation of dung. This was because the West African manatee tends to be very sensitive to lamp light at night (Lucy Keith Pers. Comm.). Infrared would have been a good instrument for night scan in general, but unfortunately, it was too expensive; also, infrared doesnǿt work well with manatees because (1) infrared does not penetrate water very well, (2) ambient water temperature is similar to manatee body temperature, and (3) exhalations are similar to ambient air temperatures; some very expensive cameras work, but only at close range (Keith 2005).

All scans were conducted with two observers: a field assistant and the researcher. We stood inside the boat and visually scanned the area around the boat, each one of us covering an angle of 180° and a distance of 300 m (maximum) from the boat for a total cover of 360° (Self-Sullivan *et al.* 2008; LaCommare *et al.* 2008).

1. Data collection

a) Weather conditions

Before beginning the scanning process, the general weather conditions (time, wind direction, sea state, and cloud cover) were recorded on the summary trip data sheet (see appendix 2). The wind velocity was determined using the Beaufort wind scale (see appendix 1). The cloud cover was determined by estimating the percentage of sky covered by clouds. Water and air temperature data were collected qualitatively (that consisted in determining whether the water was cool or hot by emerging the hand into the water).

b) Data collection on direct sightings and behavior recording

During each point scan, as a manatee was sighted, (mostly by its nostrils, water bubbles or by the cloud of mud), we counted the number of manatees. Then, we would stop scanning (since the purpose of the scan is presence or absence of a manatee) and the sighted manatee(s) were followed slowly, avoiding as much as possible noise from the contact between the paddle and the water so that the manatee should not be disturbed. As we were following the target animal, we observed its behavior it. We could also count the number of breaths (that is the number of time the animal exposes its nostrils out of the water) within a certain time interval in order to estimate the average breath rate. The animal was followed till it could no longer be tracked or till it suddenly got frighten and speeded up. We categorized behavioral states of the manatee as traveling, milling, socializing, feeding, resting or other (Self-Sullivan pers. comm.). For each sighting, we visually estimated the distance between the point where the manatee was sighted and the survey boat. The time and the geographical coordinates of each occurrence were recorded using a GPS (Global Positioning System). The numbers of fishing boats present during the scan were also recorded.

c) Data collection on indirect sightings

Data for indirect sightings were recorded using the set of indices that emerged during the focus group surveys (that is manatee, dung, torn net or grazed vegetation).

Questions were also asked to fishermen around the point scan to know whether they had recently sighted manatees within the site. Alternatively, fishermen could also report on any manatee they may have sighted within a week. We would further enquire when and where exactly the sighting occurred and what the focal animal was doing.

d) Data collection on habitat characteristics and fishing efforts

After each scan, we collected biological and physical characteristics of the water including vegetation type, water depth, pH, transparency and bottom consistence.

- The average water depth near the bank and water middle was measured using a cord ballasted at one of its ends, and then a tape-meter was used to measure the corresponding length of cord that had been submerged. A pH-tape meter was used to measure the water pH at the water surface.

- The water bottom consistency was determined with the help of a Chinese bamboo cylindrical stick of about 3 m long that has hole in its hollow center. We would send down the stick till it reached the bottom of the water, then it was pressed down into the bottom substrate till a sample forced into the a hole of the stick; the stick would then be removed from the water and the sample would be extracted and observed (see Figure 27 and 28)

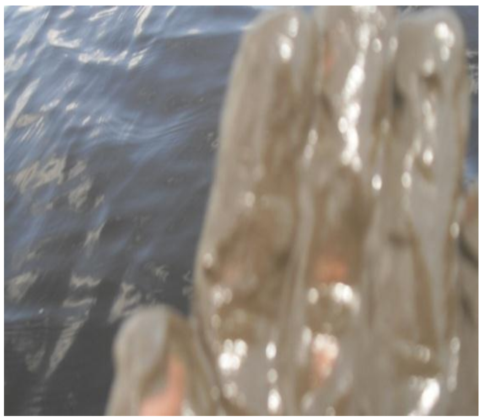


Figure 28: Picture illustrating the mud extracted from the water bottom using a Chinese bamboo pole.

Figure 27: Picture illustrating water bottom sampling using Chinese bamboo pole.

- Percentage of different vegetation type cover and hill or mountain area surrounding the site, was roughly estimated through visual observation of the landscape. The percentage of terrestrial and aquatic vegetation was estimated over the total vegetation cover of each sampling site. The percentage of grasses, herbs and shrubs were estimated relative to the total amount of all vegetation forms (Lathourder *et al,,* 2009). The percentage of emerged, submerged and free floating vegetation was estimated over the total aquatic vegetation.

- At each site we set and followed two 100 m line transects to sample the grass bank vegetation cover using a 100 m knotted rope with a knot at each one meter. The rope was randomly stretched across the bank grass vegetation cover suspected as the manatee feeding area; then, the name of each plant species in contact with the knot was recorded (Figure 29). In the event that we do not know name of the plant species, we would take a photo to aid in identification later using a catalog of common plant species found on Lake Volta (Hall 1975) or which the manatee is known to feed on (Powell and Lucy Keith, unpublished data).

Figure 29: Picture illustrating transect on one feeding area using knotted rope.

- The Secchi disk was used to measure the transparency of the water for each site (see figure 30).

Figure 30: Figure illustrating the measurement of the water transparency using Secchi Disk and a tape mesure.

- Data on fishing pressure were collected by counting the number of boats and the number of set nets (fixed and almost permanent fishing nets placed by fishermen along the bank or across a portion of the lake that they visit almost every morning to remove entangled fishes) around the site. There is a particular fishing practice in some areas of the Lake. It is called ñRoseauò (reed). It consists of making bundles of 3 to 5 Chinese bamboo poles and attaching them on a stick that is stuck vertically under the water (see figure 31). Roseau fishing effort was measured by counting the number of planted sticks and then multiplied by the average number of bamboo per bundle attached to the stick.

Figure 31: Reed fishing technique (planted sticks on which are attached under the water a bundle of Chinese bamboo).

2. Data analysis

a) Modeling manatee count and probability of occurrence.

The collected data were entered in an Excel spread sheet and exported to an R statistical package for analysis. Manatee presence/absence (1/0) and count were predicted from environmental variables, namely site, atmosphere (air and water conditions) and time of day using the generalized linear model (GLM). GLM extends the linear model theory to situations where the response variable (Y) is not Gaussian but, as in the present case, either Bernoulli variable (presence/absence) or Poisson variable (number of events/count in a time span). In the cadse of manatee occurrence, the response variable Y has only two values Y=0 (absence) and Y=1 (presence) with respective probabilities 1-p=Pr(Y=0) and p=Pr(Y=1). The mean and variance of Y are respectively E(Y)=p and var(Y)=p(1-p). The number of manatees detected during the 30-min scan period is a Poisson random variable which the mean and variance are all equal to ঌ (a non-negative constant). Clearly these two variables do not meet the ANOVA assumption of uniform variance, as the variance is equal to a function of the mean. This is the reason for using a generalized linear model (GLM) whereby a transformation of the expected (or mean) value of the response variable is predicted rather than the response variable itself. Two such transformation (or link) functions exist:

Logit link $\eta = \text{logit}(p) = \ln\left(\frac{p}{1-p}\right)$ where p is the probability of detecting a manatee, p/(1-p) is the odds ratio, and logit (p) is the logarithm of the odds ratio (case of binary response variable, presence/absence);

Log link $\eta = \ln(\lambda + c)$, with $c \neq 0$ (case of a Poisson response variable).

The transformed response is then modeled as a linear combination of predictors (independent variables), $x'\beta = \beta_0 + \sum_{i=1}^{p} \beta_i x_i$ plus a random error ε with mean 0 and variance σ^2. Depending as one us of a logit or a logarithmic link function, this model is said to be logistic or log-linear, respectively.

Variable selection is fully automated in R, making it possible to identify and retain only a subset of the most significant predictors. The departure of the data from the hypothesized model (also known as deviance) is equal to -2ln(L), where L is the maximized value of the likelihood function for the estimated model. The model deviance is approximately distributed as a chi-squared distribution with (n-k) degrees of freedom, where n is the number of data points and k is the number of parameters in the model. The Akaike Information Criterion (AIC) defined as $AIC = 2k + 2\ln(L)$ measures the relative goodness of fit of a statistical model (the smaller AIC value, the better the fit). The data were modeled using the GLM function in R (Venables and Ripley 2002).

b) Estimation of manatee densities

An average density estimate was obtained at each site as follows:

$$?_{?} = \frac{\sum_{?? ?}^{?} ?_{??}.}{?_{?} ?_{?}}$$

Where: $?_{?}$= estimated density at site s, $?_{??}$= number of sightings in site s at time t, $?_{?}$= surface sample plots at site s, and $?_{?}$= number of repetitions at site s.

III. RESULTS

A. Scan summary statistics

A total number of 51scans was carried out at 5 different sites of the Lake and at different time periods (see table X). Manatees were sighted at every scan point except at the Pongo-Pitti site, where no manatees were sighted. For the purpose of this study, the probability of manatee presence was based only on the first 30 minutes of each scan. This standardized sampling method reduces bias and enables comparison of data across both time and space. The probability differed by site and time, ranging from 0.00 to 0.50. The probability of sighting was highest at Lake Mevia. Time periods with the highest probability of a sighting in the overall sites were 0600-1000 hours (30%) and 1800-2200 hours (30%) (See table XI) and the time periods with the lowest probability of sighting a manatee in the overall sites were 0400-0600 hours (1%) and 1400-1800 hours (1%) (See table XI). Twenty-four (24) direct sightings and forty three (43) indirect sightings were recorded during the scanning. The highest number of direct sightings occurred in Lake Mevia (77.42%) and the highest number of indirect sightings occurred in the Mevia canal (Canal-Lindema-Mevia) (55.42%). The highest number of sightings was recorded between 0600 ï 1000 hours (32.56%).and 1800 ï 2200 hours (30.23%).

Table X: Summary of manatee sightings by site

Site	Approximate total surface scanned over all repeats (m2)	Total Number of scans	Number of times manatee were present during scan	Total Number of manatees counted during scan	Total Number of indirect signs of manatees detected during scan	Number of opportunistic sightings (indirect & direct)
Lake Mevia	502400	10	5	24	7	3
Plantation	520137	9	2	3	4	1
Mevia canal	350000	11	2	3	24	0
Mouth-Mwembe	41287	10	1	1	8	4
Pongo-pitti	621304	11	0	0	0	2
Total	**46804084**	**51**	**10**	**31**	**43**	**10**

Table XI: Summary of manatee sightings by time period

Time period	Total Number of scans	Number of time manatee was present during scanning	Total number of manatees counted during scan	Total number of indirect signs of manatee detected during scan	Number of opportunistic sightings	Number of reported sightings
0400-0600 hours	9	1	8	6	0	0
0600-1000 hours	11	3	6	14	2	3
1000-1400 hours	10	2	6	6	8	1
1400-1800 hours	10	1	7	4	0	0
1800-2200 hours	11	3	4	13	0	6
Total	**51**	**10**	**31**	**43**	**10**	**4**

B. Site and day period effects on detection probability

1. Data exploration using plots

The following graph suggests that site and time effects are present, as well as site by time interactions.

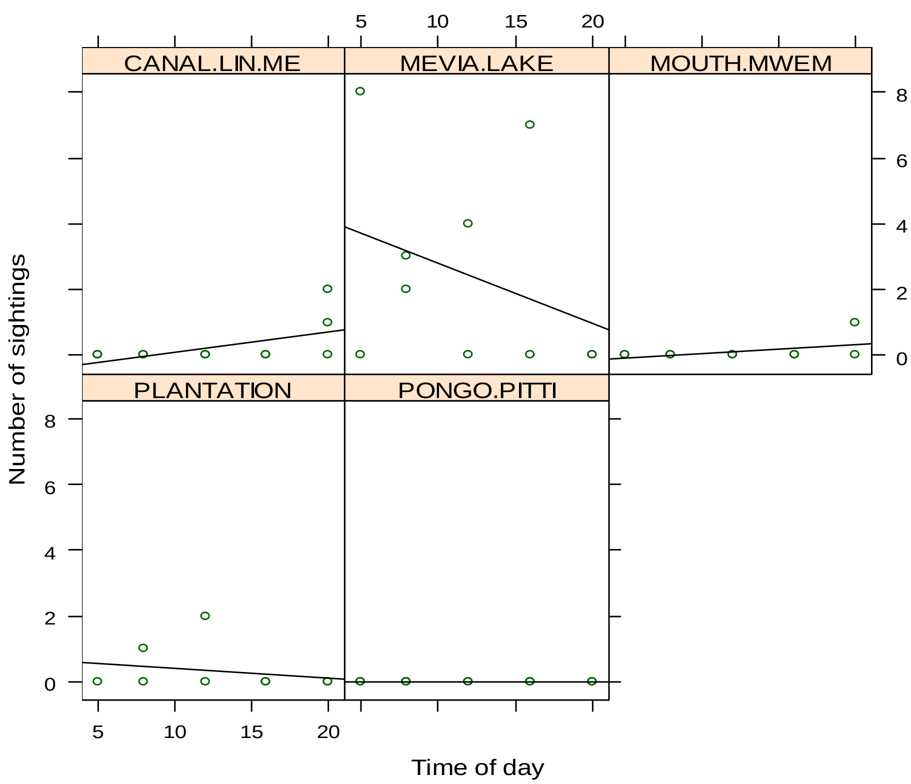


Figure 32: Scatter plots (with regression lines overlaid) of manatee counts in relation to time of day and sites.

The probability of sighting a manatee was lowest in Pongo-Pitti (0/11 scans) and highest in Lake Mevia, precisely at a site called Ohè (Site E) (07/10 scans). The regression slope for the Pongo-Pitti, Plantation, Mouth Mwembe and Mevia-canal sites are not significantly different from each other, but they are significantly different from the regression slope of Lake Mevia, which is significantly higher.

This suggests that we can lump Pongo-Pitti, Plantation, Mouth Mwembe and Mevia-canal sites together to obtain two groups: Lake Mevia (group 1) and the other four sites (group 2); the graph below illustrates the two regrouping:

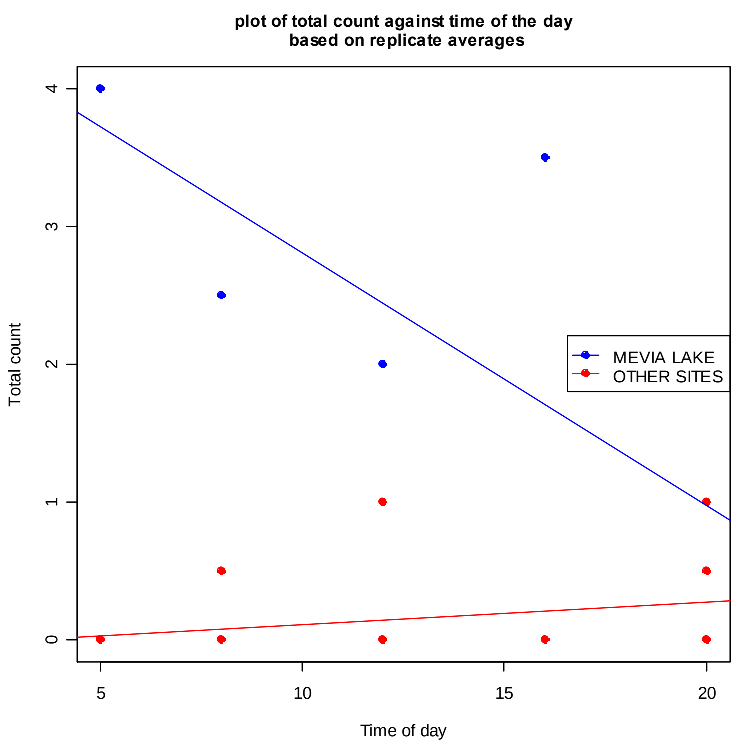


Figure 33: Plot of total count against time of the day base on replicate average.

Of the ten 30 min scans conducted at the Lake Mevia site, manatees were present during 5 scans. A total of 24 manatees was sighted; for an average of 5 manatees counted during each scan. Forty-one scans were conducted at the other four points with manatees present only during five of the scans with an average of one manatee counted during each of the five times manatees were present. The probability of encountering at least one manatee was almost four times higher in Lake Mevia (P=5/10=0.50) than at all other sites combined (P=5/41=0.12).

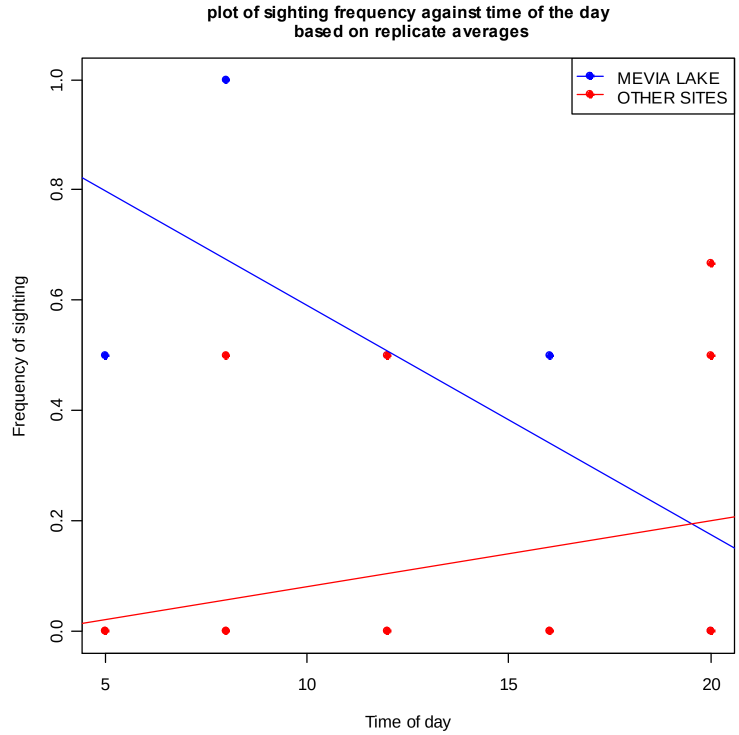


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Figure 34: Plot of probability presence against time of the day based on replicate averages.

The plot suggests that it is more likely to encounter a manatee early and late in the morning in Lake Mevia than in other parts of the Lake. On the other hand, in the evening from 1900 hours, it is more likely to encounter manatee in other parts of the Lake (in group 2).

2. Data analysis using Generalized Linear Model (GLM)

All abiotic variables with the exception of water temperature were removed due to small number of cases (for example, nearly all sightings occurred at sea state 0 and only once at sea state 1) which prevented the convergence of the full model. Due to lack of equipment, water temperature was qualitative with subjective appreciation. Therefore much emphasis was placed on that variable.

Only four variables were retained as predictors of the manatee count as well as presence-absence: group (of sites), time period (hour), water temperature, number of indirect sightings.

a) Count

Taking into consideration the above mentioned variables, three sub-models can be built by assuming that there is interaction between some of the variables as follows:

Model 1: count ~ group + hour + watr.temp + no.ind.sight + group x hour

Model 2: count ~ group + hour + watr.temp + no.ind.sight

We compared the deviances of these two sub-models in the table below, to determine which one fits the observed data best.

Table XII: Comparison of model deviances for the logistic regression of manatee sighting

Model	Df of residual	Residual deviance	Df difference	Deviance difference	P(>|Chi|)
Model 1	45	55.895			
Model 2	46	60.864	-1	- 4.969	0.026

From the deviance table it appears that it is model 1 with interaction that best fits the observations since its residual deviance is low as compared with model 2 which has no interaction. The estimated regression coefficients are given in the table below:

Table XIII: Parameter estimates, standard errors, Waldôs statistics, P-values and 95% confidence limits for the logistic model for total count.

Parameters	Site	Estimate	Standard errors	Z-value	Pr(>|z|)	95% Confidence interval
Intercept	Lake Mevia	2.40565	0.81659	2.946	0.003219	0.83789 ; 4.06474
	Other sites	-5.59851	1.45947	-3.836	0.000125	-9.01235 ; 3.10584
Time	Lake Mevia	-0.11171	0.05272	-2.119	0.034094	-0.22375 ; -0.01503
	Other sites	0.08433	0.08107	1.040	0.298256	-0.06293 0.26692
Number of indirect sighting	___	0.39783	0.15773	2.522	0.011661	0.07877; 0.70886
Water temperature	___	-0.84898	0.57103	-1.487	0.13708	-2.00565; 0.25025

AIC= 95.74

Except for water temperature and the group ñtime x other sites effectsò all other estimates are significant at probability level of 5%. Effect of group (site) on log mean count differs significantly: the Mevia site has an important increasing effect on manatee log mean count (Coef.estimated =2.405; p=0.003) contrary to the other sites that have a pronounced decreasing effect on manatee log mean count (Coef. estimated= -5.598; p<0.001). The difference in the regression coefficient of both sites indicates that, as we move from Lake Mevia site to the other sites of the lake, the number of manatee encountered decrease significantly.

The time effect on log mean count depends on the group being considered: in sites other than Lake Mevia, this effect is not significant; but in the other sites each 1-hour increase in time decreases the log mean count by a factor of exp(-0.11171) =0.89. The negative value of the coefficient estimated indicates that the number of manatee occurring (or sighted) in Lake Mevia, reduce as time progress from morning to evening and night.

Each unit of indirect sighting significantly increases the log mean count by a factor of exp (0.398) =1.49.

b) Probability of manatee presence

The same sub-model was retained after the analysis on the deviance table:

Probability ~ group + watr.temp + no.ind.sight + group x hour,

The fitted model is summarized in the table below:

Table XIV: Parameter estimates, standard errors, Waldôs statistics, P-values and 95% confidence limits for the logistic model for sighting probability.

	Site	Estimate	Standard errors	Z-value	Pr(>|z|)	Confidence interval 95%
Intercept	Lake Mevia	4.5192	5.6595	1.699	0.08927	-0.1719 ; 10.6762
	Other sites	-9.0627	3.4475	-2.629	0.00857	-17.2785 ; -3.3158
Time	Lake Mevia	-0.2959	0.1745	-1.696	0.08984	-0.7026 ; 0.0087
	Other sites	0.1339	0.1387	0.965	0.33430	-0.1244 ; 0.4474
Number of indirect sighting	___	1.1099	0.4668	2.378	0.01743	0.3691 ; 2.2579
Water temperature	___	-2.6505	1.4972	1.770	0.07668	-6.2944 -0.1731

AIC=40.688

All estimates are significant at the probability level of 10% except ñgroup other time x hourò effect.

Effects of group (sites) on the odds of sighting probability vary: site Lake Mevia has a borderline effect (i.e significant only at p=0.08927), whereas the other sites have highly significant effect (p=0.00857). Yet, the Mevia site has an increasing effect on the odds of manatee sighting probability, whereas the other sites have decreasing effect; in other words, there are greater chances of sighting as we converge from the other sites to the Lake Mevia site.

Time effect on odds of sighting probability also varies according to sites: Time effect appears to be insignificant in other sites (p=0.33430) whereas, in the Lake Mevia site, time has a slight effect (p=0.08984). Hence, the odds of manatee sighting in Lake Mevia decreases as time passes from morning to evening; each 1-hour increase in time decreases the odds by a factor of exp (-0.2959) = 0.75.

Effects of number of indirect sightings on the odds of sighting is significant (p= 0.01743); detection of an extra unit of indirect sighting increases the odds of probability by three (= exp 1.11).

Effect of temperature on odds of sighting probability is significant: when water temperature decreases from lukewarm to cold, the odds of probability decrease by a factor of exp (-2.65), almost a 93% decrease.

AIC of the odds of sighting probability model (40.688) is smaller than the AIC of the mean log count model (95.74); indicating that the statistical model ñodds of sighting probabilityò better fit than the last one. The variation in odds of sighting probability in Lake Ossa is presented in the figure below.

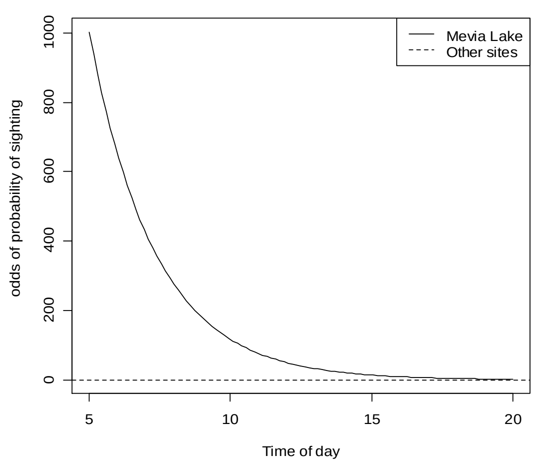

Figure 35: The logistic function expressing the odds of probability of sighting with time of day and site.

3. Site effects on indices of sighting and behavior category

a) Exploration through graph

Bar plot (with bars arranged in decreasing heights for easy reference):

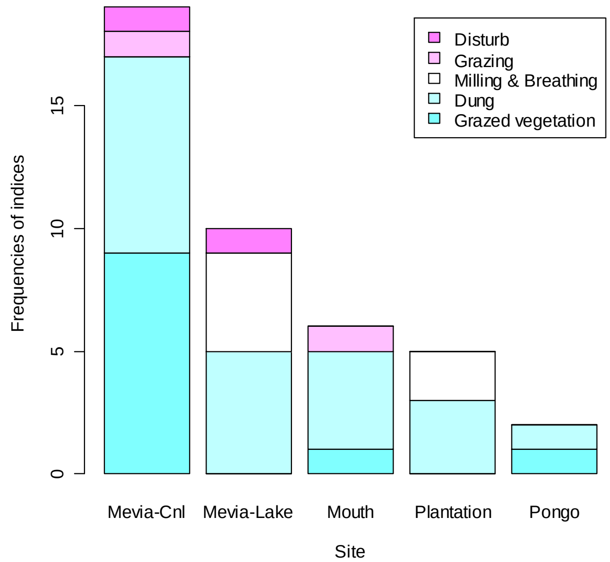

Figure 36: Distribution of frequency of different types of indices and behaviour categories in relation to scanned sites.

Indices are more diversified in Mevia-Canal than in other sites with ñdungò and ñgrazed vegetationò being the dominant indices. In Lake Mevia, the dominant indices were ñwater bubblesò and ñdungò, Mouth and Plantation sites were also dominated by the indice ñdungò.

b) Data analysis using GLM

The log-linear model for the site by index cross-tabulated data assumed a Poisson model, namely that the cell counts Y_{ij} follow a Poisson distribution with mean ε_{ij} which is predicted as log(ε_{ij})=Ŭ+ ɓ$_{i}$ + ɔ$_{j}$. The deviance table for this model is given below.

Table XV: Deviance table of the log-linear (Poisson) model for the site by indices contingency table.

	Df of residual	Residual deviance	Df difference	Deviance difference	P(>|Chi|)
Null	24	76.882			
Site	20	47.983	4	28.898	8.198e-06
Indices	16	28.446	41	19.537	0.001

Both Site and Indices Types are highly significant; the overall fit of the model is significant: the Likelihood Ratio Test is based on chi-squared statistic of 48.436 with 6 df and a P-value < 0.1%. The coefficients estimates and standard errors appear in the table below.

Table XVI: Estimated coefficients of the log-linear model for site by indices contingency table.

	Coef. estimated	Standard errors	Z-value	Pr(>|z|)	Significance
(Intercept)=Pongo	-2.340e+00	3.013e-01	7.766	8.08e-15	0.1%
Plantation	9.163e-01	2.601e-01	3.522	0.000428	0.1%
Mevia Canal	2.251e+00	2.241e-01	10.044	< 2e-16	0.1%
Lake Mevia	1.609e+00	2.355e-01	6.834	8.23e-12	0.1%
Mouth	1.099e+00	2.492e-01	4.408	1.04e-05	0.1%
Grazing	-4.167e-17	3.086e-01	-1.35e-16	1.000000	
Milling & breathing	1.016e+00	2.547e-01	3.989	6.63e-05	0.1%
Dung	2.331e+00	2.286e-01	10.197	< 2e-16	0.1%
Grazed vegetation	1.743e+00	2.365e-01	7.369	1.73e-13	0.1%

Except the behavior ñgrazingò, all estimated coefficients are significant at the probability level of 0.1%. Grazing behavior is rarely observed during the dry season in Lake Ossa. Travelling behavior was not observed for all sites.

The Pongo-Pitti site has no interaction with the indices of presence ñdung and grazed vegetationò and behavior categories ñGrazingò and ñmilling and breathingò, (coef. estimate= -2.340). During the dry season, manatee indices of presence and behavioral exhibitions are hardly encountered as we approach the Pongo-Pitti site. On the other hand, the other sites (Plantation, Mouth, Lake Mevia, Canal Lindema-Mevia) interact with manatee presence indices and behavior categories. Indeed, as we leave from Pongo-Pitti to Plantation, then from Plantation to the Mouth site, from the Mouth site to Lake Mevia and from Lake Mevia to Canal Lindema-Mevia, the abundance of indices of presence and behavior categories increases (-2.340e+00< 9.163e-01<1.099e+00<1.609e+00<2.251e+00).

Dung and grazed vegetation are the main indices for presence detection in the Lake Ossa during the dry season. Manatees were observed in all the sample sites except Pongo-Pitti. The most frequent indices encountered in Lake Ossa in dry season is the presence of dung (coef. estimated= 2.331; p< e-16), followed by grazed vegetation (Coef. estimated=1.743; P=1.73e-13).

Milling and breathing was the only behavior category commonly encountered. It was observed in Plantation site and Lake Mevia site.

4. Estimated densities in different sites

After computation, the following densities estimation was obtained for each site:

Table XVII: Estimated density for each scanned site.

Sites	Mevia Canal	Lake Mevia	Mouth Mwem	Plantation	Pong-pitti
Estimated density (Ind/km2)	0,77922078	4.7808765	2.4390244	0,6408568	0.00000

The highest concentration of manatees is found in Lake Mevia and is followed by Mouth-Mwembe, while Pongo-Pitti does not harbor any manatee during the dry season.

5. Habitat characteristics

The different habitat characteristics collected during the field survey are recorded in the table below:

Table XVIII: Habitat characteristics for each sampling site (data with the symbol * in front were collected through measurements, whereas the others without * were only through visual estimation).

	Water Characteristics				
	Pongo	Plantation	Canal Lin.Me	Mevia.Lake	Mouth.Mwem
Estimated percentage of water surface (%)	75	100	50	90	60
***Estimated water depth at the middle (cm)**	70	180	165	290	480
***Estimated depth near the bank vegetation (cm)**	55		120	63	120
***Water transparency (cm)**	50	60	75	110	55
***Water acidity**	6	6	6	6	6
Estimated percentage of sand at the bottom	75	10	35	0,5	5
Estimated percentage of mud at the bottom	25	90	65	99,5	95
	Land Scape Description				
	Pongo	**Plantation**	**Canal Lin.Me**	**Mevia.Lake**	**Mouth.Mwem**
Estimated percentage of terrestrial vegetation	70	90	25	80	50
Estimated percentage of aquatic vegetation	30	10	75	20	50
Estimated percentage of grass	70	5	80	60	40
Estimated percentage of herbs	5	0	5	10	10
Estimated percentage of shrub	20	0	15	20	50
Estimated percentage of emergent aquatic vegetation	90	70	90	80	80
Estimated percentage of submerged aquatic vegetation	0	0	0	0	0
Estimated percentage of free floating vegetation	2	0	10	5	2
Estimated total length of net along the shoreline vegetation (m)	300	0	800	500	500
Estimated percentage of hills on the landscape	0	40	20	80	40
Estimated total length of nets across the lake (m)	1000	0	300	200	200
***Estimated number of Bamboo in the water**	10 000	100	700	0	3400

The table below show the abundance of various plants species in the different sites:

Table XIX: Vegetation characteristics of manatee feeding sites.

		Pongo	Plantation	Mevia Canal	Mevia.Lake	Mouth.Mwem
Percentage of each plant species	*Phragmite sp* (sursongo)	68	0	41	67	62
	Vossia cuspidata	5	0	28	0	0
	Ludwigia leptocarpa	24	0	16	18	36
	Ceratophyllum demersum	0	0	12	1	<1
	Calamus sp (rotins)	2	0	2	11	1
	Drypteris sp (fern)	0	0	<1	0	0
	Index of diversity of herbaceous vegetation cover by manatee feeding site (-Σpi log pi)	**0,83278549**	**0**	**1,39026551**	**0,86583563**	**0,75262312**

The manatee feeding area of Mevia-canal is more diversified in grass species than other sites (Id= 1.39). The site Plantation situated in deepwater did not have any grass species (Id=0).

IV. Discussion

A. Distribution and probability of sighting manatees in Lake Ossa.

1. Effect of site and time

Manatees are present in Lake Ossa. During the dry season, the probability of sighting at least one manatee was patchy across time and space; it varied from 0.00 to 0.50 for each point. Lake Mevia, precisely at Ohe (Site E), represents the part of Lake Ossa with the highest occurrence. This point might be considered a ñhot spotò within the overall Lake Ossa. Here, manatees easily occur early in the morning between 0400 h and 1000 h. The probability of sighting a manatee in Lake Mevia decrease as time passes through the period of observation.

The probability of sighting a manatee in areas other than Lake Mevia is relatively lower, and that probability varies by time of day, with higher probabilities starting at nightfall from 1800-2200 H. However, in the Lindema-Mevia Canal, there are considerable chances of sighting manatees at their feeding sites during the night. This probability decreases as the day passes from morning at 0400 h till evening at 2200 h.

Manatee density was highest at Lake Mevia (4.78 manatees/Km2), followed by Mouth Mwembe (2.4 manatees/Km2). There were no manatees detected at Pongo-Pitti.

2. Effect of indirect sightings

Indirect sightings are indices or signs that manatees have left behind after an activity or a particular behavior (grazing, defecating and moving). Dung is the most abundant indirect indices of manatee presence observed in Lake Ossa followed by grazed vegetation. The more indirect sightings that occurred in a site the more we can hypothesize manatee presence in that site. It might be because a few manatees have been staying there for a long time or there were many manatees there; however, it is believed that indirect sightings reflect increased manatee occupancy for the site. This is true with respect to grazed vegetation and torn nets; however, as concerns dung, it happens that due to wind, dung will often be shifted through water in a site toward the wind direction or toward the mouth of the Lake. So floating dung could even leave a site where manatee are active and accumulate due to abiotic factors in a different area where manatees havenŉt defecated. It is then very important to consider the movement pattern of water and wind to link dung observation and manatee activity in a given area. In site like Lake Mevia which is surrounded by mountain that limits wind on the water surface, water is most of the time calm. Manatee dung in this site would take a long of time there before subject to drift dispersal. In Pongo-Pitti, no indices of presence were encountered during the survey, suggesting that during the dry season manatees have almost no impact in that site. Contrary to the Pongo-Pitti site, the abundant and diverse indices of presence (dung and grazed vegetation) frequently encountered at Canal Lindema-Mevia site, shows how busy and active this site is by manatee.

3. Influence of biophysical characteristics of the Lake

Compared with the other parts of Lake Ossa, Lake Mevia possesses more suitable characteristics that favor both manatee presence and detectability.

a) Depth

Lake Mevia is deeper than the other parts of Lake Ossa, except for the site of Mouth Mwembé. During the dry season, Lake Mevia (Site E) has a depth of 2.9 m at the center of the lake; this value is closer to the mean depth of resting holes for Antillean manatee (*Trichechus manatus manatus)* in the Drawned Cayne at Belize (Bacchus, 2009) and the other parts of the Lake have depth of less than 2m which also corresponds to non resting holes. This may indicate that places in Lake Mevia (precisely at Ohe) may be possible resting sites for manatees. This might explain why most of the manatees observed at this site were observed milling and could be detected by their footprints. Resting sites for moms and calves, as well as travel corridors between activity centers, may be critical habitats for manatees (Packard & Wetterqvist, 1986; Deutsch *et al*., 2007) because they provide shelter and camouflage. In general, West African manatees seem to prefer those areas that have deep pools for refuge during the drying season (Powell, 1996).

b) Bottom

The bottom of Lake Mevia was mainly muddy and not vegetated compare to other parts that are mixed with a considerable amount of sand. The muddy bottom may provide easy sliding movements to manatees at the bottom, since the risk of getting hurt by sharp or hard objects on the bottom is reduced. In general, manatees are quite rare in rocky areas (Nishiwaki, 1982, Grigione, 1996) and only use those areas as migration pathways but not as permanent suitable habitat (Powell, 1996).

c) Sea state

Water at Lake Mevia was most of the time calm (sea state 0), compared with other parts that are rarely calm go well. Low current flow (since lake systems are stagnant water) and calm water may enable manatees to rest without exerting energy to hold their position in the water columns (Bacchus, 2009). Moreover, Lake Mevia (site E), is surrounded by forested hills that protect the water surface from wind action. Previous studies reported that manatees are found in areas sheltered from swift currents, high energy surf and wind (Powell *et al.*, 1981; *cited by* Bacchus, 2009). On the other hand, surface indices (water bubbles and mud clouds) detection is easier in calm water than in agitated water (water bubbles and mud clouds are quickly wiped off by waves); that might also explain the fact that manatee occurrence was higher at site E than in the others parts of Lake Ossa.

d) Water transparency

Water transparency in Lake Mevia was the best for all sites, that is, 110 cm against less than 75 cm for other parts of the Lake. Apart from the fact that this factor increases the visibility of manatees while in the water, it also allows high contrast with the mud cloud generated by manatees as they move and thus improve our detection probability.

e) Human activity

West African manatees are elusive and often move away from an activity center to avoid human disturbance. At one location in Florida, the proportion of time Florida manatees spend in various behavioral states such as feeding, milling, and traveling in critical habitat is related to ambient noise levels with manatees spending more time in directed behavior (such as feeding) and less time in undirected behavior (such as milling) when noise levels are high (Miksis-Olds and Wagner, 2011). The Lake Mevia faces low levels of fishing activity, implying less noise and thereby disturbance. In Lake Mevia, there is no fishing bamboo sticks (or poles) planted at the water bottom and few fishing nets (approximately 300 m of net used by fishermen) set across the water as compared with other sites, especially at the Pongo-Pitti site that has an estimated fishing bamboo of 10,000 submerged under the water and approximately 1,000 m of nets in a very busy area. That may be one reason the probability of manatee presence is greater at the Lake Mevia site (0.50) than at the Pongo-Pitti site (0.00).

4. Habitat use and activity centers in Lake Ossa

a) Feeding and feeding sites

The frequency of indices and behaviors observed differ according to sites. This suggests that manatees in Lake Ossa might have different sites for different activities. Canal Lindema-Mevia may be one of the rare suitable feeding areas for manatees in the dry season in Lake Ossa. During our field survey we used to observe bank vegetation around the Lake. We noticed that bank vegetation of Canal Lindema-Mevia was frequently grazed and disturbed by manatees. The frequent occurrence of manatee feeding on that area and the presence of abundant grazed vegetation and dung suggest that Canal Lindema-Mevia is indeed a manatee feeding area during the dry season.

In other sites like Pongo-Pitti, water level at the inner limit of the bank vegetation was less than a foot. In this situation, it becomes very difficult for the manatee to reach the grass (Powell, 1996). There is also a risk of the manatee becoming stranded in even it ventures to this shallow water level area for grazing. During the rainy season, the water level would increase progressively till the previous vegetation along the bank would be totally submerged.

We identified five emergent grass species: *Phragmites sp.* (sursongo), *Vossia cuspidata, Ludwigia leptocarpa, Ceratophyllum demersum, Drypteris sp* (fern); but, only one floating plant species: *Ceratophyllum demersum. Phragmites sp.* is the more abundant grass species in the Canal Lindema-Mevia site, followed by *Vossia cuspidata.* However, manatees prefer to feed on *Vossia cuspidata* (hippo grass) which is rarer than the abundant *Phragmite sp.* or vegetation. Among the grazed grass in Mevia-canal, over 90% were represented by *Vossia cuspidata* (Figure 37) fishermen reported that during the rainy season, manatees instead feed mainly on *Phragmite sp.,* abundant in Lake Ossa. The reason might be that in the dry season, phragmites leaves are no longer fresh and become harder with sharp, thorny edges that can easily scratch the manatee skin or oral membranes; whereas, *Vossia* leaves remain fresh long after the rains are over (Vesey-fitzgerald, 1963). That provides a favorite meadow for the large herbivorous animals which tend to trample down the dense growth. Fresh shoots subsequently grow up from these beds forming an excellent dry-season vegetation for manatee consumption. In general, as was observed by Powell (1996) in riverine habitat; that manatees, particularly feed on *Vossia, Phragmites and Echinochloa*. A manatee was once sighted in Mouth of the Big Lake where there are only old *Phragmites sp.* and no *Vossia sp.* The manatee appeared to be grazing on the leaves along the bank; upon further investigation after it moved away from the site, we could observe indirect evidence of grazing at the place we thought was due to grazing. After meticulous examination, we realized that the manatee was feeding on the rhizomes of *Phramites sp.* Contrary to its leaves that appeared dry; its roots were soft and full of water. Along shore we could observe roots floating at the water surface (figure 39). When we visually compared the dung found at that time from this site, we noticed that they were similar in texture and color (see Figure 39 and 40), which could imply that indeed manatees in this area feed on rhizomes. However, we did not conduct further microanalysis of the samples in a lab for confirmation.

A fisherman also reported to us that in March 2010, he saw a manatee placenta floating in the canal near the site Canal Lindema-Mevia. Then, just a moment later, he saw two manatees, thinking they were a male and a female measuring 2.5 and 3 meters in length. This anecdote provides one line of evidence to suggest that Canal Lindema-Mevia might also be a birthing, mating or nursery site for manatees.

Figure 37: Picture of a grazed vegetation presumed left by foraging manatee at Canal Lindema-Mevia. This picture illustrates cut leaves that float to the water surface.

Figure 38: Picture of a manatee feeding site at Canal Lindema-Mevia.

It is very hard to find manatees in Canal Lindema-Mevia during the day, possibly because there is a lot of boat traffic. Fishermen, and women who sell fish, frequently use the canal during the day to get into the Big Lake, where they buy fish and take it back to the market at the border of Lake Mevia for reselling.

Figure 40: Picture of a *Phragmite's* roots, rhizomes, and stems (lower left) and manatee dung (upper right) collected near the site where we observed manatee feeding.

b) Resting behavior and resting sites

In Lake Mevia, manatees were most often observed milling and breathing, which indicates that this may be an important resting area. It is possible that at night, the same manatees at Lake Mevia would move to Canal Lindema-Mevia (feeding area) for food; then move back to Lake Mevia before dawn for resting and socializing or mating. Fishermen camping near the bank of the lake reported to us that, during the transition between the dry and wet seasons (May-June), they report hearing manatees splashing water early in the morning before dawn. We heard the same noise one morning at 5000 H when we camped along the bank of Lake Mevia; but we could not determine specific behavioral state because it was still dark.

Lake Mevia constitutes a good resting and refuge area for manatees in Lake Ossa. In fact; there is little human activity there as compared with other sites of the lake. At Lake Mevia (site E) there was less fishing activity and no fishing method using the Chinese bamboo (*Bambusa sp.*) sticks. Moreover, there was enough depth to provide camouflage for manatees making observations difficult.

5. Movement indices and behavior category

Occasionally, in Lake Mevia, we would follow a manatee for more than 30 minutes with good visibility so that we could observe the behaviors more clearly. In other words, we could actually see the manatee at the surface of water. Through these careful focal follows we documented three direct signs of manatee presence and movements:

- **Water bubbles** that appear at the surface of the water and followed the movement of the manatee. This occurred twice that one manatee at site Plantation was milling around our boat and releasing air from their mouths (measuring approximately 2cm radius). Generally, manatees do not exhale underwater. Often bubbles are the result of disturbed pockets of gas trapped in debris on the bottom during decomposition that are released as the manatee swims over the area. Additionally, bubbles are often expelled as gas from the manateeĉs digestive system through the anal opening. Manatees are hind gut digestors and the byproduct of this fermentation process is gas (Self-Sullivan, pers. comm.). We often rely on this sign in order to follow a manatee. The calmer the water, the easier it was for us to detect the bubbles. Bubble detection was easiest when the water was flat and calm like a mirror (sea state of zero). In such cases we could detect a manatee by bubbles at a distance of over 200 m.

Muddy clouds, often referred to as mud plumes, are generated by manatees when they are moving. This sign appears as a series of equidistant mud spots along the line of movement when the manatee is traveling at a constant speed in shallow water with a muddy substrate such as Lake Ossa. However, when a manatee was startled and suddenly sped up, it would often generate a very large, single mud plume that would not allow us to determine direction of movement. These mud plumes during swimming movement indicate that, similar to Florida manatees, West African manatees use broad strokes of their tail when they swim. In Florida, there is a characteristic upwelling (sometimes referred to as a footprint) at the surface of the water when manatees are traveling near the surface (Hartman, 1979). If the broad strokes are made in shallow water, with a muddy substrate, the upwelling is accompanied by a mud plume (Self-Sullivan, pers. comm.). Previous observations (Powell 1996) have been quite different for West African manatees in other areas. Based on the side to side ñwagglingò motion generated by the float as a radio-tracked manatee was moving, Powell suggested that the West African manatee, instead of swimming with its tail, where tail strokes produce regular tipping motions of the tag, was using its flipper-like forelimbs to propel itself through the water. Manatee movement made by this ñwalkingò by using their forelimbs along the bottom as allowing their body and tail to trail behind them has also been observed in Belize (Self-Sullivan, pers. comm.). It is likely that manatees exhibit combination of different swimming motions depending on their behavioral state and their ambient environment.

When the manatee is milling, the distance between two mud upwellings was almost the same (see Figures 41, 42 and 43). As the manatee sped up, the distance will become progressively longer between the plumes. A very large upwelling was generated when the manatee startled and dives down suddenly, presumably to avoid disturbance from our boat.

- **The snout** is also use to detect manatees. We followed one manatee moving for 18 min. We noticed that after each 5 to 6 minutes, the manatee would show its snout out of the water surface for 3 to 4 seconds and take one breath. An average breathing interval for manatees observed by Powell (1996) during a study in Ivory Coast was 6.2 minutes. A single submergence interval of 7 minutes for a captured manatee was also recorded by Van den Bergh (1968) *cited by* Powell (1996). In Belize, Self-Sullivan has observed significant variance in breathing intervals depending on the individual manatee and the behavioral state (unpublished data). For example, one resting manatee would surface and breathe 5 times within a 2-minute interval, then return to the bottom (in 3 meters of water) for 12 minutes. This pattern was repeated 4 times over the period of an hour. Traveling manatees tend to breathe more often, taking only one breath every 1-2 minutes (Robert Bonde pers. comm.) Most feeding manatees take one breath every 2-3 minutes (Robert Bonde pers. comm.)

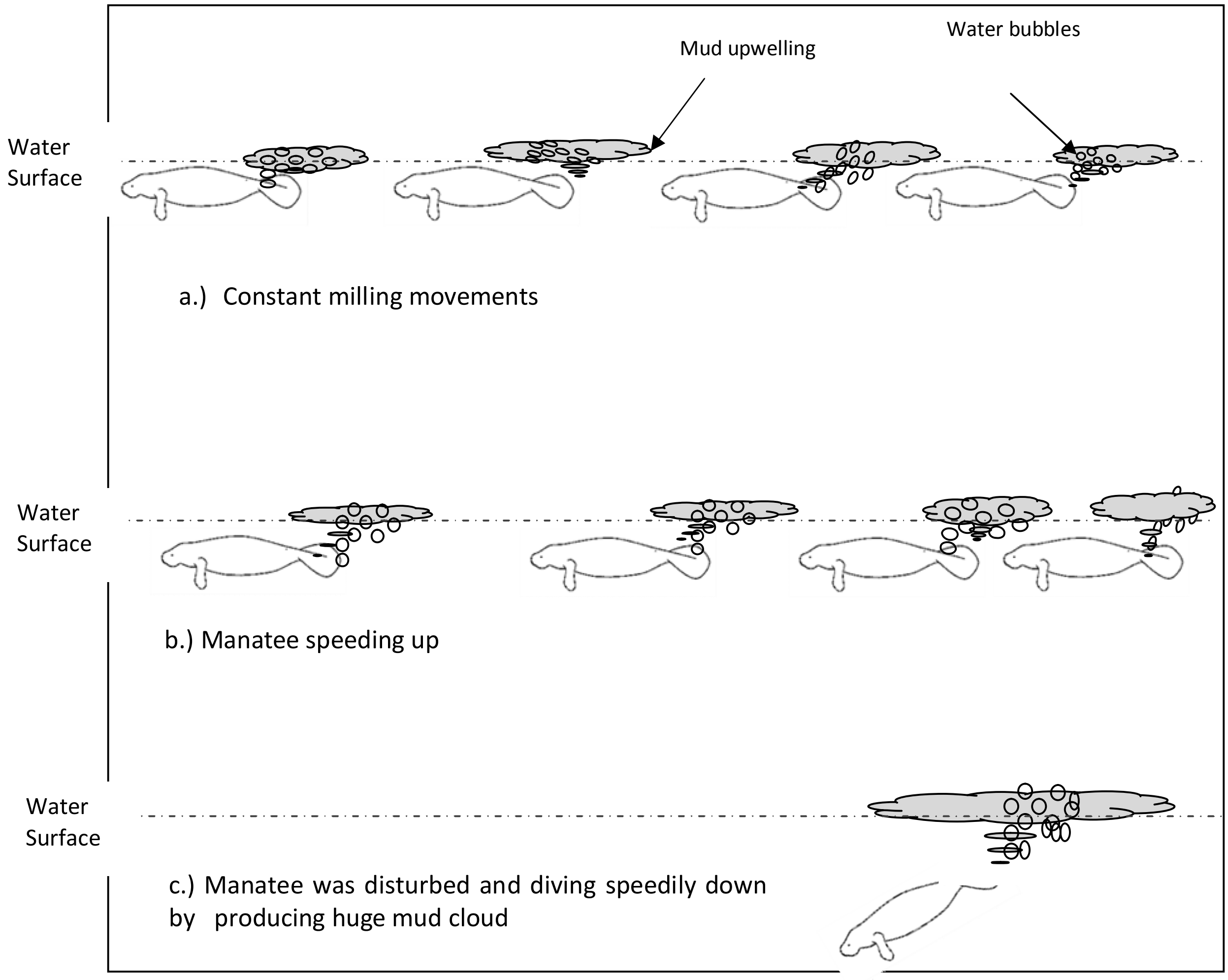

Figure 41: Description of water surface detection for determining manatee movement as in milling (a), speeding (b) and startling (c).

These signs correspond exactly to those of direct sighting by fishermen gave to us during the focus group discussion.

Figure 42: Picture illustrating mud cloud generated by manatee movements.

Figure 41: Picture illustrating water bubbles generated by manatee.

6. Threats faced by manatee

a) Fishing nets

During our survey we discovered that manatees are indeed threatened in Lake Ossa. Evidence of hunting included a sturdy manatee net that was set across the canal (see Figure 44) that links Lake Mwembe to the main canal creek, which links Big Lake to River Sanaga); this method is similar to the method used in Chad, Sierra Leone and Nigeria (Powell, 1996). We could not know whether the net had already captured a manatee or for how long it had been there. However, the presence of that net might constitute a barrier to manatee movements from Lake Mwembe to reach the other parts of Lake Ossa or to the River Sanaga and then to the sea; possibly, results in an allopathic isolation might in the future lead to reproductive isolation if that physical barrier becomes permanent. However, for the moment, there is a high risk of having a sex-ratio in that lake that does not favor good reproduction of the population.

b) Fishing using technique Chinese bamboos

The increased number of Chinese bamboo *(Bambusa sp.)* set in by fishermen to catch fish, especially catfish (*Aruis Latiscutatus),* might constitute space pollution to manatees in Lake Ossa (see Figure 45). In fact the manatee needs enough space because of its very large size (up to 4m); moreover, some of that Chinese bamboo which is sharp might hurt the manatee.

c) Evidence of hunting activity

Manatees are stealthily hunted in Lake Ossa. In August 2010, we came across fishermen who were transporting the head of a dead manatee in a bag. (see Figure 47). They may have killed the manatee during the night but reported to us that they had received it from a friend. We were also informed that there was a restaurant in Dizangue in the village Beach that used to secretly buy manatee meat from fishermen from time to time, turning them into dedicated manatee hunters. Unfortunately, when we went to the restaurant the employee refused to answer any question related to manatees.

d) Fisherman-manatee conflicts.

The manatee is not only threatened, but it also constitutes a threat for fishermen by damaging their nets. We came across a fisherman whose net had been torn by manatees in Lake Ossa (see Figure 46).

Figure 44: Picture of manatee net set across the canal between Lake Mwembe and the main canal creek.

Figure 45: Chinese bamboo in the Big Lake

Figure 46: A fisherman fishing holding a net torn by a manatee in Lake Ossa.

Figure 47: Dead manatee head from a fishermen in Lake Ossa.

CHAPTER IV: CONCLUSIONS AND RECOMMENDATIONS

I. CONCLUSIONS

In the light of the outcome of this study, it is now obvious that:

1 Fishermen in DEWR and LOWR have a good understanding of their environment regarding the West African manatee and its habitat. The fishermen have a good historical record of events marking the occurrence of the West African manateeôs presence when at the water surface. The continued observations of some of those events over time and different seasons have conferred a certain specific knowledge of manatee life, behavior and habitat.

2 From the responses of fishermen, it is clear that in DEWR and LOWR, manatees are still present in the River Sanaga downstream from the hydroelectric dam of Edea, in the Kwakwa River, River Nyong, River Dihende, Lake Ossa, Lake Tissongo, the estuary of Mbiako and Manoka and the coastline along Yoyo I and Yoyo II, Youme I and Youme II.

3 The perception of manatee biology, behavior and habitat by fishermen differ in some places from one habitat to another. In this respect, it was observed that fishermen in the rivers encountered manatees more frequently than fishermen of the lake habitat. According to fishermen in lakes and estuaries, manatees are more abundant during the dry season when water level is low, than in the wet season when water level is high; fishermen from the river and coastline instead suggested the contrary. Manatees are mostly sighted in the river during the morning, and around evening time in the other habitat types. The manateeôs meat is highly coveted and consumed in the river habitat more than in other habitats.

4 There are also other aspects of the life of manatees whose perception by fishermen seems to be common across habitat types. Manatees are frequently sighted in a group of two to three individuals; they assume these dyads and triads represent family groups, for example, a female, male, and calf. However, knowing what we know about manatee reproductive strategy in other areas, it is unlikely that fathers of calves remain with mother and calf in a family unit (Self-Sullivan, pers. comm.). Manatees are more abundant in River Sanaga around Malimba and in Lake Ossa than in other parts of the DEWR and LOWR. Malimba village has the highest number of reported manatee carcasses. Rarely does more than one dead manatee

occur at a time. The cause of manatee deaths in the drainage basin of River Sanaga is most likely due to illegal hunting.

5 Manatees are hunted for their meat, which is highly coveted by fishermen and the people. Despite the high number of manatee deaths, fishermen continue to believe that, manatees are still numerous in their respective habitat because of their high reproductive potential; they believe that a manatee can reproduce every year.

6 Fisherman-manatee conflict is obvious: some fishermen can hardly bear with the presence of manatees in the water because they damage their fishing nets and eat their fishes inside the net; this is the reason why some among these fishermen would sometimes hunt manatees and sell them as a compensation of their destroyed nets and the fishes that had believe to be eaten by manatees. Consequently, the reaction of the fishermen regarding manatees has resulted in a serious fisherman-manatee conflict. Fishermen across the DEWR and LOWR are unanimous in their belief that for the fisherman-manatee conflict to end there must be compensation in terms of money for replacement of their nets that have been destroyed.

7 In Lake Ossa, based on information provided by fishermen during the focus group, we could observe manatees directly and through indirect signs using boat-based point scan detection methods. Direct signs indicating the presence of manatees included water bubbles, mud plumes and direct observation of breaths as the snout brakes the waterÕs surface; indirect signs included grazed vegetation, feces and torn nets.

8 During the dry season in the Lake Ossa complex, manatees seem to prefer Lake Mevia where there is high probability of sighting them in the morning from 0400-1000 h. Lake Mevia, according to our investigation, provides good habitat for manatee presence and detection. Lake Mevia has deep water, with less turbid and week water current, muddy bottom substrate and low human activity; these are suitable characteristics for a manatee resting area. On the other hand, Canal Lindema-Mevia, near Lake Mevia, with its abundant vegetation and deeper water, might be the only substantial and suitable manatee feeding area in Lake Ossa during the dry season.

9 During the dry season, manatees in Lake Ossa mostly feed on *Vossia cuspidate,* and in some cases on *Phragmites sp.* rhizomes, roots, and stems.

10 All indications are that manatees are steadily hunted, though the frequency of capture remains unknown. The profusion of Chinese bamboo stick fish traps planted under the water might

constitute an obstacle to the free movement of manatees between areas within Lake Ossa. But, more importantly, the manatee net set across the canal connecting Lake Mwembe to the main canal, if left in place will not only be used to entangle manatees, b ut also to prevent ingress and egress to the system ultimately resulting in isolation of individuals

Our objectives were largely reached. However, due to time and financial constraints, it was not possible to collect field data in Lake Ossa during the rainy season. It would have enabled us to compare the distribution pattern of manatees and other parameters in the Lake during the dry and rainy season. However having established 5 transect points and collected our initial data in a systematic manner will enable comparison of data collected during the rainy season in the future.

II. RECOMMENDATIONS

Much still has to be done concerning the West African manatee in Cameroon, particularly in the DEWR and LOWR. Hence, the following recommendations are crucial to improve the conservation status of manatees in the DEWR and LOWR:

Conservation action:

- Foster collaborative management of natural resources through a participatory approach in which fishermen or farmers can express their own points of view in the process of decision making and also partake in the implementation. In fact the notion of co-management in DEWR and LOWR is very new and presently poorly implemented (Che Awah, 2010, unpublished data) where as fishermen they have sufficient knowledge that would enlighten stakeholders for an efficient decision making.

- Favor the creation of local associations for the conservation of the West African manatee in a co-management perspective, whereby fishermen and other local inhabitants would take initiative and surveillance measures for the protection of manatees.

- Sensitize fishermen and manatee hunters on relegality of illegal hunting and the importance of manatees to the aquatic system, and subsequently explain the impact of illegal manatee hunting on the environment and the human beings.

- Integrate manatee education and convey the importance of manatees to the ecosystem with the existing education programs already in place in schools.

- Implement regular and unexpected patrols by MINFOF agents in the river or in the lake to discourage illegal practices on natural resources, including the manatee. At the same time remove and destroy any manatee nets, traps, or barriers set in the water. In the course of this surveillance and patrol, emphasis should be placed on known hotspots like Lake Mevia and Canal Lindema-Mevia sites. It is also important to protect daily and seasonal travel corridors that enable manatees to move from one activity center or seasonal habitat to another.

- In Lake Ossa, regulate fishing techniques, especially the use of Chinese bamboo sticks in such a way that it would not compromise the free movement of manatees in the Lake.

- It is important to establish a sanctuary for manatee in Lake Mevia and in Bobo (Canal Lindema-Mevia) since it might be the only suitable part of Lake Ossa for their shelter and feeding ground during the dry season.

- Promote development of an ecotourism in the area, especially in Lake Mevia where patient tourists could observe the elusive and endangered West African manatees and indirect signs of their presence. Tourists should be taken there early in the morning during the dry season because this is the time of higher probability of sighting manatees in this area. Noise has to be avoided and it would be preferable to use a simple un-motorized boat. In developing an ecotourism industry, it is important to identify manatee hunters so as to sensitized them and convince them to become guides for manatee researchers and tourist.

Apply research action:

- Although the outcomes of our surveys were mainly qualitative, with some limitations, in our case, they were an important research tool, enabling us to re-evaluate and update the status of manatees in the DEWR and LOWR. DEWR and LOWR appear to harbor a significant population of manatees that face threats from hunting pressure, fishing conflicts and degradation of habitat. All these factors should be taken into consideration in future conservation efforts. In this respect, future research to estimate manatee abundance and distribution in the Lake Ossa system during the rainy and dry seasons should be designed. Additionally, habitat preferences and availability should be quantitatively assessed.

- Our field survey being limited to the dry season, it is important to carry out a comparative assessment survey during the wet season to better understand the movements and habitat use of manatees between seasons and across different habitat types.
- It would be necessary to extend this study to other areas of Cameroon were manatees are present; i.e in River Benue (in the north of Cameroon); Munaya River, River Akegamr and Manyu River (in Mamfe Region); Akpa Yafe River, Akpasang River, Ndian River and Rio del Ray River (in the Korup Region).
- Periodic surveys should be designed and undertaken on a regular basis to access the trends in manatee population numbers and habitat degradation. An assessment of the impact of climate change on the West African manatee in Cameroon should equally be considered.
- It would be beneficial to initiate fundamental and applied research on fishing techniques compatible with manatee survival in such a way it would reduce fisherman-manatee conflicts.
- Access the different potential diseases and pathogens of manatees through necropsy of carcasses
- Develop legislative tools for adapted and applied marine protected areas. In fact, the Cameroon forest law is mainly adapted to terrestrial protected areas and thus neglects a large number of marine areas.
- Extend the limit of DEWR and LOWR in such a way that it encompasses all the distribution areas of manatees in the Sanaga drainage and Gulf of Guinea including their migration corridors (see Appendix 7).

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APPENDIX

Appendix1: Sea surface state base on wind Beaufort scale

Beaufort 0: Calm (Stille) Wind velocity: 0 - 1 knot (0.0 - 0.52 m/s) Sea like a mirror.

Beaufort 1: Light Air (Flau vind) Wind velocity: 1 - 3 knots (0.52 - 1.80 m/s) Ripples with the appearence of scales are formed, but without foam crests.

Beaufort 2: Light Breeze (Svak vind) Wind velocity: 4 - 6 knots (1.80 - 3.35 m/s) Small wavelets, short but pronounced; crests have a glossy appearance, but do not break.

Beaufort 3: Gentle Breeze (Lett bris) Wind velocity: 7 - 10 knots (3.35 - 5.41 m/s) Large wavelets, crests begin to break. Foam of glossy appearance. Perhaps scattered white horses.

Beaufort 4: Moderate Breeze (Laber bris) Wind velocity: 11 - 16 knots (5.41 - 8.50 m/s) Small waves, becoming longer; fairly frequent white horses.

Beaufort 5: Fresh Breeze (Frisk bris) Wind velocity: 17 - 21 knots (8.50 - 11.07 m/s) Moderate waves, taking a more pronounced long form; many white horses are formed. Chance of some spray.

Beaufort 6: Strong Breeze (Liten kuling) Wind velocity: 22 - 27 knots (10.07 - 14.16 m/s) Large waves begin to form; the white foam crests are more extensive everywhere. Probably some spray.

Beaufort 7: Near Gale (Stiv kuling) Wind velocity: 28 - 33 knots (14.16 - 17.25 m/s) Sea keeps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind. Spindrift begins to be seen.

Beaufort 8: Gale (Sterk kuling) Wind velocity: 34 - 40 knots (17.25 - 20.86 m/s) Moderately high waves of greater length; edges of crests break into spindrift. The foam is blown in well marked streaks along the direction of the wind. Spray affects visibility.

Beaufort 9: Strong Gale (Liten storm) Wind velocity: 41 - 47 knots (20.86 - 24.46 m/s) High waves. Dense streaks of foam along the direction of the wind. Sea begins to roll. Visibility affected.

Beaufort 10: Storm (Full storm) Wind velocity: 48 - 55 knots (24.46 - 28.58 m/s) Very high waves with long overhanging crests. The resulting foam is in great patches and is blown in dense white streaks along the direction of the wind. On the whole of the surface the sea takes a white appearance. The rolling of the sea becomes heavy and shock-like. Visibility is affected.

Beaufort 11: Violent Storm (Sterk storm) Wind velocity: 56 - 63 knots (28.58 - 32.70 m/s) Exceptionally high waves. Sea completely covered with long white patches of foam lying in direction of wind. Everywhere edges of wave crests are blown into fret. Visibility affected.

Beaufort 12: Hurricane (Orkan) Wind velocity: more than 64 knots (more than 32.70 m/s) Air filled with foam and spray. Sea white with driving spray; visibility very seriously affected.

Appendix 2: Data collection sheets

MANATEE DATA SHEET B: TRIP SUMMARY - LOG SHEET

Date---

(dd-mm-yy)

Page -----of-----

(Record All Events during the trip)

TIME	WPoint	EVENT	LOC	LAT	LONG	COMMENTS

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MANATEE DATA SHEET A: TRIP SUMMARY SHEET

Day of the Week------------------- **Date**---------------- **Julian Day**--------------------------
(yy-julianday-one digit trip number) (dd-mon-yr) (001-365)

EW Team Number: ----------------**No. of EW Volunteers**---------------**Total Observers**------------------
(yy-one digit team number)

EW Team Members (first and last name):--1.------------------------------2------------------------------------
3--------------------------------------4--5------------------------------------
6--------------------------------------7--8------------------------------------

---

Researcher(s): ------------------------- Intern(s) ------------------- Field Asst: ----------------------------
(first name) (first name and initials) (first name and initials)

------------------------ ------------------------------ --------------------------------
------------------------------ --------------------------------
------------------------------ --------------------------------

Trip Summary Data Taken By: --

Habitat sampling data taken by: ---

Aquatic bank vegetation cover data taken by: ---

Sightings/detectability/ distribution Data taken by: ---

Total No. of Scans -----------------Total No. of Sightings -------------- Total No. of Manatees:--------------

GENERAL WEATHER CONDITIONS

DEPART DOCK : WEATHER CHECK I: RETURN DOCK WEATHER CHECK II

RETURN DOCK:		
-	Time: -------------------------- GMT	Time: ---------------------- GMT
-	Wind Direction: -------------	Wind Direction: -----------
-	Sea State: ---------------------	Sea State: -------------------
-	Cloud Cover: ---------------	Cloud Cover: --------------
-	Water Temp.: -------------°C	Water Temp.: -----------°C
-	Air Temp.: ----------------°C	Air Temp.: --------------°C
-	pH: ---------------------------	pH: -------------------------

Comments: ---

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MANATEE DATA SHEET E:

DATA ON MANATEE SIGHTINGS, DETECTABILITY AND DISTRIBUTION

TRIP ID: -- DATA: -----------------------------

Page…… Of……….

1. FISHING EFFORT DATA

Number of other boats in area during scan: ------------------------ Distance (closest boat) ------------------------
Manatee sighted By……………………………………………..Confirmed By………………………..
Enter one of the following: Research, Field Assistant, Intern, Volunteer, Team, Not confirmed

2. MANATEE SIGHTINGS DATA

Sighting Scan Number---Scan Start (24hrs) ---------------Scan stop---------
Sighting type (circle one): Opportunistic or scan

Way point (Garmin):-----------------------------------Accuracy----------------------

Location: --Location Code :---------------(See list for proper code)

Total Number of Manatees-----------------------------------No. of Calves----------------

1st 20minutes of SCAN: Minimum: Maximum: *Total during sighting

Total 30 minutes of SCAN: Minimum: Maximum:

Initial Distance to 1st manatee during 1st sighting (m):------------------ Time: ---------------------

Initial Movement of 1st Manatee: (Circle one of the following):

- Away from boat Toward boat milling no change undetermined

Disturbed? Yes or No

Feeding Resting Socializing Travelling Milling No Change

Undetermined

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MANATEE DATA SHEET C: HABITAT SAMPLING DATA

Page 1 of ---------

Sample ID -----------------------Data recorded By---

LOCATION DATA

LOC. CODE: --------------------WAYPOINT-------------------------LOC. NAME------------------------

PHYSICO-CHEMICAL DATA:

PHYSICAL PARAMETERS

SECCHI READINGS (Vertical secchi-take from center of boat) FOR TRANSPARENCY/TURBIDITY LEVELS

Name (volunteer who took the data)	Transparency	Depth	Turbidity
- -	*e.g CTB Clear to bottom*		
---	-------------	---------	-----------------
---	-------------	---------	-----------------
---	-------------	---------	-----------------

Air Temp °C	Surface Water Temp	Sea state Beaufort	Swell height (m)

Habitat Type: Circle the habitat characteristics of the scan point (where the boat is, NOT where the manatee might be observed)

Inshore/channel/bank/among tree stumps/none

Comments and other description--

Bottom Type from Eckman Grab:

(Circle sediment type based on grab sample): Mud –sand/pebbles---

Submerged vegetation--- other)

MANATEE DATA SHEET D:

AQUATIC BANK VEGETATION COVER ON FOOD SOURCES AND FEEDING SITES

TRIP ID: --   Date: ---------------------

Page…..of…..

Local hunter and fishing knowledge will be used to identify feeding sites and target vegetation food species. Cover-abundance ranking of plant species will be made using standard square quadrants. Cover-abundance values will be standardized to compute and compare the relative species richness and diversity of suitable manatee hunting sites.

Replica 1: Name (Volunteer who took data): --
WPoint: (range): ------------------------------------

Season: Dry or Rainy
Flooded plain or Non-flooded plain

Sample N (Grand total will be entered into database to enable computation of vegetation cover)

<u>List of plant species associated with manatee feeding habitat</u>

Species	Life form: Shrub(s) Grass(g) Sedge(sg) Herb(h) Other(ot)	Common name	Local name	Tally (frequency of occurrence)	Total

<u>Grand Total</u> =

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INDICES OF DIVERSITY OF VEGETATION COVER IN MANATEE FEEDING SITES

Category (i)	Replica 1 (frequency)	Replica 2 (frequency)	Replica 3 (frequency)	Replica 4 (frequency)
n				
$(n \log n - \sum fi \log fi)/n$				
$H_{max} = \log n$				
$J = H/H_{max}$				

H = Shannon-Weiner Diversity Index

H_{max} *= Maximum possible diversity*

J = Pielou Index of Evenness

Indirect sightings data sheet

Trip ID: é ..

Date é é é é é é é é

Waypoint: é é é é é é é é ..

Indices of presence	**Absence**	**Presence**	**Quantity**	**Distance from the boat**
Dung				
Grazed vegetation				
Torn nets				
Water bulb				
Water wave generate by manatee				
Sound produce by a manatee who is grazing				
Others index				

Appendix 3: Questionnaire sheet

Questionnaire addressed to local fishermen at the vicinity of the study area. The aim is to have a local perception on the distribution, relative abundance and habitat used by manatees in the Douala-Edea Wildlife Reserve and Lake Ossa Wildlife Reserve (translated version)

Date : é é é ../é é é é /2009

Site of interview :é . Village é é é é é é é é é é é é é

NB: This interview will focus on determining areas of occurrence of manatees and threats that affected them. This interview does not intent to expose or inculpate who so ever. The respondent can be assured of the confidentiality of his responses and when would provided, and these responses will not be used for an objective other than what has been specified above. In advance we thanks the respondent for their faithful answers to the following questions.

I- IDENTIFICATION

1- Do you know manatee**?** YES NO

2- Could you make a brief description? ....

3- Name and Prename
é é

4- Villageé ..

5- Sexe: M F

6- Age

7- Marital status: Married Bachelor Widow Divorce

8- Village of residence:
é é
é é ..

9- What is your job?

Fisherman (fish)é é é é é é .. Fisherman (Oyster) é é é é Farmeré é é .. Others é é é é é ..

10- At which season do you exert most your job?

Drying Seasoné é é é é é é é .. Rainy Season é é é é é é .. Any Season é é é é é é

11- How many times per week do you exert your job?

Less than 2 timesé é é é Between é é é é .. 2 to 4 times é é é é More than 4 times

12- Where do you use to fish? é é é é é é é é é é é é é é é é é é .

I- General Questions

1- Do you have the habit of sighting manatee?

YES Frequently NO Occasionally é é é é é

2- How frequent do you sight manatee per month?

Less than once é é é é . Between 1 and 3 times é é é é Between 4 and 6 times é é More than 6 times é é é .

3- Where do you use to sight them? (which villages)
é é é é é é é é é é é é é é é é é é .

4- Do you sight them any time you reach there? Yesé é é é . NOé é é é é

5- a.) At which period of time do you sight them often?

Morning between 5 and 11é é é é Midday Between 11 and 14é é é .. Afternoon Between 14 and 18 é é é . Evening between 18 and 21

b.) From with platform do you use to sight them?

From a Canoeé é . From the Bank é é é From a vehiculeé é é .. Other é é é é é é .

6- What was the manatee doing?

Grazingé é é Playingé é é é Resting é é é é é Breathing é é é é Other é é é é

7- a.) What do manatees eat? Precise the type of food

Grassé . Fish é é é . Oysteré é é . Othersé é é . I donœt knowé é é ..

b.) How do you know?

I have seen it é é é é In its stomach or fecesé é . I have heard it é é é é I suspect it

8- During which season do you sight them more?

Drying season é é é é é é é . Rainy season é é é é é é é .. Any season é é é é ..

9- At which tide do you sight them more?

High tide é é é . Low tide é é é .. Any tide é é é ..

10- How many were sighted averagely

Oneé .. 2 to 3é é é é 4 to 8 é é é More than 8

11- a.) How many times have you ever seen a dead manatee

Neveré é .. 1 to 3 times 4 to 6 timesé é .. more than 6 times

b.) Precise the place é ..

c.) How many were killed at once?

Only oneé é é é two é é .. 3 to 4é é .. 5 to 6 More than 6

12- what could be the cause of their death.

Huntingé é . Collision with a boaté é Captured in a net é é . Old age é é é . Food intoxication é é é . Other é é é

13- a.) what was your first time of sighting a manatee?

b.) Precise the place é é é é é é é é é é é é é .

14- a.) what was your last time of sighting a manatee?

b.) Precise the place é é é é é é é é é é é é é .

15- a.) How many times have you ever eaten manatee meat?

Never é é é 1 to 2 times é é é 3 to 6 timesé . More than 6 times é é .. I donœt know é .

b.) How do you taste the meat?

Badé é Little Goodé é .. Averageé é é é Very Goodé é é ..

16- a.) According to you how did the manatee population size has evolve during this last decade?

Reduced é é é Constant é é é é é Increased é é é é .. I donót know é é é é

b.) What can be the cause of this trend?

Fishing é é é é Hunting é é é é Accidenté é é é Absence of Hunting é é é Reproduction (multiplication) é é é é

c.) Are you happy of that trend? YES é é é é NO é é é ..

d.) Why? ....

II- SPECIFIC QUESTIONS

Question specific to fishermen

1- For how long have you been fishing?

Less than a yearé 1 to 2 years é é .. 3 to 5 Yearsé ..6 to 10 years é é .. more than 10 year

2- How many persons compose your fishing team?

Oneé é 2 to 3 é é é .4 to 6 é é .. 7 to 10é . More than 10 é é .

3- a.) How many times your net was torn by a manatee?

1 to 5 6 to 10 11 to 15 15 to 20 more than 20

4- a.) how many times a manatee has been retained in your net?

Never Once Twice 3 to 5 6 to 10

b.) Do you release them? Yes NO é é Not all the time

c.)Why?

5- Which problems manatee causes to you fishermen?

No problems Tear nets é é é Eat our fish or oyster é é .. Capsize our boaté é é

6- What can be done to solve the problem?

Compensation é é é Hunting permit é .. Establish Sanctuariesé é . I donøt know

Zone or Village :.............................

Appendix 4: Manatee focus group interview sheet

Date of the interview : ..../ ..../ 2010

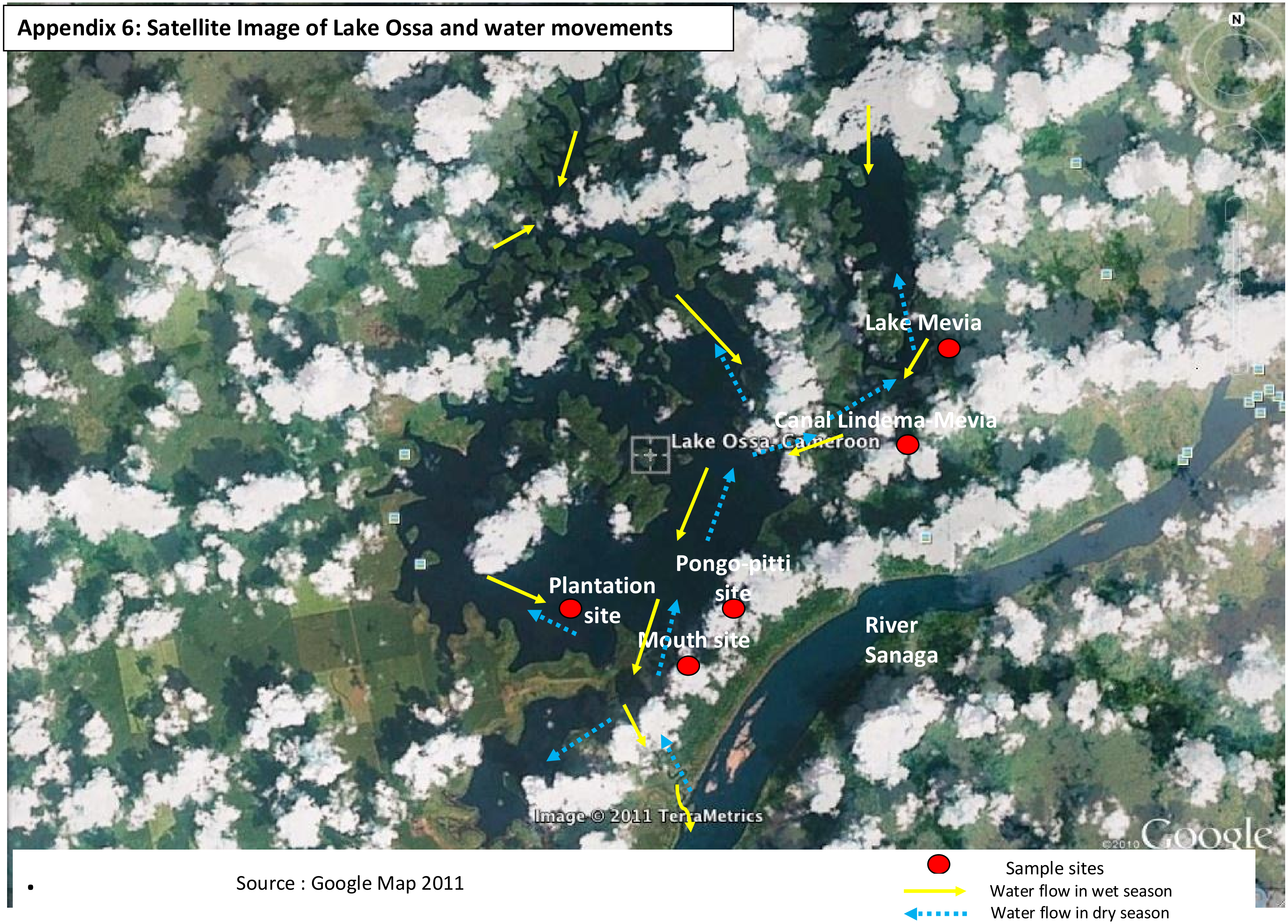
Name :...

Prename: ....

Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8
Sign or indices of manatee presence observed in your zone	Form or character of indices	At which period of day the sign is mostly sighted?	At which season the sign is mostly observed?	What are the threats faced by manatee?	Propose solutions to that	What is the threats cause by manatee to the local population?	Propose solution to that.
1							
2							
3							
4							
5							

Appendix 5: Geographical map of the Lake Ossa Wildlife Reserve (Modified from Wirmman, 1992).

Appendix 6: Satellite Image of Lake Ossa and water movements



- Source : Google Map 2011