Ecology, fisheries and trade of the holothuria resources of Sierra Leone: basis for development and management

Final Report

The Banana Islands, located southwest of the Freetown peninsula hold one of Sierra Leone's most valuable living marine resources – the Sea Cucumbers.

The fishery is open, unmanaged and uncontrolled. No record exists of the fishery; no study has ever conducted on the stocks, and their abundance and distribution are hitherto unknown.

Catch data are not recorded because the stocks are considered as trash. But one of the three international markets had recorded having imported (illegally) 10,200 kg of sea cucumbers worth at least US$300,000.00 from Sierra Leone in 2012 alone.

A study
Sponsored by: the Environment Protection Agency – Sierra Leone

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Acronymns and Abbreviations

EPA-SL	Environment protection Agency – Sierra Leone
IMBO	Institute of Marine Biology and Oceanography
MFMR	Ministry of Fisheries and Marine Resources
CITES	Convention on International Trade in Endangered Species
IUCN	International Union for the Conservation of nature
IUU	Illegal, Unregulated and Unreported
EEZ	Exclusive Economic Zone
IEZ	Equatorial Counter Current
FAO	Food and Agriculture Organisation
SPC	South Pacific Commission
MRAG Ltd.	Marines Resources Assessment Group Limited

Executive Summary

Sea cucumbers, a group of animals belonging to the Phylum: Echinodermata, Class: Holothuroidea are amongst the most valuable marine resources in the world. For this reason scientific studies show that stocks are declining worldwide.

Sea cucumber stocks are under intense fishing pressure in many parts of the world and effective conservation measures are urgently required to make their exploitation sustainable.

Sierra Leone at one time possessed the most abundant stock of commercial sea cucumbers in the entire West African sub-region.

Sea cucumbers from Sierra Leone have been solely harvested for the export market. Unknown to the Sierra Leone government, the fishery has been generating huge foreign exchange that could have earned government and the local communities considerable financial returns.

The Sierra Leone sea cucumber fishery is not managed by any rules or regulations; no catch statistics are recorded, the species form a considerable portion of the by-catch from trawlers and shrimpers, and catches of sea cucumbers are considered as trash whilst Chinese and Korean fishermen put them aside for exporting.

The primary objective of this study was to assess the stock status, establish baseline information on ecological and biological parameters, and introduce preliminary recommendations for more sustainable exploitation of sea cucumbers.

The study identified the species down to species level, identified the geographical extent of the resources along the Sierra Leone coastline, conducted monthly sampling to assess the rate of decline of the stocks, detailed the local procedures in sea cucumber processing, and made recommendations for research and management of the fishery and its resources.

Overexploitation and environmental pressures are the most serious threats to the stocks on the Sierra Leone shelf. The lack of information on the Sierra Leone fishery makes it difficult to ascertain its population characteristics, as well as determine the size and status of sea cucumber stocks. Three sea cucumber species are currently exploited and solely for the export market. Signs of stock reduction have become evident as fishers search for new fishing grounds and dive deeper and farther offshore to reach sea cucumber stocks.

The coastal communities of the Banana Islands, applying their local knowledge in conservation have imposed a closed season during the rainy season to allow the stocks to recover whilst they concentrate fishing intensity on the demersal finfishes.

The study highlighted the following recommendations:

• Underaking in-depth research on sea cucumber biology (i.e. growth, reproductive rate, etc.)

•Development of a management plan for the sea cucumber fishery, starting with the precautionary approach recommended by the fAO

- Development of post-harvest handling and mariculture techniques for stock replenishment; and
- Formulation of regulations to protect wild sea cucumber stocks and the environment at large

1 Introduction

1.1 Overview

Sea cucumbers fulfill an important role in marine ecosystems and are a significant source of income to coastal communities. Especially for developing countries, they make vitally significant contributions to local economies and the livelihood of coastal communities, being the most economically important non-finfish fishery and export in these countries.

However, the increase in coastal populations, the high demand for beche-de-mer (processed sea cucumber) from Asian countries, the ease of collection them in shallow coastal waters, and the introduction of diving equipment such as scuba, have all combined to cause overfishing of this valuable resource.

Sea cucumber stocks are under intense fishing pressure in many parts of the world and effective conservation measures are urgently required to make their exploitation sustainable.

In Sierra Leone, sea cucumbers form an important part of a multi-species invertebrate fishery. There is no domestic demand for the products and so they are entirely exported. There are no rules or regulations governing sea cucumber fishing activities, and no reasonable stock status estimates are available. As a result, the sea cucumber fishery faces managerial and technical capacity limitations.

Sierra Leone at one time possessed the most abundant stock of commercial sea cucumbers in West Africa. Hong Kong is considered to be the major global trade hub for sea cucumbers and the import statistics showed imports of 10,270 kg from Sierra Leone as compared to 1,940kg from Senegal in 2004. (According to online sources , in 2013 there was a thriving black market where a kilo might sell for US$ 660.)

Sea cucumbers from Sierra Leone have been solely harvested for the export market, and as such the fishery has been generating considerable foreign exchange that could have earned government and the local communities as well.

Despite the immense importance of sea cucumbers worldwide, information on their biology and the ecology of their stocks which is crucial for management of the resources is direly scarce.

1.1.1 Sea Cucumbers: The Global and Local Perspective

Many scientific studies on sea cucumber stocks have been undertaken around the world and they all testify that everywhere, and without exception, wild populations of commercial sea cucumbers are depleted or on the sharp decline.

In many countries, particularly in the Western Pacific region, some sea cucumbers or their organs are consumed as delicacies or as a protein component to traditional diets. However, in the majority of the countries reviewed in this document, sea cucumbers are harvested to supply the oriental market of beche-de-mer. Indonesia is the major exporter of sea cucumber from its capture fisheries.

Many additional threats have been identified for sea cucumber populations worldwide, including global warming, habitat destruction, unsustainable fishing practices (e.g. blasting), the development of fisheries with little or no information on the species, and lack of natural recovery after overexploitation.

Illegal, unregulated and unreported (IUU) fisheries are widespread in all regions, representing an indirect threat, as it fuels unsustainable practices and socio-economic demand. The critical status of sea cucumber fisheries worldwide is compounded by different factors including the lack of financial and technical capacity to gather basic scientific information to support management plans, weak surveillance and enforcement capacity, lack of political will and socio-economic pressure exerted by the communities that rely on this fishery as an important source of income. The fast pace of development of sea cucumber fisheries to supply the growing international demand for beche-de-mer is placing most fisheries and many sea cucumber species at risk.

It has also been proven that sea cucumbers do make an important contribution to economies and livelihoods of coastal communities, being the most economically important fishery and non-finfish export in many countries. Reconciling this high socio-economic significance with the need for conservation has proven to be a challenging endeavour, particularly for the developing countries with limited management capacity. Furthermore, in this face of this challenge it is evident that no single management measure will work optimally because of the numerous biological, ecological and human interventions involved.

1.1.2 Continued global overexploitation of Sea cucumbers as stocks steadily decline

Like most marine stocks, the exploited populations of sea cucumber stocks around the world usually experience a decline right from the onset of commercial exploitation, until a stable stock level is attained and exploitation reaches optimal levels.

The current high demand for dried sea cucumber product is likely to continue and increase in many Southeast Asian countries. The commonly exported product is the dried body wall in the form of the finished product called as “Beche-de-mer” or “Trepang.”

Of the 1,400 sea cucumber species known worldwide, 24–35 species are commercially exploited . These include *Holothuria scabra, H. fuscogilva, Actinopyga Mauritania, Stichius japonicas,* and *Parastichopus californicus*.

Of the 377 holothuroid species shown in the IUCN Red List (IUCN, 2013,) seven species were classified as “Endangered, or at a high risk of extinction,” and nine species were classified as “Vulnerable, or at risk of extinction.”

Global stocks of sea cucumbers have declined over the years, mostly due to overharvesting in many countries. The increase in human coastal populations, the high demand for beche-de-mer (processed sea cucumber) from Asian countries, the ease of collection in shallow coastal waters, and the introduction efficient methods and techniques, have all combined to cause worldwide overfishing of this valuable resource.

The overexploitation of holothurians Worldwide has been accelerating (Holland 1994; Conand and Byrne, 1993; Conand, 1998, 2004; Jaquemet and Conand, 1999; Trianni, 2002; Altamirano *et al*., 2004), requiring urgent management measures to address the depletion of these stock.

1.1.3 Global conservation measure for Sea cucumber stocks

Recognizing the importance of international trade as a threat to the conservation of sea cucumber species, considerable attention has been given to the possible role of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) by way of a complementary measure for regulating the sustainable use of sea cucumber fisheries.

One species, *Isostichopus fuscus* from the Galapagos Islands hotspot is currently on the CITES list. and a case study of this issue listed advantages and disadvantages on this experience that could benefit other identical fauna. Paradoxically enough, the analysis of the situation in the Seychelles, Papua New Guinea and the Philippines asserts the possible benefits of CITES to sea cucumber populations, but indicate that a listing could lead to socioeconomic impacts as well as an increased administrative burden where institutional capacity is limited.

1.2 Objectives

1.2.1 General objectives of the study

The principal objective of the present survey is to assess the status of the stock, establish baseline information on ecological and biological parameters, and introduce preliminary recommendations for a more sustainable exploitation of sea cucumbers.

1.2.2 Specific objectives of the study

These objectives are to identify and recommend a basis for the implementation of a sustainable management system for the holothuria fishery that will contribute to the optimal utilisation of the resource, sustain a fishery according to responsible fisheries management practices of exploitation, and conserve the ecological integrity of the marine ecosystem.

The study will therefore focus on the following categories:

1. Taxonomy
2. Exploitation/fishery
3. Processing, trade and commerce
4. Environmental issues and concerns
5. Trade and commerce

1.3 Significance and Beneficiaries of the Results of the Study

1.4 Significance and beneficiaries

This study was aimed at providing the first-ever essential facts on sea cucumbers in Sierra Leone, and the findings will therefore provide essentially important baseline data for further investigations. It is of utmost importance to gather sound scientific data for the management and protection of stocks in order to address the decline in stocks and establish sound principles for their sustainable exploitation

The findings will present a comprehensive review of the situation with regards to the exploitation of sea cucumbers in Sierra Leone, provide baseline information on the most fundamental questions, and ultimately point the way forward as to how best to exploit and conserve the stocks.

1.5 Methodology

Data were gathered through interviews and questionnaires handed out to fishermen at various locations. Information gathered from fisher-folks and fishing agents (i.e. buyers and exporters of beche-de-mer) included the following:

1. Location of harvest
2. Number of hours fished
3. Time and/or season of harvest
4. Species commonly harvested
5. Storage methods

During interviews the targeted fishermen were questioned about the length (duration) of their fishings trip, the number of persons involved, and the method and location of the collection.

Sea cucumbers were identified to species level and the number of individuals per species noted. Two months of length frequency distribution were also undertaken; the morphology of individuals were observed, noted and photographed, as specimens were preserved for subsequent laboratory analysis.

Informal visits were also made to processing areas in order to document size and species distributions of sea cucumber landings.

Observations were made and pictures taken of sea cucumbers in the early hours of the morning (usually at around 1-3 a.m.) when catches are brought from sea for processing.

A number of persons were also contacted and consulted on matters pertaining to the species. Discussions were held with these persons and they often pledged their assistance and support.

The study has been accomplished through the assistance of key contact persons who also assisted during focus group discussions and other protocols of investigation, such as interviews. It is expected that the people of these coastal communities with whom acquaintance has been made will continue to render assistance and provide information whenever it is requested from them.

The geographical scope and extent of the fishing grounds were identified and landing/processing sites noted. Buyers/processors were also contacted.

In the identification of the species the following websites were also consulted:

<http://www.inaturalist.org/observations/1068202> The iNaturalist

<http://www.eol.org/search?q=Holothuria+pardalis> The Encyclopedia of Life

<http://www.catalogueoflife.org/> Catalogue of Life

<www.species-identification.org> Marine Species Identification Portal

2 Review of Literature

2.1 Sea Cucumbers

The commercial exploitation of sea cucumbers has been going on for more than a century, but little is still known about the ecology, biology and population status of almost all the commercial species, and in many cases, species are being commercialised without a clear taxonomic identification of the stocks.

2.1.1 Biology of sea cucumbers

2.1.1.1 Taxonomy

Sea cucumbers are Echinoderms belong to the zoological Class Holothuroidea and comprise of about 1,717 species worldwide. Sea cucumbers are sedentary organisms and 80% of species are found between 0 m and 20 m depths. They occupy a low energy level in the marine ecosystem and play a useful role in the recycling of nutrients by breaking down detritus and other organic matter after which bacteria can continue the degradation process. They are therefore vulnerable to both climatic impacts that degrade their habitats and anthropogenic sources of pollution.

2.1.1.2 Anatomy

Sea cucumbers have a flexible, cylindrical-shaped body, moving sluggishly over the substrate floor and using their feeding tentacles to pick up food. They are close relatives of the sea urchin and sea star.

At the posterior end of the animal, the mouth is ringed by feeding tentacles.

There is a water vascular system, which aids in locomotion. Along the sides of the tube-like leathery body there are tube feet which aid in mobility. the anus lies at the very end of the body, from where the waste is disposed. On the inside of the creature, there are organs used for breathing, called respiration trees, which display Cuvierian tubules. These structures can come out the anus, and seem in most cases to be a method of defense.

2.1.1.3 Reproduction

The main mode of reproduction is sexual (broadcast spawning) although asexual reproduction through fission has previously been reported in *Holothuria atra* (Conand, 2004) and *Stichopus chloronotus* (Conand *et al.,* 2002) in La Reunion. Species closer to the equator) either display a biannual pattern with two spawning peaks or an annual pattern with a single but extended spawning peak. Species located farther from the Equator exhibit annual patterns with a single extended spawning period or two short spawning periods.

Sea cucumbers require many individuals in a population for reproduction to be successful. Holothurians populations are huge and may constitute up to 90% of animal biomass in many parts of the deep ocean which hosts large herds of these animals, grazing on the microscopic life and forms in the marine waters.

2.1.2 Ecology

When threatened, some sea cucumbers discharge sticky threads to ensnare their enemies. Others can mutilate their own bodies as a defense mechanism. They violently contract their muscles and jettison some of their internal organs out of their anus. The missing body parts are quickly regenerated.

Sea cucumbers browse slowly over the bottom, feeding on microorganisms associated with sediment particles. Then, like earthworms, they pass out strings of undigestible material such as sand grains and shell fragments.

Sea cucumbers are found all over the world, mostly on the ocean floor. They are natural scavengers, eating basically whatever it can find, which usually consists of debris found on the benthic layer. They also feed on plankton and other amoebic (organic) substances found on the seafloor, and will often use their tentacles as a means to get food.

Most species of sea cucmbers have a life span in the wild of about 5-10 years. They may attain an average size of 0.75 inches to 6.5 ft (2 to 200 cm).

2.1.3 Nutrition

Sea cucumbers are invertebrate omnivores, feeding on tiny particles like algae, minute aquatic animals, or waste materials. Like earthworms in terrestrial ecosystems, they break down the ingested particles into even smaller pieces, which become fodder for bacteria, and thus recycle them back into the ocean ecosystem..

2.1.4 Ecological and economic importance

Sea cucumbers are found in nearly every marine environment, but are most diverse on tropical shallow-water coral reefs. They range from the intertidal, where they may be exposed briefly at low tide, to the floor of the deepest oceanic trenches. They only avoid areas exposed to high wave action, and are found on all types of bottom, from muddy sand to bedrock.

Although sea cucumbers spread out in the marine environment, all sea cucumbers are ocean dwellers, though some inhabit the shallows and others live in the deep ocean. They live on or near the ocean floor—sometimes partially buried beneath it.

Sea cucumbers can be used for the purposes of food and medicine. Such countries as Japan, China, Malaysia, and Indonesia consider this unique animal to be a fine delicacy. Sea cucumbers must be processed in order to be eaten. This processing consists of drying, cleaning, and obviously packaging. The product is sold in a dehydrated form, and is then rehydrated by the consumer before it is cooked. Most people would find the "gelatinous" texture of the animal, to be dissatisfying or gross. Although, most people do not eat it in that manner, it is normally cooked in stews, soups, or braised dishes. Certain specimens of these creatures are known to be highly prized for their medicinal purposes, and some have been known to have amazing healing properties. These specimens have started entire pharmaceutical industries, based on certain extracts. People will use these extracts to

create certain creams, oils, and even cosmetics. Sea cucumber extracts have been known to have such amazing "powers" as to help heal wounds faster, and even have less scarring.

The dried form of sea cucumbers, “beche-de-mer,” has been a dietary delicacy and medicine for Asians for many centuries.

In Africa and the Indian Ocean region there are at least 12 out of 17 countries wherein sea cucumber fisheries have been documented, showing evidence of overfishing of the stocks. All exploited species are under heavy fishing pressure throughout the Asian Pacific region, whilst the most demanded species in the western Pacific are largely depleted.

In many countries, particularly in the Western Pacific region, some sea cucumbers or their organs are consumed as delicacies or as a protein component to traditional diets.

There is also an emerging market for the use of sea cucumbers in the pharmaceutical, nutriceutical and cosmetic industries.

2.1.5 A unique respiratory feature

“Respiratory trees” are a unique feature for breathing found only in sea cucumbers and not in any other echinoderm. This allows holothurians to not only excrete waste from their anus, but also respire through it.

As the animal expands and contracts its muscular body walls in a slow rhythm, this action in turn draws in and expels water, and this is where the respiratory trees extract the oxygen. There are a few species of sea cucumbers that also allow small fishes to enter and exit the anus

2.2 The Sierra Leone shelf

An interesting feature of the Sierra Leone continental shelf is its geomorphological dichotomy into a northern and a southern part; the northern half continues unto the influences of the Canary Current, and the southern half marks the marine ecology of the northernmost reaches of the Gulf of Guinea. These ecological divisions are exhaustively treated in quite a number of treatises including Coutin and Payne (1986), Showers (1995) and Johnson & Johnson (1996).The marine life of the northern Sierra Leone shelf differs considerably from that of the south: there is apparently an ecological barrier between them and the reason for which they could be treated as separate ecological units with their characteristic ichthyofauna ().

The upper reaches of the southern part fall under the influence of the physical barriers formed by the Bissagos archipelago and the Saint Ann banks, affecting the islands dotting the sub-region. It is nonetheless the most productive part of the shelf because it is strongly influenced by the incoming ECC and the Guinean Gulf.

Effluents from the many rivers emptying into the sea add their terrigenous load to the ecosystem.

Two major estuaries influence the marine ecology of the northern part of the Sierra Leone shelf: the Scarcies and the Rokel River. The Rokel/Sei River, called the Rokel in its lower and the Sei in its upper

reaches, is one of a series of narrow, more or less parallel river basins draining the Guinea highlands into the Atlantic.

Salinity and the thermocline play a decisive role in the entire Guinean Golf of which the Sierra Leone marine environment is a part.

These two ecological parameters are responsible for a distinct stratification of the aquatic communities described as the tropical demersal fish assemblages of the Guinean Gulf and detailed in Fager & Longhurst (1968), Williams (1969) and Longhurst (1969).

As a resultant of these two parameters the hydrographic regime in the Gulf of Guinea waters is affected by a relatively stable, shallow thermocline, which extends along most of the West African coast and located between 20 and 35 m depth.

Based on the bathymetry of the thermocline depth seven distinct communities of commercial species are distinguished, (Longhurst, 1969, Watts, 1958. Another scenarion is also noteworthy: the cold, high salinity waters of the Southern Central Atlantic region lie below these 30–40 m of tropical waters, and the waters separating these two masses is a transition layer of the thermocline and the halocline.

2.2.1 Diversity of the demersal fauna of the area around the Banana Islands

The demersal resources around those areas of the Banana Islands are a part of the inshore demersal stocks of the middle shelf of the Sierra Leone fauna, and this area is reputed as the richest fishing grounds on the Sierra Leone shelf.

The Sciaenid community is the most prominent ecological assemblage at 0-18m depth (Longhurst, 1963). This community make up around 23% of the entire ichthyofauna. Catch composition from the inshore grounds of Banana Islands, the shoals of St. Ann and unto Sulima, between Sierra Leone and Liberia, actually comprise 36% of the finfishes (Coutin and Payne 1986). Catch surveys of trawler operating in the Sierra Leone shelf showed 36% in 1986 and 37% in 1988. Catches from Liberia by 1985 showed 810 tonnes of Sciaenids out of a catch of 7,478t, i.e. 11% (FAO catch stats).

2.2.2 Biodiversity of the Sierra Leone Fauna

The Cape St. Mary research expedition of 1956 was the first classical comprehensive trawl survey to be completed in Sierra Leone's waters and its results were analysed by Longhurst (1963). It completed 232 trawls along transects across the shelf from Senegal to Sierra Leone using a trawl with a 22 m head-rope and 45 m bridles. This produced biomass estimates and population parameters of the principal demersal species and defined the production areas to confirm the immense biodiversity of the southern Sierra Leone shelf.

The Guinean Trawl Survey (GTS) followed in 1963-64 and conducted regular trawls of 1hr duration along 63 transects at depths of 15 m, 30 m, 40 m, 50 m, 70 m, 100 m, 200 m and 400-600 m perpendicular to the coast. In Sierra Leone, surveys were done at the end of the dry season and in the rains. From these Williams (1968) estimated the biomass of all demersal fish using the swept

area method. On the northern shelf, for example, he estimated a biomass of 188,000 t at 15-50 m depth and 40,000 t at 50-20 m depth, thus demonstrating the importance of the inshore stocks. Later Domain (1979) used the results of the GTS and Gulland's simplified yield formula to work out relative densities and a potential yield.

Longhurst (1963; 1966) identified four categories of demersal fish stocks: Sciaenid, Sparid Fauna, Deep Shelf Community and continental Slope and these were further discussed in Williams, 1968; Showers, 1996; Okera and Chaytor, 1978. Identification of the taxonomic groups of invertebrates highlighted the presence of Gastropods and Bivalves (Nickles, 1950), especially Cybium sp. Close ecological associates of the echinoderms (Seisay and ndomahina, 1977)

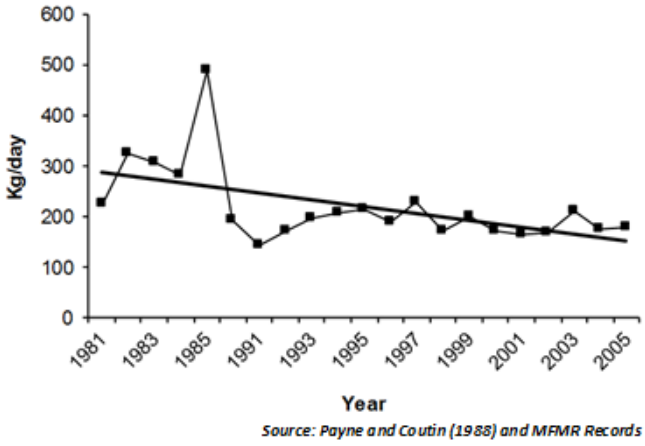
Okera and Chaytor (1978) inferred that the Banana Islands populations receive recruits from Yawri Bay and Sherbro River estuaries and further concluded that the Banana Islands with its extensive expanse of shelly-mud and shelly-sand substrates is the most productive shrimping ground in the country.

2.2.3 Underestimation of the Ecological and Economic value of Sea Cucumbers

The most abundant taxa of the demersal exploited marine resources in the southern half of Sierra Leone have been the Carangidae, Sparidae and Crustaceans (of which shrimps had the highest economic importance.)

Invertebrates such as mollusks and echinoderms (sea cucumbers) were not considered of much value. The catches of snails and sea cucumbers were discarded and not recorded, neither in the commercial catches nor in the research expeditions. These valuable resources were wasted and considered as ecological "trash" not worthy of any attention.

An inspection of the shrimp trawler catch composition (Table 1) shows that the bycatch consists of almost 22% sciaenids and 10% sparids. This emphasises the predominance of effort amongst shrimp trawlers in the shallow water and estuarine grounds. It further emphasises the high levels of bycatch for shrimp fishing since shrimp only contribute 10.4% of the shrimp fleet segment's catch (Seisay and Ndomahina 2005).



Holothurians share the same biotope as the crustaceans, and it could be presumed that a high fishing intensity on shrimps will also echo on the invertebrates. It was even noted that trawlers licensed for shrimp also intentionally targeted the valuable demersal species

Figure 1. The decline in Sierra Leone's shrimp stocks

Much of the historical and anecdotal evidence suggests that there is increasing exploitation in the fish and shrimp fisheries. This is confirmed when all the historical evidence on catches is matched with effort to show significant declines with time (Coutin and Payne 1989; Showers, 1999).

Table 1. Estimates of catch and population parameters of shrimps compared

	Shrimps		Shrimp fishery bycatch	Demersal trawl fishery
Data sets	**1981-96[a]**	**1996-2005[b]**	**1996-2005**	**1991-2005**
MSY	2,791	1,555	9,2280	6,164
F_{MSY}	21,428	4,950	2,816	4,081

[a] Showers, 1999, [b] MFMR statistical records

3 Implementation of the study

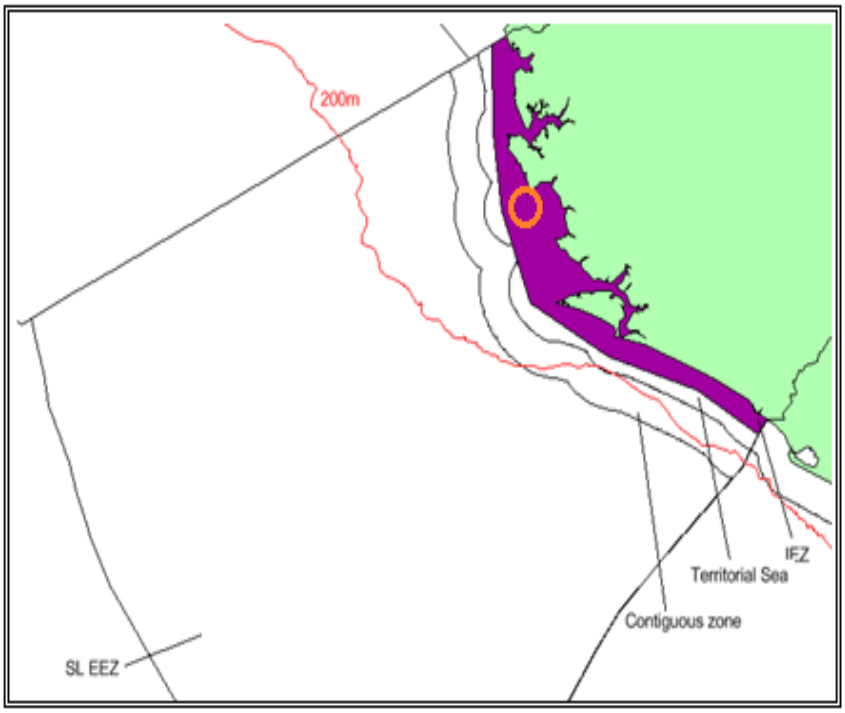
3.1 The Study Area: Banana Islands

The **Banana Islands** are a group of islands located 8007'N, 13013'W and lie off the south west coast of the Freetown Peninsula, Sierra Leone. Three islands make up the Banana Islands: two Dublin known for its beaches, and Ricketts best known for its forests. The third, Mes-Meheux is uninhabited. The total length of coastline is approximately 1350 km and is dotted by numerous offshore islands.

Dublin and Ricketts Islands have a combined population of about 900 people. The two Islands are connected by a spit of sand that is covered at high tide.

The islands were visited in the 17th century and perhaps earlier by Portuguese sailors and were settled in the late 18th and 19th centuries by freed slaves whose descendants make up most of the population of the islands today. s make up most of the population of the islands today.

Figure 2. An expanded map of the Banana Islands



The Sierra Leone Exclusive Economic Zone. (Source: MRAG.)
The red circle depicts the location of the Banana Islands.

Figure 3. The Banana Islands shown on the Sierra Leone map inset (top); The bathymetric contours of the Sierra Leone shelf, highlighting the IEZ within which is also shown the Banana Islands (in red ring) (below).

The total area of Banana Islands is less than 120 km^2. The total population is estimated to be 12,000, with 66% of the population residing on the main islands of Yap Proper, while the remaining 34% live in the outer islands.

Like most coastal communities in southern Sierra Leone the islands have limited income earning potential, but their coastal waters are rich in marine life and valuable fisheries resources, including sea cucumbers. Although sea cucumbers are not traditionally harvested as a protein source by these communities, the fishery has been active for short periods since the 1800s, mainly for export to Asian markets. In the late 1900s, harvests resumed when the Koreans were present after 1980.

3.2 Geographical distribution and habitat of sea cucumbers in Sierra Leone

The biotope on which sea cucumbers are found on the Sierra leone shelf is well known to the local fishermen. The three species encountered in this study prefer hard substrates of rock, sand and rubble.

The sea cucumber stocks are found on hard substrates along the Freetown peninsular, starting from Aberdeen to Kent, but fishery is now squarely centered around the banana Islands.

The species require a habitat with clean flowing water and the islands provide such an environment, distant from the polluted terrestrial run offs.

Figure 4. The area of the Sierra Leone coast covered by the study.

3.3 Biological and population status of Sea Cucumbers around Banana Islands

The fishing grounds found in Sierra Leone's western middle shelf are well known to be hosting an abundant stock of commercially important sea cucumbers.

The sea cucumber fishery in this area is in a relatively better condition than the sea cucumber fisheries in other parts of West Africa. The density of animals in shallow and near-shore areas is higher than in offshore and deeper areas . This study has noted the habitat range and consequently the bathymetric preferences of commercial sea cucumber species. These together with the length-frequency data on the most abundant species provide baseline information for the important sea cucumber fishery and also for comparison with future studies.

3.3.1 Three species encountered in the study

The ability to correctly identify the species being exploited is fundamental to fisheries management. In the case of sea cucumbers, identification is best done when the animals are freshly caught

because it can be more difficult after the animal has been left to “waste away” or has been boiled and dried (beche-de-mer), when its original colour and form changes during processing.

Two species are from the genus Holothuria and the third is from Pentacta, and they are: *Holothuria pardalis*, *H. pervicax and Pentacta australis.*

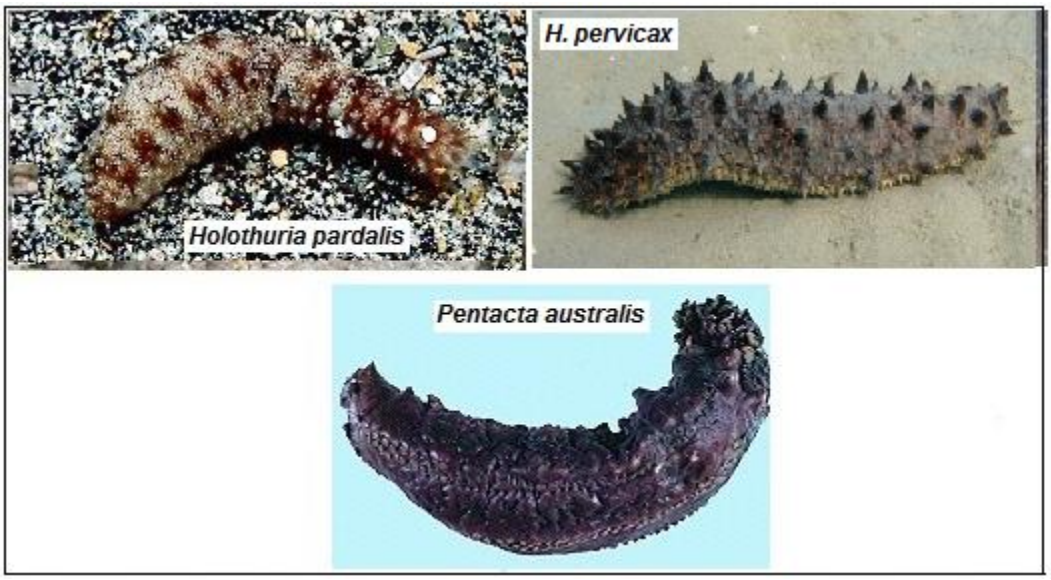


Figure 5. The three species encountered in the waters surrounding the Banana Islands

The prominence of these species was based on their percentage of occurrence in the landings and showed the following relative abundance in terms of percentage of occurrence, repectively:

Most species with the highest abundance and frequency of occurrence is the Leopard Sea Cucumber, *Holothuria pardalis* (Selenka, 1867,): *H.pardalis:* 87%; *H. percivax :* 10%; and P. *australis:*3%. The taxonomic classification of H. pardalis is as follows:

Kingdom: Animalia

Phylum: Echinodermata

Subphylum: Echinozoa

Class: Holothuroidea de Blainville, 1834

Order: Aspidochirotida

Family: Holothuriidae

3.3.2 Ecology of *H. Pardalis*

The species is often burrowed under coral rubble or blocks at shallow depths of between 0 and 10m (Muthiga *et al.,* 2007; Samyn *et al.* 2006).

The species is widespread with a geographical range from Madagascar and east Africa, to the Red Sea, Indo-west Pacific Ocean, Iranian Gulf Australia to China, and east across the Pacific to the Carribbeans.

Colour in life: grey-brown to green-brown sometimes with globular appearance (Clark & Rowe, 1971). The colour is always grey, uniform or with variable brown bands or with a series of 8-10 pairs of brown blotches along the back or with many black spots (Tortonese, 1980). It should be noted that the spicules of various specimens which have been attributed to *H. paradalis* show a wide range of form and the species is therefore in need of review (Sloan *et al.*, 1979).

The species is benthic, inshore dwelling, and also both a detritus and a deposit feeder (Rowe & Gates, 1995). Physical description shows the body is sometimes with dark spots along upper surface. It is cylindrical and tapering at its ends. It is a small species (< 100 mm), with a smooth tegument, and a thin and pliable body. Spicules are clumsy tables with a low to moderate spire and a spiny disc, and buttons

3.3.3 Length-frequency distribution

The size frequency distribution of the products give information on the mean values of the fresh organism commodity and this is in turn could be related to the size of the dried product for each species and subsequently to their grade on the international market. This parameter is also important for future monitoring in order to evaluate stock status and socioeconomic aspects of the fishery.

The distribution shows a higher mode for March than for May, which could signify the predominance of smaller sizes in May than in March in the stocks.

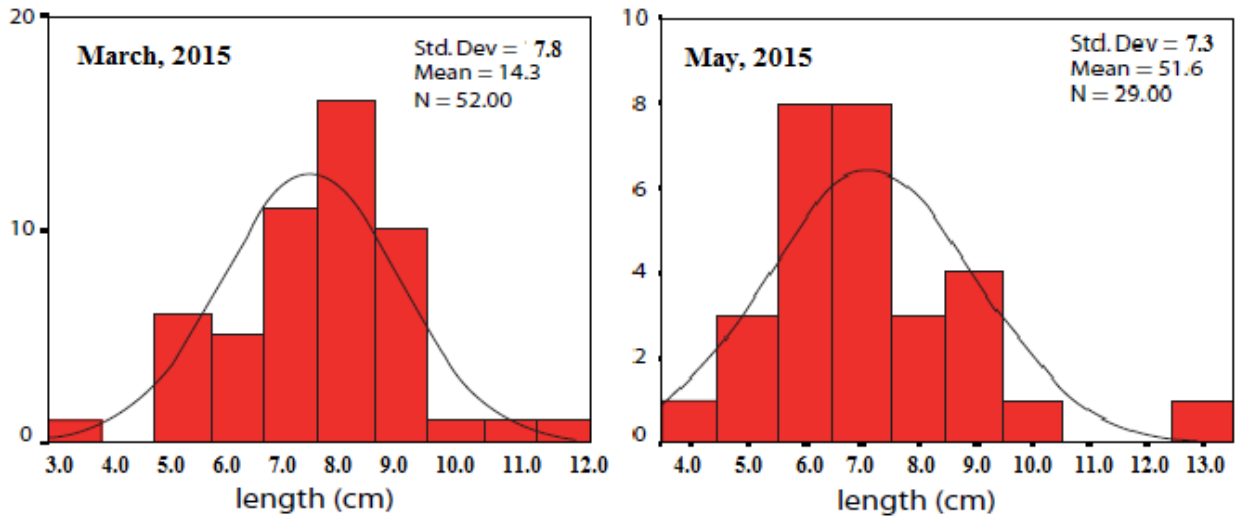


Figure 6. Length frequency distribution of *H. pardalis.*.

4 The Holothurian Fishery of Sierra Leone

4.1 Fishing for sea cucumbers

Fishing for Sea cucumbers in these islands is mainly by free diving from canoes, crewed by 2–3 fishers or by hand collection along the rocks at low tide. Once collected, the animal is gutted, graded, cleaned, boiled, smoked and dried. This is a labour-intensive process usually carried out on shore.

Sea cucumbers are collected at night by divers using underwater torch and a mask and snorkel (or goggles). The sea cucumbers are kept in the bottom of the canoe in water and brought back to shore after fishing where they are placed into buckets and held until processing. Fishing trips usually last around three hours. One-third of each bucket is filled with animals and then topped up with fresh seawater.

Keeping the sea cucumbers in buckets allows the animals to empty their intestines of sand, which makes the viscera product more edible. In general, animals are left in buckets for two to five hours, although the time varies between sites and fishermen. The sea cucumber is then processed by cutting a slit in the side of the animal with a knife to expose the viscera, and the intestine is checked for sand before being placed in a glass bottle. After the animal has been cut and emptied of its viscera, it is discarded into a separate bucket that is filled with a small amount of seawater.

4.2 Geographical extent of the fishery in a comparison between fishing areas

To determine the impact of sea cucumber fishing activities on stocks, the abundance of sea cucumbers in non-fished (or very little fished) areas was compared with the abundance in heavily fished areas over a period of three months - April-June, 2015 using the identified fishing areas in Figure 1.

The average abundance values were 21.6 individuals per day's fishing for non-fished areas (J, K, L), and 11.8 individuals per day's fishing for heavily fished areas (M, N, O, P). the assessment showed an evident pattern of increasing fishing impact on the overall abundance of sea cucumber populations around the islands.

There are no data or information available from previous studies to compare with those shown in this presentation.

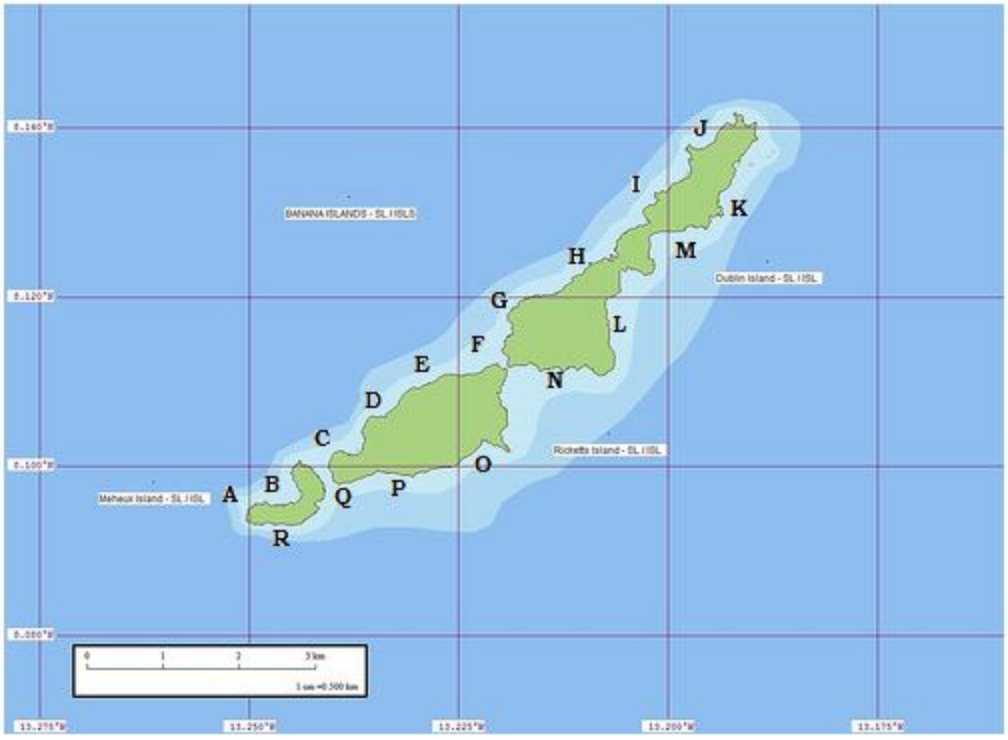


Figure 7. A map of the Banana Islands with letters pinpointing coastal areas in which fishing is presently going on.

The map of the Banana Islands in Figure 7 depicts the areas where sea cucumbers are being caught, and Table 2 shows the occurrences of the three identified species around the islands.

The present hotspot of fishing is evidently at points C, D and E on the northeastern side of Rickitts Island; that is the areas where all three species have been found and also at high relative densities. An area of low intensity is noted at M and K.

In general, a comparison of abundance between fished and non-fished areas can clearly show patterns of increasing/decreasing fishing intensity for commercial species with time series data available. And furthermore, such a scenario could indicate the impact of fishing intensity on the overall abundance of exploited species. In this case, unfortunately the absence of catch per unit of effort data cannot permit the consideration of such an inference and it is not possible to use this instance to provide evidence of overexploitation.

Table 2. Sites with sea cucumber species noted

Species	Fishing Site																	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Holothuria pardalis	*	*		*	*	*		*	*				*	*		*		*
H. pervicax			*	*	*								*		*	*		
Pentacta australis		*	*				*				*							

At present, most fishing effort has been concentrated on the central fishing ground, and the decrease in sea cucumber production is related to this area.

Although Sierra Leone's commercial sea cucumber are now exploited in depths ranging between 0 m and 3 m, *H. pervicax* and and P. *australis* are typically found in deeper waters, although in this study, they were often found in shallow areas, in depths of 0–5 m.

4.3 Processing

Holothurians are mostly marketed as dried product, and rarely as fresh or frozen (Conand, 1990, 2004; Conand and Byrne, 1993; Ferdouse, 2004; Poh-Sze, 2004; Aumeeruddy, 2007). The trade in sea cucumbers is an important source of income for the local community of fishers and for everyone within the processing and marketing chain.

In Sierra Leone, as in most developing countries, sea cucumber processing, which needs very simple and cheap materials, is carried out by villagers. General processing methods, used for the majority of sea cucumber species, involve three main steps: removal of viscera, cooking and drying (Conand, 1990; Li, 2004).

The processing of sea cucumbers has a major influence on price (Conand, 1990, 2004; Hamel *et a*l. 2001), as any fault in the process may decrease the value of the product (Conand, 1999).

There are a number of processing methods depending on the individual processor, all aimed at employing the best method for reducing weight and length losses,

Processing procedures therefore continue to evolve with time.

The major processing procedures involve the following steps.

1) Grading and cleaning seawater to remove dried slime, sand and other extraneous particles
2) Evisceration: the internal organs (intestines, gonads and respiratory track)
3) Boiling: (first time). Boiling time depends on the species.
4) Storage in salt. (Storage time depends on the species.)
5) Boiling (second time). This is repeated to destroy any bacteria, which could damage the outer layer.
6) Drying: Sun drying is considered to be better than smoking.

Although these steps are uncomplicated, they require continuous attention to obtain a standard dry product that has a good shape, texture and form. If the steps are not properly followed, the ultimate grade of the product will be negatively affected, thus significantly lowering the value of the final product.

All processing ends by cooking in brine, rinsing and sun drying.

Evisceration is often performed by making an incision on the ventral. The cut is made either in the posterior part (Anonymous 1994) or beside the mouth (Alfonso *et a*l. 2004; Li 2004).

Cooking is the most important step because it may damage the product in an irreversible way. If not cooked properly, the product may soon rot and acquire an undesirable smell (Li, 2004)

Drying may be by sun or smoke, and may take several days to several weeks, depending on the species, specimen sizes, the fire pit for smoking, and the weather.

If the product still contains a considerable amount of salt, the semi-dried product is washed, cooked for two minutes, and sun-dried. Finally, if the product is not properly dried it is directly sun-dried for three days. At the end of processing, the product is dried in an oven at 60°C for six hours and then packed into plastic bags before being exported.

This study has noted the present processing methods that exist, the variations in body morphometry due to processing. An update of data on the holothuria trade from collectors to exporters was not undertaken because the trade is made dormant because of the ebola epidemic.

Operators and exporters were not cooperative and as such it was difficult to get information on sea cucumber prices.

4.4 Trade and commerce

4.4.1 Marketing

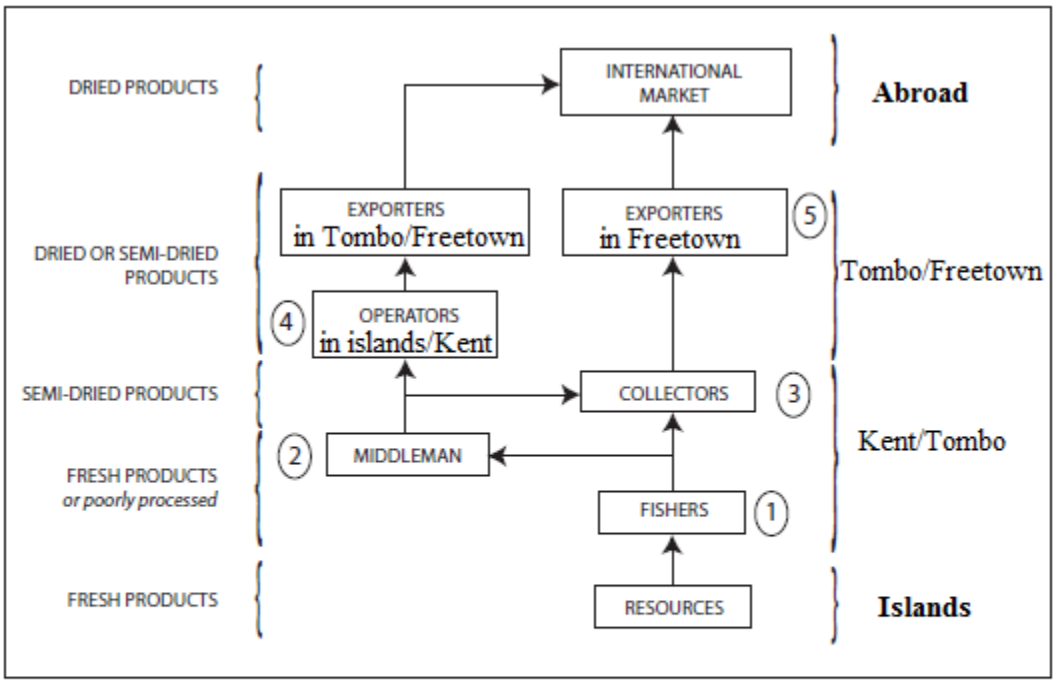
This little-known marine resource carries tremendous economic benefits but there are no records of catch and local consumption of sea cucumbers in Sierra Leone. These holothurians are harvested for the export market and the harvest can be developed into a significant fishery that generates considerable foreign exchange to constitute an important means of income generation for local communities.

The marine resource is processed through a series of steps that convert perishable sea cucumbers into a dried product. Beche–de–mer is the major marine commodity exported, and the entire annual production is currently exported to Hong Kong, Singapore and China.

The commercial chain

From collection to export, the sea cucumber processing and marketing chain may involve up to five different types of stakeholders (Figure 8).

- The fisher — a villager, man or woman, anywhere from 7 - 60 years old, who collects holothurians from the natural environment.
- The middleman — a villager, man or woman, anywhere from 25 to 60 years old, who buys sea cucumbers from fishers and resells the sea cucumbers to collectors. This person does not process sea cucumbers. In all investigated villages, people do this job occasionally. Sometimes, fisher or collector may serve in this capacity.
- The collector — a villager, man or woman, between the ages of 25 and 60 years, who buys products from fishers or middlemen. This person processes holothurians and sells the processed product to operators or exporters in town.
- The operator — a man from the city or town who buys the product from several collectors, completes the processing (if necessary), and sells it to exporters.
- The exporter — a man from the city or town who delivers the product to the international market. When they buy semi-dried products from collectors, the processing is completed using driers.



The sea cucumber processing and marketing chain
(from natural habitat to export) in Tombo/Freetown
Most used circuit: 1–3–5 (80 %)
Often used circuit: 1–3–4–5 (15 %)
Rarely used circuit: 1–2–3–5 or 1–2–3–4–5 (5 %)

Figure 8. The commercial chain for Beche-de-mer products from the islands

In more than 80% of all cases, fishers sell their fresh catches to collectors who often buy them by per piece.

Collectors sell processed products (semi-dried) to exporters in the city who finalise the processing and ensure that exports reach their final destination. In 15% of observed cases, fishers sold sea cucumbers to collectors who processed them. Collectors sold their products afterward to operators in town who were in contact with exporters from other provinces, such as Antananarivo. For the few remaining cases, fishers sold to middlemen, and the products followed the chain as mentioned above.

4.4.2 Prices of Commodities

In the international market , fresh Beche-de-mer products are classified according to species and, and quality. To determine the quality, other factors are taken in consideration, such as appearance, smell, the presence of mould, and water content.

Beche-de-mer products in the international market are classified into three commercial categories (Conand 1990, 2004): high, medium and low.

On the islands fresh products are sold in small buckets with a capacity of around 3 kg and costs Le 250,000. The bucket holds up to 60–80 pieces, depending on size. Most collectors prefer to process the sea cucumbers themselves and wait for some period of time is good to sell to operators or exporters.

In 2009, at the peak of abundance the price of fresh sea cucumbers was Le 60,000/bucket-full (capacity = 20-22kg raw) . When this amount is processed it becomes 3 kg.

In the international market and among importing countries and territories, China Hong Kong Special Administration Region (SAR), is the most important, with product arriving from most countries worldwide; some countries, such as the United Arab Emirates in the Indian Ocean, have become “intermediate” markets.

For the high and medium values, prices also depend on specimen size. The purchasing and selling is all done visually without making any measurements (either weight or length). The price varies according to buyers and the area. Collectors near the city always buy products at higher prices than those from the islands.

The product may sell for between USD 33 kg-1 and 50 kg-1 to exporters of the local market, and may reach USD 80 kg- 1 on the international market (Tuwo 2004). In fresh state, these specimens are sold between USD 2.5 and 3 piece-1, the equivalent of USD 24–30 for 8–12 specimens.

With this difference, processors may make a benefit of USD 9 to 20 kg-1 of trepang. Exporters may benefit about USD 30–47 kg-1 of Trepang. It is also important to note that the price of sea cucumbers have increased significantly over the last decade (Alfonso *et al.* 2004).

Exporters fix the prices of the products themselves, and they can buy the same product at very different prices from different fishermen.

Prices range from USD 7– 32/kg, and Singapore, Korea, Taiwan, Hong Kong and Norway are the main importing countries.

According to published statistics for sea cucumber trade imports into the Hong Kong market in 2012 (Chantal et al., 2014) highlighted only two West African countries: Sierra Leone and Senegal with imports of 10,270 kg and 1,940 kg respectively. Using a modest rate of 33 kg-1 yields an earning of around US$ 308,100 worth of sea cucumbers from Sierra Leone, of which around 95% came from the Banana Islands

From the islands processed products together with lobsters and other valuable seafoods are usually sold to Chinese and Korean businessmen or directly to Chinese restaurants and hotels in Freetown.

In such a situation the market chain follows the pattern in the diagram below.

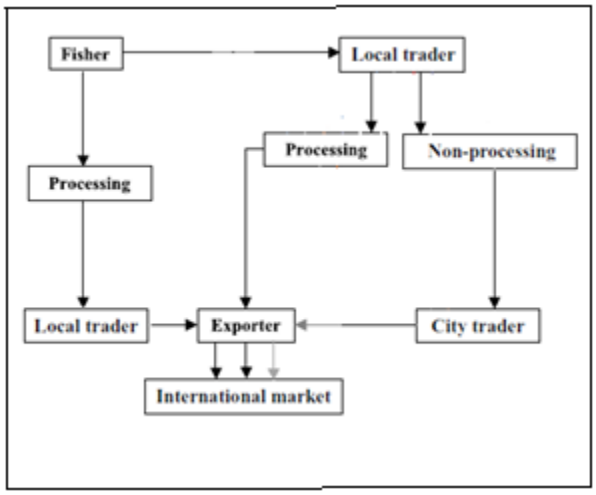


Figure 9. A simplified illustration of the Marketing chain the sea cucumber fishing industry

4.4.3 Effectiveness of current management strategies and options

The fishery is an open access one. No baseline document about the stocks from within Sierra Leone is available, and no regulations or precautionary approach is currently used for management, except issuing export licenses for the export of finished products.

There is a myriad of problems with the current status, regulation and management of sea cucumber fishery resources. In fact, there is no legislation specific to the sea cucumber fishery. However, the

local communities from their own common knowledge and experience of the dynamics of the fish stocks have instituted a closure of the sea cucumber fishery every year from june to October.

This coincides with the rainy season when large sizes of carangids and sparids are more frequent and therefore more susceptible to the fishing gear. The climatic turbulence of heavy rains and thunder force the local finfishes to leave their natural shelter from among the rocks and thereby exposing themselves to fishing.

Closed season is from June to 2nd week in September and many divers from Aberdeen and other parts of the country will rush to the Islands for the first harvests of sea cucumbers.

The closed season of the sea cucumber fishery is therefore not for the conservation of the stocks but so as not to interfere with the harvesting of the finfishes.

There is a lack of information on the population dynamics of exploited species. Illegal fishing and exporting activities are occurring. In conclusion, there is little concern about this resource, despite its ecological role and economic importance to small coastal communities.

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4.4.4 Threats to Sierra Leone's sea cucumber population

Overexploitation and environmental pressures are the most serious threats to the stocks on the Sierra Leone shelf.

Threats to the populations are expected from the impact of intense exploitation of the sea cucumber populations, global warming/climate change and other attendant environmental issues.

Many threats have been identified for sea cucumber populations worldwide and these include global warming, habitat loss, unsustainable fishing practices (e.g. blasting), the development of fisheries with little or no information on the species, and lack of natural recovery after overexploitation.

Illegal, unregulated and unreported (IUU) fisheries are widespread in all regions, representing an indirect threat, as it fuels unsustainable practices and socio-economic demand.

4.4.5 Status of the stocks

The lack of information on the Sierra Leone fishery makes it difficult to ascertain its population characteristics, as well as determine the size and status of sea cucumber stocks. Three sea cucumber species are currently exploited and solely for the export market. Signs of stock reduction have become evident as fishers search for new fishing grounds and dive deeper and farther offshore to reach sea cucumber stocks.

Sea cucumbers are especially susceptible to over-fishing because the recovery of overfished stocks is a lengthy process, taking several years. This is because holothuria, like many other invertebrates are broadcast spawners, and fertilisation success is highly dependent on population density.

Reduction of population densities by fishing may render remaining individuals incapable of successful reproduction, easily seen and collected, and sophisticated fishing techniques will not be required to capture them.

Despite the high international prominence the Sierra Leone sea cucumber fishery attained in the last decade, the fishery has continued to evolve into prominent international supplier without any significant management support.

The history and development of this fishery is further complicated by the lack of knowledge of stock size and the biology and ecology of target species or the impact of the fishery on local livelihoods and the Sierra Leon fisheries sector as a whole. Unlike marine finfish, there have been no large-scale assessments of the stocks of sea cucumbers along the coast and around the islands.

Such studies could have raised concerns about the viability of this fishery especially as trade records indicate a rapid rise to prominence of the exports from Sierra Leone since the 1990s,

But a sustained decline over the last 5-6 years has been clearly evident. It is still unclear as to the exact cause of this decline and the lack of historical information makes it difficult to discern whether the peaks and troughs are due to stock depletions, gear improvements, global markets or other socio-economic factors impacting the coastal communities. The local fishermen attribute this decline to water pollution in the form of heavy run-off from the Freetown Peninsula and Yawri Bay.

4.5 Biotope and the ecology of holothuria in Sierra Leone

The distribution of all the exploited species has been found to be on substrates of rock, rubble or sand. Distribution furthermore seems to be patchy, which is not surprising knowing the three species are also known to make seasonal vertical depth migrations.

Sea cucumbers undergo sporadic recruitment, have a relatively high natural mortality, and are slow growing. Species with these life history traits tend to have fragile populations and hence a low maximum yield per recruit that are particularly vulnerable to overfishing.

4.6 Current developments, prospects and alternatives

In response to overfishing and declining catches, and spurred by high international prices, aquaculture, sea ranching and restocking have been attempted in a number of countries.

Mariculture, sea ranching and restocking have been evaluated as possible solutions to wild sea cucumber overexploitation, and some countries have started such ventures (e.g. Australia, China, Kiribati, Philippines, Viet Nam and Madagascar). Restocking has been considered an expensive remedy to overfishing but presently, China is successfully producing an estimate of 10,000 tonnes dry weight of *Apostichopus japonicus* from aquaculture, mainly to supply local demand. This value, when converted into wet weight, is in the same order of magnitude of the total world wild catches. A feasibility study is presently being undertaken in Chile to evaluate the possible introduction of *A. japonicus,* as an alternative to capture fisheries of two wild species of sea cucumbers.

In the Asia Pacific region aquaculture is still in the early development stages, with one species of sea cucumber (*Holothuria scabra*) in trials to ascertain the commercial viability of culture and farming options

4.7 Socio-economic Issues and concerns

The marine environment located southwest of Kent on the Freetown peninsula hosts one of Sierra Leones most treasured living resources – the sea cucumbers.

The Banana Islands is a landlocked coastal community and fishing is practically the only means of livelihood for its inhabitants. Therefore the Sea cucumber resource and its industry are of vital importance to the people of these islands.

The sea cucumber fishery is basically artisanal, and the industry is therefore a highly significant contributor to the livelihood of local households, albeit in illegal and unregulated ways.

During the time of the boom of the industry the islands do not seem to have derived any benefit in terms of development from the natural resources. The products were solely for the international market and the business was run by foreigners.

Now that the industry has been showing signs of decline it is therefore imperative that appropriate management measures be effected for the sustainable exploitation of the resource

4.8 Environmental and Ecological Concerns

4.8.1 Impact of the sea cucumber fishery on the environment

Commercial harvesting of sea cucumbers leads to environmental impacts on land near sea cucumber processing camps. Further terrestrial environmental impact observations revealed mangrove destruction, halophyte clearing, and littering and solid waste disposals.

Sea cucumbers must be thoroughly processed before the final product is ready for export. This processing has detrimental impacts on the terrestrial environment, including the fauna and flora of the area. Mangroves are cut to provide firewood for boiling the sea cucumbers, plastic and other garbage is disposed off at the sites or in the sea, bird nests are destroyed and turtles are caught and eaten by the fishermen. In a small scale industry like that in the Banana Islands, this might not be significant but the cumulative effect is certainly something worth taking into consideration.

The processing of sea cucumbers into beche-de-mer is labour intensive and 1 ton of the finished product requires 10 tons of wood for fuel and smoke. Such an industry therefore can place considerable demand on the mangrove environment and the coastal ecosystem.

4.8.2 Significance of the species for Sierra Leone marine ecosystem

Sea cucumbers are considered as “cleaners of the ecosystem!” They extract bacteria and huge amounts of organic matter from bottom sediments, and some are responsible for bioperturbation and oxygenation of the sea floor. Consequently, intensive collection and harvesting are expected to

cause changes to the condition and nature of seafloor sediments with associated unknown impacts on water quality and other resources. This is already detrimental to the balance and integrity of the ecosystem.

The Sierra Leone stocks of Holothuria once showed signs of being the most abundant in the West African sub-region. The fishery is not only a valuable economic resource for the country but also a significant contributor to the livelihood of local households, albeit in illegal and unregulated ways.

The sustainability of the fishery is further jeopardized by the slow recovery of sea cucumber populations (Uthicke 2004). Overfishing of sea cucumbers is therefore a grave management concern not only for Sierra Leone but for the world in general; because the fishery is highly valuable, there is increasing worldwide demand, and, the fishery is characterized by serial local depletions and migrations to new fishing areas (Conand 1990; Conand and Byrne 1993; Lovatelli *et al,* 2004.)

4.8.3 Knowledge gaps identified/ Future research options

1. The seasonal and coastal dynamics of the ecosystem in the vicinity of the islands
2. Biology and ecology of the species in the aquatic ecological community.
1. General knowledge of the invertebrates in particular the ecosystem
2. Knowledge of 'point' sources and 'non-point' sources of pollution in the area.

4.8.4 Future research options

For an under-studied and unmanaged fishery like that od the sea cucumber fishery of Sierra Leone there is a long list of research priorities demanding urgent attention and the Significance of regeneration cannot be overemphasized. Studies showed that many Holothurians such as *Stichopus sp.* can survive the harvesting and processing procedures that are necessary in order to collect viscera. (Semper, 1868.)

The possibility that animals survive the removal of their viscera consequently provides an exciting possibility for the management of a declining fishery, where a rotational fishing scheme could boost productivity. The fact that full organ survives the harvesting (Loneragan, 2005)also shows that these Holothurian species are able to heal their cut.

Future studies should pursuea deeper understanding of the probability of survival, depending on handling procedures and the catch–return area. such research will increase the understanding of organ regeneration in the local species, and will also prove valuable for future management of this fishery.

Another long term research objective could be to assess the feasibility of culturing sea cucumbers for restocking purposes. The necessity for restocking will depend on the results of the stock assessment. However, since holothurians are easily overexploited, it is suspected that stocks have already been heavily impacted during the last few years. Experience in other countries shows that, in the longer term, the fishery may need to be supported by reseeding of juvenile sea cucumbers.

5 Conclusions and Recommendations

5.1 General

Three species are encountered on the Sierra Leone shelf, with the following percentage of relative abundance:

H.pardalis: 87%; *H. percivax:* 10%; and P. *australis:* 3%.

The length frequency distribution showed a reduction in the mean size from March to May. The closed season for fishing sea cucumber starts in June with the onset of the rainy season. The distribution graphs could indicate that towards the end of the fishing season, after high intensity of fishing, the stocks are exhausted, with the bigger sizes already taken, mean sizes get lower.

The closed season will allow the stocks to recover for better harvests when fishing resumes by the end of the year.

The thunder and lightning forces the larger carangids and sciaenids into the open for easy harvesting by the fishermen. The local people therefore close the sea cucumber fishery to concentrate on the demersal finfish fishery.

The sea cucumber fishery in the Sierra Leone has so far been looked upon as an unimportant fishery in terms of catch and economic value. Only a few Asian individuals were involved in the fishery, hiring local inhabitants in the islands to harvest sea cucumbers in shallow waters and mainly using snorkel equipment and later oxygen to facilitate skin diving. Most of the beche-de-mer produced was exported to Southeast Asian countries.

Sea cucumber resources in Sierra Leone have long been exploited by an open access fishery with no management in place. The fishery has thus remained unregulated and uncontrolled due to its unimportance and limited financial and human resources and scarcity of fishery data.

In this new millennium the fishery has experienced a rapid development since the late 1990s due to higher prices for beche-de-mer in the international market alongside dwindling stocks in many producing countries. This ushered in a period of influx of foreigners into the Sierra Leone holothuria fishery and by 2007 there were already signs of stock depletion.

The status of the species remains unknown until present. It is possible these species will continue to be the target of increased fishing pressure in future due to the growing export market demands for quality beche-de-mer.

At present there is the lack of any form of a management plans or management measures to regulate fishing pressure, including the lack of enforcement capacity will pose considerable constraints on the effectiveness of such management measures as closed seasons, minimum sizes, total allowable catches, gear restrictions, spatial and temporal closures and the establishment of marine protected areas..

The challenge to enforcement and compliance will be a common denominator for the exploitation of the stocks, and can exacerbate the unbridled illegal, unreported and unregulated exploitation of the stocks that is currently taking place.

Following any such effort to exercise control, it should be expected there'll be considerable constraints posed on the effectiveness of any proposed management measures if there'll be inadequacy in enforcement capacity.

5.2 Specific

Based on the findings of this study on the sea cucumber fishery, the following recommendations are forwarded for implementation with shortest possible time:

• conduct in-depth research on sea cucumber biology (i.e. growth, reproductive rate, etc.);

• develop management strategies specific to the sea cucumber fishery (using a precautionary approach that includes the formulation of a national fishing advisory committee);

• develop post-harvest handling and mariculture techniques for stock replenishment; and

• formulate regulations to protect wild sea cucumber stocks.

5.3 Detailed

1. Develop sea cucumber-specific management plans, including specific regulations such as regulations on gear use, size limitations, seasonal and depth closures, and total allowable catches. At present, some high-value species are severely overexploited and total bans may be needed. Management plans should: a) be based on the best available scientific information; b) take into account best practices and the precautionary principle of fisheries management; and c) involve stakeholders during their development and implementation.
2. Assessing the potential effectiveness of marine protected areas (MPAs) in managing sea cucumbers.
3. Train communities in harvesting and processing beche-de-mer in order to improve the quality and reduce the inefficiencies of current systems.
4. Develop mariculture programmes as alternative livelihood options as well as for commercial and restocking purposes.
5. Develop and implement appropriate stock assessment and monitoring programmes for sea cucumbers. These may use existing structures within fisheries authorities or work in partnerships with local research and educational institutions, NGOs or local communities. Catch and trade statistics should be collected at the species level wherever possible, and management and archiving of data should be improved.
6. Continue research on the biology, fisheries and trade of commercial sea cucumbers in WIO countries. Studies on growth, mortality and recruitment are crucial for fisheries management, and there should be continued efforts to update species inventories and resolve taxonomic

challenges; studies on the reproductive biology of key commercial species; training in the taxonomy and biology of sea cucumbers; studies on the socioeconomics and management of the fishery.

7. Improve the capacity for management including increasing resources for surveillance, enforcement and training. In particular, capacity is required in the inspection of the trade, data collection and monitoring, and the use of scientific information to implement management interventions.
8. Integrate the use of MPAs within the suit of tools for management of the sea cucumber fishery.

5.4 Towards a management plan: seminar proposed

Considering the level of awareness and management of the exploited holothurians stocks of Sierra Leone the next obvious step that follows this preliminary study is to organize a seminar of the stakeholders. The sea cucumber fishery is indeed a very profitable industry and neither government nor the local people are are anywhere near reaping the economic benefits of this valuable but delicate resource. Exports from Sierra Leone in 2012 alone reached around US$300,000 and all the government received was some pittance for a few export licences.

The significance and benefits of the proposed seminar are far-reaching: firstly, it will serve as a forum to enhance awareness among relevant stakeholders and collaborating partners about sea cucumbers. Relevant identification and scientific documents will emerge, and other items will be identified that will be useful for management and conservation.

The seminar will also serve to enhance networking and coordination among stakeholders and partners, which is crucial to the continued work on sea cucumbers that is needed in the Sierra Leone.

The purpose of a proposed management plan will be to guide the exploitation, processing and export of Sierra Leone's sea cucumber resources. The industry currently lacks any substantive historical data and technical information, and with the limited scale of scientific assessment that has been completed to date. The management plan therefore imposes sensible and locally relevant principles, using a "precautionary approach," to the exploitation of sea cucumbers in order to achieve the overall management vision articulated by government stakeholders:

The local island communities and government cooperation must work together to sustain the stocks, maintain harvests and optimise incomes, not compromising the health and integrity of the coastal environment.

The ultimate goal of the management plan will clearly underscore the primary objective: "To promote economic improvement for peoples of the islands whilst maintaining sustainable harvest and stock levels."

The study proposes the *Precautionary approach c*onsistent with the FAO Code of Conduct for Responsible Fisheries (1982) and the management objectives of the MFMR

Acknowledgement

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Appendices

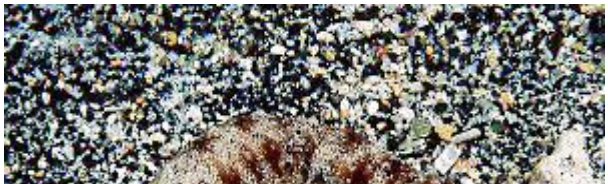
Appendix 1. Key Contacts persons during the study

Locality/Area	Name	Designation	Contact detail
Ricketts Is.	Mr. Diro Jones	Headman	n/a
Banana Is.	Mr. Ellis Roberts	Headman	n/a
Ricketts Is.	Mr. Eddie Brown	Harbour Master	076615287
Banana Is.	Mrs. Lizzie John	Community Leader	079923311
Kent	Mr. Umaru Woody	Fisherman	076286507
Kent	Mr. Michael	Fisherman	n/a
Tombo	Mr. Cham	Fisherman	030598335
Tombo	Mr. Santigie	Fish dealer	088802093

Appendix 3. Finished products of sea cucumbers on a restaurant plate.

Appendix 2. A shelled mollusk sharing the same biotope with echinoderms.

Appendix 4. *H. pardalis* in its habitat.



Appendix 5. Sea cucumbers being sun-dried in the final stages of processing

.

Appendix 9. ventral side of *H. pardalis*.

Appendix 8. Dorsal view of a young specimen of *H. pardalis*

Photo 1. In

Appendix 7. The anterial side of *H. pardalis*.

Appendix 10. sea. A sea cucumber fisherman processing his catch during the boiling stage.

Appendix 6. .

Appendix 11. Freshly caught sea cucumbers about to be processed.

Appendix 13. A near-adult specimen of *H. pardalis*.

Appendix 12. Sea cucumber slit open for salting.

Appendix 14. Sea cucumbers ready for sundrying.

Appendix 15. Boiling over fire.

Appendix 16. Beche-de-mer on a market shelf in southeast Asia.

Appendix 17. Evisceration of a fresh landing at 3 a.m. in the morning.

Appendix 18. Rresearcher and ground team at Banana Island main wharf.

Appendix 19. draining water from the boiling sea cucumber.

Appendix 20. 1 kg of Tumbus being boiled for about an hour (From video \6.)

Appendix 21. Sea cucumber boiled and dry..