2008 / 2009

Status and Management of Sea Cucumber Fishery in Sri Lanka






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ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to Canadian International Development Agency (CIDA), International Fund for Agricultural Development (IFAD) and Food and Agriculture Organization (FAO) for their financial and technical support for this difficult task.

A note of gratitude is also owed Mr. G. Piyasena, Secretary, Ministry of Fisheries and Aquatic Resources, Mr. Pathirana, Director General, Department of Fisheries, Mr. K. Haputhanthri, Chairman NARA and Ms. K.T.R. Prathapasinghe, Director General NARA for their valuable comments and advice. The support given by Assistant Directors in Puttam, Batticolloa and Kalmunaei fisheries districts and their staff members are greatly acknowledged.

We specially thank to Mr. H.S.G. Fenando, (National Project Co-coordinator), Dr. C. Amarasiri for their invaluable advice, guidance and for constantly giving us the needed inspiration and encouragement. We cannot forget the support given by staff members of CENARA project.

With great pleasure we wish to thank all the staff members of Marine Biological Resources Division of National Aquatic Resources Research and Development Agency for their support during the field survey activities.

A special word of thanks is decided to sea cucumber fisher folk, collectors, processors and exporters for giving us so much support during these activities.

CONTENTS

1. EXECUTIVE SUMMARY

Background

Sea cucumbers are fished worldwide but over-exploited in most countries (Lovatelli *et al.* 2004). Sea cucumber populations can be slow to recover from overfishing and must be managed conservatively.

In Sri Lanka, the sea cucumber fishery has operated since late 80ôs (Hornell, 1917). Now, it is based primarily on about 20 species, exported as dried óbêche-de-merò to Asian markets. Based on a need by the provinces to better understand and manage the sea cucumber resource of Sri Lanka, the project was developed by the NARA with the financial and technical assistance from Canadian International Development Agency (CIDA) and the International Fund for Agricultural Development (IFAD) and Food and Agriculture Organization (FAO). This report covers work coordinated by the Marine Biological Resources Division of NARA during 2008 and 2009 for the project from ñCapacity Enhancement of NARA staff on Resource surveys and Stock Assessmentò. It describes results of Underwater Visual surveys carried out in the Northwestern and East coast of Sri Lanka (sea cucumbers and chanks), catch and effort surveys during 2008 and 2009. Proposed management plan is also included at the end.

Methodology

A total of 500 survey sites from east coast and North Western coast were surveyed for sea cucumbers and chanks. Underwater Visual Surveys were used to assessment purposes and survey sites were geo-referenced using GPS technology. The surveys provide estimates of densities of species and biomass estimates.

GIS software (MapInfo) was used to calculate the surface area of sites. The total abundance of each species per site and the area was calculated. The total biomass and MSY were also calculated by using different methodologies. An attempt was made to calculate the TACôs for different species based on the survey results. The scientists and research assistants of NARA were trained in field survey methods and identification of sea cucumber species.

In place of a large study on movement and growth, we conducted landing surveys and a study on weight and length loss through different processing stages for selected species. Conversion ratios were calculated for each step of processing of sea cucumbers in the weight and length loss study. Weight and length losses in processing was coupled with the information of size at first sexual maturity and based on this size limit was determined for selected sea cucumber species for the landings as well as exporting. Fishing effort, Catch per Unit Effort (CPUE) and total sea cucumber production was estimated and these were compared with results from population surveys.

Results

Around 24 sea cucumbers are evident from Sri Lankan waters among which 20 are commercially exploited. High value, medium value and low value species are harvested in the commercial fishing activities and low value species are dominant both in the catches as well as in the wild population. The abundance of sea cucumbers are varied markedly among sites: species were abundant at some sites but not others. That is, distributions were quite patchy for most species. The species richness did not differ greatly between the two areas Populations of a few commercial species appear depleted, namely *Actinopyga mauritiana, Holothuria fuscogilva, Holothuria nobilis* and *Holothuria sp (pentard)* . Several other species are perhaps not critically low but are relatively sparse, namely *A. echinites*, *A. miliaris* and *H. scabra*. Most of the other commercial species are relatively common and have breeding populations at some sites that should allow for some further recruitment. Also, several species were rare in our field observations. A comparison of size-frequencies of sea cucumbers in landing and those from field surveys suggested that there was some selection by fishers for larger individuals. Populations of some species were restricted to one or two size classes, perhaps indicating infrequent recruitment. Most of the sea cucumber fishers are men aged 30-50 years. Scuba diving is the frequent fishing gear and the skin diving is also practiced in some areas. Many fishers had years of experience, but a lot of them have only recently started fishing sea cucumbers. Sea cucumbers were the most important source of income for most of the coastal communities specially in east and North West.. Many fishers only spend a couple of days fishing each week, and the Catch per Unit Effort (CPUE) of fishers varied markedly among regions. Compared to perceived historical CPUE, estimates of current CPUE from landing and interviews with fishers indicate that catch rates have declined in some regions.

Conclusions

Some stocks of sea cucumbers in Sri Lanka can probably sustain further fishing impacts, at modest levels. Stocks for some other species are low or depleted and management regulations should be brought in to ensure their breeding populations do not decline further. Fishers in some areas are still harvesting sea cucumbers intensely even though the average sizes of animals have declined and even though they believe the abundances have declined. The capture of some small animals and responses from fishers shows that more education of fishers is needed through regular visits by fisheries officers. We propose 12 recommendations for actions to be taken by the relevant authorities of Fisheries (Ministry of Fisheries, Department of Fisheries and NARA), and fishery regulations to be imposed on fishers. A management plan needs to be rapidly established in the east coast of Sri Lanka that will safeguard the reproductive potential of sea cucumber populations and their biodiversity. We recommend an adaptive management approach, whereby the management plan can be changed over time through new information from the social ecological system.

2. INTRODUCTION

Sea cucumbers are members of the Class Holothuroidea of the Phylum Echinodermata (Conad, 1990). They are highly diverse, abundant and exclusively marine invertebrates that play crucial roles in the recycling of nutrients and bioturbation processes in marine benthic communities (Preston, 1993). However they are most common in the Indian Ocean and the South West Pacific (Conad, 1990). According to James (1990), there are over 1000 species of sea cucumbers in the various parts of the world.

While over 1000 species have been described, only about two dozen are commercially important in the tropics and most of these occur in the Sri Lanka. They have been harvested for centuries in Asia and have become an important source of income for fishing communities worldwide.

Bêche-de-mer is the processed body wall of sea cucumbers. The history of bêche-de-mer fisheries goes back for thousands of years. Bêche-de-mer is in demand principally in China and South-east Asia, where it is considered a delicacy. The main markets are Hong Kong and Singapore, with smaller markets in Korea, Taiwan and Malaysia. The current high demand for bêche-de-mer now is likely to continue, and may strengthen, due in part to the high economic growth in China.

The commercial value of a species is generally determined by its size and the thickness of the body wall. Species of high commercial value such as black teatfish (*Holothuria nobilis*), white teatfish (*Holothuria fuscogilva*) and sandfish (*Holothuria scabra*) tend to be fished preferentially. Medium value species include blackfish (*Actinopyga miliaris*), deep water redfish (*Actinopyga echinites*), and yellow surffish (*Actinopyga mauritiana*). Other shallow water tropical species generally fall into the low- or no-value category (Conand, 1990).

The beche-de-mer industry in Sri Lanka is very ancient having been introduced by the Chinese. Hornell (1917) stated that beche-de-mer appear to be one of the commodities taken to China during the last one thousand years when trade existed between South India, Sri Lanka and China.

In Sri Lanka, sea cucumber fishery is presently confined to the northern cap from Kalpitiya on the Northwestern coast through the Puttlam Islands around Gulf of Mannar, Trincomalee, Pothuwil and Kalmunei in the Northeast and Eastern coastal waters of Sri Lanka (Figure 01). These are the major sea cucumber fishing areas since it has been introduced to Sri Lanka.

There are no records on local consumption of sea cucumbers in Sri Lanka. Beachï deï mer is the major commodity that is produced in Sri Lanka and the entire annual production is currently exported to Singapore, Hong Kong and China. As there is import and re export mechanisms as well as a shortage of continuous information regarding the annual exports and lack of statistical data based catch and effort monitoring, it is not easy to estimate the annual production of sea cucumbers.

The fishery is open access and no any regulation or precautionary approach was adapted so far except issuing license for divers and transportation of the product. So this is totally an unregulated fishery. With increasing demand for beachï deï mer in international market, fishers have increased their fishing effort continuously. Now fishery is showing some signs of population depletion, including lower volumes of high value species and fishers having to travel further, and concerns were raised regarding the sustainability of the fishery. Since there was no baseline data on the fishery, there was limited precautionary measures have been implemented so far.

Very little targeted research on sea cucumbers has taken place in Sri Lanka previously. The first available record of sea cucumber from Sri Lanka was dated back 1808 (Joseph and Moiyadeen, 1988). The first detailed studies of the holothurians fauna of Sri Lanka was made when Professor Herdman made his visit to Sri Lanka in 1902. The 30 species of holothuroids collected by him were studied in detail and reported by Joseph Pearson in 1903. This is by far the largest collection of Holothuroids ever collected from the waters of Sri Lanka (Joseph and Moiyadeen, 1988).

Studies on sea cucumber fishery in northwestern coastal waters (specially in Kalpitiya) of Sri Lanka has been carried out in late 80ôs and eight commercially important sea cucumber species has been listed out (Moiyadeen, 1993). According to Joseph and Moiyadeen, (1988), more than seventy species of holothuroids have been recorded from Sri Lanka in time to time and thirteen of these are consumed in various parts of the world.

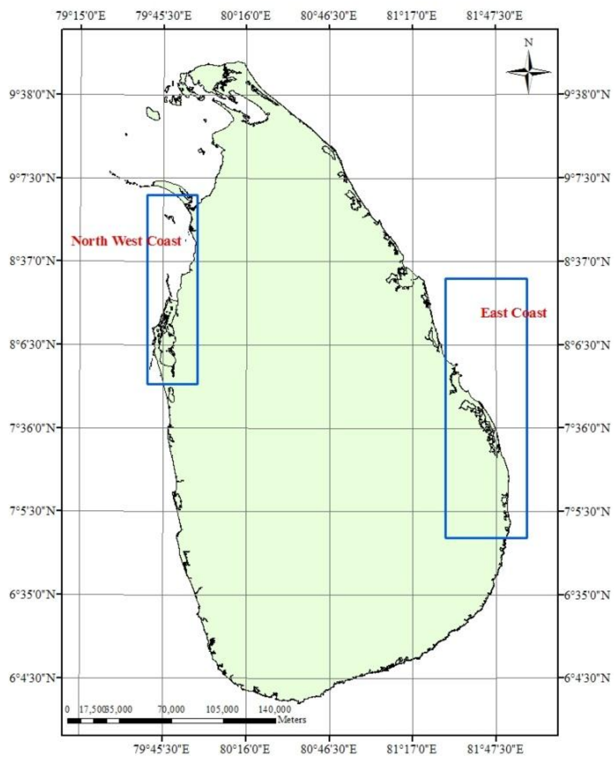


Figure 01: Major fishing areas of sea cucumber

The fishery for sea cucumber in Sri Lanka is influenced greatly by the monsoon winds during the south west and north east monsoons, which bring about much wave action and currents in the sea increasing the turbidity of water making it difficult to spot the animals. Moreover, the inter-monsoon rain also pours in water from river mouths into sea making it more turbid.

Hence off the North western coast, from Puttlam to Mannar, harvesting occurs intensively during the North east monsoon (from October to April) i.e. when the south west monsoon (May to September) has subsided, the inter-monsoonal rains have ceased and the water has become clear.

In the east coast (Trincomalee, Kalmunaei and Pothuwil) fishing is undertaken during the south west monsoon period. However the industry is not completely folded up during the ñoff seasonò.

No special gear or net is devised exclusively to catch sea-cucumbers and it is mainly harvested by hand picking either through scuba diving or skin diving. Scuba diving is carried out all the major landing sites except in Mannar. Sea cucumbers are defenseless animals and no resistance is offered at the time of capture. Further they do not try to escape and so it is easy to catch. Fiberglass Reinforced (FRP) boats powered by 15 or 25HP engines are the main vessels used for fishing.

Two to three divers and the boat operator go for a fishing trip in Kalpitiya, Trincomalee, Kalmunaei and Pothuwil area while 8 to 10 divers use one boat in Mannar area.

The fishing crafts leave around 7.30 a.m. ï 8.00 a.m. and return around 2.30 p.m. ï 3.30 p.m. when it is carried out sea cucumber fishing at day time. Night fishing is also carried out in both areas. When night fishing is done they leave around 6.00 p.m. and come back in the early morning around 2.00 a.m. ï 3.00 a.m.

There are about 4500 to 5000 dependant families through the sea cucumber fishing activity. Around 1500 to 2000 families engage in the beach de-mer- fishery in Kalpitiya Peninsula and they have permanently settled in various parts of Puttalam lagoon. The rest of the families have been settled in Mannar, Batticoaloa and Trincomalee areas while some migrate between the areas during the season to dive for fresh sea cucumbers. They either join local divers on a contract basis or work for a dealer or processor.

Study Objectives

In recent years, there has been some evidence of at least local depletion in Sri Lankan sea cucumber fishery and recognized urgent need for research on this fishery to formulate sustainable management measures

Unfortunately, there was very little information available to assess the status of the Sri Lankan sea cucumber fishery populations. In the absence of reliable long term fishery dependant data, a stock survey was the only viable method for determining the size and status of fished populations. Stock size and indications of stock status are two useful parameters on which to base robust management strategies. A survey would collect distribution and abundance data on all available sea cucumbers even those not yet fished. So it was decided to carry out underwater visual survey for the sea cucumber and chank fisheries by having following objectives. This would basically provide the data for a first estimate of stock status, and be the baseline for future, efficient monitoring of stock size.

1. Carry out both fishery dependant and fishery independent surveys in the major sea cucumber fishing areas to study the stock status of sea cucumbers.
2. Based on the survey results, suitable management plans will be implemented to ensure the sustainable utilization of sea cucumber resources through active participation of community who are directly involve in fishing activities.
3. Provide sufficient training to NARA research staff to enable them to carry out /supervise sea cucumber surveys in other parts of Sri Lanka

SECTION 3.1

METHODOLOGY FOR

UNDERWATER VISUAL SURVEY ON

SEA CUCUMBERS

3.1. PROJECT ACTIVITIES AND METHODOLOGY

3.1.1. Personnel and training

Training was given to the project Research Officers, Research Assistants and divers in the field survey methods and species identification. Detail training was given to the survey staff in the identification of sea cucumber species, measurements of live animals, and the various methodologies for censusing sea cucumbers and chanks (Figure 1). The sea cucumber Identification sheets were prepared to use in the field.

Training of scientific staff

Training of scientific staff

Taking length measurements

Taking weight measurements

Figure 1: On the job training given to the project staff

Scientists as well as commercial divers actively participated for the survey activities. The commercial divers were trained on survey methodologies and they were also given on the job training (Figure 2). Commercial divers were trained by the NARA research staff.

Divers Training ï East coast

Divers training ï NW coast

Divers training - Underwater

Divers training - Underwater

Figure 2: Training of commercial divers

Further the onboard research staff were trained for data recording and navigate to sampling sites by using hand held GPS (Figure 3).

Navigate to sampling sites by using GPS

Onboard data recording

Figure 3: Training onboard research staff

3.1.2. Survey area and site selection

Following information were used to identify the survey area.

a. Information collected through interviewing the fishermen in the area

   Fishermen were interviewed to collect the information about the fishing ground and habitat types. The maps were given to the fishing folk to demarcate the sea cucumber fishing grounds as well as non fishing grounds (Figure 4)

b. Available maps in the area

   The geographical information, depth and habitat information were gathered through the available maps in the excising fishing areas of the east coast and Northwestern coast of Sri Lanka.

c. Fishermen logbook or their personal diary

   Normally divers record the fishing position and number of individual caught in each day in their personal diary. This information was also collected to demarcate the survey area.

Interviewing the fishermen

Fishermen help to demarcate the fishing grounds

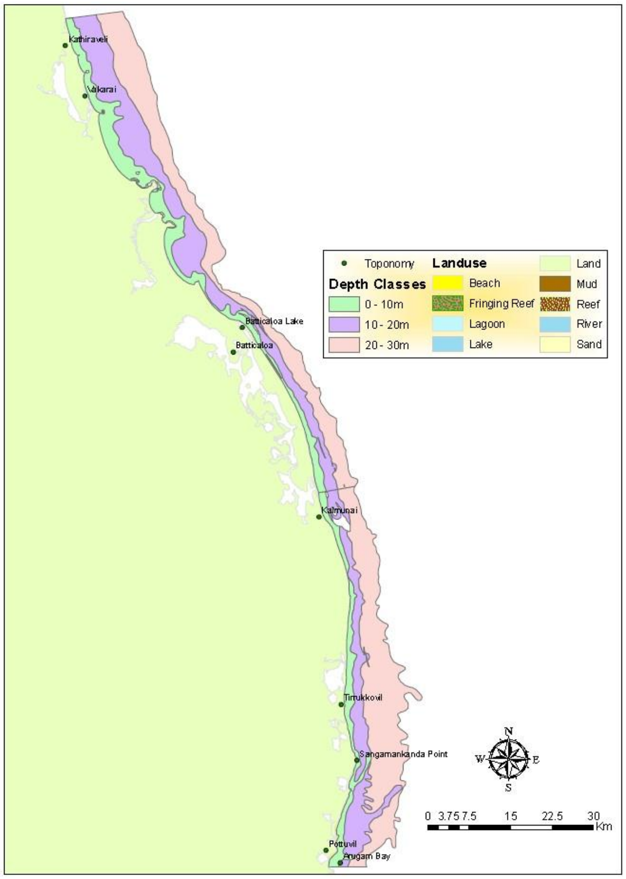
Figure 4: Collect information to demarcate the survey area

3.1.3. Survey type

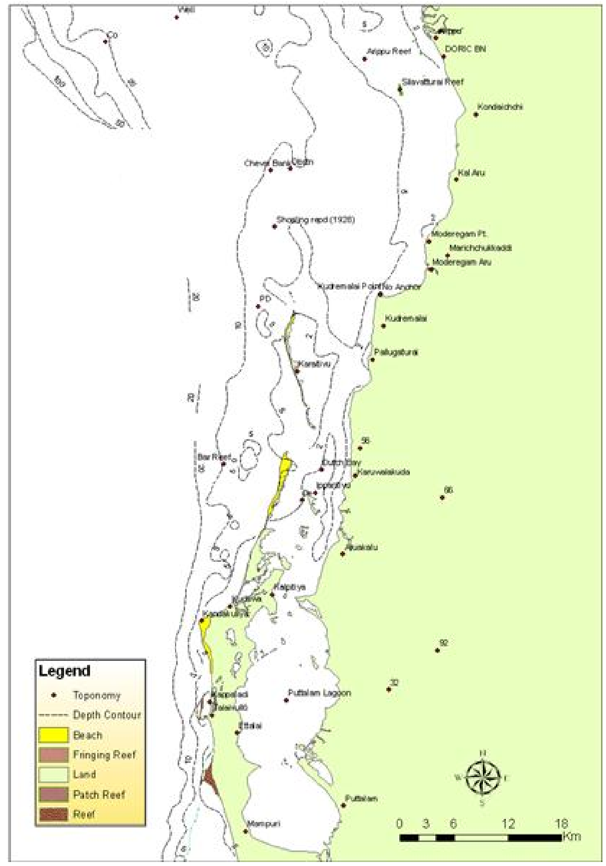
As the fishing activities are basically carried out through diving (skin and scuba), it was decided to carry out **Underwater Visual Survey** (UVS) with the help of scuba divers both from commercial as well as scientists. According to the literature, underwater visual survey is the most suitable technique to assess the population who are having sedentary behavior.

3.1.4. Survey area

As sea cucumber and chank fishery is presently confined to East and North western coastal waters, it was decided to do the surveys in those areas. The east coast survey area was demarcated from Wakarai to Sangamankanda which covers both Batticoalloa and Kalmunaei fisheries district and the along shore distance of the study area extended 190.047 km. The North west coast study area extends from Mampuri to Arippu where there are 111.57 km shore distance and the study area also bounded by Puttlam and Mannar fisheries district (Figure 05).



Survey area ï East coast



Survey area ï Northwestern coast

Figure 5: Survey area for the sea cucumber and chank resources

The sea cucumber fishery in Sri Lanka occurs mainly in the shallow (<40m deep) parts of the North West and Eastern coastal waters. Since it was not possible to sample deeper than 30m for safety reasons the study area was confined to water depths up to 30m which covered an area of 1305.92 km^2 in the East coast and 2054.19 km^2 in the North west coast. The depth wise breakdown of the survey area is summarized in Table 1.

Table 1: The estimated survey area in east coast and the North western coast

Strata	East coast area (sq km)		North west coast area (sq km)	
	Batticoaloa	Ampara	Puttlam	Mannar
0 - 10	163.98	76.04	289.29	398.13
10 - 20	287.19	151.06	208.91	488.51
20 - 30	288.59	339.05	328.77	64.90
Reef	6.61	7.77	91.90	41.58
Total	746.37	573.92	623.05	1195.18

3.1.5. Survey time

By considering time of the year where we have minimum disturbance in the sea and maximum visibility, decision was made to carry out the surveys in the following time period (Table2).

Table 2: Time frame for the surveys

Area	**Survey time**
East coast (Survey 1)	June to August 2008 (Real survey was carried out from 11^{th} July to 3^{rd} August)
East coast (Survey 2)	June to July 2009 (Real survey was carried out from 19^{th} June to 3^{rd} July 2009)
North West coast (Survey 1)	September to November 2008 (18^{th} October to 6^{th} November)
North West coast (Survey 2)	Schedule to do in October

3.1.6. Sampling design

A Geographic Information System (GIS) geodatabase was assembled from existing bathymetric and habitat data extracted by heads-up digitizing of scanned and geo referenced nautical charts. The coastline, reefs and shoals were digitized from Landsat & ETM+ satellite data.

As there are very little historical data as well as sea cucumbers preferable habitats we decided to do random sampling for the pilot survey and decision were made to do stratification based on the pilot survey results if possible.

3.1.7. Pilot Study

A pilot study was carried out in the east coast to trial the field sampling techniques and obtain estimates of mean abundance and variance of sea cucumbers so that an analysis could be done to determine the (a) basis on which to stratify; and (b) number of samples to take. The original plan was to sample 25 m, 50 m and 100m belt transects at 90 sites randomly allocated (Figure 6) throughout the 0 ï 30m depth zone. Fifteen sites were sampled using the methods described by Long *et al.* (1996) for sampling sea cucumbers in Torres Strait. After sampling 15 sites and not collecting any sea cucumbers the pilot was abandoned and modifications were made to base the survey design on the field data collected during the pilot such as the time to sample a site and time to travel between sites. Additional information from local commercial sea cucumber fishermen was also used for the final design.

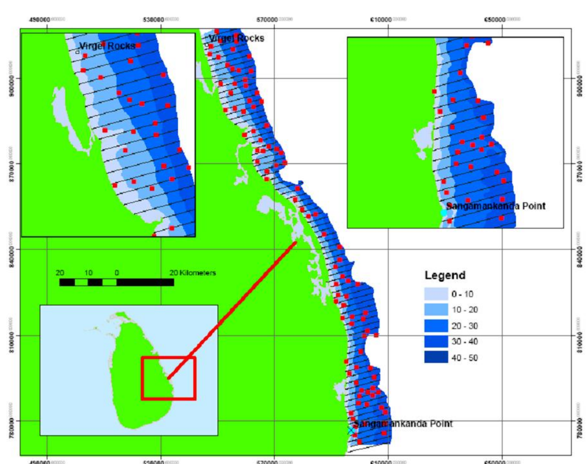


Figure 6: Sampling sites for pilot survey in the East coast of Sri Lanka

The outcome of the pilot study was to increase the transect length from 50 to 100 m

Sampling sites were randomly allocated throughout the study area using Hawthôs tools (www.hathstools.com). Sites were constrained to be at least 1 km apart. This essentially divided the study area up into 1 km x 1 km primary sampling units with one 100 x 2 m transect subsample randomly taken inside 500 randomly chosen primary sampling units.

The 1 km minimum distance was used to more evenly distribute sampling effort throughout the study area and prevent clumping and gaps that could occur if random sampling was based on the 100 x 2m transect as the primary sampling unit.

3.1.8. Field Sampling

The survey employed rapid marine assessment techniques that have been employed in sea cucumber surveys in Torres Strait (Long *et al.*, 1996), Moreton Bay (Skewes *et al.*, 2002), the Timor MOU Box (Skewes *et al.*, 1999) and Milne Bay Province, PNG (Skewes *et al.*, 2002) and Seychelles. Field work was undertaken by a team of divers operating from a dinghy and locating sample sites using portable Global Positioning System (GPS). At each site either a diver or divers swam along a 50 m transect and recorded resource and habitat information 2 m either side of the transect line. At each site, the substrate was described in terms of the percentage cover of sand, rubble, limestone platform, coral or terrestrial rock and mud. Other benthic taxa such as black coral and whip coral and the percentage cover of other conspicuous biota such as seagrass and algae were also recorded. Sea cucumbers and other benthic fauna of commercial[1] or ecological interest within the belt transect were collected and returned to the dinghy and measured and weighed back at the NARA base station (Figure 6)

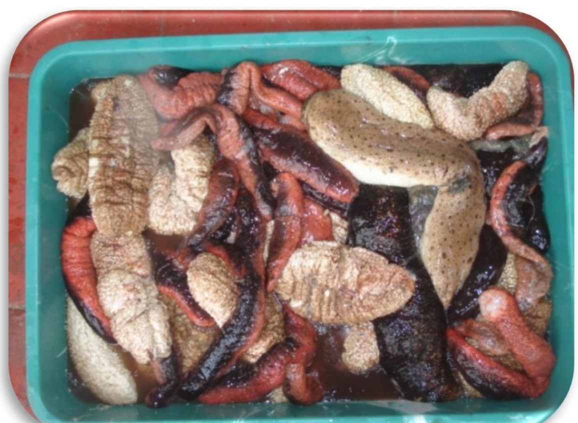
Boats are ready to go to survey activities

Survey boat is in sampling site

Divers are ready to go down

Covering a transect by a commercial diver

Collecting sea cucumbers within a transect



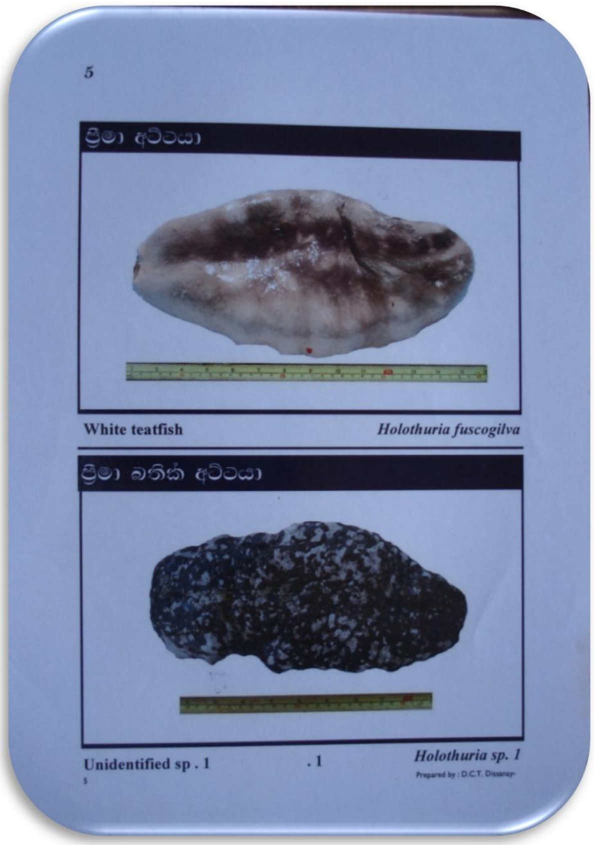
Collected sea cucumbers

Figure 6: Steps of survey activities

3.1.9. Species identification

Species identifications were made through the use of published books, scientific journal articles, museum journal articles, and correspondence with internationally-renowned taxonomists. The sea cucumber identification sheets were prepared and these were also used in the field for the species identification (Figure 7)

Sea cucumber Identification sheet 1



Sea cucumber Identification sheet 2

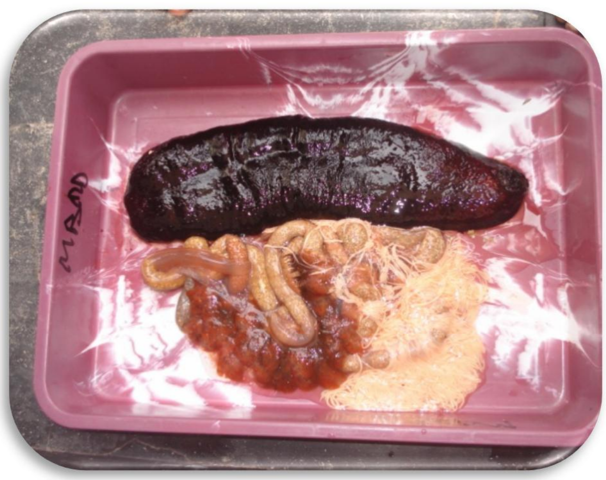
Figure 7: Field identification sheets for sea cucumbers

3.1.10. Size and weight measurements

Length and weight measurements of collected sea cucumbers were taken at the base station.
The body length was measured to nearest 1 cm and weighed to nearest 1 g using an electronic balance. The animals were allowed approximately 1 minute to drain before being weighed. Both the whole weight and gutted weight were taken. Apart from these measurements, gut contents as well as reproductive organs were collected for further biological analysis (Figure 8)

Measuring length of collected sea cucumbers

Measuring weight of collected sea cucumbers



Gutting of animals

Gut contents and reproductive organs

Figure 8: Length weight measurements and biological sampling

3.1.11. Data Management

A database was created in MS-Excel to store and maintain the integrity of the field data. All of the data were stored in this way. An important step in this operation was to attribute a unique identifying number for each sampling site. These unique identifiers provided a link between the transect survey observations, animal measurements and geographic coordinates. The unique identifiers equally correspond in the GIS interface to the geographic object (i.e. transect). The survey datasheet is annexed in Appendix 1.

Pre defined sampling sites were located using the handheld GPS and were transferred on navigation software and associated to the data in MS-Excel tables. Data manipulations, e.g., to calculate average abundances, densities and error estimates, were made in MS-Excel and MS access with the help of SPSS software. The summary data were then imported into a GIS application, MapInfo, in order to illustrate results geographically. Tables were automatically created on MapInfo by opening Excel results tables. Associated coordinates allowed us to position field data information on their object transect.

3.1.12. Data analysis

Calculation of the average densities of each species within transect is simple: it is just a computation using the transect data, standardized to individuals per hectare. Abundance estimates take into account the actual survey area in which the animals occur.

To calculate abundance, we firstly multiplied the density of each species by the survey area. This provided mean estimates, with associated standard error, of the number of individuals of each species within survey area. The equation to calculate abundances of each species is given below.

The following two approaches have been used to estimate the Maximum Sustainable Yields (MSY) of sea cucumber fisheries in Alaska, Moreton Bay, Torres Strait (Skewes, 2006) and rock lobsters in Torres Strait (pitcher, 1992)

The first method has been used for new and developing invertebrate fisheries where there is little data to formulate a stock-recruitment relationship, and is a version of the surplus production model that requires only the biomass estimate (usually assumed to represent virgin biomass) and natural mortality (M) (Gulland, 1983) such that

$$MSY = ½ MB_0$$

The model is based on the logistic function that assumes that maximum population growth is highest at intermediate population sizes. In practice the proportion of the breeding population required for MSY may be larger than this, and various authors have suggested that the scaling factor should be reduced to 0.2 (Perry, 1999). This approach has been used to produce MSY estimates for beche-de-mer fisheries in this study.

The second approach to determining optimal catch rates is to use an estimate of the optimal fishery mortality rate (F_{opt}) based on natural mortality, such that F_{opt} = 0.6 M (Perry, 1999), which has been suggested as a robust method for TAC calculation for a broad range of species. The exploitation rate u, being the proportion of the population fished for a given F can then be calculated using the formula

$$u = F/Z\ (1-\exp-Z)$$

Where Z is the total mortality rate (M+F). The MSY can then be calculated using the estimate of biomass B, such that

$$MSY = u * B$$

The natural mortality (M) is the other parameter that needs to calculate MSY using both models. The estimates of natural mortality have been produced for some *Holothurian* species and it probably varies by species, by age, and even spatially and temporally. According to (Conand, 1990), mortality estimates are in the range of M = 0.6 to 1.0 (55 to 37 percent survival annually). The published estimates of natural mortality for the tropical holothurians species were used in this analysis.

These estimates of MSY should only be used as an indicator of the potential annual yields that could be gained from this fishery given stable recruitment. The models have several assumptions, the most important being that there is no spatial stock structure. Also, when populations are substantially below virgin biomass, recruitment may become depressed and the assumptions underlying the model are further breached. Depleted sea cucumber populations risk dilution effects hampering recruitment at low stock levels. This effect is likely to occur for broadcast spawners at low abundances such that the fertilization success in the water column is much reduced due to the dilution of the gametes in the water column.

These factors mean it is likely that the optimal catch rate is substantially less than the lowest calculated MSYs for exploited populations. We therefore recommend TACs for exploited species that are half the lowest calculated MSY. Additionally, TACs are limited to no more than 10% of the model biomass. We feel that TACs < 10 t would be impractical to enforce, prone to being exceeded and a risk of overexploitation. The above are contained in a set of rules for calculating suggested TACs for each species based on stock status and MSY estimates (Table 3). Using these rules, we calculated recommended TACs for each species.

Table 3: Rules of calculating TACs for each species

Rule	**TAC**
Stock status: unexploited	MSY
Stock status: exploited	0.5 × MSY
Stock status: overexploited	0 t
MSY estimate < 10 t	0 t
TAC > 10% B_0	TAC = 10% B_0

SECTION 3.2

RESULTS

EAST COAST UNDERWATER VISUAL SURVEY 2008 (PART 1)

3.2.1. Survey area

500 sampling sites were allocated to east coast (Figure 9) and only day diving were carried out in the first survey. It was not possible to carry out night diving activities due to the security situation of the area during the survey period.

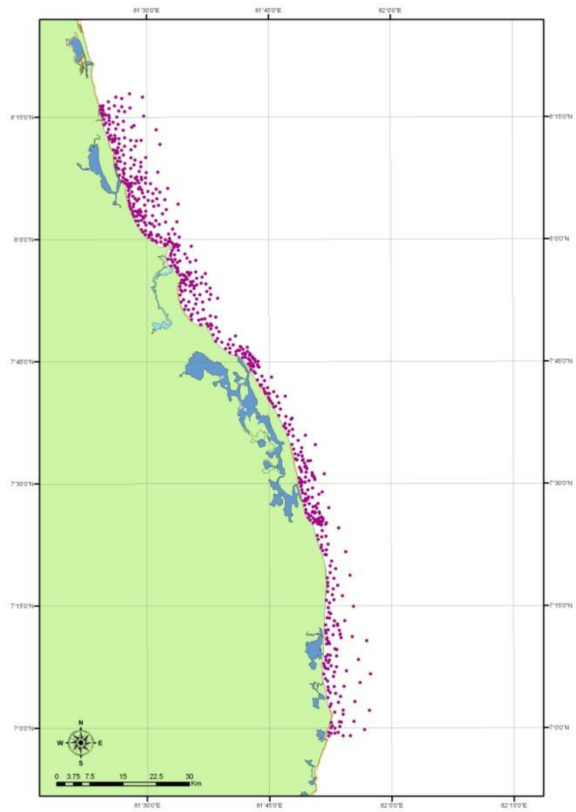


Figure 9: East coast sampling sites

3.2.2. Species observed

We recorded 24 species (or varieties at least) of large sea cucumbers during all the surveys and these species are summarized in Table 3 including Scientific name, English name and the local names coupled with their commercial importance. The taxonomy of commercial sea cucumber species is not stable. Several prospective species observed during the survey require identification or confirmation of tentative identification. All the sea cucumber species come across during the surveys are in Figure 10.

Out of these, only 12 species were recorded in the first phase of the East coast survey and results are summarized in Table 4.

Table 4: Identified sea cucumber species during underwater visual surveys

No	Scientific name	English name	Local name	Commercial value
1	*Actinopyga echinites**	Deep water redfish	Goma attaya	Medium value
2	*Actinopyga miliaris***	Blackfish	Kalu attaya	Medium value
3	*Actinopyga mauritiana***	Surf redfish	Gal attaya	Medium value
4	*Bohadschia argus***	Leopard fish	Koti attaya	Low value
5	*Bohadschia atra***	Tigerfish	Nari nool attaya	Low value
6	*Bohadschia marmorata***	Chalkyfish	Duburu Nool attaya	Low value
7	*Bohadschia similis***	Brownspotted sandfish	Line nool attaya	Low value
8	*Bohadschia* unidentified sp. 1**		Sudu nool attaya	Low value
9	*Bohadschia* unidentified sp. 2**		Kiri nool attaya	Low value
10	*Bohadschia* unidentified sp. 3**		Kiri nool attaya	Low value
11	*Holothuria atra*	Lolly fish	Narri attaya	Low value
12	*Holothuria edulis*	Pinkfish	Rathu attaya	Low value
13	*Holothuria fuscogilva**	White teatfish	Preema attaya	High value
14	*Holothuria hilla*			No value
15	*Holothuria leucospilota*			No value
16	*Holothuria nobilis**	Black teatfish	Polanga attaya	High value
17	*Holothuria scabra**	Sand fish	Jaffna attaya	High value
18	*Holoturia spinifera*	Brown sand fish	Disco attaya	Low value
19	*Holothuria sp(pentard)**		Preema bathik attaya	High value
20	*Stichopus chloronotus***	Greenfish	Dabalaya	Low value
21	*Stichopus herrmanni**	Curryfish	Sani attaya	Low value
22	*Thelenota ananas*	Prickly redfish	Annasi attaya	Low value
23	*Thelenota anax**	Amberfish	Poona attaya	Low value
24	*Acaudina molpadioides***		Uru attaya	Low value

*The scientific names of these species were confirmed by Prof. C. Conad and Dr. Sven Uthicke

** The scientific names of these species need to be confirmed

Holothuria nobilis

Holothuria fuscogilva

Holothuria sp. (pentard)

Holothuria scabra

Holothuria atra

Holothuria edulis

Holothuria spinifera

Bohadschia unidentified sp. 1

Bohadschia marmorata

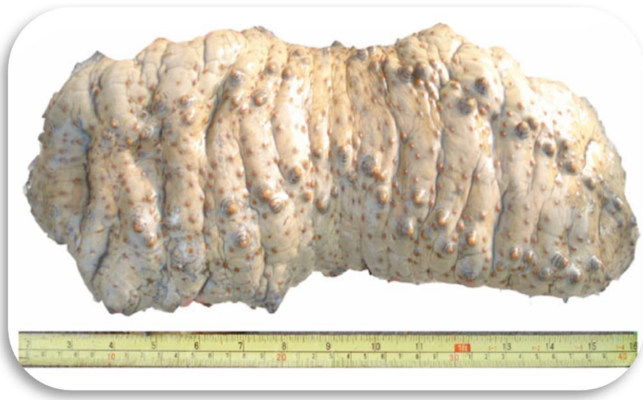
Bohadschia argus

Bohadschia atra

Bohadschia unidentified sp. 2

Bohadschia similis

Bohadschia unidentified sp. 3



Thelenota anax

Thelenota ananas

Stichopus chloronotus

Stichopus herrmanni

Acaudina molpadioides

Actinopyga mauritiana

Actinopyga echinites

Actinopyga miliaris

Holothuria hilla

Holothuria leucospilota

Figure 10: Sea cucumber species found in underwater visual surveys

Twelve sea cucumber species were recorded from the initial stage of east coast survey and results are summarized in Table 5.

Table 5: Identified sea cucumber species in East coast survey (Phase 1)

No	Scientific name	English name	Local name	Commercial value
1	*Actinopyga echinites*	Deep water redfish	Goma attaya	Medium value
2	*Actinopyga miliaris*	Blackfish	Kalu attaya	Medium value
3	*Bohadschia argus*	Leopard fish	Koti attaya	Low value
4	*Bohadschia atra*	Tigerfish	Nari nool attaya	Low value
5	*Bohadschia marmorata*	Chalkyfish	Duburu Nool attaya	Low value
6	*Bohadschia* unidentified sp. 1		Sudu nool attaya	Low value
7	*Holothuria atra*	Lolly fish	Narri attaya	Low value
8	*Holothuria edulis*	Pinkfish	Rathu attaya	Low value
9	*Holothuria fuscogilva*	White teatfish	Preema attaya	High value
10	*Holothuria nobilis*	Black teatfish	Polanga attaya	High value
11	*Holothuria sp(pentard)*		Preema bathik attaya	High value
12	*Stichopus chloronotus*	Greenfish	Dabalaya	Low value

3.2.3. Abundance Estimate

The mean abundance per hectare is summarized in Table 6 and it indicates that the highest abundance is from *Holothuria edulus* followed by *Holothuria atra.* It is obvious that the mean abundance of high value species are negligible compared with the low value species.

3.2.4. Biomass Estimate

The biomass estimates for different sea cucumber species are summarized in Table 7 and the reported the highest biomass was from *Holothuria atra* while *Stichopus chloronotus* reported the lowest.

Table 6: Mean abundance of each sea cucumber species found in East coast

Species Name	**Mean per ha**	**Sd**	**CIL**	**CIU**
Holothuria atra	24.12	53.63	19.34	28.90
Holothuria edulus	39.86	87.44	32.06	47.65
Holothuria fuscogilva	0.62	5.54	0.13	1.12
Holothuria nobilis	0.31	3.93	0.00	0.66
Other *Holothurians*	2.17	14.77	0.86	3.49
All *Holothuria* species	67.08	109.09	57.35	76.81
Bohadschia marmorata	5.69	27.02	3.28	8.10
Bohadschia sp.1	6.52	29.76	3.87	9.18
All *Bohadschia* species	12.73	44.14	8.80	16.67
Stichopus chloronotus	5.18	25.65	2.89	7.46
All *Stichopus* species	5.18	25.65	2.89	7.46
Actinopyga echinites	2.17	13.30	0.99	3.36
Actinopyga miliaris	3.11	16.44	1.64	4.57
***All Actinopyga* species**	5.28	22.04	3.31	7.24
All Sea cucumber species	90.27	129.83	78.69	101.85
High value sea cucumbers	1.04	7.13	0.40	1.67
Medium value sea cucumbers	5.28	22.04	3.31	7.24
Low value sea cucumbers	83.95	124.35	72.86	95.04

Table 7: Total Biomass (tons) of each sea cucumber species found in the East coast

Species Name	Total Biomass (tons)
Holothuria atra	766.8
Holothuria edulus	412.8
Holothuria fuscogilva	132.8
Holothuria nobilis	73.1
Bohadschia marmorata	593.1
Bohadschia sp.1	606.8
Stichopus chloronotus	68.0
Actinopyga echinites	198.1
Actinopyga miliaris	253.1

3.2.5. MSY and Total Allowable Catch (TACs) Estimates

MSY estimates were carried out according to the two major procedures described under the methodology. The estimated MSY according to the first approach is indicated in MSY1 column and the second approach was in MSY2 column in Table 8.

Recommended TACs were then formulated using the lowest MSY estimates and stock status using the rules defined under methodology. Six species had zero TACs due to being over-exploited or having a low MSY estimate (< 10 t). The bulk of this TAC is be made up of low value species (1161 t or 68.0 %) such as *H. atra* and *Bohadschia sp.* Most of the high value and medium value species seem to be overexploited or close to be overexploited.

3.2.6. Distribution of sea cucumbers in study area

There is wide variation in the spatial distribution and abundance of sea cucumbers in the study area (Figure 11).

Table 8: MSY and TACôs Estimates for commercial sea cucumbers

Species Name	**Total Biomass (T)**	**MSY1(T)**	**MSY2 (T)**	**TAC (T)**
Holothuria atra	766.8	153.4	229.5	15.3
Holothuria edulus	412.8	82.6	123.6	< 10
Holothuria fuscogilva	132.8	26.6	31.5	< 10
Holothuria nobilis	73.1	14.6	17.3	< 10
Bohadschia marmorata	593.1	118.6	161.8	11.9
Bohadschia sp.1	606.8	121.4	165.5	12.1
Stichopus chloronotus	68.0	13.6	20.4	< 10
Actinopyga echinites	198.1	39.6	54.0	< 10
Actinopyga miliaris	253.1	50.6	69.0	< 10

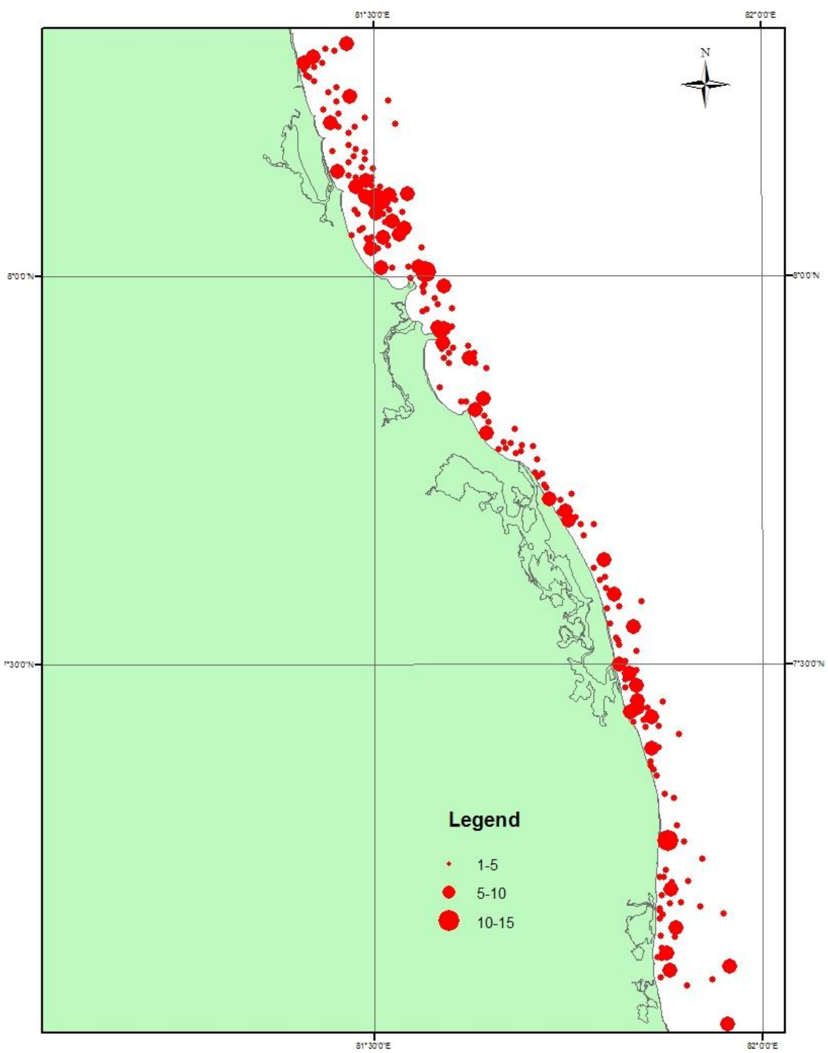


Figure 11: Abundance and spatial distribution of sea cucumber in East coast

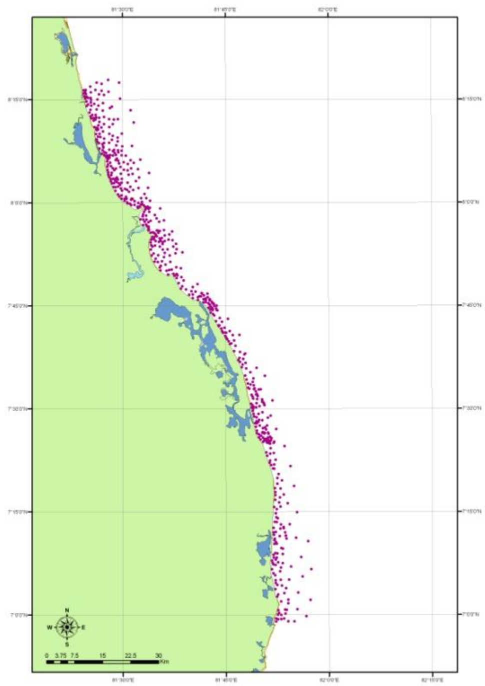
SECTION 3.3

RESULTS

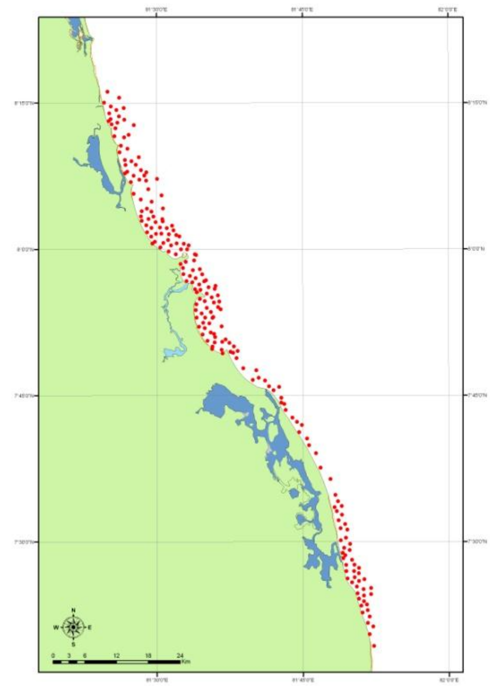
EAST COAST UNDERWATER VISUAL SURVEY 2009 (PART 2)

3.3.1. Survey area

The same sampling sites which were designed in the first phase were repeated for the day diving activities while 210 sampling sites were newly allocated for the night diving activities (Figure 12).



Day diving sites



Night diving sites

Figure 12: Survey sites ï East coast

3.3.2. Species observed

Thirteen species of sea cucumbers were recorded this survey having two species which were not recorded previously and results are summarized in Table 9. Compared to last year three new species (*Holoturia spinifera, Thelenota anax* and *Bohadschia similis*) which were not recorded in the last time were identified from this area during this survey and all these species are frequent at night. According to the fishers this is the first time that they observed *H. spinifera* and *Bohadschia similis* there was no any documented information about the abundance of this species in East coast of Sri Lanka. However most of the high valuable species were not recorded. Two new species which were not recorded previously were also identified (Figure 13)

Table 9: Identified sea cucumber species in East coast survey (Phase 2)

No	Scientific name	English name	Local name	Commercial value
1	*Actinopyga echinites*	Deep water redfish	Goma attaya	Medium value
2	*Actinopyga miliaris*	Blackfish	Kalu attaya	Medium value
3	*Bohadschia marmorata*	Chalkyfish	Duburu Nool attaya	Low value
4	*Bohadschia similis*	Brownspotted sandfish	Line nool attaya	Low value
5	*Bohadschia* unidentified sp. 1		Sudu nool attaya	Low value
6	*Holothuria atra*	Lolly fish	Narri attaya	Low value
7	*Holothuria edulis*	Pinkfish	Rathu attaya	Low value
8	*Holothuria leucospilota*			No value
9	*Holoturia spinifera*	Brown sand fish	Disco attaya	Low value
10	*Stichopus chloronotus*	Greenfish	Dabalaya	Low value
11	*Thelenota anax*	Amberfish	Poona attaya	Low value
12	*Unidentified sp*			
13	*Unidentified sp*			

Unidentified Species

Unidentified species

Figure 13: Two new records from the east coast survey

3.3.3. Abundance Estimate

The mean abundance per hectare is summarized in Table 10 and it indicates that the highest abundance is from *Holothuria edulus* followed by *Holothuria atra*. It is obvious that the mean abundance of high value species are further declined compared with the previous survey.

Table 10: Mean abundance of each sea cucumber species found in East coast

Species Name	**Mean per ha**	**Sd**	**CIL**	**CIU**
Holothuria atra	17.2	42.51	14.95	19.45
Holothuria edulus	36.7	53.50	33.3	38.01
Holothuria fuscogilva	0.12	2.2	0.0	0.20
Holothuria nobilis	0.10	1.5	0.00	0.33
Holothuria spinifera	13.4	35.57	11.85	14.90
Other *Holothurians*	2.5	10.45	1.25	3.70
All *Holothuria* species	70.02	145.73	61.35	76.59
Bohadschia marmorata	5.15	12.50	3.12	7.98
Bohadschia sp.1	6.50	17.45	3.89	9.25
Bohadschia similis	3.55	9.42	2.18	5.77
All *Bohadschia* species	15.2	39.37	9.19	23.00
Stichopus chloronotus	2.25	11.35	1.66	3.24
All *Stichopus* species	2.25	11.35	1.66	3.24
Actinopyga echinites	1.97	10.45	0.90	3.15
Actinopyga miliaris	3.15	14.75	1.73	4.95
***All Actinopyga* species**	5.12	25.2	2.63	8.1
Telenata anax	12.2	24.78	8.65	15.93
All *Telenata* species	12.2	24.78	8.65	15.93
High value sea cucumbers	0.22	3.7	0	0.53
Medium value sea cucumbers	5.12	25.2	2.63	8.1
Low value sea cucumbers	99.45	217.53	80.85	118.23

3.3.4. Biomass Estimate

The biomass estimates for different sea cucumber species are summarized in Table 11 and the reported the highest biomass was from *Telenata anax* while *Holothuria nobilis* reported the lowest. This clearly indicates that night species, *Telenata anax* is dominant in the wild and it is not possible to make any comparison with the previous survey as we did not cover the night activities last time. Further this reveals that there are considerable amount of *H. spinifera* resource in the east coast of Sri Lanka.

Table 11: Total Biomass (tons) of each sea cucumber species found in the East coast

Species Name	Total Biomass (tons)
Holothuria atra	652
Holothuria edulus	381
Holothuria fuscogilva	30
Holothuria nobilis	17
Holothuria spinifera	281
Bohadschia marmorata	505
Bohadschia sp.1	527
Bohadschia similis	151
Stichopus chloronotus	31
Actinopyga echinites	138
Actinopyga miliaris	195
Telenata anax	752

3.3.5. MSY and Total Allowable Catch (TACs) Estimates

MSY estimates were carried out according to the two major procedures described under the methodology. The estimated MSY according to the first approach is indicated in MSY1 column and the second approach was in MSY2 column in Table 12.

Recommended TACs were then formulated using the lowest MSY estimates and stock status using the rules defined under methodology. Six species had zero TACs due to being over-exploited or having a low MSY estimate (< 10 t). The bulk of this TAC is be made up of low value species such as *H. atra* and *Bohadschia species* and *Telenata anax.* Most of the high value and medium value species seem to be overexploited or close to be overexploited.

Table 12: MSY and TACôs Estimates for commercial sea cucumbers

Species Name	Total Biomass (T)	MSY1(T)	MSY2 (T)	TAC (T)
Holothuria atra	652	130	195	13
Holothuria edulus	381	76	114	< 10
Holothuria fuscogilva	30	5	8	< 10
Holothuria nobilis	17	2	4	< 10
Holothuria spinifera	281	45	77	< 10
Bohadschia marmorata	505	101	138	10.1
Bohadschia sp.1	527	105	144	10.5
Bohadschia similis	151	24	35	< 10
Stichopus chloronotus	31	6	9	< 10
Actinopyga echinites	138	22	38	< 10
Actinopyga miliaris	195	31	53	< 10
Telenata anax	752	120	178	12

3.3.6. Distribution of sea cucumbers in study area

There is wide variation in the spatial distribution and abundance of sea cucumbers in the study area (Figure 13).

Figure 13: Map of the study area showing the density of all sea cucumbers at each study site

SECTION 3.4

RESULTS

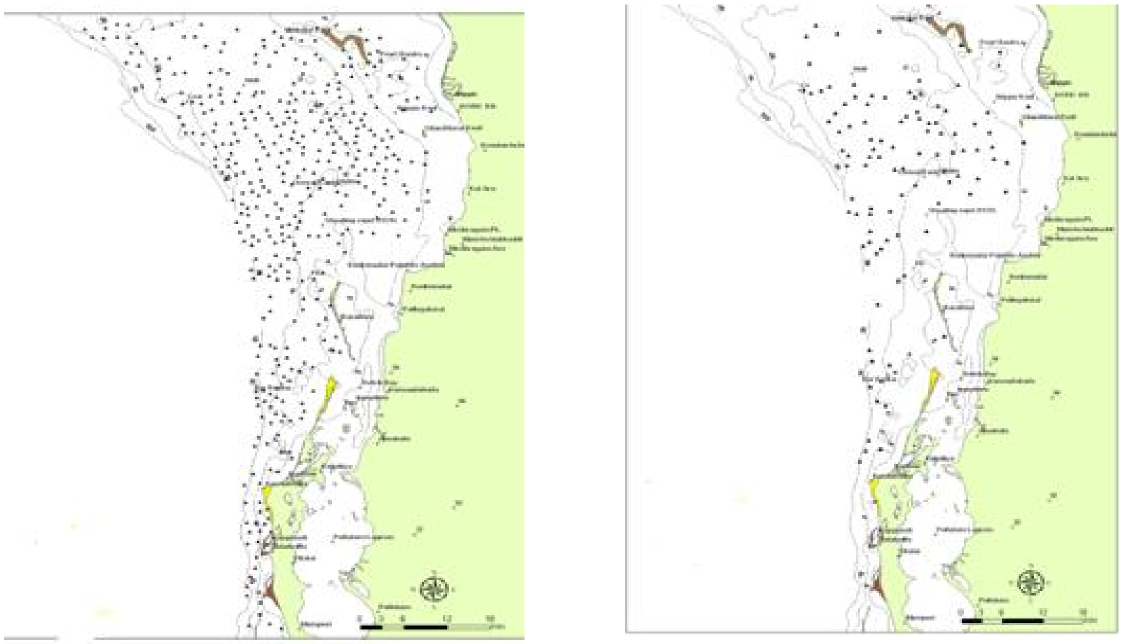
NORTHWEST COAST UNDERWATER

VISUAL

SURVEY 2008 (PART 1)

3.4.1. Survey area

Five hundred sampling sites were allocated among which 400 sites were for day diving and the remaining were for night diving activities (Figure 14).



Day diving sites Night diving sites

Figure 14: Survey sites ï North west coast

3.4.2. Species observed

Twenty species of sea cucumbers were recorded this survey (Table 13). Five species (*Bohadschia similis*, *Bohadschia* unidentified sp. 2, *Bohadschia* unidentified sp. 3, *Holoturia spinifera* and *Thelenota anax*) were reported only at night diving activities. Other species except *Holothuria fuscogilva*, *Holothuria hilla*, *Holothuria nobilis* and *Holothuria sp (pentard)* were reported only day diving and the rest of the species could be found both day and night diving activities. However, high value and medium value species were reported very rarely.

Table 13: Identified sea cucumber species in North West coast survey

No	Scientific name	English name	Local name	Commercial value
1	*Actinopyga echinites*	Deep water redfish	Goma attaya	Medium value
2	*Actinopyga miliaris*	Blackfish	Kalu attaya	Medium value
3	*Bohadschia atra*	Tigerfish	Nari nool attaya	Low value
4	*Bohadschia marmorata*	Chalkyfish	Duburu Nool attaya	Low value
5	*Bohadschia similis*	Brownspotted sandfish	Line nool attaya	Low value
6	*Bohadschia* unidentified sp. 1		Sudu nool attaya	Low value
7	*Bohadschia* unidentified sp. 2		Kiri nool attaya	Low value
8	*Bohadschia* unidentified sp. 3		Kiri nool attaya	Low value
9	*Holothuria atra*	Lolly fish	Narri attaya	Low value
10	*Holothuria edulis*	Pinkfish	Rathu attaya	Low value
11	*Holothuria fuscogilva*	White teatfish	Preema attaya	High value
12	*Holothuria hilla*			No value
13	*Holothuria leucospilota*			No value
14	*Holothuria nobilis*	Black teatfish	Polanga attaya	High value
15	*Holothuria scabra*	Sand fish	Jaffna attaya	High value
16	*Holoturia spinifera*	Brown sand fish	Disco attaya	Low value
17	*Holothuria sp(pentard)*		Preema bathik attaya	High value
18	*Stichopus chloronotus*	Greenfish	Dabalaya	Low value
19	*Stichopus herrmanni*	Curryfish	Sani attaya	Low value
20	*Thelenota anax*	Amberfish	Poona attaya	Low value

3.4.3. Abundance Estimate

The mean abundance per hectare is summarized in Table 14 and it indicates that the highest abundance is from *Holothuria edulus* followed by *Holothuria atra.* The results indicate that the mean abundance of high value species are negligible compared with the low value species and this is common phenomena both in east and northwestern coast.

3.4.4. Biomass Estimate

The biomass estimates for different sea cucumber species are summarized in Table 15 and the reported the highest biomass was from *Holothuria edulus* while *Holothuria (pentrad) sp* reported the lowest.

Table 14: Mean abundance of each sea cucumber species found in North west coast

Species Name	Mean per ha	Sd	CI L	CI U
Holothuria atra	89.92	252.15	67.38	112.45
Holothuria edulus	138.15	345.95	107.23	169.07
Holothuria spinifera	14.55	74.35	7.91	21.20
Holothuria fuscogilva	0.31	5.09	0.00	0.77
Holothuria nobilis	0.10	2.28	0.00	0.31
Holothuria scabra	1.35	15.59	0.00	2.74
Holothuria (pentrad) sp	0.21	0.50	0.11	0.45
Holothuria lecospolata	1.10	0.13	0.08	0.13
Other Holothurians	1.46	13.62	0.24	2.67
All *Holothuria* species	**246.15**	**709.65**	**182.95**	**309.79**
Bohadschia marmorata	3.85	25.43	1.57	6.12
Bohadschia similis	5.09	38.46	1.66	8.53
Bohadschia sp.1	4.05	26.20	1.71	6.40
Bohadschia unidentified sp. 2	0.10	0.26	0.09	0.13
Bohadschia unidentified sp. 3	1.04	0.00	0.00	0.00
All *Bohadschia* species	**13.10**	**90.35**	**5.03**	**21.17**
Stichopus chloronotus	5.72	31.02	2.95	8.49
Stichopus varigatus	0.21	0.30	0.18	0.23
All *Stichopus* species	**5.93**	**31.31**	**3.13**	**8.72**
Telenata anax	5.30	46.97	1.10	9.50
All *Telenata* species	**5.30**	**46.97**	**1.10**	**9.50**
Actinopyga echinites	1.56	14.53	0.26	2.86
Actinopyga miliaris	3.33	24.99	1.09	5.56
All *Actinopyga* species	**4.89**	**35.24**	**1.74**	**8.04**
All Sea cucumber species	**275.36**	**913.53**	**193.95**	**357.22**
High value sea cucumbers	1.98	23.46	0.11	4.27
Medium value sea cucumbers	4.89	39.52	1.35	8.42
Low value sea cucumbers	269.54	854.83	192.10	344.91

Table 15: Total Biomass (tons) of each sea cucumber species found in the North west coast

Species Name	**Total Biomass (tons)**
Holothuria atra	1950.29
Holothuria edulus	1951.39
Holothuria spinifera	415.98
Holothuria fuscogilva	104.66
Holothuria nobilis	24.03
Holothuria scabra	118.33
Holothuria (pentrad) sp	5.55
Holothuria lecospolata	112.08
Bohadschia marmorata	513.48
Bohadschia similis	294.34
Bohadschia sp.1	447.59
Bohadschia unidentified sp. 2	10.76
Bohadschia unidentified sp. 3	84.71
Stichopus chloronotus	107.82
Stichopus varigatus	49.62
Telenata anax	445.04
Actinopyga echinites	148.57
Actinopyga miliaris	279.77

3.4.5. MSY and Total Allowable Catch (TACs) Estimates

MSY estimates were carried out according to the two major procedures described under the methodology. The estimated MSY according to the first approach is indicated in MSY1 column and the second approach was in MSY2 column in Table 16.

Recommended TACs were then formulated using the lowest MSY estimates and stock status using the rules defined under methodology. All the sea cucumber species except *H. atra* and *H.edulus* have TACs less than 10t and this may be due to overexploitation. The bulk of this TAC is be made up of low value species. Most of the high value and medium value species seem to be overexploited or close to be overexploited.

Table 16: MSY and TACôs Estimates for commercial sea cucumbers

Species Name	Total Biomass (T)	MSY1 (T)	MSY2 (T)	TAC (T)
Holothuria atra	1,950,286.93	390.06	583.70	39.01
Holothuria edulus	1,951,385.98	390.28	584.03	39.03
Holothuria spinifera	415,981.84	66.56	113.48	6.66
Holothuria fuscogilva	104,659.65	16.75	28.55	1.67
Holothuria nobilis	24,034.19	2.88	5.70	0.29
Holothuria scabra	118,328.33	18.93	32.28	1.89
Holothuria lecospolata	2,081.18	0.42	0.62	0.04
Bohadschia marmorata	513,482.15	82.16	140.08	8.22
Bohadschia similis	294,343.35	47.09	28.61	4.71
Bohadschia sp.1	447,586.49	71.61	122.10	7.16
Stichopus chloronotus	107,820.38	21.56	32.27	2.16
Stichopus varigatus	49,621.36	7.94	13.54	0.79
Telenata anax	445,039.21	53.40	105.49	5.34
Actinopyga echinites	148,572.88	23.77	40.53	2.38
Actinopyga miliaris	279,766.20	44.76	76.32	4.48

3.4.6. Distribution of sea cucumbers in study area

There is wide variation in the spatial distribution and abundance of sea cucumbers in the study area (Figure 15). The results clearly indicate that the sea cucumber distribution is very patchy.

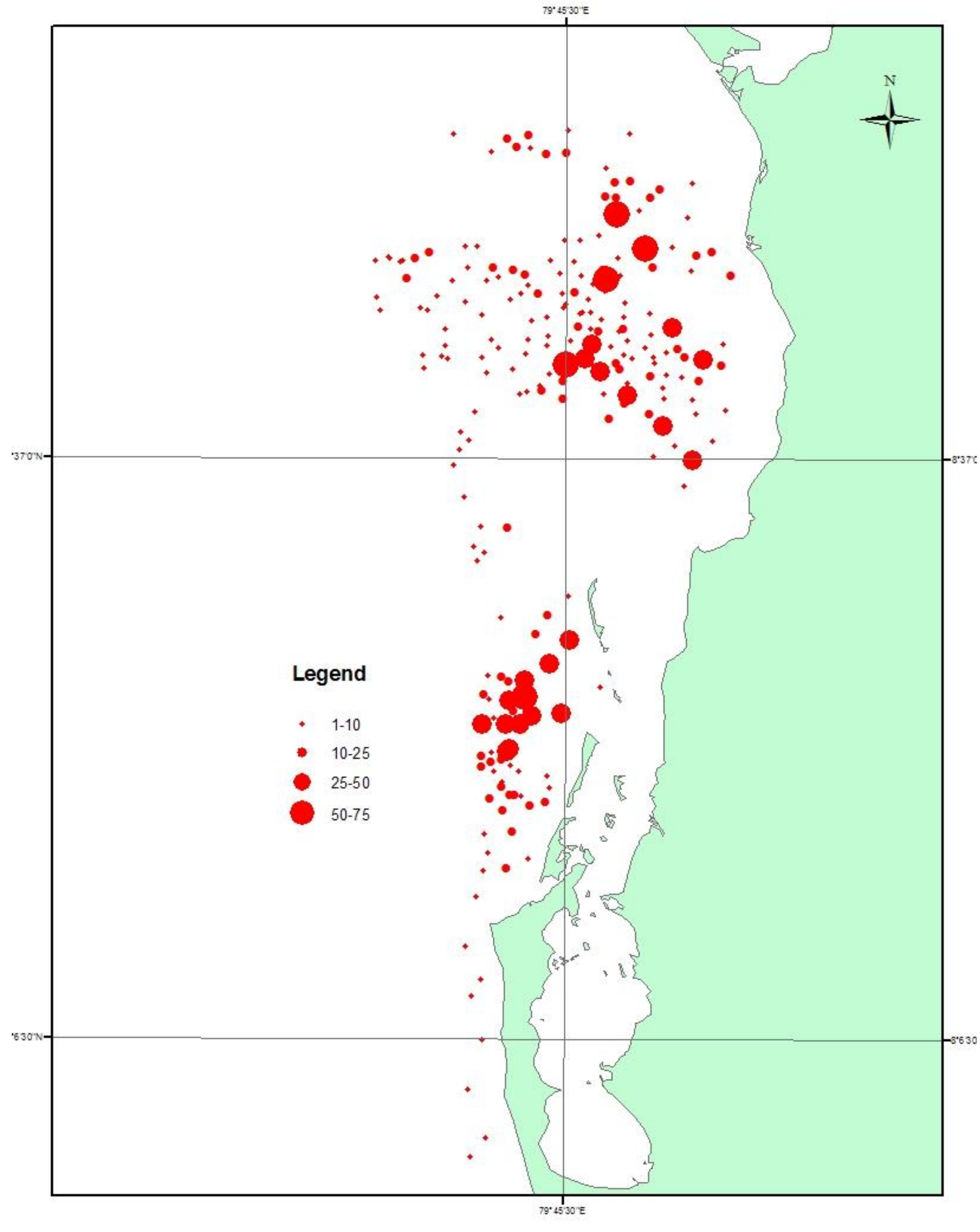


Figure 15: Abundance and spatial distribution of sea cucumber in North West coast

SECTION 3.5

RESULTS

NORTHWEST COAST UNDERWATER

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SECTION 4.1

METHODOLOGY FOR

FISHERY DEPENDENT SURVEY ON

SEA CUCUMBERS AND CHANKS

4.1.1. Study area

Catch and effort data of the sea cucumber fishery in the north western coastal waters of Sri Lanka were collected at the major landing centers in Kalpitiya from October 2008 to April 2009 and this will be continued during the coming season too. Though it was unable to carry out regular field data collection in the east coast, we are trying to collect the data from divers and collectors personal records.

4.1.2. Frame survey

Frame survey was carried out in the east and north western coast to identify the major and minor landing sites, fishing effort, information on divers and localized migration pattern and the fishing season. The frame survey data sheet is attached in Annex 1.The major landing sites were assigned for the catch and effort data collection while the effort data were collected at the minor landing sites.

4.1.3. Catch and Effort data collection

The catch data were collected by making regular weekly field visits to the landing centers in Kalpitiya peninsula and relevant datasheets (catch and effort data sheet, biological datasheet) are in Annex 1. On each day more than 95% of the total number of boats operated was sampled randomly (Figure 17). Sampling was done as soon as the catch was landed. At the landing sites, sea cucumbers were grouped according to the species and the total length of each individual was measured to the nearest 1 cm using a measuring board. At the time of measurement, these sea cucumbers were alive. Before taking length measurements slight pressure was applied to their bodies. Then they start to elongate and at one point no further elongation takes place. The total length was measured at this point. The total weight of each individual was also measured using a field balance. Weight of each individual was taken before evisceration and after evisceration.

The catch of different species, total catch and the number of divers engaged in the fishing operation were recorded for each boat sampled. Time of fishing and information about the fishing ground were obtained by interviewing the fishermen. The total number of boats operated in a particular day was also recorded to estimate the total catch for the day.

All the newly found species were brought the laboratory for further identification. The gut contents and the reproductive organs were collected together with the length and weight for biological sampling.

Frame survey activities ï counting effort

Major landing site at Kalpitiya

Minor landing site at Kalpitiya

Commercial catches - Mixed

Commercial catches ï One species

Taking length measurements

Figure 17: Activities related to catch and effort data collection

4.1.4. Data analysis

In the present analysis, one fishing trip was considered as a unit of effort. Total catch and effort for each month and the monthly variation of the catch of each of the most abundant species were estimated from the data collected on each sampling day.

The monthly total production (MTP) of sea cucumber fishery was estimated as the product of mean catch (in numbers) per boat (CPUE), mean number of fishing operations per day (NFO) and the mean number of fishing days for that particular month (MRD):

$$MTP = CPUE \times NFO \times MRD$$

SECTION 4.2

RESULTS OF FISHERY DEPENDENT SURVEYS

4.2.1. Results of the frame survey

The identified major and minor landing sites in the North West and east coast are summarized in table 17 with the existing fishing efforts.

Table 17: Identified major and minor landing sites through frame survey

Area	Landing site	Status	Fishing Effort
NW	Uddappuwa	Minor	8
	Sinnapaduwa	Major	23
	Kandakuliya	Minor	5
	Kudawa	Major	27
	Kalpitiya	Major	48
	Wannimundalama	Major	97
EC	Kathirawelli	Major	25
	Wakarei	Minor	5
	Kayankerni	Major	13
	Oddamawadi	Major	25
	Kalkuda	Major	7 + 10 (oru)
	Punnakuda	Minor	8
	Navaladi	Major	15
	Kaththankudi	Major	12
	Kalmunei	Major	10
	Kalmuneikudi	Minor	5
	Palamunei	Minor	9
	Akkarapaththuwa	Major	13
	Komariya	Minor	7

4.2.2. Fishing season

Fishing season for sea cucumbers along the north western coast of Sri Lanka starts in the middle of October and continues until the end of April of the following year. The fishing activities in east coast starts in middle May and continues up to late September. Therefore, this fishery is seasonal. No fishing is carried out when the sea is rough.

4.2.3. Seasonal migration

All most all the divers in North west coast migrate to east coast specially to Wakarei, Kathrawelli, Kayankerni, Oddamawadi, Kaththankudi, Palamunei, Akkaraepaththuwa and Komariya during the offseason. The traditional divers in east coast are restricted to the Punnakuda, Navaladi, Kalmunaei and Kalmunaeikudi. However there are no records about the divers migration from east to Northwest though it has happened in vice versa.

4.2.3. Fishing crafts

The fishing crafts used is FRP boats with 15 or 25 Hp outboard motors. In some landing sites (Kalkuda) traditional orus are also used as the fishing crafts (Figure 18). Normally two divers and a boat operator go for a fishing trip but sometimes there are three divers onboard.

The fishing crafts leave around 7.30 am ï 8.00 am and return around 2.30 pm ï 3.30 pm when day diving activities are carried out. When night fishing is done they leave around 7.00 pm and come back in the early morning around 2.00 am. There are variations in fishing depths in day and night diving activities. Day diving is carried out up to 30 m while night diving is restricted 8 to 10 m.

FRP boats with outboard motors

Traditional fishing craft (Oru)

Figure 18: Commonly used fishing craft for sea cucumber fishery

4.2.4. Fishing gear

Sea cucumbers are mainly harvested through diving and hand picking. The scuba diving is carried out by almost all the divers (Figure 19) and skin diving is practiced by the fishers who are using traditional crafts as the major vessel. Four to five Oxygen tanks are used for a fishing trip when scuba diving is practiced and true fishing time is varied from 30 to 45 minutes per tank.

Scuba diving ï Major fishing method

Filling of scuba tanks in ñwadiyaò

Figure 19: Scuba diving activities and scuba tanks

4.2.5. Species dominance in the commercial catches

Twenty sea cucumber species were commercially exploited in the North West (NW) and East coast (EC) of Sri Lanka (Table 18). Some species are restricted only to east coast while some are in North western coast. However most of the species are commercially exploited in both the areas. *Holothuria spinifera* is the numerically dominant species in the commercial catches followed by *Holothuria atra.* However *Holothuria atra* was the most predominant species in the wild. The difference was due to selective harvesting based on the economic returns.

Table 18: Commercially exploited sea cucumber species in Sri Lanka

No	Scientific name	English name	Local name	Area
1	*Actinopyga echinites*	Deep water redfish	Goma attaya	NW & EC
2	*Actinopyga miliaris*	Blackfish	Kalu attaya	NW & EC
3	*Actinopyga mauritiana*	Surf redfish	Gal attaya	EC
4	*Bohadschia argus*	Leopard fish	Koti attaya	EC
5	*Bohadschia marmorata*	Chalkyfish	Duburu Nool attaya	NW & EC
6	*Bohadschia similis*	Brownspotted sandfish	Line nool attaya	NW
7	*Bohadschia* unidentified sp. 1		Sudu nool attaya	NW & EC
8	*Bohadschia* unidentified sp. 2		Kiri nool attaya	NW
9	*Bohadschia* unidentified sp. 3		Kiri nool attaya	NW
10	*Holothuria atra*	Lolly fish	Narri attaya	NW & EC
11	*Holothuria fuscogilva*	White teatfish	Preema attaya	NW & EC
12	*Holothuria nobilis*	Black teatfish	Polanga attaya	NW & EC
13	*Holothuria scabra*	Sand fish	Jaffna attaya	NW
14	*Holoturia spinifera*	Brown sand fish	Disco attaya	NW
15	*Holothuria sp(pentard)*		Preema bathik attaya	NW & EC
16	*Stichopus chloronotus*	Greenfish	Dabalaya	NW & EC
17	*Stichopus herrmanni*	Curryfish	Sani attaya	NW and EC
18	*Thelenota ananas*	Prickly redfish	Annasi attaya	NW & EC
19	*Thelenota anax*	Amberfish	Poona attaya	NW & EC
20	*Acaudina molpadioides*		Uru attaya	EC

4.2.6. Catch and Effort

Figure 20 shows the variation of fishing effort (in number of boats operated per day) in the day and night fishing activities. The highest fishing effort was observed in December 2008 for the day fishing activities and it decreases gradually after that and night fishing activities were dominant since January.

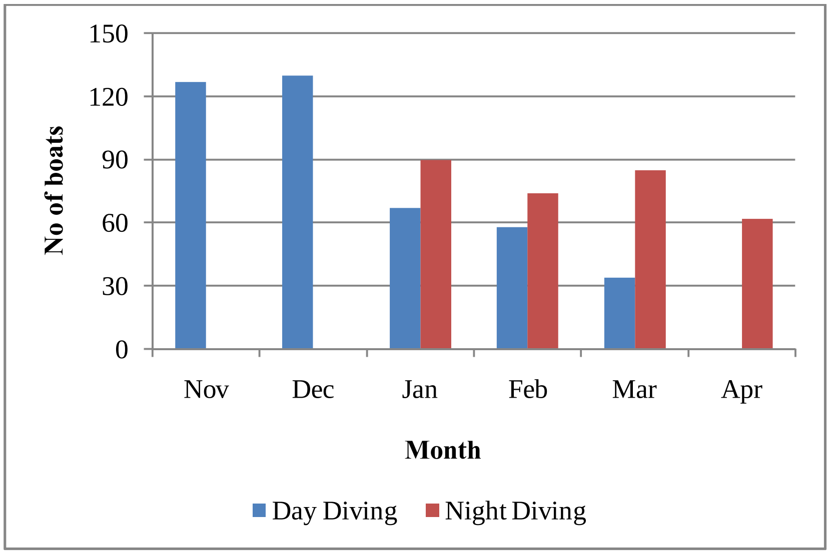


Figure 20: Total fishing effort in day and Night diving activities - NW coast

Monthly variation of total sea cucumber production (Number of individuals) is summarized in Figure 21 and the monthly variation of sea cucumber production (species wise) is summarized in Table 19.

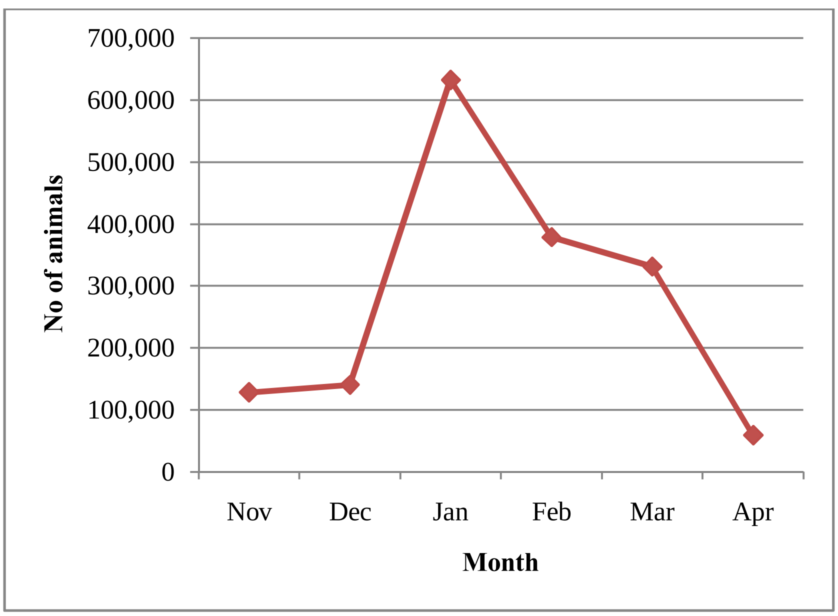


Figure 21: Monthly variation of total sea cucumber production

Table 19: Monthly variation of sea cucumber production (species wise) in NW coast

Month	November	December	January	February	March	April	Total
Holothuria scabra	725	324	2,907	2,099	1,432	347	7,833
Holoturia spinifera	0		532,142	269,010	203,677	35,574	1,040,403
Holothuria atra	62,263	78,173	33,068	35,785	18,628	504	228,421
Holothuria fuscogilva	227	95	32	0	35	0	389
Holothuria nobilis	0	77	16	103	0	0	196
Holothuria sp(pentard)	295	292	0	0	0	0	586
Actinopyga miliaris	5,451	6,183	3,127	2,679	987	0	18,426
Actinopyga echinites	1,027	968	1,474	1,210	455	0	5,133
Bohadschia marmorata	17,881	16,472	10,690	7,948	3,186	0	56,176
Bohadschia unidentified sp. 1	15,533	17,031	13,975	9,520	3,109	0	59,168
Bohadschia similis	0	0	12,683	16,711	21,781	6,045	57,219
Thelenota ananas	45	0	8	10	0	0	63
Thelenota anax	0	0	0	20,935	61,501	15,070	97,506
Stichopus chloronotus	24,399	20,290	22,585	12,343	16,179	1,058	96,854
Stichopus herrmanni	45	162	55	188	0	0	451
Total	127,891	140,066	632,759	378,540	330,971	58,597	1,668,825

Total sea cucumber production increases gradually since the starting of fishing season, becomes maximum in January and gradually declined after that. *Holothuria spinifera* reported the maximum production followed by *Holothuria atra* and the reported lowest production was from *Thelenota ananas*.

4.2.7. Variation in CPUE (Catch per Unit Effort)

The CPUE was calculated in terms of catch per boat per day and catch per diver per day. Figure 22 shows the monthly variation of catch per boat in day and night fishing activities. The CPUE in day diving shows gradual increasing trend from November to January and there after it decreases gradually. The highest CPUE in night diving was reported with the starting of fishing activities in January and the lowest CPUE was at the end of the fishing season in April.

Figure 23 shows the monthly variation of catch per diver per day (Catch per Unit Effort) in two different fishing activities. The trend is much similar to the previous.

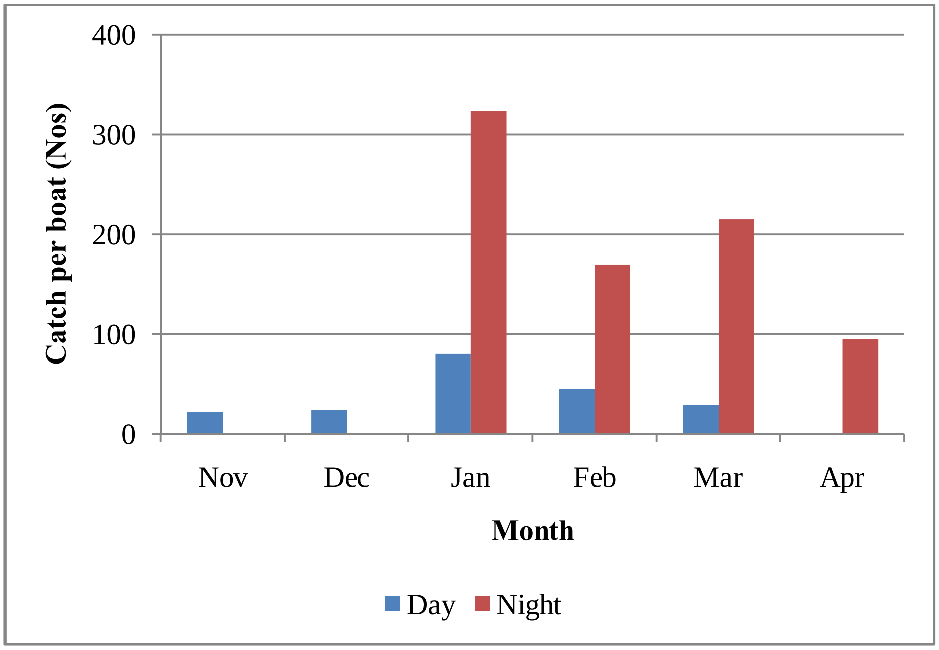


Figure 22: Monthly variation of CPUE in terms of catch (Nos) per boat

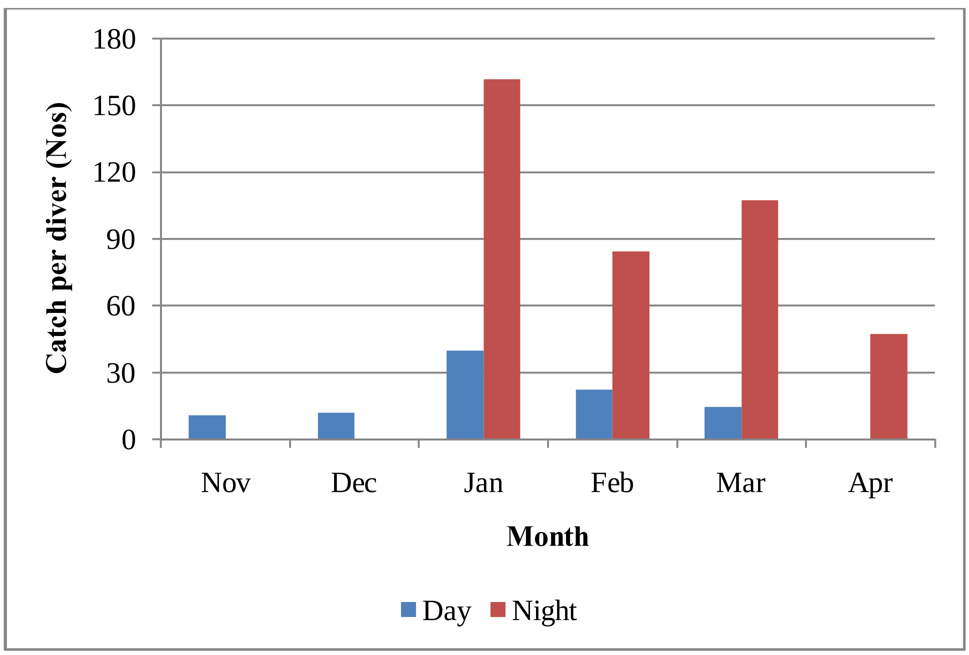


Figure 23: Monthly variation of CPUE in terms of catch (Nos) per boat

4.2.8. Length and weight of commercially exploited sea cucumbers

The length and weight ranges of commercially exploited sea cucumbers are summarized in table 20. The maximum length (56.1cm) was evident for *B. marmorata* while maximum weight (4200g) was evident in *H. fuscogilva.* The lowest values for length and weight 11.1 cm and 107 g respectively) were evident for *H. scabra*.

Table 20: Length and weight ranges of commercially exploited sea cucumbers in NW coast

Name	Length (cm)	Mean length (cm)	Weight (g)	Mean weight (g)
Holothuria scabra	11.1 - 29.5	18.2	107 ï 720	271.95
Actinopyga miliaris	17.2 - 41.3	27.5	220 ï 4000	675.59
Actinopyga echinites	13.5 - 30.7	22.59	374 -1325	669.2
Bohadschia marmorata	19.6 - 56.1	33.8	150 ï 3125	1148.42
Unid. Bohadschia sp	18.3 - 40.5	28.6	232 ï 1700	730.19
Holothuria atra	20.5 ï 35.4	27.2	350 ï 1100	595.00
Holothuria fuscogilva	25.2 - 46.2	35.6	1000 ï 4200	1892.19
Holothuria nobilis	23.8 - 41.7	34.2	985 ï 2500	1719.32
Holothuria sp. (Pentrad)	20.4 ï 40.2	33.3	845 - 2900	1524.35
Holothuria spinifera	14.5 ï 31.9	24.2	150 - 412	295.80
Thelenota anax	19.3-38.5	27.4	125 ï 495	378.25
Stichopus chloronotus	25.2 ï 38.7	31.3	285 ï 950	565.70

4.2.9. Market value of commercial sea cucumbers

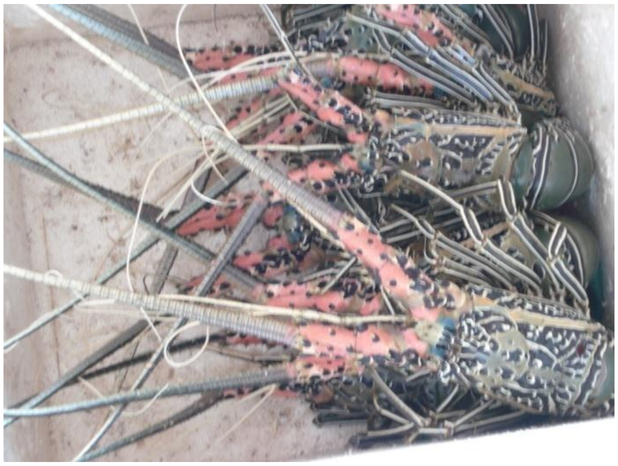
Value of the fresh sea cucumber is varying with the species. Table 21 shows the selling prices of sea cucumber species. There are higher market value for *H. nobilis* and *H. fuscogilva* while *Holothuria atra and Stichopus chloronotus* have the lowest market value.

Table 21: Selling price of commercial sea cucumber species

Name	Price (LKR)
Holothuria scabra	900.00
Actinopyga miliaris	500.00
Actinopyga echinites	500.00
Bohadschia marmorata	225.00
Unid. *Bohadschia sp*	225.00
Holothuria atra	40.00
Holothuria fuscogilva	1500.00
Holothuria nobilis	1200.00
Holothuria sp. (Pentrad)	1200.00
Holothuria spinifera	120.00
Thelenota anax	60.00
Stichopus chloronotus	40.00

4.2.10. By-catch species

Lobsters and some rock fish are frequently found as the by-catch species from sea cucumber fishery (Figure 25).



Lobsters as by-catch

Rockfish as by-catch

Figure 25: Major by-catch species in sea cucumber fishery

4.2.11. Constrains

The divers always complain that the Indian trawlers who are carrying their activities in Mannar are the big threat to sea cucumber industry in North west coast of Sri Lanka. During our survey we also came across such activities operated by Indian boats. The Indian vessels and some of their target species are summarized in Figure 25.

Indian vessels in Mannar

Lobster species targeted by Indian vessel

Figure 25: Activities carried out by Indian vessels in Mannar area

4.2.12. Discussion

There are four major sea cucumber landing sites in North western coast and eight sites in east coast. Fishing season is controlled by the monsoon pattern of the country and fishing activities are carried out non monsoon period. As a result of this fishing season in North western coast (October to April) is different from East coast (May to September). However there are slight variations of the fishing season from year to year. By taking the advantage of differences in fishing season in the two areas some fishers migrate between the areas during the season to dive for fresh sea cucumbers. More than 90% migrate from North West coast to East coast during the season but there are few records about the migration from east coast to North West coast. The migrant fishers either join local divers on a contract basis or work for a dealer or processor.

James (1994) reported that there are as many as 49 species of sea cucumbers in Indian Ocean whereas only 24 species are known from the Indian coast. These 24 species also inhabit the Gulfof Mannar (James, 1994d). According to Moiyadeen (1993), there are eight commercially important sea cucumber species in Sri Lanka. However the results of this study reveal that there are 20 commercially important sea cucumber species in the North western and east coast of Sri Lanka. Of these, *Actinopyga mauritiana*, *Bohadschia argus* and *Acaudina molpadioides* found only in east coast while *Holothuria scabra* and *Holothuria spinifera*, *Bohadschia similis,* Unidentified *Bohadschia sp 2* and Unidentified *Bohadschia sp 2* found only in the commercial catches of North West coast. All the other commercially exploited sea cucumber species could be found both East and North west coast.

The highest catches recorded from the *Holothuria spinifera* followed by *Holothuria atra* in the North west coast of Sri Lanka. The lowest abundant of high value species were also evident in the commercial catches in both the areas. The findings of the fishery independent survey results are also confirmed by the results of catch statistics. Though we found *Holothuria spinifera* fishing grounds in East coast through the second survey, still there are no records from commercial fishing activities for this species.

Due to the security situation in the country we could not able to collect the catch and effort data in east coast regularly as in North West coast during the last year. However we will make an attempt to collect the catch and effort data through the collectors and fishers and hope this will be success.

SECTION 5

PROPOSED SIZE LIMITS FOR LANDINGS AND EXPORTS FOR THE SELECTED SEA CUCUMBERS

5.1. Introduction

Sea cucumbers are highly diverse group of animal, found in many marine habitats at all latitudes, from foreshore to greater depths, playing an important ecological role in benthic communities as deposit feeders (Birkeland, 1989; Byrne, 1998). Many species of sea cucumbers are edible and an increasing demand world-wide for the dried body wall (beche-de-mer) has led to unsustainable fishing of natural stocks. The over-exploitation of traditional fishing grounds in the Pacific and Indian Oceans prompted fishers to migrate to new locations to target less valuable species (Conand 2004).

In Sri Lanka, the fishery is open access and no any regulation or precautionary approach was adapted so far except issuing licenses for diving and transportation. Further, to avoid the exploitation of undersized individuals, the exporters are not allowed to export the product if it exceeds **200 pieces for 1kg.** So the fishing activities are not under proper management procedure except having some precautionary approaches. Recently there are some signs of population depletion, including lower volumes of high value species and fishers having to travel further, and concerns were raised regarding the sustainability of the fishery.

In Sri Lanka, research on holothurians or any other Echinodermata species are at a very preliminary level. Intensive research studies are needed to be undertaken in the field of stock assessment, reproductive biology and ecology of sea cucumbers to prepare and implement a proper management plan for the sustainable utilization of this resource.

It is necessary to consider the several biological aspects such as age, growth, longevity, spawning, fecundity, recruitment distribution and size at first maturity for the proper management of this fishery. Several management practices including close season, close areas, size restriction and sea ranging have been implemented by several countries as conservative measures. Among these, size regulation is considered as the most effective and the important measure for conservation of sea cucumber and many regulations have been imposed under this. The sea cucumber population will be depleted drastically if the immature individuals were exploited continuously.

Reporting the weights of sea cucumbers in exports or studies using fishery-dependent surveys is fraught with difficulty and associated with errors because they can be in various stage of commercial processing at the time they are measured. Some studies have been conducted on various holothurian species to determine the average change in weight from whole, unprocessed animals to dried beche-demer (Conand, 1990, Skewes *et al*,2004). Animals sold or presented by fishers were in various forms of processing into beche-de-mer. On some occasions, the catch was just gutted**;** other times the animals are with gut; other times they were dried already. We need to convert the individual length /weight back to whole body length / weight in order to have a common unit for the purpose of analysis and make recommendation for implementing management practices.

This study aims to determine the changes in length and weight of some commercially exploited sea cucumber species in Sri Lanka from whole live through to fully process (dried) product which are ready for market. The findings of this study will be coupled with the available length or weight at first maturity information to determine the minimum size limit for commercial exploitation and exports. For the purpose of proper monitoring, it is advised to consider the minimum size limit proposed for the export products based on the correlation between the live and processed products as well as information on size at first sexual maturity.

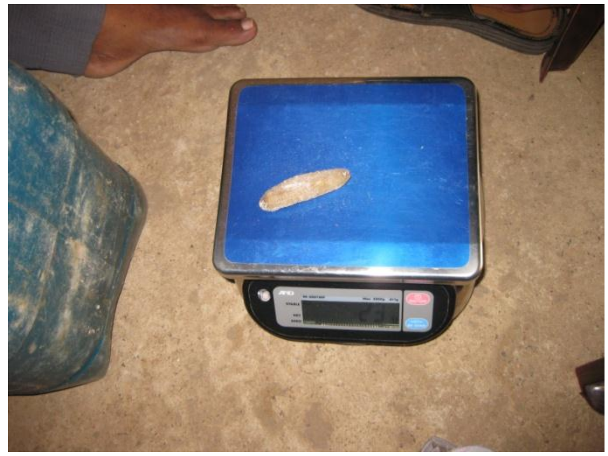
5.2. Methodology

The 30 to 40 samples of each species (*Stichopus chloronotus*, *Thelenota anax, Holothuria atra,* and *Bohadschia* sp 1) were obtained from the fishers at the landing sites and the remaining process was continued with the help of processing factories in the North western coast of Sri Lanka. Weights of individual sea cucumbers at different processed stages were gathered by tracking individuals through the processing chain in the processing factories. The tags were attached to each specimen and each individual was followed through the process train, from live whole to final product.

In the landing sites, the animals were drained on the deck of the boat for approximately 1 minute, and then the whole body length and weight were taken (to nearest 1cm in length and 1g in weight) using the measuring tape and an electronic balance. The viscera were then removed, by cutting the animals as practiced by the fishers and gutted length and weight measurements were taken. Tags were placed through the body wall of the animals; a plastic label was threaded through the anus with fishing line. Samples were then transported to the processing factory for further processing. Once in the processing factory samples were weighed after first boiling, removal from the salt, second boiling and at the different stages of drying up to final dried product beche-de-mer (Figure 26).

The length and weight loss of each sea cucumber species were calculated at each successive stage of processing. The available information of size at first maturity (length and weight) was coupled to establish minimum landing size and the information on processing was used to determine the suitable size for export materials. The study period was extended up to 3 weeks starting from 2nd April 2009.

Measuring length



Measuring weight

Tagged animals

Measuring tagged animals

Figure 26: Different activities related to tagging of sea cucumber

5.3. Results

5.3.1. Major steps of processing

Different species of sea-cucumbers are processed in different ways. Though there are some modifications from species to species, the major processing procedure of sea cucumbers involves the following steps.

1. Grading and cleaning

After the sea cucumbers are brought to the landing site, grading and cleaning them in sea water is carried out to remove dried slime, sand and other extraneous particles (Figure 27a). While cleaning, the animals are squeezed to remove the water absorbed during storage.

2. Evisceration

After cleaning evisceration is carried out, a small slit is made near the posterior end with a sharp knife (Figure 27b). Then the intestine, gonads and the respiratory trees run out of the slit immediately.

3. Boiling (first time)

After evisceration, sea cucumbers are boiled in a clean barrel. Sea cucumbers are subjected to stirring during the boiling (Figure 27c). The boiling time depends on the type of species and a wire mesh is used to remove the boiled product from the barrel.

4. Store in salt or burying

The boiled product (Figure 26d) is either stored in salt (Figure 27e) or buried in the moist sand to activate the bacterial decomposition. Again the storage time depends on the species.

5. Boiling (second time)

All the species are boiled once again to destroy all remnants of bacteria which digested the outer layer.

6. Drying

Drying is one of the most important operations in the processing of sea-cucumbers. Sun drying is considered to be better when compared to smoking. Sun drying is very frequent and the boiled sea cucumbers are transferred to drying platforms or mats for sun drying (Figure 27f)

Figure 27a : Grading of sea cucumbers

Figure 27b: Removal of internal organs

Figure 27c: Boiling of sea cucumbers

Figure 27d: Boiled Sea cucumbers

Figure 27e: Boiled sea cucumbers in salt

Figure 27f: Sun drying on gunny mats

5. 3.2. Length and weight changes of *Stichopus chloronotus*

Stichopus chloronotus is locally known as **Dabala attaya**, has firm, rigid ventrally flattened body. Body of the *S. chloronotus* is dark green to black in colour with dorsally arranged double row of large papillae which are yellow in colour. The live form and the proceed form of *Stichopus chloronotus* are illustrated in Figure 28a and Figure 28b.

Figure 28a: *Stichopus chloronotus* – Live

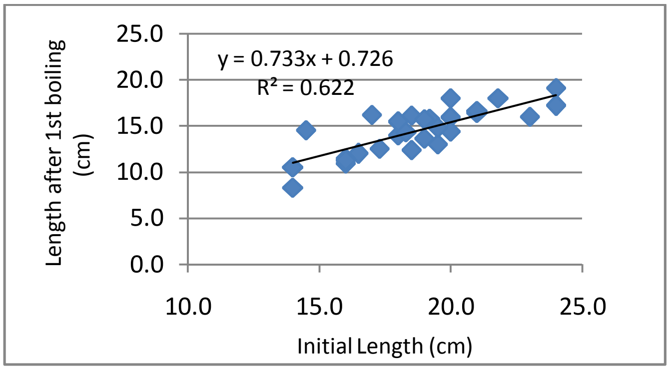
Figure 28b: *Stichopus chloronotus*- Processed

The percentage length and weight losses (an average) of *Stichopus chloronotus* in the major processing steps are summarized in Table 22 and the graphical relationship is in Figure 29.

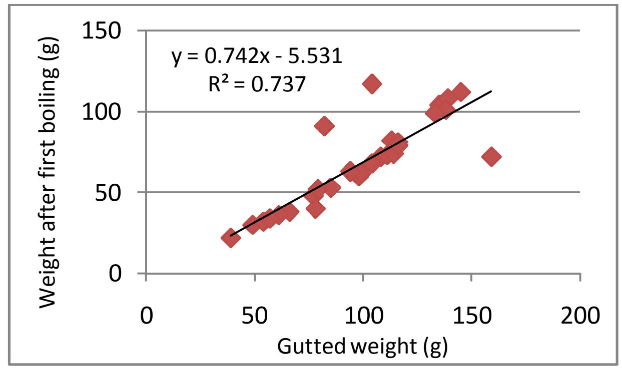
Table 22: Percentage length and weight changes of *S. chloronotus* on processing

No	Processing steps	Percentage length ± SD (cm) with respect to initial length	Percentage weight ± SD (g) with respect to whole live weight
1	Fresh specimens	100 (18.6 ± 2.7 *)	100.00 (145.81 ± 40.93*)
2	Evisceration		67.18 ± 10.80
3	First boiling	76.8 ± 7.6	44.88 ± 10.74
4	Second boiling	58.5 ± 6.8	26.71 ± 7.39
5	First step of drying	38.0 ± 4.3	6.96 ± 2.27
6	Dried product	36.2 ± 4.5	3.87 ± 1.03

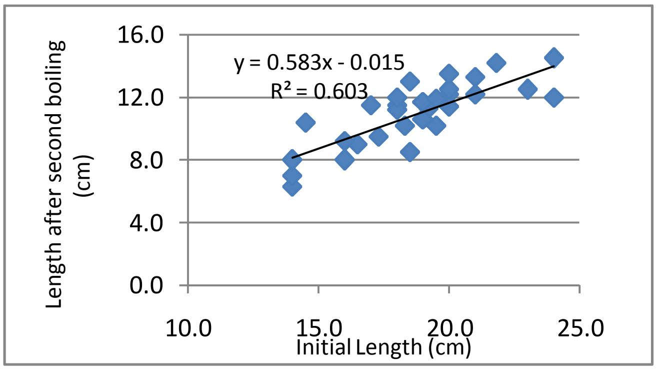
*This indicates the real length / or weight value.



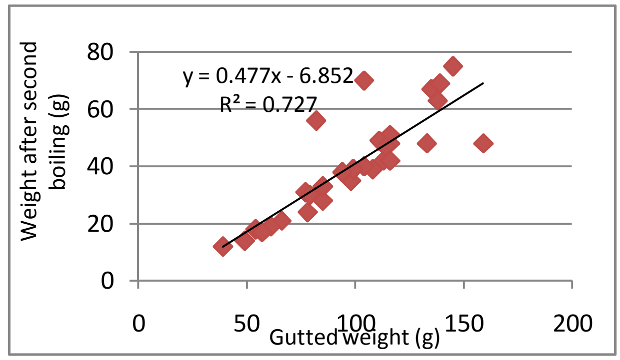
Initial length vs length after first boiling



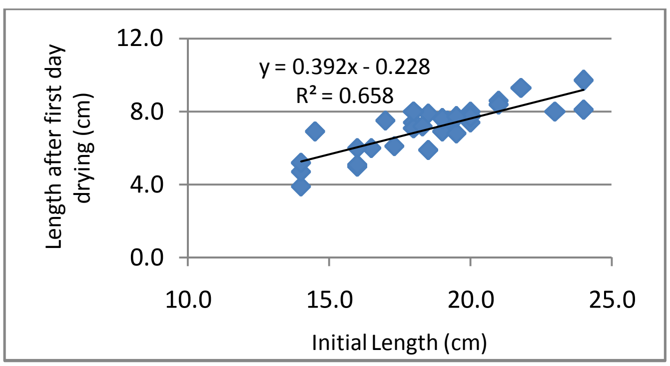
Gutted weight vs weight after first boiling



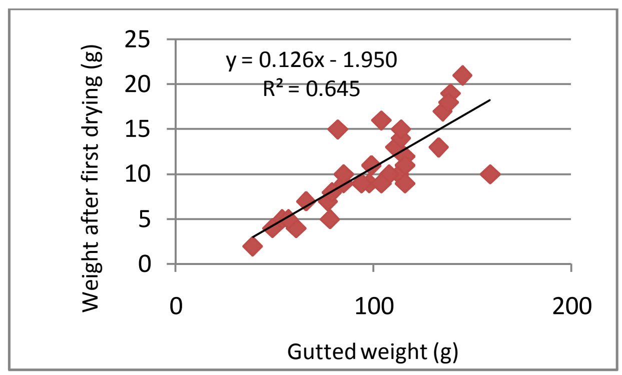
Initial length vs length after second boiling



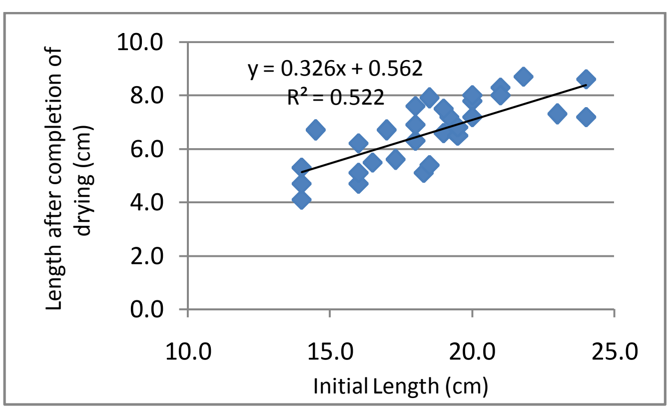
Gutted weight vs weight after second boiling



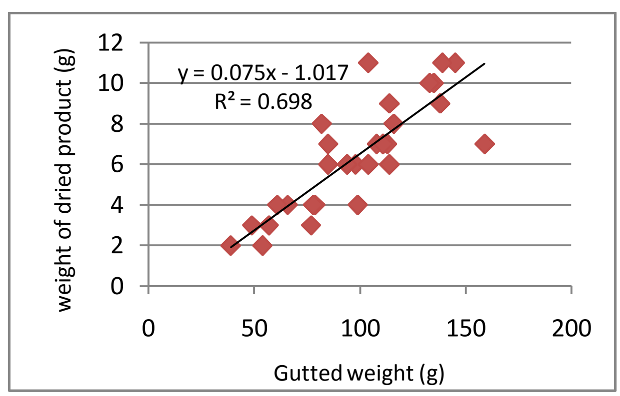
Initial length vs length after first phase of drying



Gutted weight vs weight after first drying



Initial length vs length of final product



Gutted weight vs weight of final product

Figure 29: Length and weight changes of *S. chloronotus* in the major steps of processing

It indicates that there is 63.8 % length reduction and 96.13 % weight loss (whole live weight) of *Stichopus chloronotus* when it is processed to beche ï de-mer.

5.3.3. Length and weight changes of *Thelenota anax*

This species is locally known as **Poona attaya**. The body of *Thelenota anax* is firm, rigid, squarish in cross section and flattened ventrally. Dorsal body (bivium) is cream in colour with large beige dots and entirely covered with numerous conical papillae. Trivium (ventral surface) is also beige in colour. The bivium is demarcated from the trivium by a row of large papillae. The anus is terminal and the ventrally located mouth is surrounded by a circle of 18 large brown tentacles. The live and processed forms of *Thelenota anax* are illustrated in Figure 30a and Figure 30b.

Figure 30a: *Thelenota anax* – Live

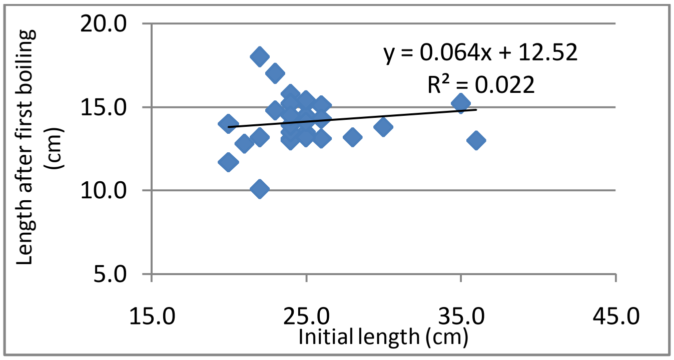
Figure 30b: *Thelenota anax* - Processed

The percentage length and weight losses (an average) of *Thelenota anax* in the major processing steps are summarized in table 23 and the graphical relationship is illustrated in Figure 31.

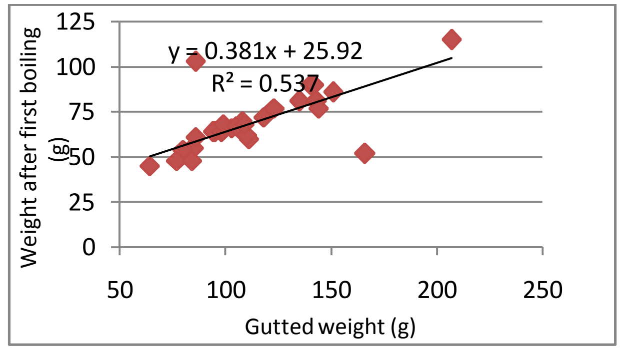
Table 23: Percentage length and weight changes of *T. anax* on processing

No	Processing steps	Percentage length ± SD (cm) with respect to initial length	Percentage weight ± SD (g) with respect to whole live weight
1	Fresh specimens	100 (24.8 ± 3.6 *)	100.00 (314.81 ± 68.16*)
2	Evisceration (gutted)		36.01 ± 8.80
3	First boiling	58.1 ± 9.5	22.41 ± 4.98
4	Second boiling	46.3 ± 6.6	9.73 ± 2.25
5	First step of drying	38.1 ± 5.7	7.52 ± 1.66
6	Dried product	35.5 ± 4.9	6.23 ± 1.46

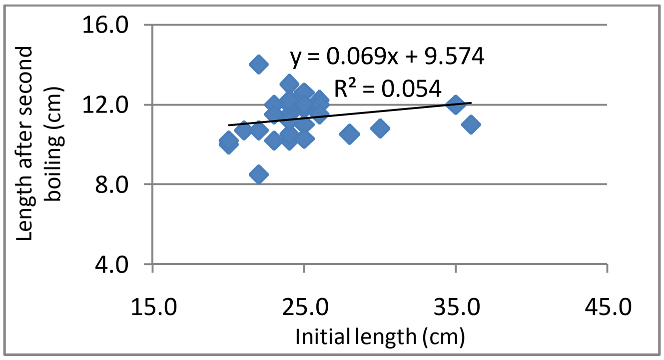
*This indicates the real length / or weight value



Initial length vs length after first boiling



Gutted weight vs weight after first boiling



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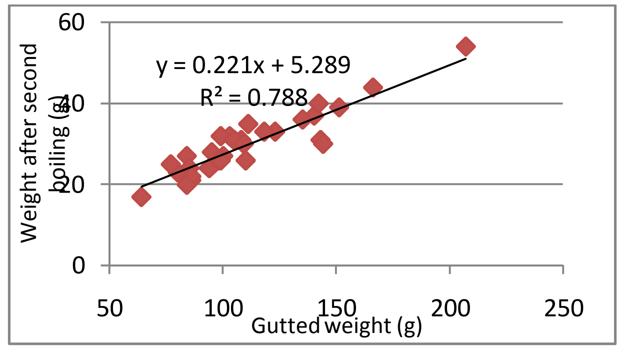
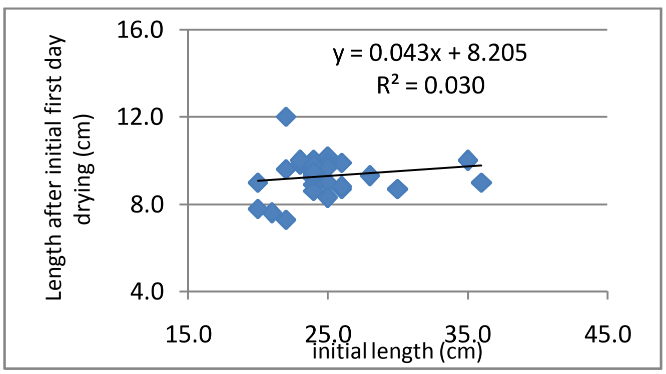
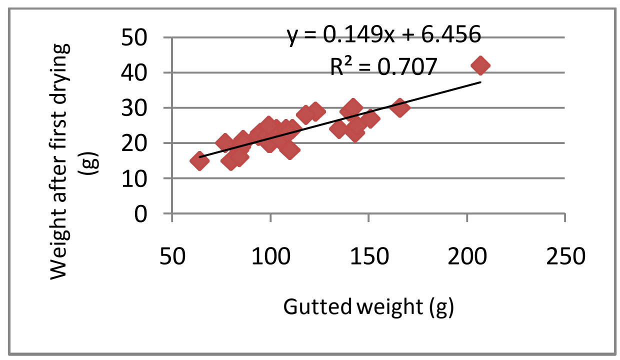


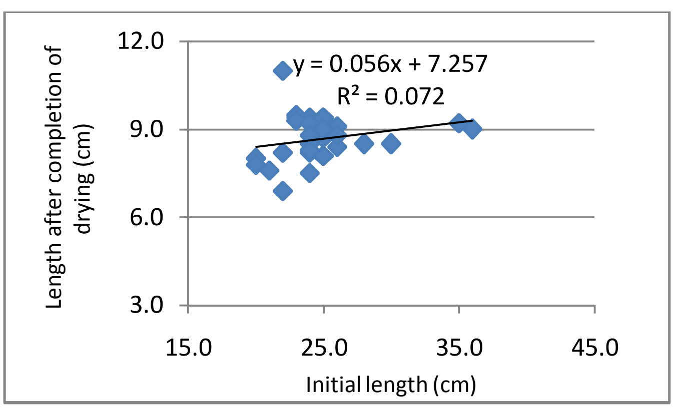
Gutted weight vs weight after second boiling



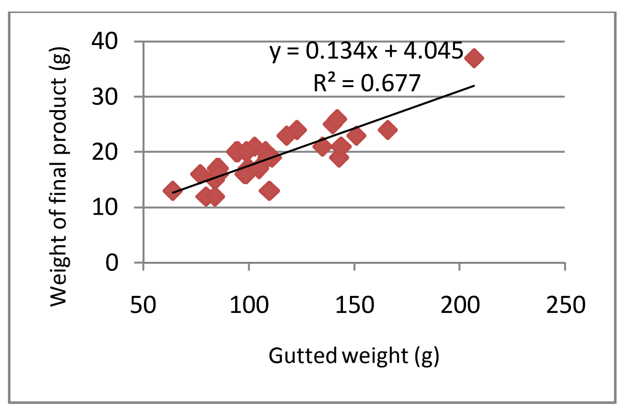
Initial length vs length after first phase of drying



Gutted weight vs weight after first drying



Initial length vs length of final product



Gutted weight vs weight of final product

Figure 31: Length and weight changes of *Thelenota anax* in the major steps of processing

It indicates that there is 64.5 % length reduction and 93.77 % weight loss (whole live weight) of *Thelenota anax* when it is processed to beche ï de-mer.

5.3.4. Length and weight changes of *Holothuria atra*

Holothuria atra has an elongated cylindrical body with rounded ends and this species is locally known as **Nari attaya**. Tables and rosettes are the most predominant spicules in the tegument. The body is entirely black. A red fluid is secreted upon rubbing the body surface vigorously and when live specimens are handled, a red fluid stains the hand. The live and processed forms of *Holothiria atra* is illustrated in Figure 32a and Figure 32b.

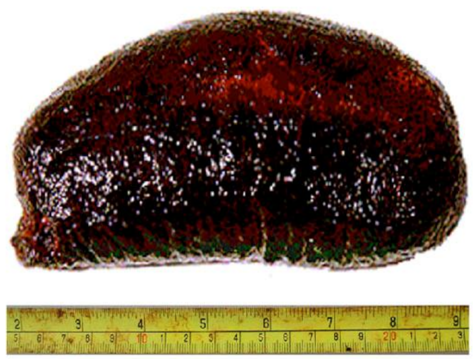


Figure 32a: *Holothuria atra* – Live

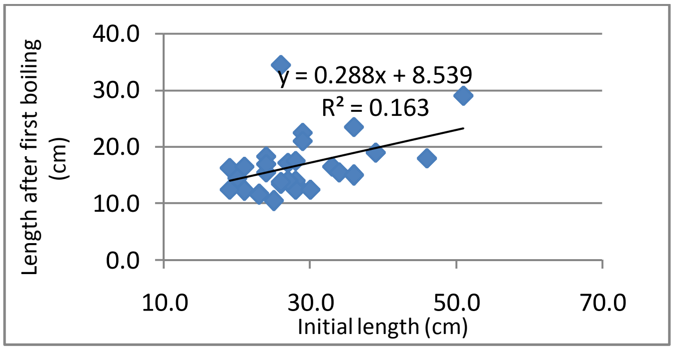
Figure 32b: *Holothuria atra* - Processed

The percentage length and weight losses (an average) of *Holothuria atra* in the major processing steps are summarized in Table 24 and the graphical relationship is illustrated in Figure 33.

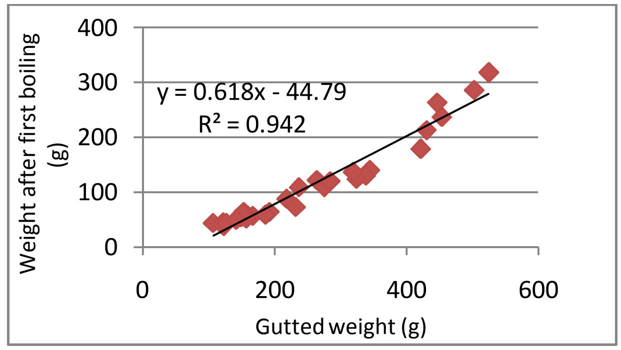
Table 24: Percentage length and weight changes of *H. atra* on processing

No	Processing steps	Percentage length ± SD (cm) with respect to initial length	Percentage weight ± SD (g) with respect to whole live weight
1	Fresh specimens	100 (28.3 ± 7.5 *)	100.00 (440.76 ± 219.12*)
2	Evisceration (gutted)		52.99 ± 10.66
3	First boiling	60.5 ± 18.6	25.99 ± 12.74
4	Second boiling	51.9 ± 12.2	20.98 ± 10.01
5	First step of drying	45.3 ± 10.9	13.47 ± 7.38
6	Dried product	43.6 ± 9.5	9.46 ± 4.68

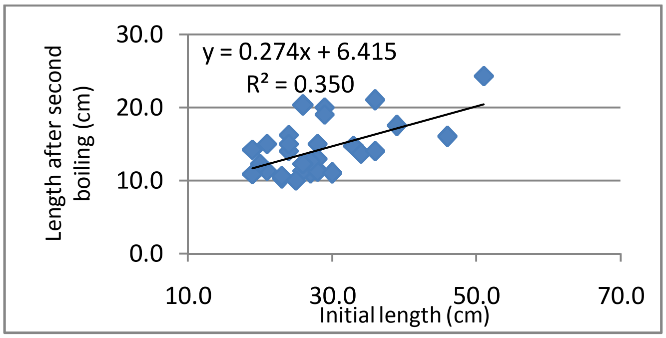
*This indicates the real length / or weight values



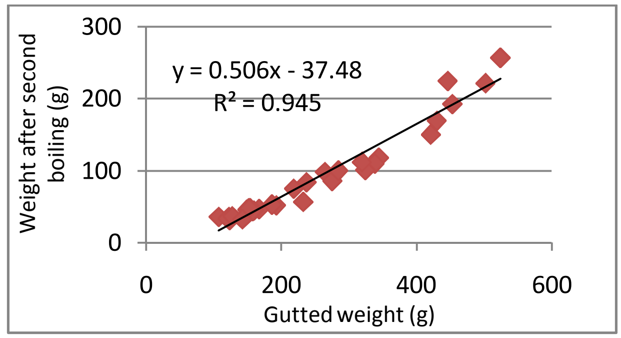
Initial length vs length after first boiling



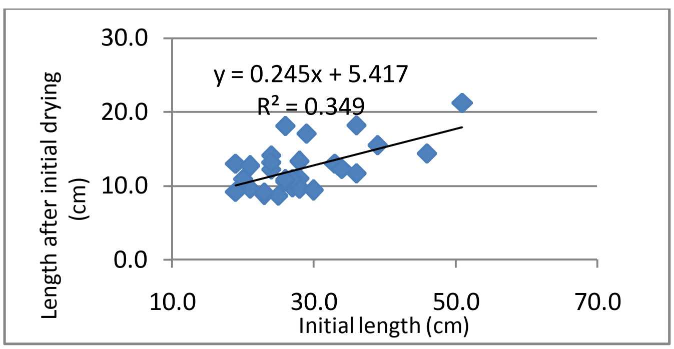
Gutted weight vs weight after first boiling



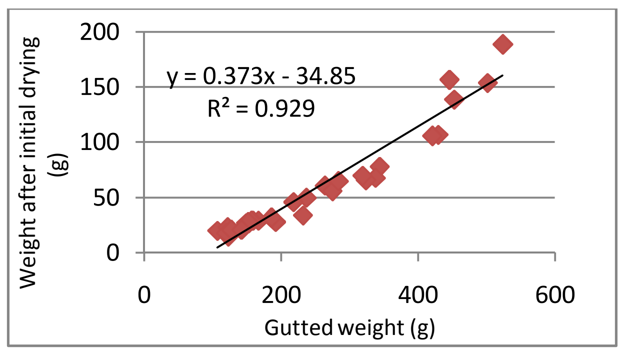
Initial length vs length after second boiling



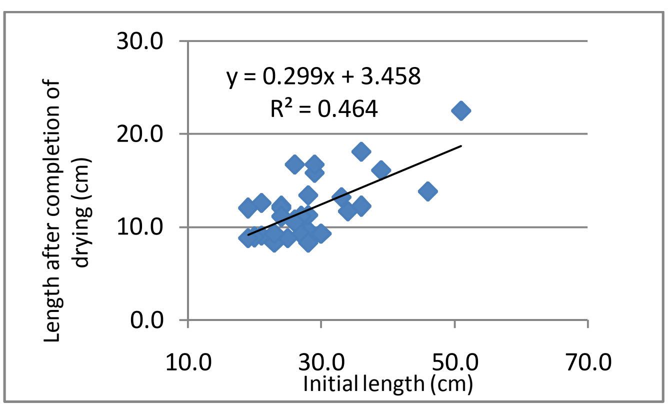
Gutted weight vs weight after second boiling



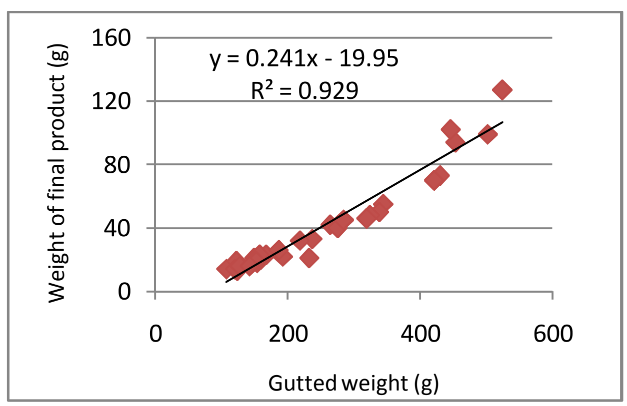
Initial length vs length after first phase of drying



Gutted weight vs weight after first drying



Initial length vs length of final product



Gutted weight vs weight of final product

Figure 33: Length and weight changes of *Holothuria atra* in the major steps of processing

It indicates that there is 56.4 % length reduction and 90.54 % weight loss (whole live weight) of *Holoyhuria atra* when it is processed to beche ï de-mer.

5.3.5. Length and weight changes of *Bohadschia* sp 1

This species is locally known as **Sudunool attaya** and has a short and thick body with the slightly flattened ventral surface. Body colour is highly variable usually light brown with small brown dots. White sticky threads are expelled when they are disturbed. Spicules are in the form of spinose and branched rods. The live and processed forms of *Bohadschia* sp 1is illustrated in Figure 34a and Figure 34b.

Figure 34a: *Bohadschia* sp 1– Live

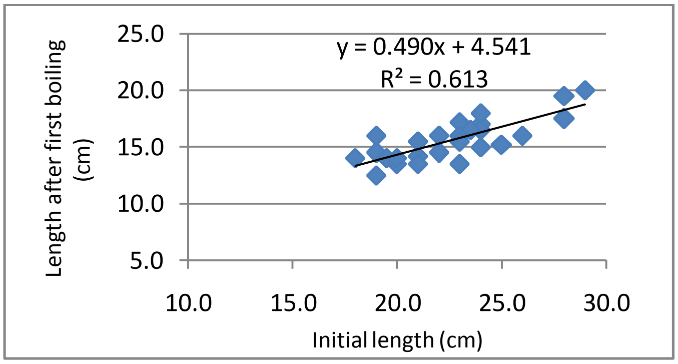
Figure 34b: *Bohadschia* sp 1- Processed

The percentage length and weight losses (an average) of *Bohadschia* sp 1in the major processing steps are summarized in Table 25 and the graphical relationship is illustrated in Figure 35.

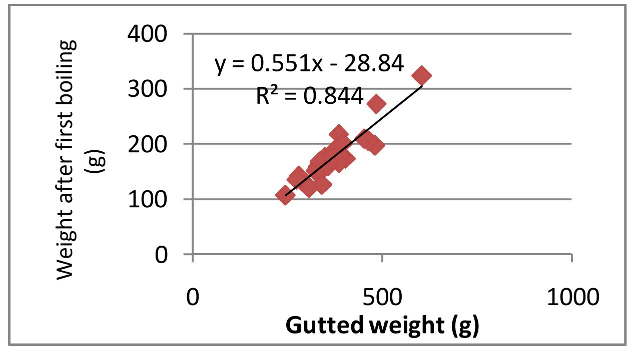
Table 25: Percentage length and weight changes of *Bohadschia* sp 1on processing

No	Processing steps	Percentage length ± SD (cm) with respect to initial length	Percentage weight ± SD (g) with respect to whole live weight
1	Fresh specimens	100 (22.6 ± 2.7 *)	100.00 (590.33 ± 152.54*)
2	Evisceration (gutted)		65.29 ± 14.55
3	First boiling	69.4 ± 5.5	30.97 ± 8.30
4	Second boiling	60.9 ± 4.6	24.68 ± 6.44
5	First step of drying	55.2 ± 4.8	15.01 ± 3.99
6	Dried product	52.8 ± 5.1	10.28 ± 2.65

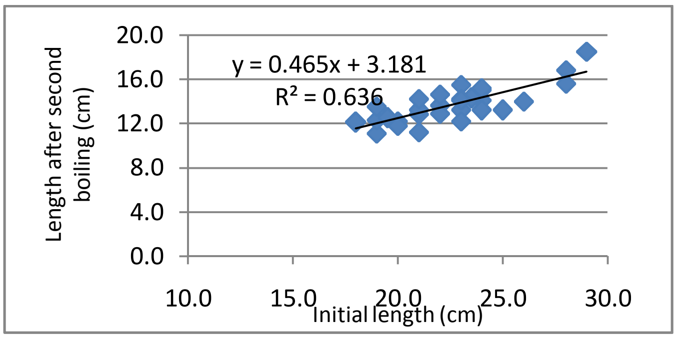
*This indicates the real length / or weight values



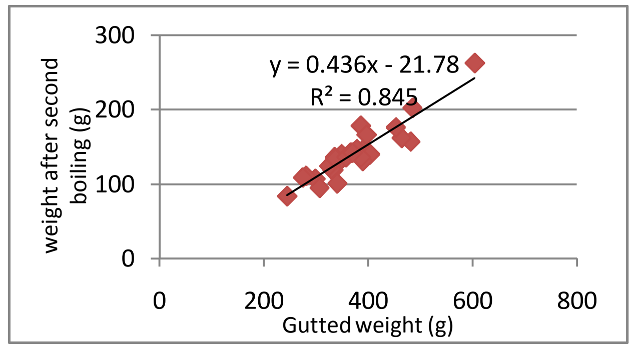
Initial length vs length after first boiling



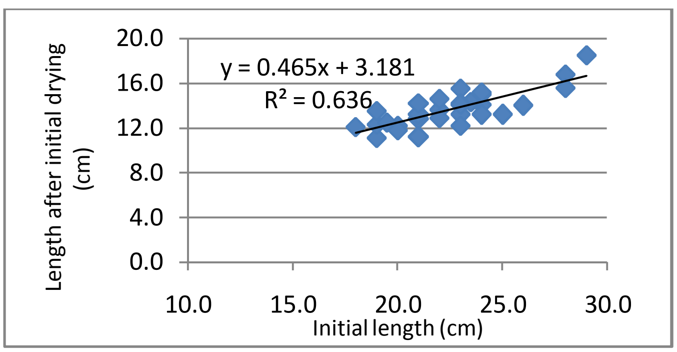
Gutted weight vs weight after first boiling



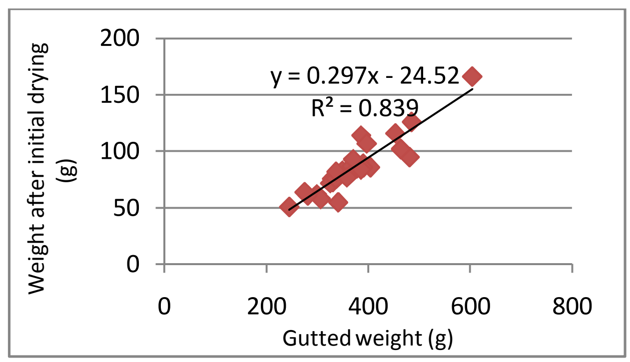
Initial length vs length after second boiling



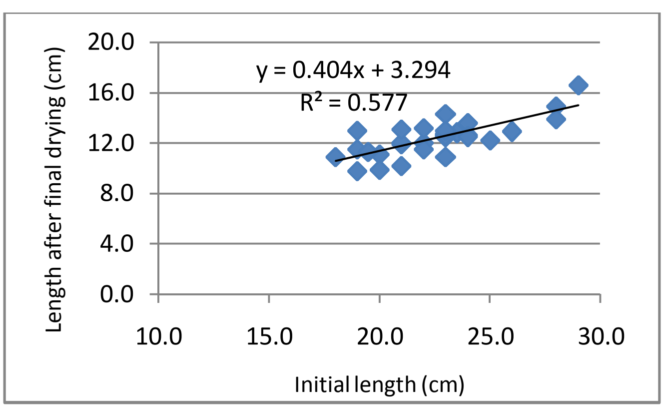
Gutted weight vs weight after second boiling



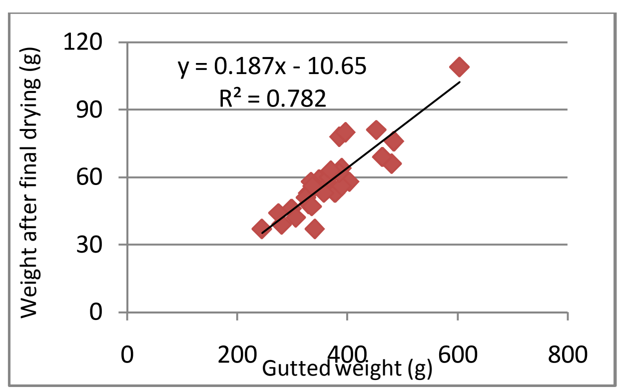
Initial length vs length after first phase of drying



Gutted weight vs weight after first drying



Initial length vs length of final product



Gutted weight vs weight of final product

Figure 35: Length and weight changes of *Bohadschia* sp 1 in the major steps of processing

It indicates that there is 47.2 % length reduction and 89.72 % weight loss (whole live weight) of *Bohadschia* sp 1 when it is processed to beche ï de-mer.

5.3.6. Information on first sexual maturity

Table 26 summarizes the length and weight at first sexual maturity of selected four species of sea cucumbers and this is based on the published literature and the research on reproductive biological studies.

Table 26: Length (cm) and weight (g) of first sexual maturity

No	Species	Length at first maturity (cm)	Weight at first maturity (g)
1	*Stichopus chloronotus*	15.5	100
2	*Thelenota anax*	25	180
3	*Holothuria atra*	16. 5	160
4	*Bohadschia* sp 1	20	290

5.3.7. Proposed size limits for landings and exports

An attempt was made to estimate the minimum landing size for the above sea cucumber species based on the information on first sexual maturity. Then these estimated values were in cooperated with the processing data to verify the size at landings. The estimated minimum landing size and the processing sizes on each species is summarized in Table 27.

Table 27: The estimated minimum landing size and processing size (length (cm) and weight (g)

No	Species	Estimated minimum landing length (cm)	Estimated minimum processing length (cm)	Estimated minimum landing gutted weight (g)	Estimated minimum processing weight (g)
1	*Stichopus chloronotus*	16	**6.5**	100	**10**
2	*Thelenota anax*	26	**8.5**	180	**27**
3	*Holothuria atra*	17	**8.0**	160	**15**
4	*Bohadschia* sp 1	21	**10.6**	290	**45**

5.4. Discussion

As shown in similar studies, the proportion of weight loss through processing varied markedly among species. If export data of dried length and weights of sea cucumbers are to be converted to fresh (landing) weight, it is far more accurate to convert data on a species-by-species basis than to use one approximate factor to convert weights of all species combined. Even within genera, we found large variations in conversion factors for lengths and weights.

According to our findings, the dried *Stichopus cloronotus* represented just 3.3 percent of their initial body weight concurs closely with 3.9 per cent stated by Skewes (2004). According to Skewes (2004), the weight of dried *H. atra* ranges from 2.6 ï 7.7 percent of its live weight but this study reported the less weight loss than him. It is difficult to make any comparison for *Thelenota anax* and *Bohadschia* sp 1 due to unavailability of published literature.

However, the live weight relationships were generally more variable (lower R^2) than the gutted weight relationships. This variability in live weight can be attributed to variable amounts of water and sediment in the digestive track and the respiratory tree (Sewell, 1991) and means that live wet weight is a less reliable estimate of somatic weight than gutted weight.

By considering the information of size at first maturity of each species and changes in processing, we were able to determine the minimum landing size for selected sea cucumber species. For the means of better management, it was decided to correlate the changes in weight and length during processing. Minimum landing size for both fresh and processed product was estimated and this will help to strength the monitoring programme both at the landing as well as exporting. Further, findings of parts of this study will help formulate new management practices.

5.5. Benefits

These relationships will be useful for the stock assessment, management and monitoring of the beche-de-mer fishery in Sri Lanka. The regressions of individual weights will be used to convert live weights from size frequencies gathered in the field during population surveys and catch monitoring to produce comparable weights for gutted weight and processed weight. This will be used for producing TACs in gutted weight and the equivalent likely processed product weight.

The average recovery rates provide an insight into the efficiency of the processing methodologies as they now stand, for comparison with data from other areas and historical data and for assessing the effect of any future changes in processing techniques.

The conversion ratios contained herein are the best estimator for converting pooled catch data from one processed state to another, where the size frequency of the catch is not known.

SECTION 6

RECOMMENDATIONS FOR SEA CUCUMBER FISHERIES MANAGEMENT

6.1. Major concepts for management

It is necessary to have better management plan to ensure sustained yields for fishers. This means that the exploitation today does not take away potential income resources from future generations in Sri Lanka. Many sea cucumber fisheries worldwide have experienced ñboom-and-bustò cycles (Lovatelli et al. 2004), where fishing pressure and revenues increase over several years then the stocks become quickly depleted to states where fishers can no longer make profit and fishing activity ceases for many years. A recent example of this is the sea cucumber fishery in Egypt, which collapsed after just four years of intensive fishing (Lawrence et al. 2004, Hasan 2005).

In Sri Lanka, the fishery is open access and no any regulation or precautionary approach was adapted so far except issuing licenses for diving and transportation. Further to avoid the exploitation of undersized individuals, the exporters are not allowed to export the product if it exceeds 200 pieces for 1kg. Hence the fishery is totally an unregulated. Recently there are some signs of population depletion, including lower volumes of high value species and fishers having to travel further, and concerns were raised regarding the sustainability of the fishery. The results of the underwater surveys confirm the risk of the overexploitation of some sea cucumber species. In the context of fishery sustainability, we need to take immediate management measures specially to east coast.

1. It is a need to ban the day diving activities for some period in the east coast of Sri Lanka to safeguard the further depletion of stocks. This suggestion is based on the outcomes of the two underwater surveys carried out in the east coast in 2008 and 2009. However, before implementing this measure, it needs to have detail discussion with all the stakeholders. To some, this scenario may seem sensationalist. But the reality is that many national fishery authorities have recently had to instigate moratoriums on fishing sea cucumbers because stocks became depleted through unregulated or imprudent fishing. In the past decade, commercial fishing of sea cucumbers has been banned in Solomon Islands, Palau, Vanuatu, Tonga, and for some species in Fiji and Australia (Kinch et al. 2008).

2. Another concept that we need to pay our attention is the need to maintain the reproductive capacity of sea cucumbers populations. Sea cucumbers are sedentary and gonochoric ð i.e. they move relatively slowly and individuals are male or female, not

hermaphroditic. This means that they must find each other, or get close to each other, during spawning periods. If animals are too far apart, they may not find mates in spawning periods or the sperm released from males is too far from females to successfully fertilize the oocytes (unfertilized eggs) that they expel. When this occurs, the reproduction from those populations fails to compensate for annual mortality of animals, and the population declines to a point where the animals become locally extinct or reproductively extinct ð i.e. some individuals may still exist but there is no effective reproduction. This effect is called the Allee effect (Allee 1938) or ódepensationô, and is believed to be a primary cause of collapse of many invertebrate fisheries, particularly sedentary groups. In some sea cucumber fisheries, negligent over-fishing depleted the populations to levels at which they could not recover, even 50 years after fishing stopped (Battaglene and Bell 2004). Obviously, it is valuable to know the density at which populations need to be maintained to allow successful reproduction. However, such density thresholds are poorly known for sea cucumbers. Bell *et al.* (2008) overview the scant research on minimum viable densities for successful fertilization in sea cucumbers and speculate that the ñthreshold densities to avoid depensation for most tropical sea cucumbers will be in the range of 10 to 50 individuals ha-1 over substantial areas, depending on species and locationò. The management of the sea cucumber fisheries in Sri Lanka should therefore evaluate densities of adult sea cucumbers of each species regularly and gauge whether sufficient numbers of dense populations exist in the fishery to ensure that populations will be replenished after the losses from fishing

3. Another management goal should be to maximize the money earned by fishers for each animal collected. This means preventing the capture of small animals, and two germane points should be considered. Firstly, larger animals give greater returns to fishers because they are heavier and the sale price and export price is governed by weight, not numbers of individuals. Secondly, larger bêche-de- mer command much higher prices than smaller pieces per kilogram. Thus, a one-kilogram animal may be worth ten times the value of an animal harvested at 250 grams. In this context, minimum legal size limits provide better long term benefits for all stakeholders with commercial interests because the resource is exploited in a way that maximizes profit

4. In a broader context, fisheries management should ensure that the animals can play their natural role in maintaining ecosystem health. Thus, a precautionary approach links fisheries management intimately with general environmental management (FAO 1996). Sea cucumbers consume detritus, made up of dead organic matter like decaying algae, sea grass and bacteria. They convert these ówasteô materials into animal flesh, that can re-enter the food chain, and they convert some of the organic matter into dissolved nutrients that can be re-used by reef flora (Uthicke, 2001). Thus, sea cucumbers play an important role in recycling nutrients in marine eco systems. Moreover, some species bury into sediments at some times of the day and, in doing so, are believed to contribute to sediment health by aerating the surface layers. Therefore, although this has only been demonstrated at very small scales, maintaining adequate numbers of sea cucumbers should improve the health of the shallow marine eco systems.

5. The important management goal should be to maintain and improve the biodiversity values of marine eco systems. Tourist operators, scientists and conservation groups have interests in communities that are speciose. The management plan for these sea cucumber fisheries should ensure that rare species or those vulnerable to local extinction, are preserved on each area. This requires underwater assessments to document species richness and nominate rare species. So it is recommended to assess the sea cucumber population at least two years interval through underwater resource assessment. The responsibility of the management authorities is then to prohibit fishing of rare species and maintain biodiversity by closing fishing of certain commercial species that become threaten.

6. It is suggested to develop a management plan and test it. This starts with establishing the desired outcomes of the management (i.e. what are the goals?). Decisions are then made about what management regulations are best suited to the fishery to achieve the outcomes and what actions are needed by the managers to implement and sustain them. The last phase involves a critical appraisal some time later (e.g., some years after implementing the management rules) of whether the management scheme delivered the desired outcomes. For example, the fishery service should see if the average size of exported sea cucumbers is larger and whether breeding populations are returning to healthier densities. This approach is needed especially when biological and ecological information on the species is limited, as is the general case for sea cucumbers.

6.2. Management recommendations

The recommendations are guided by the general goals outlined in the previous section. The recommendations are based on findings from the different research components of the project and published results and accounts from other similar fisheries. In this chapter two sets of management recommendations are proposed:

(1) Actions should be taken by the fisheries services (Ministry of Fisheries, Department of Fisheries)

(2) Fishery regulations that should be imposed on the fishers and processors.

Most of the proposed regulations are already being applied in other countries, and we do not present these as new ideas.

A – Actions by the Fisheries Service (Ministry of Fisheries/ Department of Fisheries/ NARA)

1. *Strengthen education and communication with fishers*

This does not suggest that fishers donꞌt know anything and they are unaware of the fishery rules. It is best to view this as a need for more interactions between fisheries officers and fishers, than a lack of comprehension by fishers.

An education plan should also be more than just a campaign to tell fishers and processors about the fishery rules. It is necessary to communicate with fishers and processors, and this should be formally scheduled to ensure that all fishers are told the fishery regulations and each receives some face-to-face education about sea cucumbers, the fishery, and the status of stocks. It should involve discussion between government officers (Fisheries Inspectors, Researches in NARA), and fishers about the growth and reproductive biology of the species in non-scientific terms. The education program should ensure that fishers understand how stocks replenish themselves after being fished, how old animals are that they are fishing, and the sizes at which animals mature. Only through this understanding they will appreciate the need for size limits and fishing reserves and be prepared to respect them. All of the stakeholders should be educated to understand why the fishery regulations are in place and how each regulation acts to improve the benefits for all stakeholders.

A communication plan should modify periodically by which fishery officers and other agents interact with fishers. Fishers and processors should be helped to receive newsletters, both local and regional, and information aids like identification guides. Feedback should be gathered from the fishers about changes in the species, sizes, catch rates, and sites where they fish, and this is best done using organized data sheets so the information can be later compiled and shared. The communication strategy should also work the other way ð to inform fishers about new studies or the evolution in exports or resource densities.

2. Instruct and train customs officers to record exports for species separately

It has been a recurrent key recommendation from international workshops that exports of bêche-de-mer from countries must be recorded by species, not species groups (Lovatelli et al. 2004, Friedman et al. 2008). Export data is easy and cost-effective to collect when compared to field data or sociological surveys. It can provide valuable insights into changes in the amount and species being collected by fishers, which can serve as cost-effective indicators of overfishing. However, it is impossible to use export data as indicators for assessing evolution in fishing when records are taken for species groups instead of species. The weights of exported bêche-de-mer must be recorded for each species.

Unfortunately, exports of bêche-de-mer from Sri Lanka are recorded only in broad categories of species groups. This is inadequate for fishery management, and does not conform to the standards requested by the United Nations-FAO for global monitoring of fishery captures (Lovatelli et al., 2004). While it is true that dried sea cucumbers are difficult to identify, this task can be made easy with some brief training by fishery officers. Identification of bêche-de-mer is not an impossible task. It is possible to prepare a poster or identification cards for custom officers to help them recall names of species based on dried bêche-de-mer.

3. ***Help to improve the quality of processing by fishers***

Some of the value of bêche-de-mer is attributed to the size of the animals but much of the value can be gained or lost through the boiling and drying stages. Profit will be lost if sea cucumbers are handled roughly, boiled too long or too hot, or not dried well enough. Processors are quite aware of good techniques for handling, boiling and drying sea cucumbers to achieve a top quality bêche-de-mer. But some do not use good processing methods, and this was a frequent complaint of exporters. The relevant authorities should promote the training of fishers in optimum methods of processing sea cucumbers into bêche-demer and this should involve practical workshops organized by the Ministry of Fisheries / Department of Fisheries. Improved processing by fishers will allow greater óvalue addingô to harvested animals and increase the overall economic gains from the same amount of captured animals. At the same time, it will avoid wasted value of bêche-de-mer that can come with poor processing. While many processors simply want to buy uncooked sea cucumbers so they can do the boiling and drying themselves.

4. Develop a schedule for surveillance and inspections

The responsible government Authorities (Ministry of Fisheries/ Department of Fisheries) should establish a periodicity for inspecting catches and exports of sea cucumbers. It should be made clear who will do the inspections and how often.

Inspecting processed and semi-processed sea cucumbers at processing centers will generally be easier than inspecting landings of fishers. There are many fewer processors, and they are easier to contact than fishers. Inspecting the sizes and species of sea cucumbers at processing centers will force processors to buy only animals that are sanctioned by the management plan. The processors will naturally impose these same restrictions on the product they buy from fishers. Thus, fishers will be forced to leave certain species and small animals because all processors will refuse to buy them, rather than through the risk of being inspected by government agents. Nonetheless, some inspections of fishers should also take place, and a number of these inspections should be scheduled each year.

Enforcement of the fishery regulations (recommended below) should be strict and severe. It should establish penalties for the sale or purchase of animals that are under the size limit or on a list of prohibited species, and for the sale or purchase of sea cucumbers from unlicensed fishers. Firm penalties will benefit processors, the stocks, and eventually fishers too.

5. Develop a plan for monitoring wild stocks and fishing

The relevant government bodies (Ministry of Fisheries/ Department of Fisheries / NARA) should commit to conducting a predetermined number of landing surveys every year. These are not time consuming, and require little equipment and technical capacity.

The form in Appendix 1 can be used for recording data. The data should be entered into a database and analyzed each year to examine changes in CPUE, species collected and size frequencies of the animals.

Surveying the sea cucumber populations in the field requires a great deal of equipment and some technical competence. We recommend that it is necessary to schedule to re-census sites every 2 to 3 years. There should also be predefined limits of acceptable stock abundance and predetermined actions to take if stocks have declined lower than the limits. Some new sites, not covered in the current project, could be surveyed in addition to re-censusing some of the same sites described here. The field evaluations will provide a basis for removing some species from the list of permitted species if stocks appear depleted, and conversely for reinstating other species onto the list if their populations have recovered to predetermined levels at which they could be fished again.

B – Regulations imposed on fishers

6. Impose conservative size limits for fresh (unboiled) and dried sea cucumbers

Minimum legal size limits should be placed on both dried and fresh sea cucumbers. Sizes will be much easier to verify on the dried product (bêche-de-mer) than on fresh animals. However, fishers generally agreed that size limits should also apply to live animals, rather than caught, gutted or salted animals. A simple plastic ruler with graduations corresponding to size limits of species would be the easiest tool for fishers to use to verify sizes of animals in the water. This could easily have small colour photographs next to the graduation marks. Body length rather than body weight seemed the preferred metric by stakeholders to regulate minimum size limits. The minimum legal size limits should best be based on studies on the size at first sexual maturity of sea cucumbers, rather than opinions by fishers and processors about what are ñgood sized animalsò. As a minimum, the L90 (estimated body length at which 90% of the population is mature) from the size-at-maturity analysis curves could be used as the minimum legal size. As best practice, the size limits should be large enough such that animals can have at least one year to spawn after reaching maturity. Therefore, a more conservative approach would be to add some centimeters to the L90 so that most animals have a year of protection before reaching legal fishing size.

There may be some benefit in grouping species that have similar estimated size limits, rather than having many different sizes for fishers and processors to remember. This will involve a trade-off between loss of some rigor of the optimum size based on size-at-maturity studies and gains in simplicity of the size limits. For example, there are about 20 species that are fished in Sri Lanka but perhaps these could be allocated into 6 to 8 size-limit groups. But at the beginning, we can practice this regulation for some selected species.

7. Establish a list of species permitted to be caught and sold

There are some species that are naturally very uncommon (i.e. ñrareò) in and others that appear to have become uncommon through excessive fishing. We observed that both groups of species are fished in Sri Lanka; i.e. some fishers do occasionally collect a few individuals of ñrareò species even ones that we have not recorded in this study. A list of species permissible for capture, sale and export should therefore be established and set in the management plan. It should also seem logical to fishers that only common species should be exploited. Species that are naturally very uncommon, or ñrareò, should be prohibited from capture to preserve biodiversity on reefs; a goal of management discussed above and an explicit consideration for the precautionary approach to fishery management (FAO 1996).

Likewise, species with depleted stocks should also be prohibited from capture to allow some years for their breeding populations to recover to abundance levels that can again withstand some light fishing pressure.

In order to avoid ambiguity as to the origin of processed sea cucumbers for export, it would be best to establish the same list of permissible species to all over the country. Those species not on the list should not be collected, sold, purchased or exported. Fishers and processors should also understand that the list will be re-evaluated periodically ð species may be added or removed depending on field population surveys.

There were several species that appear to be naturally rare, at least in terms of our transect surveys, and some for which we did not find any individuals but they are reported to exist in Sri Lanka. Several of these very uncommon species could be large enough and have thick enough body walls to be of interest to fishers.

Some species are, therefore, rather vulnerable to over-exploitation and should be management conservatively, in ways that maintain sufficient breeding populations on reefs so populations can replenish themselves after losses from fishing.

Populations of *Actinopyga mauritiana Holothuria scabra, Holothuria fuscogilva, Holothuria nobilis* and *Holothuria sp (pentard)* also appear low to very low at most localities, but there are still a small number of dense or moderately dense breeding sub-populations. A conservative measure would be to ban fishing of these species now.

Alternatively, it could impose large minimum size limits on these species in particular, and monitor stocks in the coming years. At the next review of the list of permissible commercial species, these species should be evaluated in close detail.

The advantage of species-specific closures is that fishers can still collect other species. We encourage an adaptive process by which species can be added or removed depending on new information about stocks. We also recommend a conservative approach; that is, remove species from the list of those that fishers can collect if stocks appear low ð donőt wait until stocks are depleted. This will avoid the need for restocking, which is a very costly intervention that has its own problems of altering the natural genetic variation of populations and hurdles of research on release strategies.

8. Fishers licensed and buyers licensed

As is currently practiced, all commercial fishers must obtain a license from the Department of Fisheries in order to carry out sea cucumber fishing activities. Moreover, it would be best to have separate permits or ćconcessionsô for collecting and selling sea cucumbers in particular.

The separate permits for fishing sea cucumbers would serve to better regulate the impact of fishing, since this would mean that not all fishers can harvest sea cucumbers. That is, it would limit opportunistic shifting of resources by fishers. The Department of Fisheries would also better know who is fishing this resource, which would simplify the communication of information about this fishery.

Likewise, buyers, processors and exporters should be licensed for those activities. In the same way as for fishers, a license for processors and the obligation to submit logbooks would aid in the regulation and communication of the fishery.

For example, those fishers or processors who do not submit logbooks, are caught with undersized animals, or are caught with prohibited species could be refused a license the following year.

9. Introduce logbook system to collect catch data

We need to think about the collection of catch data from fishers, collectors and processors regularly. For this it is good to implement a log book system and a procedure to monitor it. It needs to implement new regulations regarding this and if somebody fails to submit the logbook, they are not issued fishing license for the following year. By this way, it is easy to obtain the data on regular basis and it will provide time-series analyses of evolution in catches among the regions.

10. Limited entry – restrict the number of licensed fishers

The fishers and the processors viewed that it is better to limits on the number of fishers licensed to collect and sell sea cucumbers. The survey results shows that stocks of some species are relatively healthy, stocks of many others appear vulnerable to being depleted if fishing effort is not reduced. We recommend that it needs to restrict the number of licenses issued to fishers as a means of reducing total fishing effort. Based simply on the average population abundances of sea cucumbers, we believe the number of licenses for fishing sea cucumbers should be restricted.

The reducing the number of licensed could be done through inspection of annual logbooks and only renewing licenses to fishers who are seriously fishing sea cucumbers (i.e. fishers regularly collecting sea cucumbers) and also maintaining and submitting the logbook. However, we believe that this should not mean only issuing license to fishers that intensively fish sea cucumbers, or those which only fish sea cucumbers. It will be far better for fishers to be able to harvest other resources, so that they have some ‘resilience’ to changes in the markets or resource, than to encourage fishers to only exploit one resource. A different approach would be to impose the size limits, species-specific closures and reporting rules and renew licenses only to those fishers that adhere to the regulations.

11. Catch reporting and sale reporting by fishers and processors

Obviously, the fishery will be best managed if the relevant authorities have accurate and timely data on catches. This data can show variations in CPUE and species captured over time and among locations. This should best be achieved by forcing fishers to complete logbooks of daily catches and submit them each semester or year as a condition of license renewal. As mentioned earlier, all of the processors said they had either been in contact with, or purchased sea cucumbers from, unlicensed fishers. This makes management harder since the number of fishers is unknown and not everyone can be informed about the fishery regulations.

Fishing by unlicensed fishers also undermines fishers’ confidence in the way in which the fishery is managed and their willingness to adhere to regulations. For example, they can start to ask “why should I be restricted to catching certain sizes and reporting if others are not?” One way to reduce the incidence of unlicensed fishing is to oblige processors / collectors to complete purchase receipts provided by the Ministry of Fisheries / Department of fisheries each time they buy sea cucumbers. The processors should record the fisher’s name and license number and have the fisher sign the receipt. In theory, unlicensed fishers should then not be able to sell to processors and at the same time we can collect the accurate catch data. The receipts should include weights for each species of animal sold, and these measurements are generally made by the processors anyway. The department should be strict about the non-renewal of licenses to fishers and non-renewal of buyers’ licenses if reporting is inadequate. If all processors believe that the rules will be applied to all, then they will be more likely to refuse purchasing sea cucumber if they know that other processors cannot buy them either.

In principle, catch quotas should be based on a reasonable estimate of the total standing stock of the resource in the fishery and a reasonable estimate of the fishing mortality that the stock can sustain without diminishing population size. An even more important hurdle with quotas is determining whether they are set per person (individual quotas) or apply to the whole fishery. Having a quota for the whole fishery (a ‘global’ quota), instead of individual quotas, means that industrialized fishers can catch the majority of the catch early and leave other small-scale fishers without a livelihood for the rest of the year after the quota has been reached. So it seems that the allocation and equity of individual quotas among fishers is also problematic. Further, it seems that quotas would be hard to administer.

Seasonal closures can be used in other types of fisheries for two purposes: (1) to prevent fishing of animals during seasons when they are more vulnerable to capture, such as when animals aggregate to spawn or move to exposed sites on reefs to spawn, and (2) to limit the amount of days in a year that fishers have to collect the animals. The first use does not apply to the vast majority of sea cucumbers, because they do not aggregate (other than in loose pairs or trios) nor move to more visible places to spawn. The second is fine, except that it deprives fishers of earning an income for some months. As shown in this study, many fishers rely on sea cucumbers as their primary source of income. Fishing closures already exist in varying degrees specially due to monsoon.

Rotational closures are used in some well-organized fisheries where there are few fishing groups and where there are clear access rights over fishing grounds. Examples of rotational closures in sea cucumber fisheries can be found at the Great Barrier Reef in Queensland. However, rotational closures would be problematic for a number of reasons. The most cited problem was how to manage the surveillance of the fishing zones where there are many fishers and many of the sites are many kilometers offshore. Another commonly argued problem was the resources needed to demarcate, and mark, the various fishing zones. Further the annual rotational closures would mean the fishers in a locality were all fishing in a smaller area each year, so quotas would need to be set for each zone to ensure the resource was not depleted.

6.3. Conclusion

The sea cucumber fisheries in Sri Lanka are multi-species in nature. The resource needs fisheries management plans that consider the perpetuity of each species in the context of meta population structure of stocks. The projectôs field surveys showed that the community composition varied greatly among the survey sites and that sea cucumbers were not abundant at all sites. Resource managers should seek to ensure that there are at least some sites in each region that have dense breeding populations. These populations can act as source sites for neighboring areas where abundances may be low.

There were few study sites where valuable sea cucumbers were very abundant. Some commercial species were quite infrequent in our field surveys and are sought after by processors. Our study suggests that populations of *Actinopyga mauritiana Holothuria scabra, Holothuria fuscogilva, Holothuria nobilis* and *Holothuria sp (pentard)* are too low to support further exploitation.

Our field surveys and fishery-dependent surveys show that at least 20 species of sea cucumber are collected by fishers and about 10 to 12 of these are collected commonly. The species of high value are sought after by processors, but some species were not well represented in the landings of fishers. This tends to suggest that stocks of these species are depleted, in line with results from our field studies.

Training in processing is most needed. Some animals are collected at a small size, near or below the size at first maturity estimated by Conand (1993). This means there is some ‛recruitment overfishing’. Size limits must be implemented avoid this phenomena and it should be large enough to protect animals to maturity and allow them at least another year to contribute to spawning. If the taking of small animals was more evident, more education of fishers by fishery officers is needed.

The immediate implementation of proper management plan is must to ensure the sustainability of this resource in future.

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Appendix 1

UNDERWATER RTESOURCE SURVEY - SURVEY DATA SHEET

Day Diving ☐ **Night Diving** ☐

Site ID	
Site Coordinates	
Latitudes	
Longitudes	
GPS No	

Date DD MM YY	
Time	
Name of the Observer	
Name of the Recorder	

In Time	
Out Time	
Water Depth (m)	
Visibility	
Water Current	
Habitat Type	

	Sea Cucumber / Chank species	Length (cm)	Weight (g)	Collection of gut samples (Y/N)	Number of the sampling bottle
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Remarks

FRAME SURVEY DATA SHEET

SRI LANKA – FAO/CIDA – FRAME SURVEY FOR CHANK AND SEA CUCUMBER FISHERIES		
FORM TYPE: SCNK **FORM NO:**		**Data Collector:** ____________
Fisheries District:		
FI Division:		**Date:** ___/___/___
Location:		

FISHING UNIT			
Owner(s):		**Crew:**	
Reg.No:		**Type of craft:**	
License No.		**Length (ft):**	**HP:**

FISHING METHOD(S)

Target species

Sea cucumber: ☐

Chank: ☐

Day fishing: ☐ **Night fishing:** ☐

FISHING SEASON IN CURRENT LOCATION (Months)

1	2	3	4	5	6	7	8	9	10	11	12

SEASON IN OTHER LOCATION

Location:

1	2	3	4	5	6	7	8	9	10	11	12

ONBOARD EQUIPMENT

GPS	Light Source	SCUBA (Diving)	SKIN (Diving)	Other equipment
☐	☐	☐	☐	

Other relevant information

CATCH AND EFFORT MONITORING SHEET

1	Date					
2	Landing site					
3	Total number of boats operated					
4	Total number of boats sampled					
5	**Boat Number**					
6	Depature [Time]					
7	Arrival [Time]					
8	True diving Time [Hours]					
9	Number of diver / divers per boat					
10	Number of tanks per diver					
11	Average Fishing / diving depth [m]					
12	Total income					
13	Fuel cost					
14	Share of the diver					
	Catch / Species					
15	*Holothuria scabra*					
16	*Holothuria spinifera*					
17	*Holothuria atra*					
18	*Holothuria edulis*					
19	*Holothuria fuscogilva*					
20	*Holothuria nobilis*					
21	*Holothuria sp(pentard)*					
22	*Actinopyga miliaris*					
23	*Actinopyga mauritiana*					
24	*Actinopyga echinites*					
25	*Bohadschia argus*					
26	*Bohadschia marmorata*					
27	*Bohadschia similis*					
28	*Bohadschia sp 1*					
29	*Thelenota ananas*					
30	*Thelenota anax*					

31	*Stichopus chloronotus*						
32	*Stichopus herrmanni*						
33	*Acaudina molpadioides*						
	Others						
34	Chanks						
35	by-catch						

LENGTH AND WEIGHT DATA SHEET

Date [ ] Landing site [ ]

Boat No	Species	Length (cm)	Un-gutted weight (g)	Gutted weight (g)

SEA CUCUMBER AND CHANK - BIOLOGICAL SAMPLES DATA SHEET

Date ______ Landing site ______

Species	Code	Length (cm)	Un-gutted weight (g)	Gutted weight (g)
