SEA CUCUMBER CONSERVATION IN PALK BAY AND GULF OF MANNAR, INDIA

FINAL REPORT OF FAO-BOBLME SUPPORTED PROJECT

"AN EVALUATION OF THE CURRENT CONSERVATION MEASURES ON SEA CUCUMBER STOCKS IN PALK BAY AND GULF OF MANNAR OF INDIA"

Central Marine Fisheries Research Institute,
Kochi- 682018

September 2014 - June 2015

ICAR
CMFRI
BAY OF BENGAL LME
Food and Agriculture Organization of the United Nations

Final report of

FAO-BOBLME supported project

An evaluation of the

current conservation measures on sea cucumber stocks in Palk Bay and Gulf of Mannar of India

Central Marine Fisheries Research Institute,

Kochi-682018, India

September 2014–June 2015

Project team

Principal Investigator: **Dr P.S Asha,** Principal Scientist

Research Centre of CMFRI,

South Beach Road, Karapad,

Tuticorin-628001, Tamil Nadu

Email: ashasanil@gmail.com

Co-Investigators: **Dr B. Johnson,** Scientist

Mandapam Regional Centre of CMFRI,

Marine Fisheries P.O, Mandapam Camp,

Ramanathapuram District - 623 520,

Tamil Nadu

Email: jsfaith@gmail.com

Shri. L. Ranjith, Scientist

Research Centre of CMFRI,

South Beach Road, Karapad,

Tuticorin-628001, Tamil Nadu

Email: ranjith_bfsc@yahoo.co.in

Senior Advisor: **Dr E Vivekanandan**

Emeritus Scientist (ICAR),

Research Centre of CMFRI,

75 Santhome High Road,

Chennai 600 028

Email: evivekanandan@hotmail.com

Research Scholars: **Subin C.S**

M. Sheik Mohamed

Executive summary

Sea cucumber fishery and trade were one of the top non-finfish income streams for the coastal people of Palk Bay and Gulf of Mannar in the South East coast of India. As there was no regulation to control the fishery, there was a concern on decline in sea cucumber populations. In order to conserve the over-exploited stocks, the Ministry of Environment, Forestry and Climate Change, Government of India banned the fishery and trade of sea cucumbers by including them under Wild Life Protection Act 1972 since 2001. The enforcement of a blanket ban of sea cucumber fishing over the last 14 years might have helped in reviving their populations; at the same time, the ban would possibly had a social and economic impact on scores of people, who were dependent on the sea cucumber fishery. To understand the situation, the Bay of Bengal Large Marine Ecosystem (BOBLME) project approved a short term project to Central Marine Fisheries Research Institute (India). The project was intended to understand the sea cucumber stocks and implications of the ban on the livelihood of fishers in Palk Bay and Gulf of Mannar. The purpose of the project was also to suggest management options for conservation and sustainable use of sea cucumber resources.

The project was implemented during the period January-June 2015 in Gulf of Mannar and Palk Bay. Under the project, the following activities were undertaken: (i) inception workshop; (ii) preparation of status paper, (iii) sea cucumber resource surveys; (iv) interview surveys; (v) stake holder consultations and (vi) final workshop. The abundance of the sea cucumbers was measured by trawl and dive surveys following standard methods. Population characteristics were estimated for sea cucumber resources from both Gulf of Mannar and Palk Bay and were statistically interpreted.

Swept areas of 545,200m^2 (13 trawl hauls) in Gulf of Mannar and 213,100m^2 (12 trawl hauls) in Palk Bay were covered during the study period. Sea grass was the major trawl catch component and sea cucumbers constituted the fifth major group and comprised 3.4 and 3.04% of the catch respectively at Gulf of Mannar and Palk Bay. A very high positive correlation was noticed between sea cucumber and sea grass biomass at both stations ($p<0.001$).

In Gulf of Mannar, among the trawl survey sites, the density ranged between 325 and 13079 nos. ha^{-1} and biomass between 3.3 and 19.5kg ha^{-1}. In the dive survey, the density varied from 750 to 7875nos.$ha^{-1}$and the biomass from 171.2 to 2235.2kg ha^{-1}. In Palk Bay, the density ranged between 8033 and 1389nos.ha^{-1} in the trawl survey; and between 125nos.ha^{-1} and 6875nos.ha^{-1}in the dive survey. The biomass ranged between 0.065 and5.23kg ha^{-1} and 31.3 and 2950kg ha^{-1} in trawl and dive survey sites respectively.

Nine sea cucumber species with varying commercial values were collected from Gulf of Mannar. Medium valued *Stichopus horrens* was the major species with a mean density of 1599.8±619.2 nos. ha^{-1} followed by *Holothuria leucospilota, H.atra,Bohadschiamarmorata,H.scabra* and *H. spinifera*. Species like *Colochirus quadrangularis*, *Holothuria edulis* and an unidentified *Bohadscia* species were reported in small numbers. In Palk Bay, six sea cucumber species were recorded. 84.7% of the total catch was comprised of high valued *H. scabra* followed by *H.atra*, *H.spinifera,B. marmorata, S.horrens* and *H.leucospilota.* The variation in density for species like*Holothuria scabra*, *H.atra* and *H. leucospilota, B.marmorata* and *S. horrens* between Gulf of Mannar and Palk Bay was statistically significant ($p<0.01$). The diversity and density of sea cucumbers were higher in Gulf of Mannar than in Palk Bay which might be due to the higher depth and heterogeneous habitat in the region.

The high valued *H.scabra* population wascomparatively larger in Gulf of Mannar but majority of them were medium sized in Palk Bay. The length distribution pattern is unimodal for most of the species in Gulf of Mannar and Palk Bay. In Gulf of Mannar, the major species *Stichopus horrens* was collected from 59.7% of the survey sites and 13.6% each of the survey sites recorded their population in higher abundance of >5000nos.ha^{-1} and >1000 nos.ha^{-1} and the juveniles were abundantly distributed in seven sites. In Palk Bay, the major species *H.scabra* was reported from 96.2% of the survey sites and 19.2% of the sites reported their density >5000 nos.ha^{-1} and 30.8%

with >1000 nos.ha^{-1} and 34% with juveniles.The studies on length weight relationship indicated the allometric growth in sea cucumbers and it appears to be the general case of tropical holothurians and suggests that for a given length, the individuals collected from Gulf of Mannar were stouter than those collected from Palk Bay.

The interview survey targeted respondents involved in fishing/trade of sea cucumber. After the declaration of ban, 31% of the respondents discontinued the activity and others are continuing the sea cucumber fishing/trade. Those who discontinued reported that the ban has affected their livelihood. Before ban, most of the fishermen (85 %) sold sea cucumbers in the form of *beche-de-mer* (processed) and remaining (15%) sold the sea cucumbers in fresh form. During ban only 5% fishermen were processing and rest of the fishermen (95 %) was selling in fresh form. When compared to exporters share, fishermen received only half of the share in the sea cucumber marketing channel. The fishermen opined that the ban may be lifted at least for a few commercially important species with effective participatory co-management and conservation measures.

Considering the past experience of the project personnel, interview surveys and discussions with the stakeholders and experts on sea cucumbers, it was possible to bring out strong recommendations. As the moratorium on sea cucumbers is not effective and illegal fishing and trade are continuing; and there are indications that stocks have not declined in the last 14 years, it is suggested that the moratorium may be lifted and fishing may be opened with strict regulations.The opinion gathered from interview surveys and consultations with stakeholders suggests that a set of at least 4 or 5 regulatory measures may be needed to manage sea cucumber fisheries like seasonal closure during peak spawning periods, pulse fishing/rotational fishing, establishment of minimum legal size for fishing and processing, spatial closure and no take zone, gear limitation, catch quota, species and habitat protection and trade management etc.

Up gradation of already developed seed production techniques of two sea cucumber species (*Holothuria scabra* and *H.spinifera*) by CMFRI for mass production for restocking and mariculture is recommended as a favourable option for stock recovery along Gulf of Mannar and Palk Bay.

It is suggested that effective management of sea cucumber fishery could be achieved by following the ecosystem approach along with co-management. Since sea cucumbers are shared stock between India and Sri Lanka, it is important to arrive at bi-national agreement. It is recommended that a holistic approach for the management of Palk Bay and Gulf of Mannar may be followed by (i) setting up of a cooperative mechanism within the existing bi-lateral framework of the Governments of India and Sri Lanka, (ii) enhancing the knowledge on ecological characters and conducting impact assessments, (iii) ensuring conservation of resources and restoring fisheries habitats, (iv) ensuring effective stakeholder participation,(v) promoting livelihood options, and (vi) strengthening institutions and capacities.

Acknowledgements

We would like to express our sincere gratitude to the Food and Agriculture Organization (FAO) of the United Nations, and the Bay of Bengal Large Marine Ecosystem (BOBLME) Project for their financial support to this project.

We are extremely thankful to Indian Council of Agriculture Research (ICAR), New Delhi for permitting us to undertake this project.

We gracefully acknowledge the support and encouragement of Dr A.Gopalakrishnan, Director, Central Marine Fisheries Research Institute (CMFRI)-Kochi, Dr A.K.Abdul Nasser and Dr P.P.Manojkumar, Scientists-In-Charge - Mandapam Regional and Tuticorin Research Centres of CMFRI throughout the project work.

Special thanks to Dr E.Vivekanandan, (Retired Principal Scientist CMFRI and Senior Adviser to this project) for his valuable guidance, immense help and support throughout the study period and in preparation of the report.

Thanks are extended to Dr K.Vinod, Principal Scientist, Calicut Research Centre of CMFRI and staff of CMFRI offices at Kochi, Tuticorin and Mandapam for supporting the project in various ways.

We are grateful to all the experts and officials from State Fisheries Department, Universities, GOMBRT, Forest and Wild Life Department, Wild Life Crime Control Bureau, Coast Guard, Navy and NGOs namely, MSSRF, ICSF, DHAN foundation and Reliance foundation for their effective participation in workshops.

Our heartfelt thanks to all the respondents, data enumerators and the fisherfolk community in Gulf of Mannar and Palk Bay for their support and help in field works, on-board sampling and their active participation in the workshops conducted under the project.

Table of contents

1. Introduction 1
1.1. Purpose of the study and objectives 1
2. Material and methods 3
2.1. Study area 3
2.2. Trawl surveys 3
2.3. Dive visual transects 7
2.4. Socio-economic/interview survey 10
3. Results and discussion 15
3.1. Trawl catch component 15
3.2. Numerical density and biomass of sea cucumbers in Gulf of Mannar and Palk Bay 16
3.3. Variation in sea cucumber species density in Gulf of Mannar and Palk Bay 18
3.4. Length frequency distribution of sea cucumbers in Gulf of Mannar and Palk Bay 21
3.5. Distribution and abundance of sea cucumbers in survey sites of Gulf of Mannar and Palk Bay 25
3.6. Weight–length relationships (WLR) of sea cucumber species in Gulf of Mannar and Palk Bay 32
3.7. Socio-economic/interview survey 33
3.7.1. Fishermen perception on sea cucumber biology, ecology and population 33
3.7.2. Mode of sea cucumber fishing 33
3.7.3. Economics of sea cucumber fishing before the ban 35
3.7.4. Effect of ban on their livelihood 36
3.7.5. Sea cucumber supply/value chain 36
3.7.6. Average market price for processed and fresh sea cucumber 38
3.7.7. Management measures suggested by the fishers 38
4. Conclusion 40
5. Recommendations on sea cucumber conservation 40
5.1. Principles and objectives of management 41
5.2. Potential measures for management 41
5.2.1. Regulatory measures 42
5.2.2. Restocking programme 45
5.2.3. Implementation 45
6. References 49
Appendix I Tables 54
Appendix II Photographs 60
Appendix III Questionnaire for socio economic survey 65
Appendix IV Report of the finalization workshop on FAO BOBLME Project 69

List of tables

Table 1 Number of respondents selected proportionally for the study from the selected villages in the Gulf of Mannar 13

Table 2 Number of respondents selected proportionally for the study from the selected villages in Palk Bay 14

Table 3 Sea cucumber density (nos.ha^{-1}); (mean±SE) in Gulf of Mannar and Palk Bay 19

Table 4 Commercial value of sea cucumber species caught from Gulf of Mannar and Palk Bay 20

Table 5 Population densities of major sea cucumber species reported 20

Table 6 Mean (±SE) length (cm) of sea cucumbers in Gulf of Mannar and Palk Bay; the values in parenthesis are range 24

Table 7 Mean (±SE) weight (g) of sea cucumbers in Gulf of Mannar and Palk Bay; the values in parantheses are range 24

Table 8 Sizes at first maturity and juvenile population of major sea cucumber species in Gulf of Mannar and Park Bay 25

Table 9 Length and weight relationship of major sea cucumber species from Gulf of Mannar 32

Table 10 Length and weight relationship of major sea cucumber species from Palk Bay 33

Table 11 Respondents' perception on sea cucumber biology and ecology 33

Table 12 Economics of sea cucumber fishing before the ban 35

Table 13 Economics of sea cucumber fishing during the ban 36

Table 14 In what ways sea cucumber ban affected your livelihood 36

Table 15 Average market price for processed sea cucumbers (1US$ = Rs 64 approximately) 38

Table 16 Effective management measures as suggested by the respondents for sustaining the sea cucumber stocks if the ban is lifted 38

List of figures

Figure 1 Trawl survey location in Gulf of Mannar (GPS readings are provided in Appendix I-Table 17 & 18) 5

Figure 2 Trawl survey location in Palk Bay area (GPS readings are provided in Appendix I-Table 17 & 18) 6

Figure 3 Dive survey location in Gulf of Mannar (GPS readings are provided in Appendix I-Table 17 & 18) 8

Figure 4 Dive survey location in Palk Bay (GPS readings are provided in Appendix I-Table 19 & 20) 9

Figure 5 Map showing the study area in Gulf of Mannar 11

Figure 6 Map showing the study area in Palk Bay 12

Figure 7 Relative abundance of trawl catches components in (a) Gulf of Mannar and (b) Palk Bay 16

Figure 8 Numerical density of sea cucumbers in Gulf of Mannar (a) trawl survey (b) dive survey 17

Figure 9 Biomass of sea cucumbers in Gulf of Mannar (a) trawl survey (b) dive survey 17
Figure 10 Numerical density of sea cucumbers in Palk Bay (a) trawl survey (b) dive survey 17
Figure 11 Biomass of sea cucumbers in Palk Bay (a) trawl survey (b) dive survey 18
Figure 12 Relative abundance of sea cucumber species observed (a) Gulf of Mannar (b) Palk Bay 19
Figure 13 Length and weight frequency distribution of sea cucumbers in Gulf of Mannar 23
Figure 14 Length and weight frequency distribution of sea cucumbers in Palk Bay 24
Figure 15 Distribution of Sichopus horrens in Gulf of Mannar 27
Figure 16 Distribution of Holothuria atra in Gulf of Mannar 28
Figure 17 Distribution of Holothuria leucospilota in Gulf of Mannar 29
Figure 18 Distribution of Holothuria scabra in Palk Bay 30
Figure 19 Distribution of Holothuria atra in Palk Bay 31
Figure 20 Distribution of respondents based on mode of fishing of sea cucumber before the ban 34
Figure 21 Distribution of respondents based on sea cucumber fishing/trade during the ban 34
Figure 22 Market channel that existed in sea cucumber trade before the ban 37
Figure 23 Market channel in sea cucumber trade during the ban 37

Acronyms used

AD	Assistant Director
ADSGAF	Association of Deep Sea Going Artisanal Fishermen
ANOVA	one way analysis of variance
ARIF	Alliance for Release of Innocent Fishermen
BOBLME	Bay of Bengal Large Marine Ecosystem
CAS	Centre for Advanced Studies
CIFT	Central Institute of Fisheries Technology
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMFRI	Central Marine Fisheries Research Institute
CPUE	Catch per Unit Effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DD	Deputy Director
DHAN	Development of Humane Action Foundation
EAFM	Ecosystem Approach to Fisheries Management
EDC	Education Development Centre

FAO	Food and Agriculture Organization
GOMBRT	Gulf of Mannar Biosphere Reserve Trust
GOMD	Gulf of Mannar Dive survey
GOMT	Gulf of Mannar Trawl survey
GPS	Global Positioning System
HOD	Head of Division
ICAR	Indian Council of Agricultural Research
ICSF	International Collective in Support of Fishworkers
IFS	Indian Forest Service
IUCN	International Union for Conservation of Nature
LOA	Letter of Agreement
MKU	Madurai Kamaraj University
MLS	Minimum Legal Size
MOU	Memorandum of Understanding
MPEDA	Marine Products Export Development Authority
MSSRF	MS Swaminathan Research Foundation
NETFISH	Network for Fish Quality Management & Sustainable Fishing
NGO	Non-Governmental Organisation
NOAA	National Oceanic and Atmospheric Administration
PBD	Palk Bay Dive survey
PBT	Palk Bay Trawl survey
RAP	Region Asia-Pacific
SPC	Secretariat of the Pacific Community
SPSS	Statistical Package for the Social Sciences
TNFU	Tamil Nadu Fisheries University
USA	United States of America
USD	United States Dollar
WCCB	Wildlife Crime Control Bureau
WLR	Weight-Length Relationships
ZSI	Zoological Survey of India

1. Introduction

Sea cucumbers (class Holothuroidea) are elongated tubular or flattened soft-bodied marine benthic invertebrates. They have a leathery skin, their length ranging from a few millimetres to a metre (Lawrence, 1987). They occur in most benthic marine habitats worldwide, in temperate and tropical oceans, and from the intertidal zone to the deep sea (Hickman *et al.,*2006), but their greatest abundance and diversity occur in the tropical Indo-Pacific region (Conand, 2004). They are consumed both in dried (called *trepang* or *beche-de-mer*) and wet forms, with muscles cut in strips and boiled (Sloan, 1984). As an age old practice, the *beche-de-mer* production was introduced by the Chinese more than thousand years back.

Apart from the nutritional importance, they are important ecologically as suspension feeders, detritivores and prey. As suspension feeders, sea cucumbers regulate water quality by affecting carbonate content and the pH of the water (Massin, 1982). Deposit feeding sea cucumbers change the size of ingested particles and turn over sediment via bioturbation, thereby altering the stratification and stability of muddy and sandy bottoms (Massin, 1982). Holothurians are also important prey in coral reef and temperate food webs (Birkeland *et al.* 1982; Birkeland, 1989; Francour, 1997) both in shallow and in deep water (Jones and Endean, 1973; Massin, 1982), where they are consumed particularly by fishes, sea stars and crustaceans (Francour, 1997). In addition to the ecological importance, their fisheries are of great social and economic importance to many coastal communities.

Sea cucumber fisheries are one of the top non-finfish income streams for coastal peoples throughout the Indian Ocean, Southeast Asia and the Pacific. Sea cucumber fisheries have expanded worldwide in catch and value over the past two to three decades (Conand, 2004; FAO, 2008). Inadequate fishery management along with certain disadvantageous biological traits-like late age at maturity, slow growth, low rates of recruitment and broadcast spawning behaviour have caused overexploitation of this resource and fishery is showing the signs of severe depletion in many producing countries (Lovatelli *et al.,* 2004; Bruckner, 2006; Kinch *et al.,* 2008). The fishing pressure on sea cucumber population has been extraordinarily intense in recent decades placing species and coastal livelihoods at risk (Toral Granda *et al*., 2008; Purcell *et al.,* 2013). Of the 377 sea cucumber species examined, the International Union for Conservation of Nature (IUCN) has classified seven species as endangered or at high risk of extinction and nine species as vulnerable or at risk of extinction (www.iucnredlist.org) which may serve to guide future evaluation by CITES for listing the species on Appendix II or III in order to set conditions on the trade of these species (Conand *et al.,* 2014).

1.1. Purpose of the study and objectives

In India, holothurians are mainly distributed in Gulf of Mannar and Palk Bay, Andaman and Nicobar Islands, Lakshadweep Islands and Gulf of Kutch. In addition, they are distributed in small numbers along some other parts of the mainland coast of India. However, the fishery was restricted to only Gulf of Mannar and Palk Bay of southeast coast of India. The fishery was artisanal in nature. The fishery consisted of fishermen, who are divers, the processors who act as middlemen and the exporters. The fishery was mainly on high valued *Holothuria scabra* and the medium valued *H. spinifera* and occasionally on medium valued *Actinopyga miliaris* and *A.echinites* and *Stichopus hermanni* based on their availability. The processed '*beche-de-mer'* was exported mainly to Singapore from India, because of the lack of domestic '*beche-de-mer*' markets. During 1996-97, India exported 70 metric tonnes of '*beche-de-mer'*, which decreased to 3.81 metric tonnes during 2001 (Hong Kong SAR import statistics).

Owing to the dramatic decline of catch and size of the specimens fished, the Ministry of Environment, Forests and Climate Change, Government of India imposed a ban on export of

beche-de-mer less than 8 cm sea cucumbers in 1982. Apart from this other fishing restrictions not focused on holothurians also contributed to the protection of sea cucumbers. In India, sea cucumber fishery was not organized and hence management measures could not be effectively implemented. The fishery of sea cucumbers came to a standstill from June 2001 when the Ministry listed all holothurians as protected animals along with 50 other marine species under the Indian Wild life Protection Act, 1972. The fishermen and traders strongly objected this as it severely affected their livelihood. Since then several instances are reported on clandestine removal and illegal trade of both raw and dried sea cucumbers with neighbouring countries especially Sri Lanka where sea cucumber fishery and trade have not been banned.

In spite of the implementation of the ban for the last 14 years, no long term assessment has been made to understand whether the protection of sea cucumbers has yielded the desired results. The only publication indicating overexploitation of sea cucumbers in Gulf of Mannar and Palk Bay before the ban was by James and Baskar (1994). The short term survey conducted by the Zoological Survey of India (ZSI) in Gulf of Mannar in 2007, six years after the commencement of the ban reported the availability of seven species with *H.atra* as the dominant species (Venkataraman, 2007). The survey conducted by ZSI in 2011-12 indicated the occurrence of nine and seven species in Gulf of Mannar and Palk Bay, respectively (Venkataraman *et al.,* 2012). The survey also revealed the dominance of *H.scabra* in Palk Bay at a density of 0-169 ind.ha^{-1} in 2011 and 0-100 ind.ha^{-1} in 2012 and dominance of *H.atra* at a density of 0 to 7650 ind.ha^{-1}, followed by *H. scabra* 0-1400 ind.ha^{-1} in Gulf of Mannar area (Venkataraman *et al*,. 2012).

The enforcement of ban on the capture and trade of sea cucumbers for the last 14 years might have helped reviving their population; at the same time, the ban would possibly have social and economic impacts on scores of people, particularly the fishers, who were dependent on the sea cucumber fishery, and later resorted to clandestine removal and trade. Various representations have been made from fishermen welfare agencies to different authorities highlighting the negative impacts of the ban, which had affected their income. It was realized that a survey on the sea cucumber resource is necessary as well as a survey on the opinion of fishers of Gulf of Mannar and Palk Bay area, who are supposed to be solely dependent on holothurians for their livelihood.

A fundamental barrier to improved knowledge and management of sea cucumbers is the lack of data on population abundance/biomass and basic biological parameters of most species. The large dependent coastal population in the Gulf of Mannar and Palk Bay, high value of the species and the ease with which the sea cucumbers can be collected, allows illegal harvest, leading to potential biological and ecological vulnerability of the stocks. It is therefore imperative to analyse and understand the impact of the ban, through a case study, on the conservation of sea cucumber resources in the wild and its implications on the livelihood of the fishers. With this background, the Central Marine Fisheries Research Institute (CMFRI, Indian Council of Agricultural Research), India submitted a project proposal “An evaluation of the current conservation measures on sea cucumber stocks in Palk Bay and Gulf of Mannar of India”, to the Bay of Bengal Large Marine Ecosystem Project (BOBLME, Food and Agriculture Organization), which was approved by the BOBLME, as the proposal is very much in line with BOBLME objectives. The project has a focus on conservation of critical transboundary habitats, such as the Gulf of Mannar, and also promotes the improved management of key fisheries resources. A Letter of Agreement (LOA/RAP/2014/37) was signed between FAO and ICAR for provision of services by CMFRI relating to the project.

Following the LoA, the following activities were completed since inception of the project:

1. Project inception workshop was held in Central Marine Fisheries Research Institute, Mandapam in December 2014. In the workshop, methodological framework for the project was discussed with fishermen, traders, village leaders, officials of fisheries and forest departments, scientists and academicians.
2. A status report “Sea cucumbers in Gulf of Mannar and Palk Bay, southeast coast of India” was submitted to BOBLME in February 2015.

3. Underwater surveys and trawl surveys on sea cucumber population were conducted in selected sites in Gulf of Mannar and Palk Bay during January-June 2015.
4. Interview surveys were held during January-May 2015 with fishermen to (a) obtain their insights into conservation and their own roles in conservation, and (b) understand the impact of sea cucumber listing on their socioeconomics and livelihood.
5. Interaction with other stakeholders to analyse the impact of listing on resources was held in May-June 2015.
6. A project final workshop was held in Tuticorin on June 30, 2015 with the participation of fishermen, traders, village leaders, officials of fisheries and forest departments, scientists and academicians.

This final report has been prepared by consolidating the results of the underwater and trawl surveys, interview surveys and project final workshop.

The objectives of the project are as follows:

- To generate information on the stock status of different sea cucumber species along Gulf of Mannar and Palk Bay.
- To evaluate the effectiveness of current conservation measures on the sea cucumber stock.
- To suggest effective, renewed management strategies for conservation of the stock.

2. Material and methods

2.1. Study area

The studies were carried out during the period January-June 2015 in Gulf of Mannar and Palk Bay of southeast coast of India. Gulf of Mannar, the large shallow bay is located between south-eastern India and north-western Sri Lanka and is about 130-275 km wide and 160 km long. A 21 islands system is located between Rameshwaram and Tuticorin covering an area of 623 ha, which is declared as a marine park by Ministry of Environment and Forests, Government of India. The Palk Bay, which is contiguous with Gulf of Mannar on the northern side is the water way between south east India and northern Sri Lanka and is about 64-137 km wide and 137 km long. The survey stations were selected based on previous research documents on sea cucumber landings and also after discussion with fishermen. The abundance of sea cucumbers was measured from trawl and dive surveys following standard methods.

2.2. Trawl surveys

The swept area method was adopted using a trawler (overall length: 15m; engine horse power: 285). Prawn trawl nets, modified with added sinkers or bobbins in the foot ropes locally called as 'Attai madi' were used for the sea cucumbers survey. The areas from 08°46.555 N;078°18.846 E in Gulf of Mannar and from09°15.861 N;79°20.470 Ein Palk Bay were covered. The trawl operations were carried out at a depth of 4-19 m in Gulf of Mannar and 4.5-16m in Palk Bay and locations are presented in Figure 1 and 2. The details of markings were saved in a hand held GPS (GARMIN 72) and are presented in **Table 17**&**Table 18** of **Appendix I**. Each trawl tow was made for 30 to 60 minutes after considering the nature of the bottom.

Biomass estimation was made following the description of swept area method by Vivekanandan (2005). The distance travelled by the trawl was calculated using the formula **D = V * t,** where **V** is the velocity of the boat and **t** is the time spent in trawling. The swept area **'a'** was estimated as **a** = **D ∗ h ∗ x2,** where **D** is the distance covered during each tow, **h** is the length of the head-rope of the trawl net, **X2** is that fraction of the head-rope length (**h**), which is equal to the width of the path swept by the trawl. The value of **X2 = 0.5** as suggested by Pauly (1980) was used in the present study. After the over haul of trawl content, the catch component was sorted out and weighed. The estimate of the average biomass (kg) per km^2 was calculated by using the formula **b = CPUE/(a*X1)**, where

CPUEis the catch per unit hour, "**a**" = area swept, **X1** = the proportion of the fish in the path of the gear that are actually retained by the net. The **X1** is usually chosen between 0.5 and 1.0, considering the sessile nature of sea cucumbers, but spill over of the resource on the sides of the path of the gear., X1 = 0.75 (Vivekanandan, personal communication),which is reasonable for sedentary stock was considered for analysis.

Figure 1Trawl survey location in Gulf of Mannar (GPS readings are provided in Appendix I-Table 17 & 18)

Figure 2Trawl survey location in Palk Bay area (GPS readings are provided in Appendix I-Table 19 & 20)

2.3. Dive visual transects

The underwater dive survey, a rapid marine assessment technique, which is commonly used for sea cucumber surveys (Long *et al.,* 1996), was employed in the present study. The sampling sites were selected at a depth range of 3-20m in Gulf of Mannar and 3-8m in Palk Bay. The survey locations are given in Figure 3and 4. The sampling sites were located using a portable global positioning system (GPS) device and are given in **Table 19**&**Table** 20 of **Appendix I**. At each station, traditional small boats with a team of two divers (scuba and skin) was operated for transect survey. The area from 08°45.188 N;078°20.252 E in Gulf of Mannar and from09°37.750 N;78°59.359 Ein Palk Bay were covered. A 50m measuring tape was laid over the sea bottom which served as the transect line. One diver swam along transect to record habitat structure and resources along 1m on either side of the transect line and another diver was engaged in sea cucumber collection for biometric measurements. A total of 1400 m^2 (14 locations) in Palk Bay and 900 m^2 (9 locations) in Gulf of Mannar were covered in the survey.

In both the trawl and dive surveys, the locations were marked with Google Earth Ver. 5.1.3533.1731. The collected sea cucumbers were identified up to species level following standard literature (James, 1995; Purcell *et al.,* 2012). All sea cucumbers were individually weighed and measured for total length after relaxing for a while for the water to drain. The body length was measured to the nearest 1cm using soft measuring tape and weighed to the nearest 1g using an electronic balance. The size at first maturity for most of the sea cucumber species was collected from available literature and those specimens below the size at first maturity were considered as juveniles. After measurement all the specimens were released to the natural environment.

Figure 3Dive survey location in Gulf of Mannar (GPS readings are provided in Appendix I-Table 17 & 18)

Figure 4Dive survey location in Palk Bay (GPS readings are provided in Appendix I-Table 19 & 20)

The numerical density and biomass of sea cucumbers were estimated at all the stations. Weight-length relationships (WLR) are used for estimating the weight corresponding to a given length and we estimated the WLR following the equation (Cone, 1989). **$W = aL^b$**., where **W** = weight in g, **L** = body length in cm, **a** = the ordinate, **b** = the slope of the curve. The parameter **'a'** is a scaling coefficient for the weight at length of the sea cucumber species. The parameter **'b'** is a shape parameter for the body form of the sea cucumber species. In general, the exponent **'b'** would have a value around 3.0 because the volume of a 3-dimensional object is roughly proportional to the cube of length for a regularly shaped solid and the deviation from 3.0 indicates the direction and rate of change of form or condition. If, **b**<3.0, it indicates a decrease in condition or elongation in form with increase in length, whereas **b**>3.0 indicates an increase in condition or increase in height or width with increase in length. The results were statistically interpreted and the correlation and one way analysis of variance (ANOVA) were tested in SPSS 7.5 statistical package.

2.4. Socio-economic/interview survey

The interview survey with an expost-facto research design was undertaken in Gulf of Mannar and Palk Bay. In Gulf of Mannar, Ramanathapuram and Tuticorin districts; and in Palk Bay Ramanathapuram, Pudukottai and Thanjavur districts were selected for the survey. A total of 21 villages in Gulf of Mannar and 20 villages in Palk Bay (Figure 5 & 6) were selected for the survey based on available documents on sea cucumber occurrence and discussions with fishermen and officials of fisheries and forest departments. A total of 400 fishermen who are engaged in sea cucumber fishery (like skin diving, trawl fishery and other modes of small-scale fishing), 80 middlemen and 20 traders were selected using proportionate random sampling technique from the selected villages (Table 1 & 2). The details related to sea cucumber fishing and its economics were collected from the fishermen whereas the details pertaining to general information on sea cucumbers, marketing, trade and management measures were collected from all the respondents. Data collection was done through interview method, key-informant interview and focused group discussion.

Figure 5Map showing the study area in Gulf of Mannar

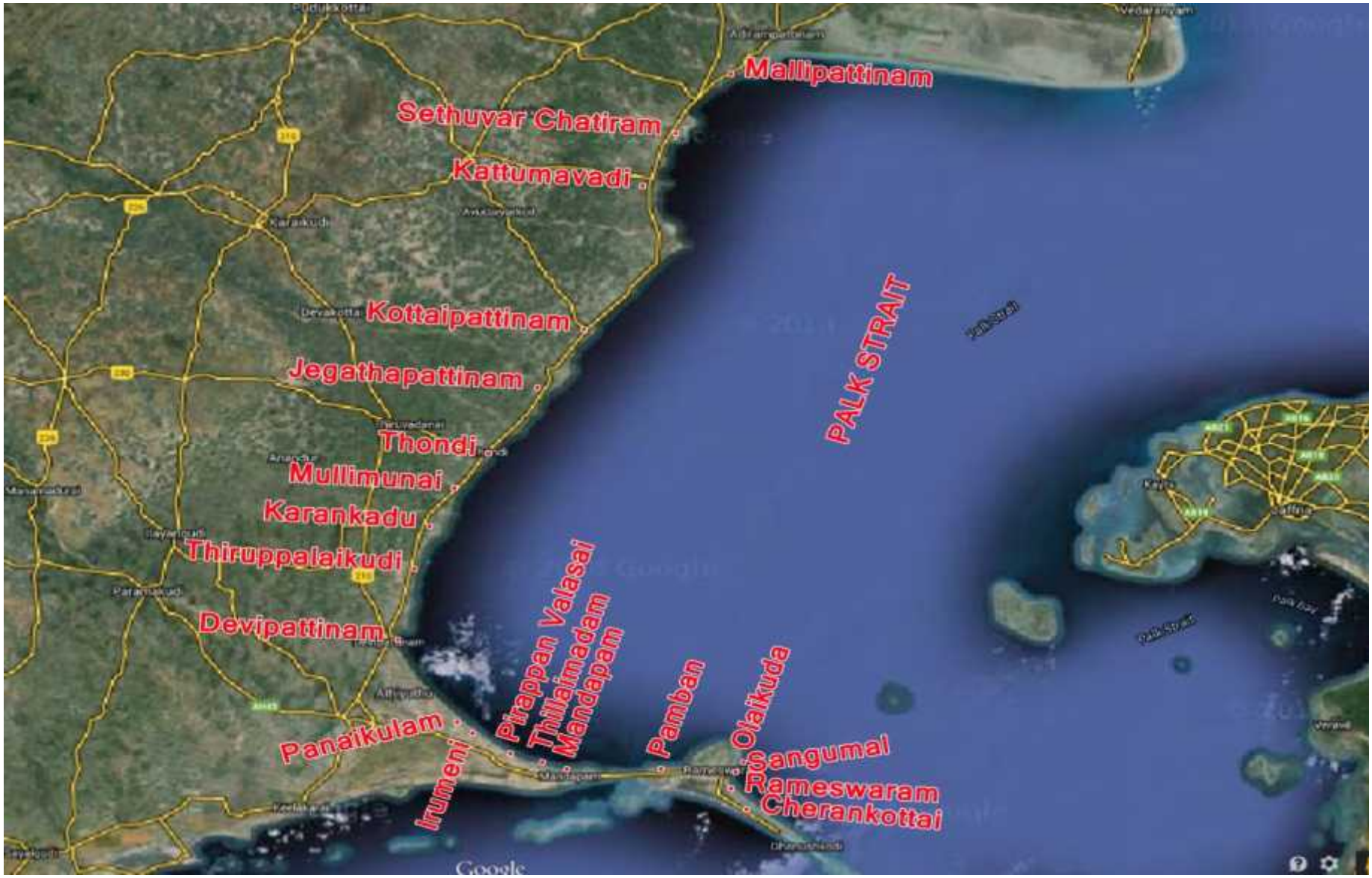


Figure 6Map showing the study area in Palk Bay

Table 1 Number of respondents selected proportionally for the study from the selected villages in the Gulf of Mannar (n = 276)

Village	Fishermen	Middlemen	Traders
Muguntharayarchathiram	14	0	0
Kundhukal	12	2	0
Pamban	3	0	0
Mandapam	10	0	1
Vedalai	22	4	2
Seeniappadarka	12	2	0
Pudumadam	7	0	0
Periyapattinam	11	0	0
Muthupettai	7	0	0
Kalimankundu	9	0	0
Keelakarai	12	4	1
Ervadi	12	4	2
Valinokkam	12	4	0
Kannirajapuram	18	0	0
Vembar	10	5	1
Kattapadu	10	4	1
Sippikulam	11	0	0
Keelavaipar	10	0	0
Tharavaikulam	4	1	0
Therespuram	10	5	1
Tuticorin	12	2	2
Total	**228**	**37**	**11**

Table 2 Number of respondents selected proportionally for the study from the selected villages in Palk Bay

(n = 224)

Village	Fishermen	Middlemen	Traders
CheranKottai	16	5	1
Rameswaram	5	3	1
Sangumal	9	0	0
Olaikuda	8	5	1
Pamban	2	2	0
Mandapam	10	3	0
Pillaimadam	3	0	0
PirappanValasai	4	0	0
Irumeni	19	0	0
Panaikulam	13	2	0
Devipattinam	24	5	1
Thiruppalaikuti	6	3	1
Karankadu	7	5	1
Mullimunai	7	5	1
Thondi	10	0	0
Jegathapattinam	5	0	0
Kottaipattinam	5	0	0
Kattumavadi	7	0	0
Sethuvarsathiram	2	3	1
Mallipattinam	10	2	1
Total	**172**	**43**	**9**

Tools of analysis

Percentage analysis and Garrett ranking were done to process the data and to arrive at meaningful conclusions. The data obtained from the respondents were systematically tabulated for the purpose of analysis.

Garrett's ranking technique was used to identify and rank the attributes based on what ways the sea cucumber ban has affected their livelihood. Garrett's ranking technique provides the change of orders into numerical scores. The prime advantage of this technique over simple frequency distribution is that the reasons and factors are arranged based on their importance from the point of view of respondents.

Garrett's formula for converting ranks into percent is given below:

Percent position = $100^{*} (R_{ij}-0.5)/N_{j}$ where, R_{ij}= Rank given for i^{th}factor by j^{th} individual

N_{j} = Number of factors ranked by j^{th}individual

The per cent position of each rank was converted into scores referring to the Table given by Garret and Woodworth (1969). For each attribute, the scores of individual respondents were added together and divided by the total number of respondents for whom scores were added. The mean scores for all the factors were arranged in descending order, ranks were given and the most important attributes were identified. The scoring values are given in**Appendix I**.

Limitation of the study

The present study relied on primary data collected through the survey methodology. The information was collected from the respondents based on their memory and experience and bias cannot be eliminated completely. However, care was taken to avoid personal bias while capturing information. Limitations like getting only seasonal information, having data for a specified period of time, dependence on data that is word of mouth (with its inherent contradictions) as primary data could not be ruled out.

3. Results and discussion

3.1. Trawl catch component

A total swept area of 545,200m^2 (13 trawl hauls) in Gulf of Mannar and 213,100m^2 (12 trawl hauls) in Palk Bay were covered during the survey. The trawl catch composition is given in Fig. 7a and b. Sea grass was the major catch component in both sites and constituted 76.4 and 50.2% of the total catch respectively. It was found that an average 96.14±23.9; 42.91±13.8 kg ha^{-1} of sea grasses were removed per hour of trawling from Gulf of Mannar and Palk Bay respectively. Echinoderms other than sea cucumbers were the second dominant group, which was comparatively higher in Palk Bay. Bony fishes were the fourth major component at both sites and were comparatively higher in Palk Bay than in Gulf of Mannar. Sea cucumber constituted the fifth major group and comprised 3.4 and 3.04% respectively at Gulf of Mannar and Palk Bay. Sponges were noticed comparatively in higher biomass in Palk Bay (14.25%) than in Gulf of Mannar. Other components like molluscs, crustaceans were also recorded at both sites in small quantities; whereas elasmobranchs and dead corals were noticed only in Gulf of Mannar. The biomass of trawl catch component at both stations is given in **Table 21**of**Appendix I**.

In the trawl survey the sea cucumber biomass was 3.28kg ha^{-1} and 2.59kg ha^{-1} at Gulf of Mannar and Palk Bay respectively and was lower than recorded in earlier reports of 5.7 kg ha^{-1} and 3.8 kg ha^{-1} at the same locations (Venkataraman *et al.,*2012). The present survey was conducted for a short duration which could not account for the seasonal variation in sea cucumber abundance.Lampe (2013) has highlighted the influence of environmental parameters like, salinity, temperature, turbidity and nutrient composition on holothurian distribution and occurrence. The high percentage of sea grass removed as by catch from both the ecosystems in the present study indicated the need for their protection as habitat for sea cucumbers. The higher abundance of sea cucumbers in sea grass and coral reef has been discussed by several authors highlighting the importance of these habitats in the early life history stages for settlement (Conand, 2008; Friedman *et al*., 2011). In the present study a very high positive correlation was noticed between sea cucumber and sea grass biomass at both sites ($p<0.001$).

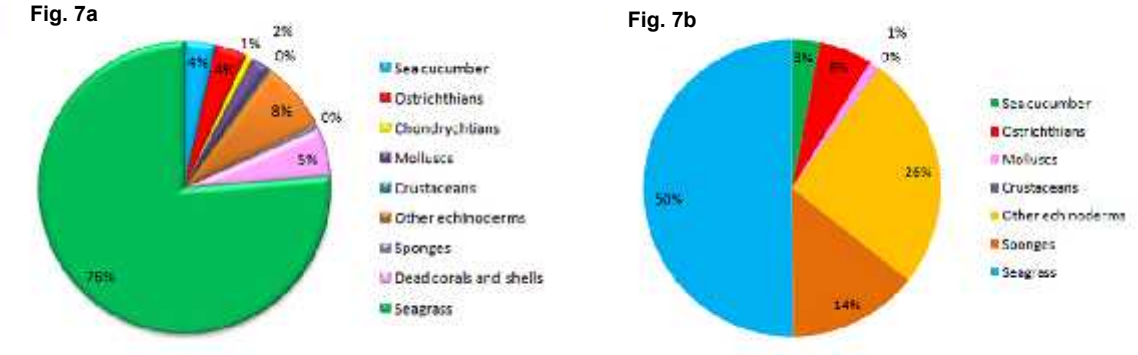


Figure 7 Relative abundance of trawl catches components in (a) Gulf of Mannar and (b) Palk Bay

3.2. Numerical density and biomass of sea cucumbers in Gulf of Mannar and Palk Bay

The variation in the density and biomass of sea cucumbers between sampling sites in the Gulf Mannar trawl survey is given in Figures 8(a)& 9(a). Among the 13 trawl survey stations, maximum density of 13,079nos.ha^{-1} was at 7.6m depth in GOMT8, followed by 10,895nos.ha^{-1} at 4.5m depth in GOMT12. The lowest value of 325.2 nos.ha^{-1}was noticed in deeper areas of 19 m depth in GOMT3. The maximum biomass of 19.5kg ha^{-1} was at 4.5m depth in GOMT6 followed by 3.29kg ha^{-1}at 7.6m depth in GOMT8 and the lowest biomass (0.798 kg ha^{-1}) was at 6.1m depth in GOMT10.

The density and biomass of sea cucumbers in the Gulf Mannar dive survey sites are given in Figures 8(b) & 9(b)comparatively lesser density was observed in dive survey. The maximum density of 7875 nos.ha^{-1} was at 10m depth in GOMD8 followed by 3750 nos.ha^{-1}at 12 m depth in GOMD2. The lowest value of 750nos.ha^{-1} was at 7m depth in GOMD5. The maximum biomass of 2235.2kg ha^{-1} was at 20m depth in GOMD7 followed by 1641.2kg ha^{-1} at 10 m depth in GOMD8. The lowest value of 171.2 kg ha^{-1} was noticed at 4m depth in GOMD1.

In Palk Bay, among the 12 trawl stations, the highest density of 8032.8nos.ha^{-1} was noticed at 15m depth in PBT2 followed by 7291.7nos.ha^{-1}at 4.5m depth in PBT8. The lowest density of 1388.9nos. ha^{-1} was noticed at 4.5m depth in PBT11 (Figure 10a). The highest biomass of 5.23kg ha^{-1} (15m depth) was in PBT3 followed by 4.95kg ha^{-1} (4.5m depth) in PBT7. The lowest of 0.065 kg ha^{-1} was noticed (5 m depth) in PBT12 (Figure 11a).

The variation inthe density and biomass of sea cucumbers between dive survey sites in Palk Bay is given in Figure 10b. Among the 14 stations surveyed, the maximum density of 6875 nos. ha^{-1} was noticed at 8m depth in PBD3 followed by 1875nos. ha^{-1}at 3.5m depth in PBD13. The lowest density of 125 nos.ha^{-1} was noticed at 5m depth in PBD1, PBD5 and PBD14. The maximum biomass of 2950 nos.ha^{-1} was at 3.5m depth in PBD14 followed by 998.7nos.ha^{-1} at 8m depth in PBD3 and the lowest value of 31.25 kg ha^{-1} was at 5m depth in PBD1(Figure 11b). The higher biomass observed in the dive survey might be due to the selective fishing for large sized sea cucumbers.

Fig. 8a

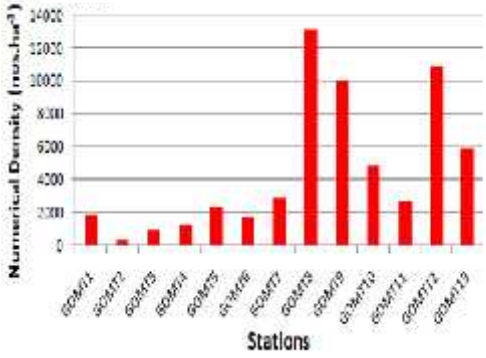


Fig. 8b

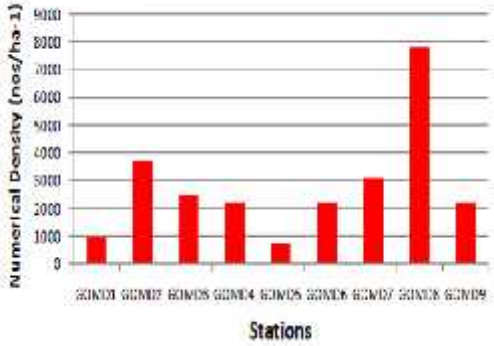


Figure 8 Numerical density of sea cucumbers in Gulf of Mannar (a) trawl survey (b) dive survey

Fig. 9a

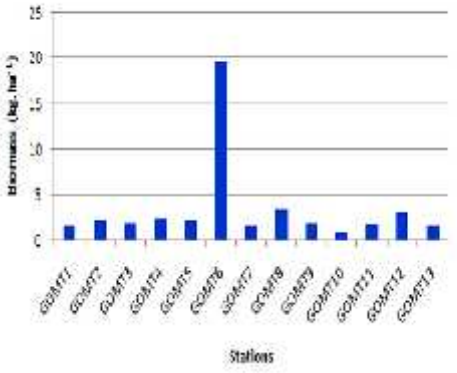


Fig. 9b

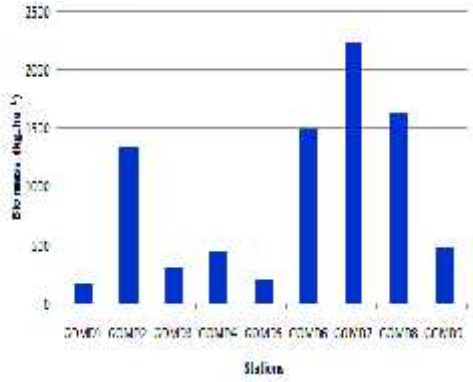


Figure 9Biomass of sea cucumbers in Gulf of Mannar (a) trawl survey (b) dive survey

Fig. 10a

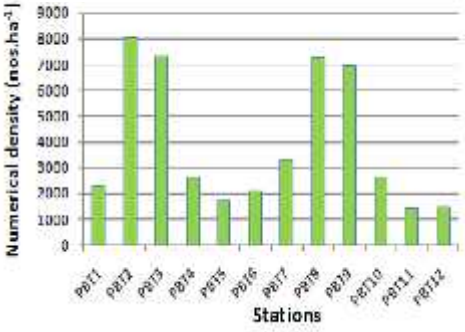


Fig. 10b

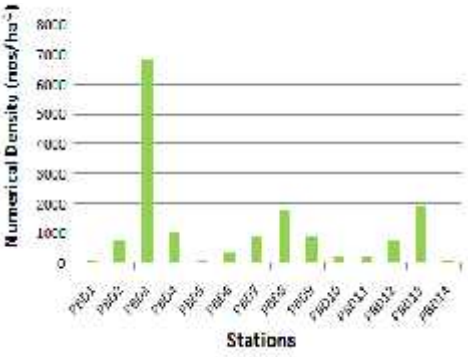


Figure 10Numerical density of sea cucumbers in Palk Bay (a) trawl survey (b) dive survey

Fig. 11a

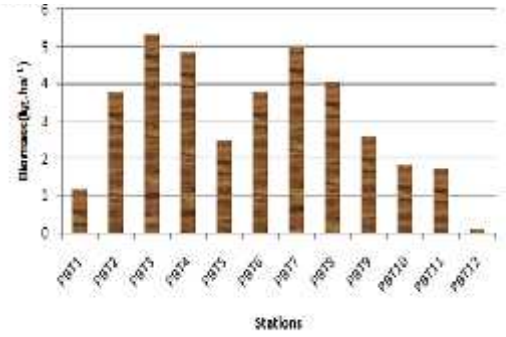


Fig. 11b

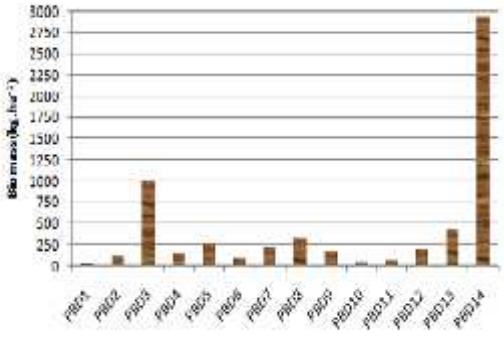


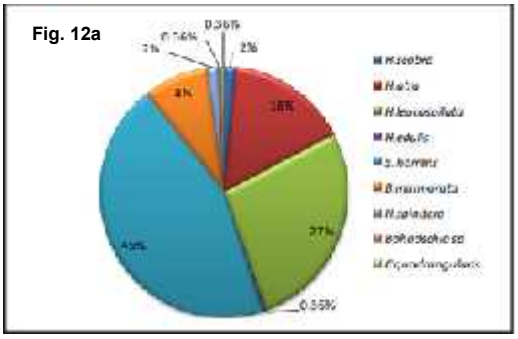
Figure 11Biomass of sea cucumbers in Palk Bay (a) trawl survey (b) dive survey

3.3. Variation in sea cucumber species density in Gulf of Mannar and Palk Bay

In the present study, the biomass estimated in survey sites varied in accordance to the abundance of massive species like *Bohadschia marmorata* and *Holothuria scabra*, rather than dominance of lean species like *Holothuria atra*, *H. leucospilota* and *Stichopus horrens* etc., Due to this species wise variation in body forms and average body weight of sea cucumbers, density of sea cucumbers as a whole was considered to assess the ecosystem variation in population status. The relative abundance of different sea cucumber species collected from both trawl and dive survey sites in Gulf of Mannar and Palk Bay is given in Figure 12 (a and b); the mean value and range in density of sea cucumber species are given in Table 3. The commercial value of sea cucumber species is determined by the length and thickness of the body wall, in addition to the size, colour, shape and appearance of the processed product-*beche-de-mer* (Purcell, 2014). The current international market values of different sea cucumber species caught from Gulf of Mannar and Palk Bay are given in Table 4.

Nine sea cucumber species with varied commercial values in the international market were collected from Gulf of Mannar. In general, low valued species were dominant. The medium valued *Stichopus horrens* was the major species with the highest mean density of 1599.8±619.2nos.ha^{-1} comprising 44.5% of the total catch followed by 27.4% of low valued *Holothuria leucospilota* with a mean density of 987.4±362.5nos.ha^{-1}. The low valued *H.atra* was in third position with a mean density of 767.7±177.01nos. ha^{-1} and constituted 15.9% to the total catch. *Bohadschiamarmorata* was the 4th major species and the high valued *H.scabra* and medium valued *H.spinifera* were available in small quantities (1.5% each) *Colochirus quadrangularis*, *Holothuria edulis*and an unidentified *Bohadschia*species were also found in small quantities (Figure 12(a) and Table 3).

In Palk Bay, compared to Gulf of Mannar area, the population was dominated by a single species -the high valued *H.scabra* (84.7%) with a mean density of 2352.6±546.7nos.ha^{-1}. Other sea cucumber species like low valued *H.atra* (8.98%),medium valued *H.spinifera* (3.5%) and low valued *B.marmorata* (1.95%) were recorded in small quantities. Species like *S. horrens* and *H.leucospilota* (0.39% each) were also recorded in a few numbers (Figure 12(b) and Table 1).



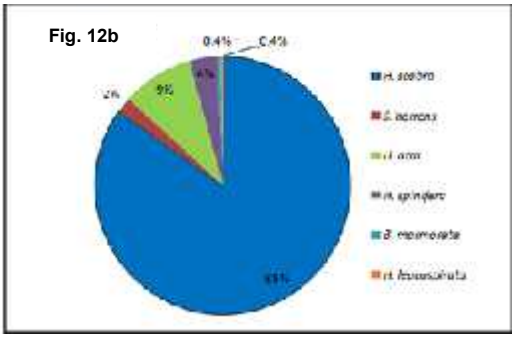


Figure 12Relative abundance of sea cucumber species observed (a) Gulf of Mannar (b) Palk Bay

Table 3 Sea cucumber density (nos.ha^{-1}); (mean±SE) in Gulf of Mannar and Palk Bay

S.no.	Species	Mean (±SE) and range of density (nos.ha^{-1})	
		Gulf of Mannar	Palk Bay
1.	*Holothuria scabra*	178.94±110.2 (0-1818.2)	2352.6±546.7 (0-7868.9)
2.	*H. spinifera*	69.14±33.02 (0-545.5)	75.5±57.7 (0-1315.8)
3.	*H. atra*	767.7±177.01 (0-2096.4)	190.3±101.9 (0-1827.7)
4.	*H. leucospilota*	987.4±362.5 (0-7875)	5.21±5.21 (0-125)
5.	*H. edulis*	11.4±11.4 (0-250)	-
6.	*Stichopus horrens*	1599.8±619.2 (0-9536.8)	6.8±6.8 (0-163.9)
7.	*Bohadschia marmorata*	192.9±89.1 (0-1750)	10.9±10.9 (0-261.1)
8.	*Bohadschia sp*.	11.36±11.4 (0-250)	-
9.	*Colochirus quadrangularis*	34.4±34.4 (0-757.6)	-

Table 4 Commercial value of sea cucumber species caught from Gulf of Mannar and Palk Bay

S.no.	Speciesname	Common name	Local name	Value (USD kg^{-1} dried)
1.	*Holothuria scabra*	Sandfish	Vella attai	115-1668
2.	*Holothuria spinifera*	Brownfish	Cheeni/Raja attai	160-188
3.	*Holothuria atra*	Lollyfish	Kuchi attai	4-63
4.	*Holothuria leucospilota*	White threadfish	Karup attai	1.3-5
5.	*Holothuria edulis*	Pinkfish	Pink attai	4-20
6.	*Stichopus horrens*	Dragonfish	Pura attai	56-83
7.	*Bohadschia marmorata*	Chalkfish	Nool attai	9-22
8.	*Bohadschia sp*.	-	-	-
9.	*Colochirus quadrangularis*	Thorny sea cucumber	Not designated	*

***** valued for ornamental purpose

The numerical density of various sea cucumber species obtained in the present study in Gulf of Mannar is comparable to previous estimate from the same location or to those reported from elsewhere (Table 5). Lower density of high valued *H. scabra* in Gulf of Mannar might be due to the historical fishing pressure and the inability of the stock to repopulate to its original level; similar observation have been reported in several parts of Indo Pacific region (Lovatelli *et al*.,2004; Uthicke and Conand 2005).

In Palk Bay, the present study revealed the dominance of high valued *H.scabra* in fairly good numbers in all the stations, irrespective of the fishing pressure from illegal activities. The mean density was very much higher than the previous estimates made from the same locations (Table 5). Higher density was noticed for other low valued species also. The high density population of *H.scabra* in Palk Bay in shallow areas indicated the need for further survey in deeper areas. The continuous monitoring survey is essential for the development of time series data on population characteristics. The low density of medium valued *H.spinifera* which is a nocturnal species might be due to the inadequate number of night samplings. An observation similar to one reported for nocturnal species by Dissanayake and Stefansson (2010) in Sri Lankan waters.

Table 5 Population densities of major sea cucumber species reported

Species	Location	Density (nos.ha^{-1}) (mean±SE)/range	Source
Holothuria scabra	Gulf of Mannar (India)	178.9±16.2	This study
" "	" "	174±117	(Venkataraman, 2007)
" "	" "	1.2±1.7 in 2011	(Venkataraman, *et al*., 2012)
" "	" "	70.6±23.6 in 2012	" "
" "	Palk Bay (India)	2352.6±546.7	This study
" "	" "	39.98±59.03 in 2011	(Venkataraman, *et al*., 2012)
" "	" "	18.09±28 in 2012	" "
" "	Australia	173.47±43	(Skews *et al*., 2004)
" "	Mahout Bay (Oman)	1770-4000	

" "	Abu Ramada Island (Red Sea)	8570-9591	(Al-Rashdi et al., 2007) (Hasan, 2004)
Holothuria atra " " " " " "	Gulf of Mannar (India) " " " " " "	767.7±177.6 1268±419 0.140±74 440-6000	This study (Venkataraman, 2007) (Venkataraman *et al*., 2012) (Asha *et al*., 2015)
Bohadschia marmorata	Gulf of Mannar (India)	192.9±89.6 302±184 0.02±0.12	This study (Venkataraman, 2007) (Venkataraman *et al*., 2012)

The total number of commercial sea cucumber species reported in the present study is more or less similar to the previous reports of Venkataraman *et al*.(2012), but lower than the earlier observation of 27 species made by James (1995) and 39 species by Sasthri (1998) from Gulf of Mannar area. The less number of species in the present study might be due to inadequate sampling without covering the entire habitat. The diversity and density of sea cucumbers were comparatively higher in Gulf of Mannar than in Palk Bay, which might be due to the high diversity of habitat like coral reefs, sea grass, salt marshes and mangroves, rocky, sandy and muddy shores etc., and more depth in Gulf of Mannar along with other physical, chemical and biological factors of the ecosystem. The density of species like*Holothuria scabra*, *H. atra* and *H. leucospilota, Bohadschia marmorata* and *Stichopus horrens* was significantly different between Gulf of Mannar and Palk Bay ($p<0.01$).

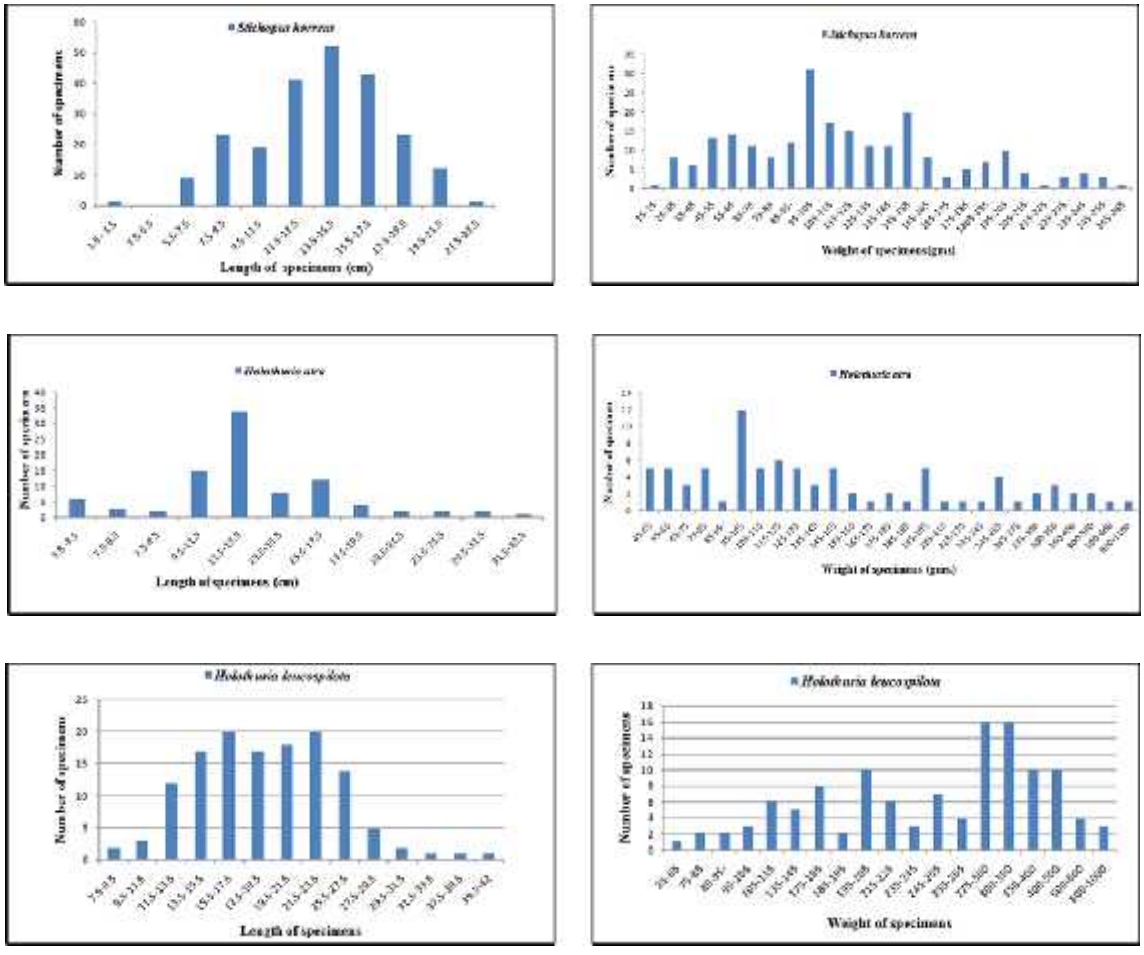
Comparatively a higher average density of total sea cucumbers was estimated in Gulf of Mannar (3853±152.3 nos.ha^{-1}) than in Palk Bay (2428.5±504.6 nos.ha^{-1}) and these values are very much higher than the depleted population reported in the Milne Bay (27 nos.ha^{-1}) (Skewes *et al.,*1999, 2002,) and are higher than 350±648 and 90±130 nos.ha^{-1} reported in the north west and east coasts of Sri Lanka (Dissanayake and Stefansson,2010) Moreton Bay (1035 nos. ha^{-1}) and Solomon Islands (1115 nos. ha^{-1}) (Skewes *et al.,* 2004; Buckius *et al.,*2010) but lower than Heron Island (8460 nos. ha^{-1}) (Klinger and Johnson 1998).

3.4. Length frequency distribution of sea cucumbers in Gulf of Mannar and Palk Bay

The length frequency distributions of sea cucumber species in Gulf of Mannar and Palk Bay are summarized in Figures 13 & 14 and the range and mean length and weight are given in Tables 6 and 7. In Gulf of Mannar, the major species, *Stichopus horrens* has a length range of 2.5-23.5 cm with a mean of 13.95±0.23 cm; and weight range of 20-265 g (mean-117.9±3.40 g). Most of the specimens were medium sized with highest frequent size class of 13.5-15.5 cm and 95-105 g for length and weight respectively, whereas in Palk Bay, the specimens are comparatively smaller, with the highest

size frequency of 7-9 cm and 75.1-100 g for length and weight respectively. The size at first maturity of *Stichopussp* estimated as 22 cm (Conand 1993) suggest that majority of *Stichopus* sp. collected during the study period were not mature. Specimens of *Holothuria scabra* were comparatively larger in Gulf of Mannar with the higher frequency of size class 14.5-24.5 cm and 300-350 g. In Palk Bay,the *H. scabra* specimenswere medium sized with the highest size class of 16.1-18 cm and 201-250 g for length and weight, respectively. Majority of the unexploited *H. atra* population in Gulf of Mannar were comparatively smaller than in Palk Bay, where as specimens of *H. leucospilota,H. spinifera* and *Bohadschia marmorata* were larger in Gulf of Mannar and only a few specimens of these species were reported from Palk Bay.

In the present study, though all the specimens of *Bohadschia marmorata* wereadult, juveniles constituted the major share of other species in both Gulf of Mannar and Palk Bay (Table 8). Except for *Stichopus horrens* fromGulf of Mannar which is comparatively smaller, the mean length estimated for all other species from both the ecosystems are comparable to the values obtained in the previous estimates (Venkataraman *et al*., 2012). For *H. scabra* specimens, the mean length was much higher than the Warrior reef measurements by Skewes *et al*.,(2004) and those of Abu Rhamde Island (Hasan 2004). The population structure of *H. scabra* in Palk Bay during April indicated the dominance of breeders of 13-16 cm in length (age: 2 years) as per the growth estimates of Haemel *et al*.,(2001). Venkataraman*et al*.,(2012) also observed the dominance of breeders during April in Palk Bay. The most frequent size category of *H. atra* in the present study was much lower than those reported from Sri Lanka (Dissanayake and Stefansson, 2010). The length distribution pattern is unimodal for most of the species, but the difference in size between Gulf of Mannar and Palk Bay might be due to the variation in depth, substrate type and environmental factors of these two ecosystems as opined by Mercier *et al.* (1999).



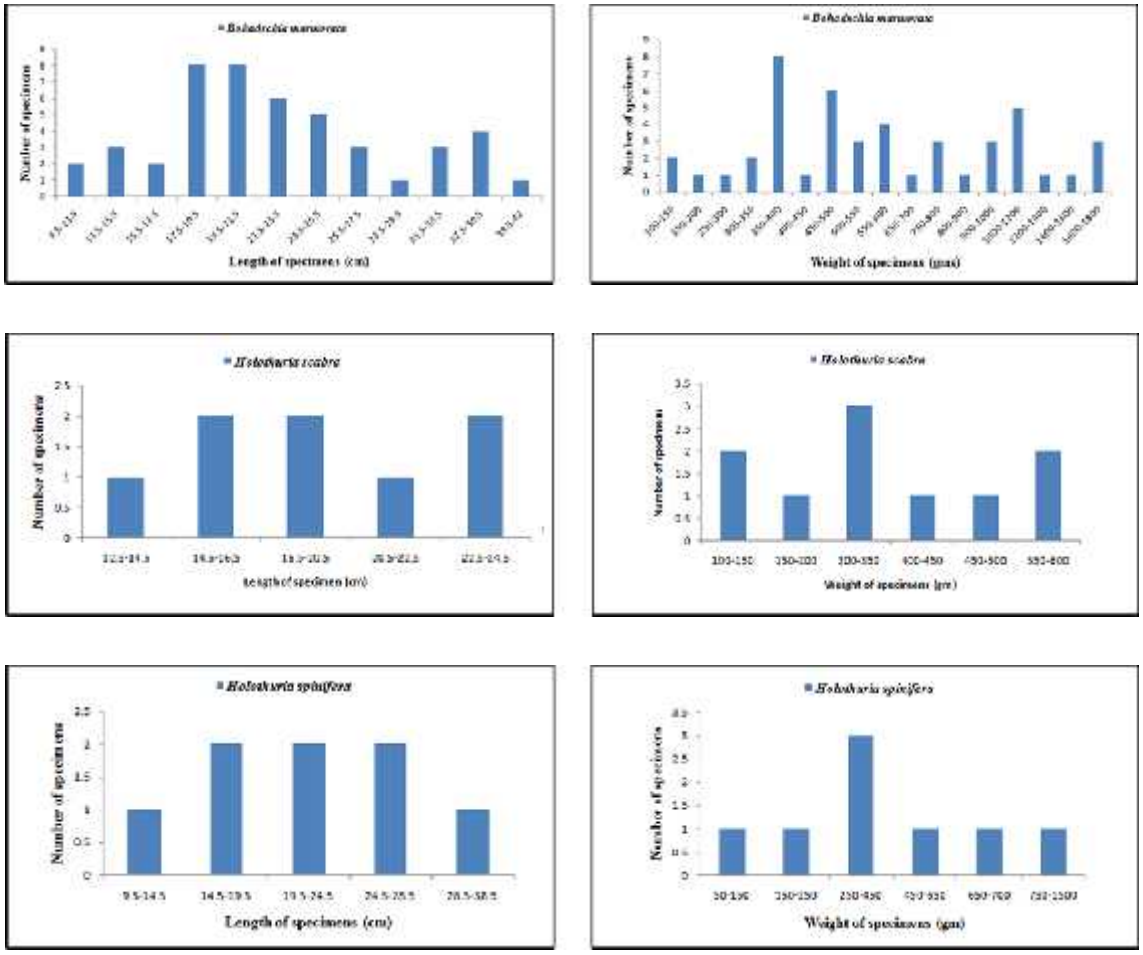
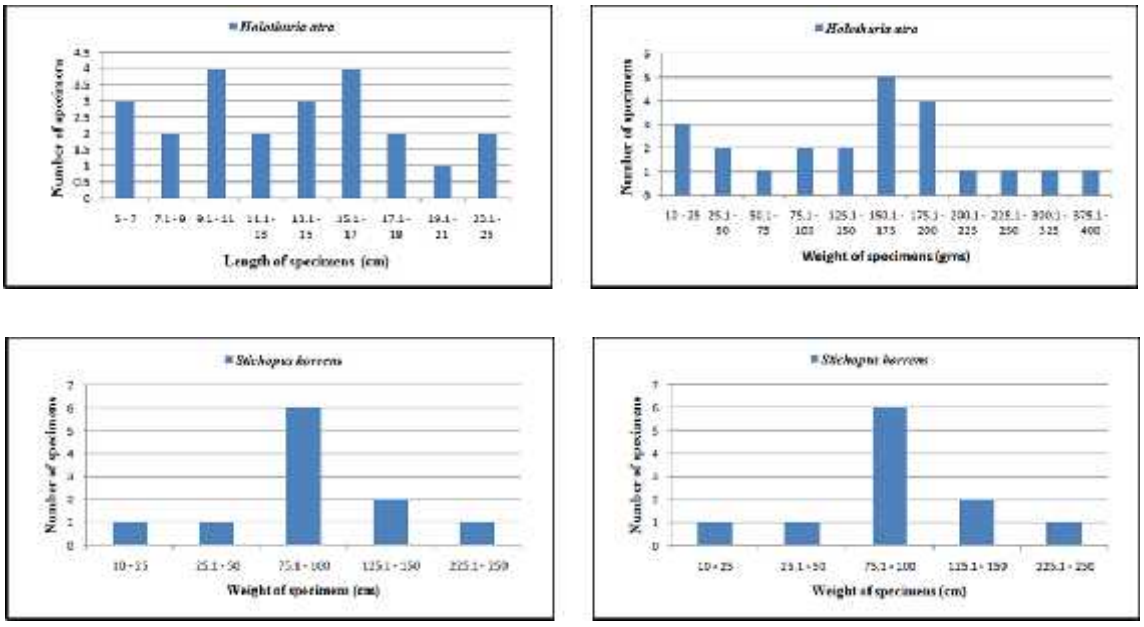


Figure 13 Length and weight frequency distribution of sea cucumbers in Gulf of Mannar



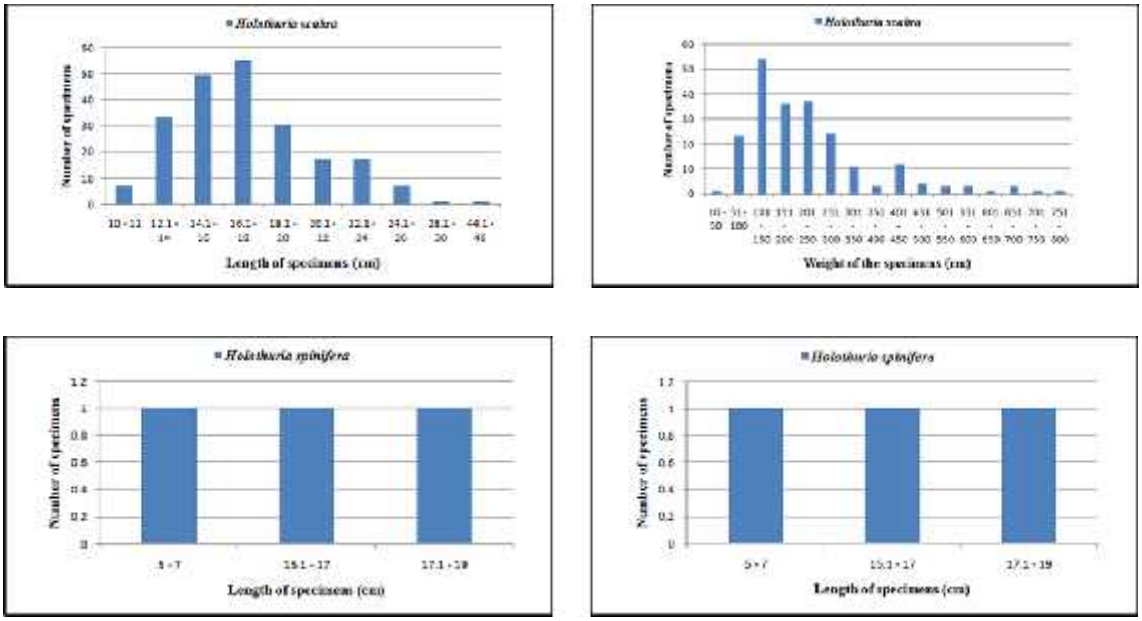


Figure 14Length and weight frequency distribution of sea cucumbers in Palk Bay

Table 6 Mean (±SE) length (cm) of sea cucumbers in Gulf of Mannar and Palk Bay; the values in parenthesis are range

S.no.	Species	Mean (±SE) and range of length (cm)	
		Gulf of Mannar	Palk Bay
1	*Holothuria scabra*	19.21±1.44(12.5-24.5)	17.27±0.26(10.8-45.2)
2	*H. spinifera*	22.6±3.06(9.5-38)	13.46±4.27(5-18.6)
3	*H. atra*	14.09±0.49(6-32)	13.46±1.11(5.1-24.8)
4	*H. leucospilota*	20.06±0.46(7.3-42)	50±0.0.0
5	*H. edulis*	20±1.00(19-21)	-
6	*Stichopus horrens*	13.95±0.23(2.5-22)	12.70±1.45(7-22.5)
7	*Bohadschia marmorata*	23.12±1.07(11-41)	36.5±0.0
8	*Bohadschia sp*	24±2.005(22-26)	-
9	*Colochirus quadrangularis*	5.65±0.35(5.3-6)	-

Table 7 Mean (±SE) weight (g) of sea cucumbers in Gulf of Mannar and Palk Bay; the values in parentheses are range

S. no.	Species	Mean (±SE) and range of weight (g)	
		Gulf of Mannar	Palk Bay
1	*Holothuria scabra*	360.63±68.07(115-580)	231.79±9.42 (50-780)
2	*H.spinifera*	466.88±138.41(50-1300)	166±81.64 (8-280)
3	*H.atra*	170.65±15.53 (40-1100)	149.78±20.03 (10- 400)
4	*H.leucospilota*	259.34±12.52 (20-1000)	700±0.0.0
5	*H.edulis*	275±25.07 (250-300)	-
6	*Stichopus horrens*	117.96±3.40 (20-260)	104.55±17.06 (10-230)
7	*Bohadschia marmorata*	714.78±62.15 (100-1800)	750±0.0

8	*Bohadschia sp*	1090±290.87 (800-1380)	-
9	*Colochirus quadrangularis*	10.25±0.25 (10-10.5)	-

Table 8 Sizes at first maturity and juvenile population of major sea cucumber species in Gulf of Mannar and Park Bay

Species	Size at first maturity		Reference	Gulf of Mannar		Palk Bay	
				Percentage of population (%)		Percentage of population (%)	
	Length (mm)	Weight (g)		Adult	Juvenile	Adult	Juvenile
Stichopus horrens	<160	-	Purcell *et al*., 2012	32.06	67.94	26.92	73.08
Holothuria scabra	<210	-	" "	43.75	56.25	26.88	73.12
H. atra	<160	-	" "	28.57	71.43	33.33	66.67
H. leucospilota	<210	-	" "	32.79	67.21	100	0
Bohadschia marmorata		<90g	" "	100.00	0	100	0

3.5. Distribution and abundance of sea cucumbers in survey sites of Gulf of Mannar and Palk Bay

The distribution of major sea cucumber species, the areas of their higher abundance in terms of density >1000 and 5000 nos.ha^{-1} and the juvenile abundance in Gulf of Mannar and Palk Bay are given in Figures 15-19.In Gulf of Mannar, the major species *Stichpus horrens* was collected from 59.7% of the survey sites between a depth of 6-7.6 m and their population inhigher abundance (>5000nos.ha^{-1} and >1000nos.ha^{-1}) was reported from 13.6% each of the survey sites and the juveniles were abundantly distributed in seven sites - GOMD3, GOMT4, GOMT5, GOMT8, GOMT9, GOMT10 and GOMT12 (Figure 15). *H.leucospilota,* was collected from 63.6% of the survey sites and only 27.3% of the survey sites reported their population >1000-5000nos. ha^{-1} and the juveniles were predominant in seven sites (Figure 16). *Holothuria atra,* the most widely distributed species in Gulf of Mannar (reported from 68.2% of survey sites) and their abundance (>1000nos.ha^{-1})was noticed in 31.8% of the survey sites and the juveniles were distributed in five sites (Figure 17). The higher densities (>1000nos.ha^{-1}) of *B.marmorata* were recorded in 4.5% and for *H.spinifera* in 22.8% of the survey sites. The high valued *H.scabra* was recorded only from 4 sites at a maximum density of 1818 nos. ha^{-1}. Other species like *Cholochirus quadrangularis, H.edulis* and an unidentified *Bohadschia* specieswere seen from only one survey site in Gulf of Mannar.

In Palk Bay,out of the 25 nos. of survey sites, the most dominant *H. scabra* was collected from 96.2% of the survey sites between depths of 3-16m. 19.2% of the survey sites reported their higher abundance (>5000nos.ha^{-1}) and 30.8% with >1000nos.ha^{-1}. Juveniles were abundant in 32% of survey sites (Figure 18). *H.atra* was the second dominant species collected only from 19.23% of the sites and 7.7% of the sites reported the density >1000nos.ha^{-1} (Figure 19). *H.spinifera* was reported from 7.7% of the survey sites. Species like *B.marmorata*, *Stichopus horrens* and *H. leucospilota* were collected only from 3.8% of the survey sites at a density >500nos.ha^{-1}. In general the holothurian distribution in both ecosystems was patchy in nature and no correlation was noticed between sea cucumber density and depth of water column.

According to Purcell (2009), as a tentative indicator, population density below 100nos.ha^{-1} could be classifiedas low and density below 30nos.ha^{-1} as at critical level at which population may fail to repopulate effectively. Except for a few sites, majority of the sites in both the ecosystems do not belong to the above two categories.Dissanayake and Stefansson (2012) pointed out that *H.atra* densities were highest in association with the mean grain size of about 0.7–1.2 mm and the organic carbon contents between 2 and 3.5% of dry weight. Sediment grain size could be considered as an important factor which governs the habitat preference of sea cucumbers. In the present study, high density of sea cucumbers was noticed in places with bottom substrate of more coarse sand (**Table 22,Appendix I**). A high negative correlation was noticed between fine sand and sea cucumber density ($p<0.001$). The high abundance of medium valued *S. horrens* and low valued *H.atra* in Gulf of Mannar might be due to their high reproduction rate and adaptability to different habitats like sea grass beds, coral reefs, rocky, sandy and muddy shores etc. (Chao *et al*., 1994). Similarly *H.scabra* population in good numbers in the Palk Bay, in spite of fishing pressure from clandestine fishing might be due to its favorable environment.

Figure 15 Distribution of *Sichopus horrens* in Gulf of Mannar (- density >5000 nos. ha^{-1}; - density- >1000nos.ha^{-1}; - juvenile distribution)

Figure 16 Distribution of *Holothuria atra* in Gulf of Mannar (- density >5000 nos. ha^{-1}; - density>1000nos.ha^{-1}; - juvenile distribution)

Figure 17 Distribution of *Holothuria leucospilota* in Gulf of Mannar (- density >5000nos.ha^{-1}; -density>1000nos.ha^{-1}; - juvenile distribution)

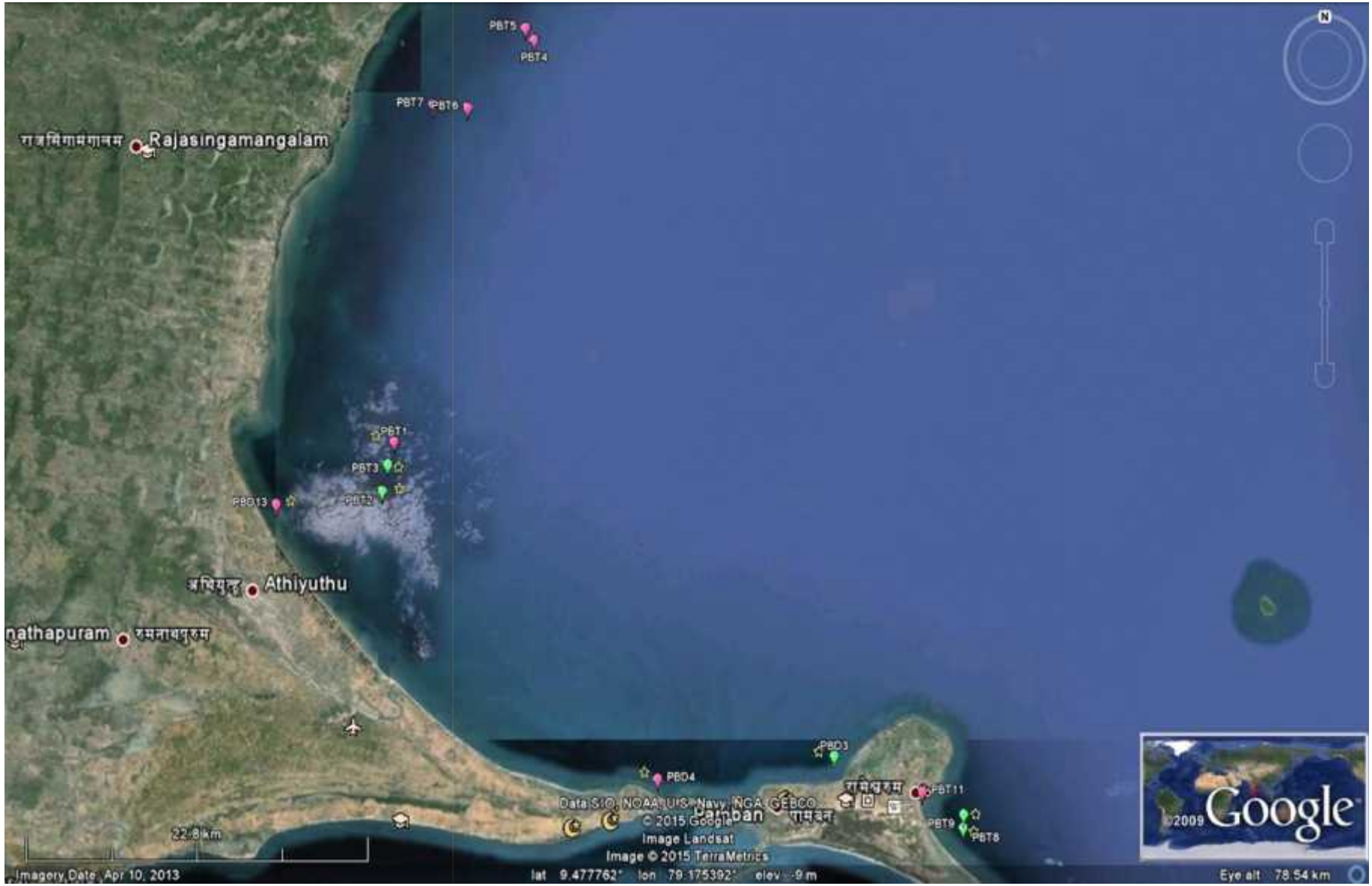


Figure 18 Distribution of *Holothuria scabra* in Palk Bay (- density >5000nos.ha^{-1}; -density - >1000nos.ha^{-1}; - juvenile distribution)

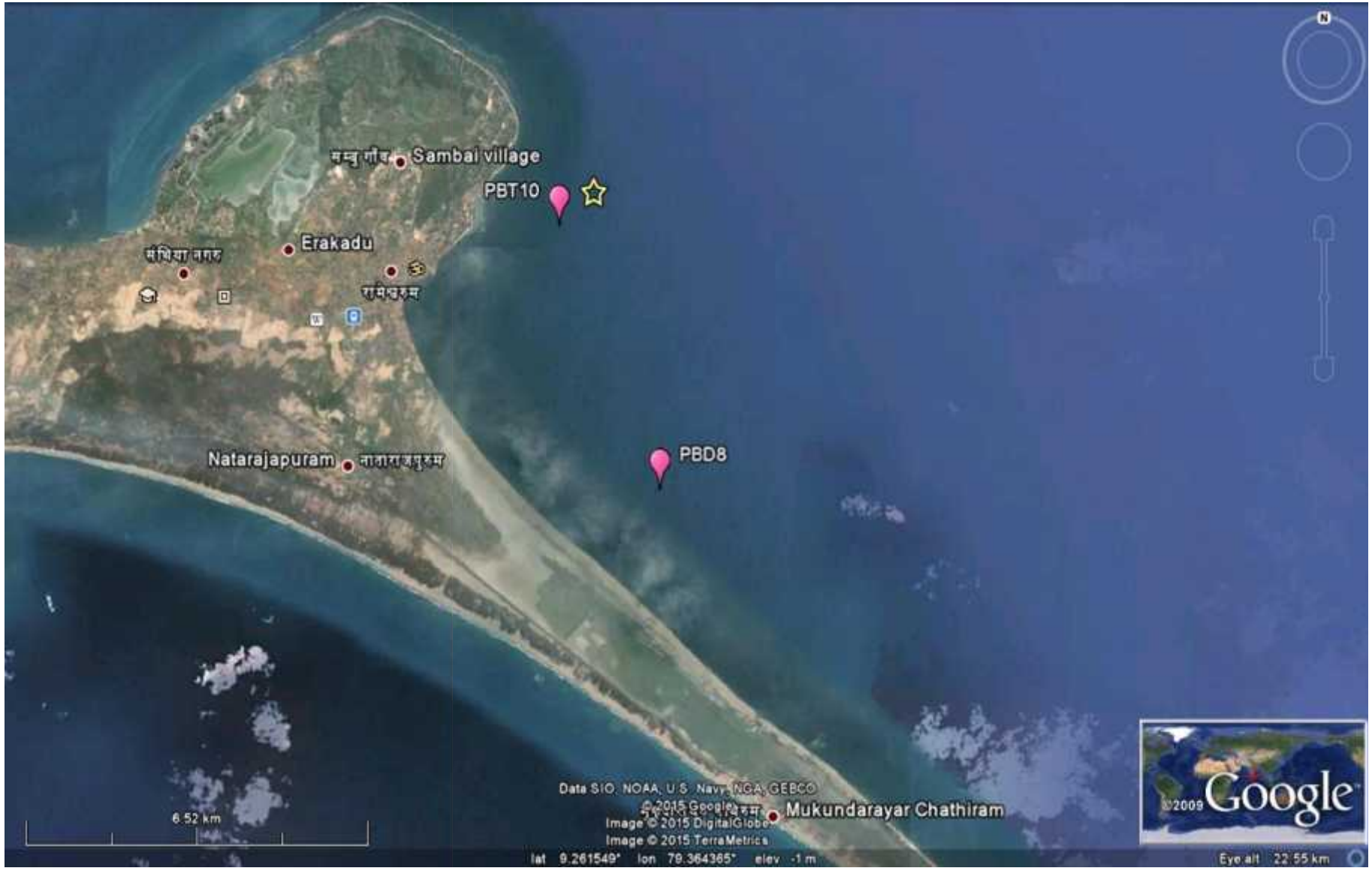


Figure 19 Distribution of*Holothuria atra* in Palk Bay (- density >5000 nos. ha^{-1}; -density - >1000nos.ha-1; – juvenile distribution

3.6. Weight–length relationships (WLR) of sea cucumber species in Gulf of Mannar and Palk Bay

The weight-length relationships were performed for major sea cucumber species collected during the survey and the results are given in Tables 9 & 10. In Gulf of Mannar, the b value ranged from 1.2693 (*Stichopus horrens*) to 2.6449 (*Holothuria scabra*) whereas in Palk Bay, it was between 0.883 (*S.horrens*) and 2.2269 (*H.scabra*). These values indicate the allometric growth and it appears to be the general case of tropical holothurians (Herrero-Pérezrul and Reyes-Bonilla, 2008; González-Wangüemert *et al*., 2014). Similar allometric result with exponent b values of 1.83 and 1.92 were also obtained from the weight-length relationship of *Isostichopus fuscus* from Espíritu Santo Island, México (Herrero-Pérezrul and Reyes-Bonilla, 2008) and of *S.chloronotus* from Samoa, (Eriksson, 2006). In the case of *S.horrens*, the exponent value and coefficient of determination varies conspicuously between the ecosystems i.e., 1.2693 (Gulf of Mannar; R^2= 0.591) and 0.883 (Palk Bay; R^2= 0.1681). This might be due to the sampling bias, as except *H.scabra*, only a few specimens of other species were analysed from Palk Bay.

The studies by González-Wangüemert *et al*. (2014) on sea cucumber populations from the Aegean Sea revealed that the exponent b values for *H.polii* ranged from 3.79 to 6.68 suggesting these species are growing allometrically but are heavier specimens. The order in which the species are lean in Gulf of Mannar is as follows (*S.horrens*>*H.leucospilota* >*H. atra*>*H.spinifera*>*H.scabra*) and for Palk Bay (*S.horrens*>*H.atra*>*H.scabra*). The allometric coefficient observed in length-weight power relationship of *H.scabra* for Gulf of Mannar (2.6449) and Palk Bay (2.2269) is consistent with values obtained for Oman population - 2.18 (Al-Rashdi *et al*.,2007), New Caledonia - 2.28 (Conand, 1990) and Vietnam - 2.84 (Pitt and Duy, 2004). However for a given length, the individuals collected from Gulf of Mannar were stouter than those collected from Palk Bay. These differences could correspond to actual biological differences in relation to the environmental conditions prevailing between the two ecosystems. In the present study, the exponent b values are less than 3.0 which indicate that most of the sea cucumber species have elongated bodies. Moreover, a and b exponents, coefficient of determination values varied between the two ecosystems.

Table 9 Length and weight relationship of major sea cucumber species from Gulf of Mannar

Species names	Weight-length relationship	R^2 (coefficient of determination)	No of specimens
Stichopushorrens	$y = 3.917x^{1.269}$	0.591	243
Holothuria scabra	$y = 0.1308x^{2.6449}$	0.849	8
H. atra	$y = 1.8104x^{1.664}$	0.575	86
H. leucospilota	$y = 2.4436x^{1.5238}$	0.547	147
H.spinifera	$y = 0.4439x^{2.1734}$	0.891	8
Bohadschia marmorata	$y = 4.9096x^{1.5532}$	0.583	46

Table 10 Length and weight relationship of major sea cucumber species from Palk Bay

Species names	Weight-length relationship	R^2 (coefficient of determination)	No of specimens
Stichopushorrens	$y = 9.5587x^{0.883}$	0.1681	11
Holothuria scabra	$y = 0.3666x^{2.2269}$	0.6786	217
H. atra	$y = 1.5901x^{1.6732}$	0.5036	23

3.7. Socio-economic/interview survey

3.7.1. Fishermen perception on sea cucumber biology, ecology and population

Out of nine statements in Table 11, the first five statements were related to sea cucumber biology and the last four to its ecology. For each statement the respondents gave their response in a five point continuum starting from "strongly agree to strongly disagree". Fishermen perception and knowledge about sea cucumber biology is less in comparison to their knowledge about its ecology, since 5-30% of respondents did not know any information on sea cucumber biology (Table 11).

Table 11 Respondent's perception on sea cucumber biology and ecology

(N=500)

Statement	Strongly agree (%)	Agree (%)	Undecided (%)
Sea cucumber are sedentary	75	20	5
Sea cucumber are nutritious food	60	35	5
Medicines are prepared from sea cucumbers	40	30	30
Sea cucumber can be easily exploited	60	30	10
Holothurians help to recycle the detritus	45	40	15
Sea cucumber are fully buried	60	38	2
Sea cucumber are half buried	60	38	2
Sea cucumber appear during dawn	60	40	0
Sea cucumber appear during dusk	40	60	0

The respondents had a better perception and knowledge about sea cucumber population which is evident from their response regarding the availability and the status of sea cucumber population. Sea cucumber fishers opined that the availability of sea cucumber is more during the months of March to May in Gulf of Mannar and October to December in Palk Bay. Depth of collection of sea cucumbers ranged from 1.35 to 8.77m (Gulf of Mannar) and from 0.67 to 5.5m (Palk Bay).

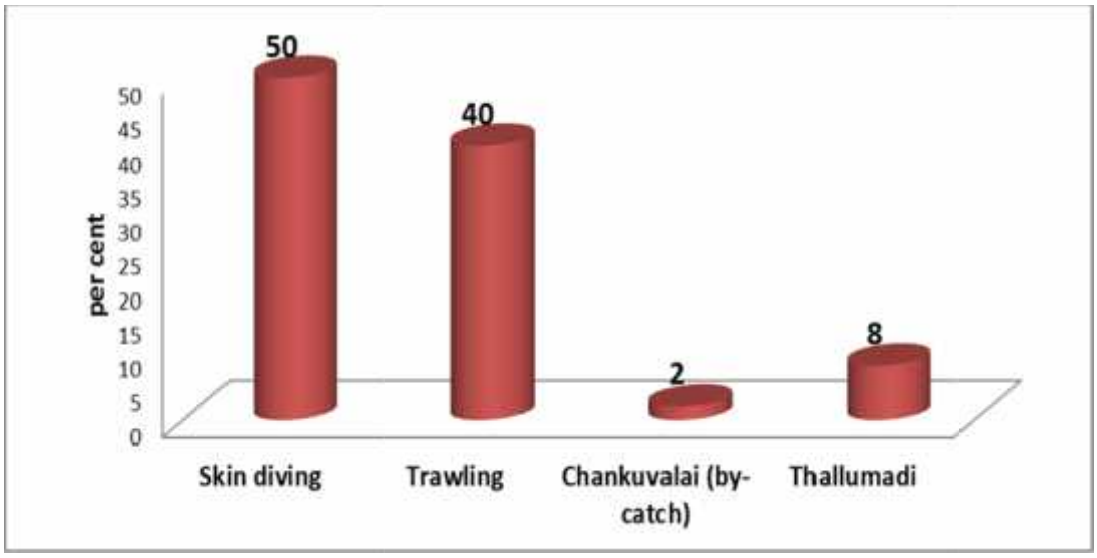
Almost all respondents expressed that the sea cucumber population has increased during the ban. However, they also reported clandestine removal of sea cucumbers and accidental catch in trawlers. Further, they stated that they get 2 to 5 numbers of sea cucumbers per month as incidental catch in a motorized &non-mechanized fishing unit (like mini trawl) and 10 to 15 numbers of sea cucumbers per month in a mechanized fishing unit (like trawl).

3.7.2. Mode of sea cucumber fishing

Sea cucumber fishing was mainly carried out by skin diving and trawling. The skin divers involved in sea cucumber collection used country craft with outboard engine to reach the area where sea cucumber availability is more in the sea (5-8m depth). The overall length of trawlers used for sea cucumber fishing was 11-20m, with 70-120 horse power engines. The length of trawl net was 13m

with cod end mess size of 25mm. A few fishers were also getting sea cucumbers in mini-trawl/indigenous trawl which is locally called *thallumadi* and as by-catch in indigenous bottom-set gillnet which is locally called *chankuvalai.* The overall length of country craft used for sea cucumber fishing with *thallumadi* was 4-10 m. The length of *thallumadi* was 8m, with cod end mess size of 15-25mm.

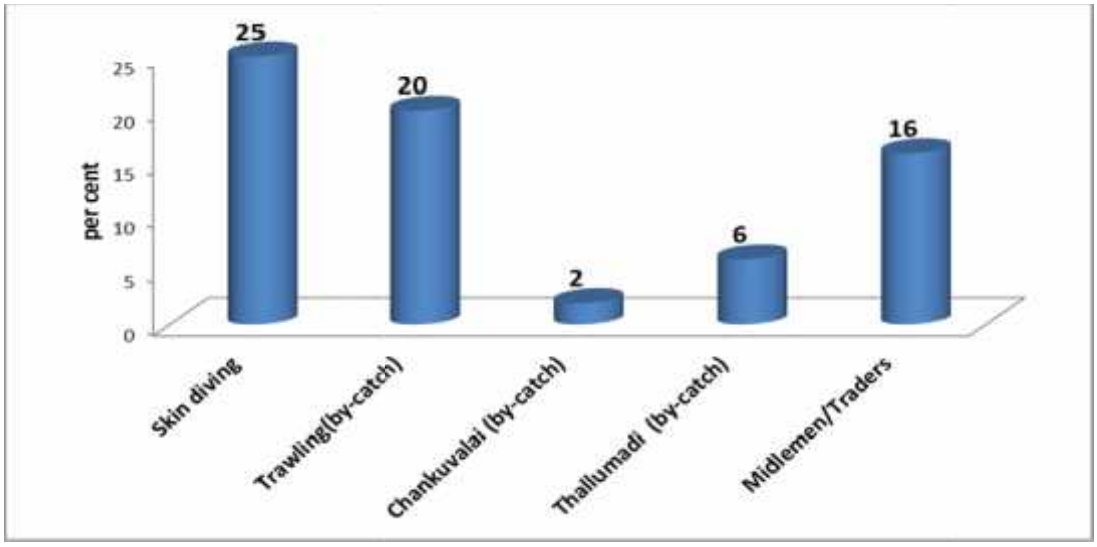
About 50% of the respondents opined that the sea cucumbers were mostly exploited by skin diving and 40% said that trawling was the major gear before ban (Figure 20). About 10 % of fishers told that they were getting sea cucumbers in *thallumadi* and as by-catch in *chankuvalai.* Before the ban, both fishermen and fisherwomen were involved in sea cucumber fishing.



(n=400)

Figure 20 Distribution of respondents based on mode of fishing of sea cucumber before the ban

All the respondents in the survey were involved in fishing/trade of sea cucumber before the ban, but 31% of the respondents discontinued the activity after declaration of ban. The remaining 69% are continuing the sea cucumber fishing/trade. Fishers expressed that during the ban, sea cucumbers were mostly taken by skin diving (25%) followed by trawling as by-catch (20%) (Figure 21). They also get sea cucumbers in smaller quantity in *thallumadi* and *chankuvalai* as by-catch. They also told that genuine fishermen (27%) and middlemen/traders (4%) have discontinued sea cucumber fishing.



(N=500)

Figure 21 Distribution of respondents based on sea cucumber fishing/trade during the ban

3.7.3. Economics of sea cucumber fishing before the ban

Table 12 Economics of sea cucumber fishing before the ban

Mode of fishing sea cucumber	Expenditure incurred per trip (operating cost) (Rs)	Gross revenue per trip (Rs)	Operating ratio (operating cost/gross revenue)
Skin diving	1,000	5,000	0.20
Trawling	32,600	54,000	0.60
Thallumadi	1,900	4,000	0.47
Chankuvalai (by-catch)	1,800	3,000	0.60

Before the ban, the average operating cost of sea cucumber fishing by skin diving, trawling and *thallumadi* fishing was Rs.1,000/-, Rs.32,600/- and Rs.1,900/- per trip respectively with gross revenue of Rs.5,000/-, Rs.54,000/- and Rs.4,000/- per trip respectively. Unlike skin diving, operational cost and revenue from trawling and *thallumadi* includes catch of species other than sea cucumbers. The operation cost of skin diving includes rent for the boat, fuel and food expenses. The operating ratio (operating cost/gross revenue) for sea cucumber fishing was less for skin diving (0.2), followed by *thallumadi* (0.47) and trawling (0.60). It is evident from Table 12 that sea cucumber fishers were able to get good revenue before the ban. Fishermen were getting gastropods, catfishes, crabs and breams in *chankuvalai* along with sea cucumbers as by-catch (total operating cost per trip was Rs.1,800/- and gross revenue was Rs. 3,000/-). Sea cucumber fishing through skin diving was most economically efficient than other modes of fishing as the cost of operation and investment were very low.

The average operating cost of sea cucumber fishing by skin diving during the ban was Rs. 1,200/-per trip with gross revenue of Rs. 4,000/-per trip with the operating ratio (operating cost/gross revenue) of 0.3 (Table 13). Fishermen were getting catfishes, goat fishes, breams, silver biddies, needle fishes, squids, cuttlefishes, and gastropods in trawling along with sea cucumbers as by-catch (total operating cost per trip was Rs.36,700/- and gross revenue was Rs.50,000/-). Fishermen were getting shrimps, seahorses, breams, silver biddies and squids in *thallumadi* along with sea cucumbers as by-catch (total operating cost per trip was Rs.2,100/- and gross revenue was Rs.3,000/-). In *Chankuvalai,* gastropods, catfishes, crabs and breams are caught along with sea cucumbers as by-catch (total operating cost per trip was Rs.2,100/- and gross revenue was Rs. 2,500/-). As in the pre-ban period, sea cucumber fishing through skin diving was economically most efficient during the ban than the other modes of fishing as the cost of operation and investment were very low. However, the revenue in terms of operating cost was five times in the pre-ban period, which has reduced to 3.3 times in the ban period because fishers were receiving a lesser revenue share during ban as it is a clandestine activity. Moreover most of the fishers were selling the fresh sea cucumbers during ban for which they receive lower prices.

Table 13 Economics of sea cucumber fishing during the ban

	Expenditure incurred per trip (operating cost) (Rs.)	Gross revenue per trip (Rs.)	Operating ratio (operating cost/gross revenue)
Skin diving	1,200	4,000	0.30
Trawling (by-catch)	36,700	50,000	0.73
Thallumadi(by-catch)	2,100	3,000	0.70
Chankuvalai(by-catch)	2,100	2,500	0.80

3.7.4. Effect of ban on their livelihood

Garrett's ranking technique was used to identify and rank the attributes based on what ways sea cucumber ban has affected their livelihood (Table 14).Those who left the sea cucumber fishing due to blanket ban reported that it has affected their livelihood. There was a loss in their regular income as they were not able to do other fishing activities due to lack of capacity for investment. As a consequence, their debts increased and they were unable to give quality education to their children. They also found difficulty in arranging marriages of their daughters. Only a few fishers reported that there is an increase in the migration of fishermen to other districts and states in search of occupation after implementation of the ban.

Table 14In what ways sea cucumber ban affected your livelihood

S. no.	Particulars	Score	Garrett rank
1	Affected the standard of living	72.9	I
2	Loss in regular income	55.2	II
3	Increase in debts	40.3	III
4	Loss in savings	33.6	IV
5	Not able to provide quality education to children	25.0	V
6	Lack of investment to shift to new fishing options	17.6	VI
7	Before blanket ban, sea cucumber fishing was a remunerative option during 45 days trawl ban. But due to blanket ban, sea cucumber fishing is not possible during trawl ban period	11.4	VII
8	Difficulty in arranging marriages for their daughters	7.8	VIII
9	Increase in migration of fishermen who are involved in sea cucumber collection to other districts and states in search of occupation	3.8	IX

3.7.5. Sea cucumber supply/value chain

Before ban, most of the fishermen (85) sold sea cucumbers in the form of *beche-de-mer* (processed) and others (15%) sold fresh sea cucumbers. Three to six days were required for *beche-de-mer* preparation and the expenditure was Rs.25 per kg. During ban only 5% of fishermen were engaged in processing and were incurring an expenditure of Rs. 44 per kg. Rest of the fishermen (95%) was selling in fresh form. Mostly fishermen sell the sea cucumbers to local agents. Almost all the respondents stated that they do not consume sea cucumber.

Majority of the fishers sold the sea cucumbers in processed form (boiled, skin peeled, sun and shade dried) to first level middlemen. In every location there were many first level middlemen, who collected the processed sea cucumbers in small quantities and sold to second level middlemen. The product was sold to third level middlemen who covered a larger area. The third level middlemen sold the processed sea cucumbers to the traders. The traders, after suitable packing sold it to exporters. Further exporters; export the packed sea cucumbers to the international markets.

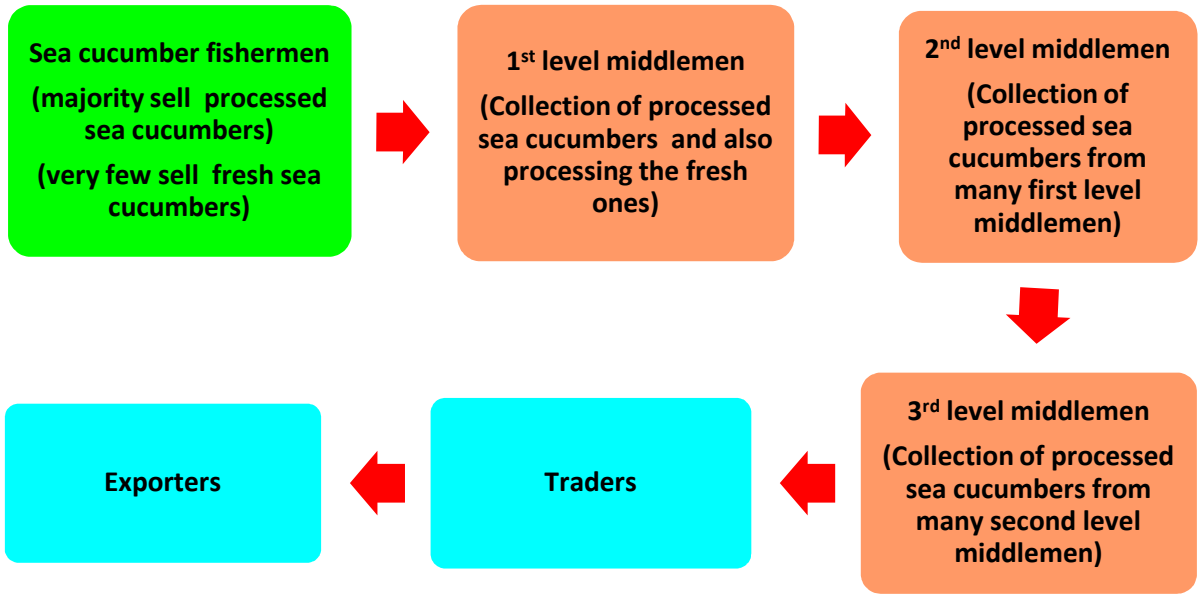


Figure 22 Market channel that existed in sea cucumber trade before the ban

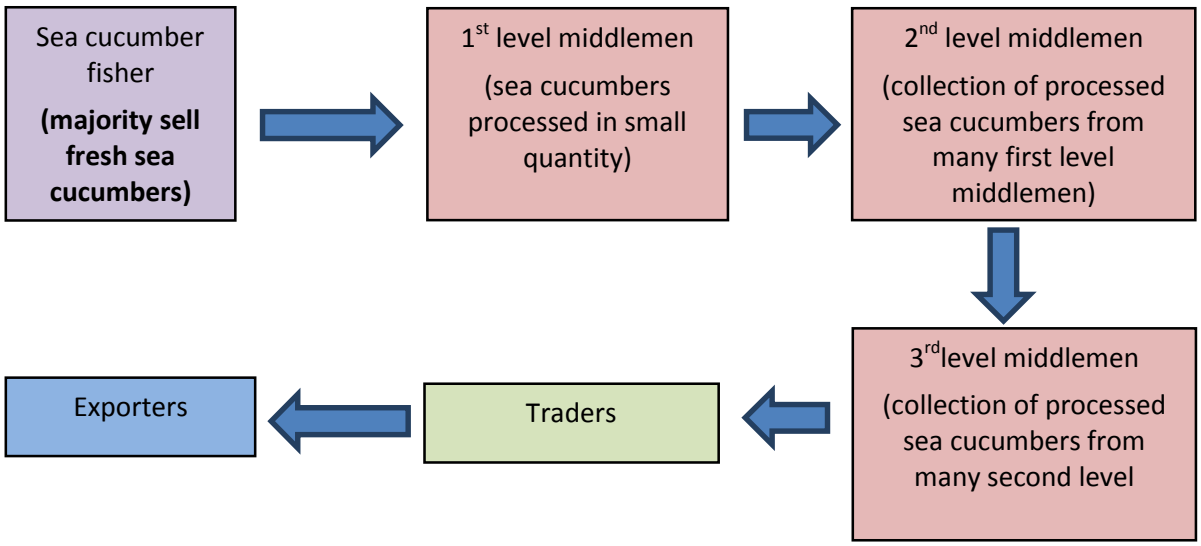


Figure 23Market channel in sea cucumber trade during the ban

When compared to before ban, during the ban majority of fishers sell sea cucumbers in fresh form. Only the first level middlemen process the sea cucumbers. Hence the fishers are not at the receiving end to get good returns when compared to what middlemen, traders and exporters get.

3.7.6. Average market price for processed and fresh sea cucumber

All those in the supply chain received a better price for processed sea cucumbers in comparison to unprocessed ones, since the fresh sea cucumbers cannot be stored for long duration and the processed sea cucumbers can be readily used for consumption and medicine preparation. Processed sea cucumbers are sold based on count (20 or 45 counts per kg), whereas fresh ones are sold based on size (25-30 or 10-15 cm per piece). Before the ban, the trade was mostly on 20 counts per kg of processed sea cucumbers. During ban fishers mostly sell the fresh (*Holothuria scabra – vella attai*) sea cucumbers of length 25-30 cm (approximately 500 g) to the first level middlemen for Rs.150/- per piece. Sea cucumbers of length 25-30 cm are mostly preferred, since it will give a desirable size after processing. However, some fishermen were also selling fresh sea cucumbers of length 10-15 cm (approximately 250 g) to the first level middlemen for Rs.50/- per piece. The first level middlemen process the sea cucumbers. To get one kilogram of processed sea cucumbers, 10 kg of fresh sea cucumbers (20 pieces of length 25-30 cm or 40 pieces of length 10-15 cm) are required.

Table 15 Average market price for processed sea cucumbers (1US$ = Rs. 64 approximately)

Actors in supply chain	Before ban (Rs. per kg)		After ban (Rs. per kg)	
	20 counts	45 counts	20 counts	45 counts
Fishermen	5,000	2,000	9,000	3,000
1st level middlemen	5,100	2,100	9,600	3,500
2nd level middlemen	5,300	2,250	10,400	4,100
3rd level middlemen	5,600	2,500	11,800	5,000
Traders	6,200	3,400	15,000	7,000
Exporters	10,50	5,000	18,000	11,400

In the last 15 years after implementation of ban, the price of sea cucumbers has doubled at every level in the market chain (Table 15). The increase in price is due to the high demand in international markets, which resulted in increase of price over the years. At every level in the market chain, the price of larger sea cucumbers (20 counts) was 2 to 2.5 times higher than the smaller ones (45 counts). Fishermen continue to get approximately 50% of the value of sea cucumbers before and during the ban. The maximum profit before the ban was for the exporters, who sold the products for Rs. 10,500 (for 20 counts) by investing only Rs.6,200, i.e., a profit of about 70% over investment. However, during ban, the profit margin (% over investment) is almost equally distributed along the market chain. This may be because of fear that all are involved in illegal activities and do not want to be exposed. Before ban, traders were not revealing the export price to the fishers/middlemen, which is not possible now.

3.7.7. Management measures suggested by the fishers

We asked the respondents to suggest some effective management measures if a suggestion has to be made to lift the ban. The findings are depicted in Table 16 below.

Table 16 Effective management measures as suggested by the respondents for sustaining the sea cucumber stocks if the ban is lifted

Management measures	(N=500)(%)
Size restriction	80
Gear limitation	55
Strict enforcement of banned gears and fishing methods	75
Seasonal closure	90

Catch quotas	2
Rotational harvest closures	75
No-take zone	5
Stock enhancement through sea ranching	70
Awareness programme on conservation	60
Licensing	5
Reporting the catches	2

1. **Seasonal closure**

The option for closure of sea cucumber fishing during peak spawning period of the year to enable successful breeding and recruitment for the commercially important species was suggested by a majority of the fishers if the ban is lifted. Seasonal closures have been used in some sea cucumber fisheries elsewhere (Bruckner, 2006; Toral-Granda *et al*., 2008). Temporal closures could be viewed as a measure to protect sea cucumbers at certain critical times of the year such as spawning period (Bruckner, 2006).

2. **Size restriction**

The option to allow the harvest of sea cucumbers above 10-15 cm size and restricting the collection of undersized of less than 10-15 cm was suggested by a majority of the fishers. Restriction in the collection of sea cucumber brooders was also suggested by them. This suggestion has been made previously by Conand (1989) who reported that recent research on the reproductive biology of the majority of commercial species of holothurians allows recommendations to be made on size regulations for the fresh or processed, product based on size at first sexual maturity. A principal use of size limits in sea cucumber fisheries is to protect juveniles and recently matured adults to allow individuals one or more seasons to spawn before they can be fished (Purcell *et al*., 2009). James (2004) suggested that 'rational exploitation can be allowed subject to size regulations and catch quota systems for sea cucumber fishing trade as done in other countries'. He also suggested that 'divers should not be allowed to collect sea cucumbers during the breeding season and certain areas should be declared as closed for divers so that the brood stock could be protected.'

3. **Strict enforcement of banned gears and fishing methods**

Use of banned gears (pair trawling, *roller madi, thallumadi*) should be stopped completely and stringent measures can be taken to stop dynamite fishing. Efforts also may be taken to reduce the number of trawlers.

4. **Rotational harvest closures**

A periodic, temporal and spatial shifting of fishing effort in a systematic way among demarcated fishing grounds was suggested by three-fourth of the respondents.

5. **Stock enhancement through sea ranching**

It was suggested to enhance the wild population of sea cucumbers through land based hatchery production of juveniles and sea ranching the same at selected areas.

6. **Awareness programme**

Conducting periodical awareness programme on conservation of sea cucumbers at village level was suggested by nearly two-third of the respondents.

7. **Standardization of commercial level seed production techniques of selected species of sea cucumbers and farming trials**

It was suggested to undertake the standardization of commercial level seed production of selected species of sea cucumbers namely *Holothuria scabra* and *H.spinifera*. Farming trials may also be undertaken to find out the feasibility of sea cucumber production through aquaculture. It was also suggested to train the fishermen groups on commercial level seed production techniques of selected species of sea cucumbers and farming trials. The creation of spawning population in near-shore waters should inadvertently support stock rebuilding (Robinson and Pascal, 2009).

8. **Only 5% of respondents suggested that certain areas can be demarcated and designated as no-take zone in consultation with the local communities.**
9. **Only 5% of respondents suggested that the fishermen cooperatives can be given license for sea cucumber trade.**

Majority of the respondents suggested that the participatory co-management of sea cucumber and conservation can be done through community monitoring at village level, for which they suggested establishment of Councils at the village level for management/conservation of sea cucumbers. The local institutions such as fishermen associations and fisherwomen cooperatives can be included for effective management of sea cucumber fishery. Apart from these community organizations, non-government organisations, and self-help groups may be considered as stakeholders for effective management of the resources.The implementation of a co-management regime in the Galapagos has increased the effectiveness of license and quota control and reduced conflict between management and fishers (Shepherd *et al*., 2004). Similar successful cases from many countries show that co-management will be effective.

4. Conclusion

The present survey on sea cucumber resources indicated differences in abundance, biomass and species composition between Gulf of Mannar and Palk Bay. Because of the short duration of the project, it is hard to arrive at strong conclusions whether the sea cucumber population has recovered during the last 14 years of moratorium of fishery and trade of sea cucumbers. However there are indications that the population has improved and appears better than previous estimates from the same location during 2011-2012. Fishermen interview survey showed that the sea cucumber populations in Gulf of Mannar and Palk Bay have significantly improved after the implementation of ban. Most of the fishermen and traders who were engaged in sea cucumber fishery before the ban have resorted to illegal fishing and trade making the Wild Life Protection Act ineffective. The fishermen want the ban to be lifted at least for a few commercial species. They are agreeable to follow regulatory measures for conservation of resources with participatory co-management.

5. Recommendations on sea cucumber conservation

The project has attempted to gather information on sea cucumber resource availability through trawl and dive surveys; and the opinion of fishermen, traders, researchers, conservationists and managers on the status of the resource as well as potential measures that could be taken to sustain the resource. As the project duration was short, and was operational effectively for a period of only about six months, it is hard to arrive at conclusions and recommendations solely from the results of this project. However, from the past experience of the project personnel, interview surveys and discussions with the stakeholders and experts on sea cucumbers, it is possible to bring out strong recommendations based on the analysis of the findings. The recommendations suggested in this section are the outcome from the following sources:

1. Results of resource surveys of the current project
2. Existing management measures and their functioning
3. Interview surveys with stakeholders
4. Published scientific papers and reports
5. Formal and informal expert consultations

These sources have provided multiple indicators to understand the status of the resources and to arrive at potential management options for conservation and sustainable use of the resource. While the conclusions from this project refer to sea cucumber resources in Gulf of Mannar and Palk Bay, the recommendations, to a large extent, are applicable to sea cucumber resources along the Indian coast.

Indian national law bans gathering and trade of Schedule I listed species, a more stringent but legitimate policy option within the CITES agreement. While technically illegal, sea cucumber fishery and trade continues and may be increasing in future. Almost everyone engaged in the fishery and trade opposes the ban since its inception in 2001. Moratorium may be effective in saving the stocks from extirpation if removals are effectively stopped and monitored. However, livelihood dependence on the resource has led to illegal removals and trade. Nevertheless, enforcement of ban might have helped reviving the population of sea cucumbers in Palk Bay and Gulf of Mannar; at the same time, the ban has social and economic impacts on scores of people, particularly the fishers, who were dependent on the fishery. Reforming or allowing controlled capture of wild population appears to be the preferred policy solution.

5.1. Principles and objectives of management

Setting objectives is a vital early step by managers to choose regulatory measures and management actions. The objective of sea cucumber management is that the resources should be conserved and sustainably utilized. Any long-term management plan must ensure that people and wildlife can coexist. The communities should have access to the resources and at the same time take the responsibility to conserve and sustainably use it. Conservation and sustainable use will provide a practical and integrated approach. There are several opportunities to achieve this and there are also global evidences that this twin objective could be achieved by active and genuine participation of communities and government institutions.

To set appropriate sea cucumber management measures, it is necessary to have reasonable amount of information on the status of the resource. It is also important to consider biological and ecological attributes for various regulatory measures and management of sea cucumbers. In spite of research on sea cucumbers, the data availability on basic biological parameters such as growth, mortality and recovery rates, movement, spawning season, longevity, habitat preference etc. are not sufficient to arrive at robust management decisions in Gulf of Mannar and Palk Bay. While dedicated research effort is required to collect the above information, inadequate data on the resources should not be an excuse. The managers must go ahead and implement best management practices on precautionary approach while gathering more information in order to assess stocks, fishing and effectiveness of management measures (FAO, 2013). In the case of India, the moratorium on sea cucumbers is in existence for the last 14 years, and the current resource estimates suggest that regulatory measures need not be very conservative as those for fully exploited stocks.

5.2. Potential measures for management

The sea cucumber fishery in Palk Bay and Gulf of Mannar is typically small scale, spatially structured, targeting sedentary stocks. This is totally different from that of highly mobile fish species. The potential management measures for sea cucumber fishery may be grouped under three major categories: (i) regulatory, (ii) restocking, and (iii) implementation. While the first is a bundle of measures imposed on fishers and traders, the second is a stock recovery measure and the third is a

road map for establishing the mechanism for institutionalising and implementing the first two set of measures.

The potential management measures suggested in this Chapter are a toolkit that could be used in specific situations and locations. All the tools in the kit may not be required, and selection depends on the management objectives, fishery types, species to be managed, acceptance by stakeholders and technical capacity of the managers. The opinion gathered from interview surveys and consultations with stakeholders suggests that a set of at least 4 or 5 regulatory measures may be needed to manage sea cucumber fisheries. It is important to note that each regulatory measure has advantages and constraints.

5.2.1. Regulatory measures

Seasonal closures:

For seasonal closure, it is necessary to consider the spawning period of important species of sea cucumbers. Seasonal closures could protect reproductive stocks of sea cucumbers. However, this measure would be difficult to implement because reproductive seasons may extend for many months and species exhibit asynchronous spawning periods. This would be especially problematic in the Palk Bay and Gulf of Mannar, where the sea cucumber resources are multi-species. It is suggested that seasonal closure may be considered for the peak spawning periods and frequency of spawning months of sea cucumber population.

In locations close to the equator, *H.scabra* is known to display a biannual pattern with two spawning periods (Muthiga *et al.,* 2010). In general, spawning of several species of sea cucumbers in tropical seas coincided with the warmest months. In India, seasonal fishery closure is followed for mechanised boats for 45 to 60 days every year. This applies to Gulf of Mannar and Palk Bay as well, where a closure of 45 days is followed for the last 15 years during summer months from April 15 to May 30 based on the peak spawning season of commercially important finfish and shellfish species. As trawlers are included in the closure, the by catch of sea cucumbers is reduced even though sea cucumbers are not the focus of closure. To increase the effectiveness of seasonal closures with reference to sea cucumbers, it is important to close other forms of target fishing for sea cucumbers such as dive fishing and mini trawl (*thallumadi*) fishing during the 45-day closure.

Considering the ease with which sea cucumbers can be removed, a 45-day annual ban may not be sufficient. In the initial years after lifting the moratorium on the sea cucumber fishery and trade, the sea cucumber fishery may be closed for six months during January-June, which may be reviewed and revised in the later years.

Pulse-fishing or rotational fishing:

In contrast to seasonal closure, a pulse fishing strategy (Friedman *et al.,* 2011) allows fishing for one or several years across the fishery followed by an inactive period of several or many years. In this strategy, however, the ecological and social risks need to be considered. Shifting livelihood in years of closure will not be acceptable to fishers and traders and there would be pressure to prolong pulse fishing beyond safe ecological limits. Supply chain will also be disrupted in years of closure. In contrast, several decades of modest fishing have resulted in stable stocks in a few regions (Purcell *et al.,* 2013). In India, the moratorium may be relaxed for one year, but with restrictions on the fishery. By observing the behaviour of fishermen and traders and the response of the resources, decision could be taken on continuation of pulse fishing with changes in restrictions.

Minimum Legal Size (MLS):

MLS is the minimum individual length or weight of sea cucumbers that can be legally fished or traded. Size limits are species-specific and can pertain to fresh, live animals or to animals in various stages of processing. The purpose of prescribing MLS is to protect juveniles and allow mature individuals to spawn for one or two seasons. Correspondingly, MLS has to be set for *beche-de-mer* as well. MLS will differ from species to species because the length-at-first maturity differs from one

species to another. Though MLS is followed in several countries, it is not easy to determine MLS. The first limitation is that the important species of sea cucumbers contract the body when handled. Hence, body weight may be a better measurement to determine the size-at-maturity, but a good measuring balance is required for determining the body weight. Conand (1990) has estimated the size-at-first maturity of *H. scabra* and *H. lessoni* as 125 g and 310 g drained body weight, respectively. The second limitation is non-availability of information on size-at-first maturity for the species in Gulf of Mannar and Palk Bay. In the absence of this information, the practice that was followed earlier, i.e., restricting the export of *beche-de-mer*below 75 mm, which was accepted by the fishermen in interview surveys, may be revoked.

Spatial closure and no-take zone:

In the northern Gulf of Mannar, an area of 560km^2 encompassing 21 uninhabited islands, surrounding coral reef areas and shallow water habitat is a Marine National Park since 1986. A Biosphere Reserve is located within the park, which is a protected area. Fishing and other human activities are prohibited within the Biosphere Reserve. Though the impacts of the reserve on the resources have not been assessed, it is possible that three decades of protection would have helped recovery of stocks, including sea cucumbers. However, there is no protected area in Palk Bay, where the density of seagrasses is higher. Extension of area under protection and introduction of protected area in Palk Bay would greatly help recovery of habitats as well as resources. In addition to this, areas of sea cucumber abundance may be marked and declared as no-take zones. Marine reserves, unless very large, will rarely satisfy the conservation objectives for all species in a multi species fishery.

Marine reserves may be particularly useful for sea cucumbers because effective spawning and fertilisation seems to require high densities of breeding population, which may not occur in most of the open fishing grounds (Bell *et al.,* 2008). As increasing abundance of juveniles and adults within the marine reserves can have spill over effect through dispersal of animals to surrounding areas, these supplemented stock can be exploited sustainably.

Gear limitation:

Gear limitation will avoid risks to the resources and to the environment as well. Operation of a few destructive gears such as pair trawl, *thallumadi* (minitrawl) and *roller madi* has been banned by the Government of Tamil Nadu. However, these gears are illegally operated in the inshore areas and in seagrass habitats causing harm to sea cucumbers and other associated fauna. Under Marine Fishing Regulation Act (1981), trawlers are not permitted to operate in inshore areas but this restriction is often violated by the fishermen. Vigilance and surveillance on the operation of these gears and strict implementation on banned gears will reduce damage to seagrass beds and other benthic organisms including sea cucumbers.

Catch quota:

Individual quotas, allocated to each fisher or licensed fishing group, can providea way to equitably distribute potential earnings from the resource among fishers. By providing fishers with secured access to a given proportion of the stock, individual quotas can help to maximise the value of the overall catch. For example, fishers will collect only large or valuable sea cucumbers because there is an incentive to be choosy and fill their quota with high value animals.

The majority of illegal removal of sea cucumbers in Palk Bay and Gulf of Mannar is by small scale fisheries. Small scale here means the simplicity of fishing gears and boats and artisanal nature in which animals are collected .The trawlers, which generate sea cucumber by-catch, are of about 13-15 m overall length; the boats with outboard motor are of 7–9 m overall length; and the remaining removal is by skin diving from shallow waters. However, the number of participants in the fishery, though it could not be precisely determined, appears to be large. For fisheries with very high participation, catch quota may be based on conservative extrapolations from the number of boats in each fishery or number of sea cucumber fishers determined from fishery-dependent surveys. While

it is a challenge to fix a quota for trawl by catch, actions should be taken to (a) license the fishers engaged in target and by catch fishery, (b) insist on regular submission of logbooks and receipt books for verification of sales, (c) deny renewal of licence for non-compliance, and (d) carry out random inspections at processing facilities.

Species protection:

IUCN has listed *H. scabra* as "endangered or at high risk of extinction"; *H.spinifera* as data deficient, and *A. miliaris, A. echinites* and *S. hermanni* as "vulnerable or at risk of extinction". Of 39 species recorded in Gulf of Mannar and Palk Bay, the fishery and trade is mostly restricted to two species, namely, the high valued *Holothuria scabra* and medium valued *H. spinifera*. A few other medium valued species, namely, *Actinopyga miliaris, A. echinites* and *Stichopus hermanni* are fished and traded occasionally. The most widely traded species are also the species which are available in relatively higher abundance. There is an option here that the regulatory measures mentioned above may be restricted to the two abundant species, while the less abundant ones may be declared as protected species. The caveat is that species-specific bans do not prevent serial depletion of other species further down the value chain as lower-value species will be targeted by fishers, at the same or higher rate, when high-value species become scarce. It might be advisable to set a shortlist of allowable species, and to implement capacity and effort limitations (e.g. short fishing seasons).

Habitat protection:

The distribution and abundance of sea cucumbers are closely associated with benthic habitats. In the Palk Bay and Gulf of Mannar, they are associated with sand dominated habitats and mudflats, coral reefs and soft corals and seagrass meadows. Several species are known to display specific habitat preferences. *H. scabra* and *H. spinifera* are associated with sandy bottom and mudflats, while *Actinopygaspp.*is associated with coral reefs and reef flats (James, 1994). Seagrass beds are also important habitats for *H. scabra* and several other species since the larvae and juveniles of sea cucumbers rely heavily on seagrasses for settling cues and early life stages (Mercier *et al.,* 2000). In India, the coral reefs are protected under Wild Life (Protection) Act 1971, but not the seagrass beds. The seagrass beds are used as trawling ground by *thallumadi* (minitrawl), which remove a large number of sea cucumbers, other associated fauna in addition to cutting and removing seagrasses from roots and causing turbidity of bottom sediments. It is important to protect and restore the critical habitats such as seagrass beds and coral reefs for conservation of sea cucumber and associated resources.

Trade management:

The illegal trade of sea cucumbers in Palk Bay and Gulf of Mannar at present involves a lengthy market chain of fishers, several middlemen, traders and exporters. If regulatory fishery of sea cucumbers is permitted, it should be ensured that fishers receive a fair share of the export value by monitoring the income generated by the fishery and the economic importance to various players. The manager should monitor the overseas market force so that any increase in demand and price can help plan ahead for adapting management to avoid over fishing. It may open opportunities for fishers that are not apparent. For example, monitoring seasonal variation in demand for products and suitably declaring seasonal closure will be beneficial to the fishers. Monitoring the whole market chain from fisher to exporter allows government agencies to verify or set appropriate taxes and duties. It is necessary to have a process by which price data from the international market can be obtained regularly. Managers should also seek to involve Marine Products Export Development Authority (Ministry of Commerce) and customs department in the country to support or conduct monitoring of export prices of sea cucumbers.

If properly managed, there is scope for obtaining a certification for the sea cucumber fishery of Palk Bay and Gulf of Mannar.

5.2.2. Restocking programme

Aquaculture:

One of the favourable options for recovery of sea cucumber stocks is through restocking of juveniles and adults through hatchery production and aquaculture. In India, the CMFRI succeeded seed production of *H.scabra* in 1988 (James *et al.,*1988) and *H.spinifera* in 2001 (Asha and Muthiah, 2002). Further research helped refining and standardising mass production of seed of the two species (James *et al.,* 1994; Asha 2005). It is possible to upgrade these techniques for mass production and sea ranch and restock the population. Restocking can be done in Palk Bay and Gulf of Mannar, but the critical factors are fund availability, technological expertise, support, and good ecological understanding of target species. Selection of sites and species for restocking is difficult and a thorough ecological understanding is necessary. It is also possible to use a part of the hatchery produce for farming into adults. The farmed adults may be used for export. India may move to provide regulated permits for the collection of broodstock of threatened species for establishing hatchery and aquaculture programmes and certification that exports are from farmed stocks. There should be clear objectives, benchmarks and indicators, and monitoring of restocking programmes as well as using the adults for export purpose. Otherwise, the uses of the investments will be limited. It is also important not to heavily rely upon aquaculture programmes and abandon regulatory measures. This is because aquaculture does not necessarily safeguard extinction in the wild, unless explicit restoration measures are implemented. There is also a need for training on various aquaculture aspects of sea cucumbers. These include low-technology aquaculture (e.g. capture-based aquaculture), multitrophic co-culture strategies and use or implementation of hatcheries and development of strategies for community-based mariculture.

5.2.3. Implementation

Ideally, sustaining sea cucumber fisheries is possible by allowing only a small number of species to be harvested, applying input controls, reducing the number of fishers per unit of fishing ground, improving the socio-economic status of human communities, and strengthening enforcement capacity. An overarching goal in the management of sea cucumber fisheries should be to safeguard the reproductive capacity of breeding stocks so that the resources are available to future generations. While we recognise that all these are difficult to achieve, it is possible to move towards meeting these goals by a careful planning process.

All the regulatory and restocking measures suggested above may not be required. By not putting all eggs in one basket, the most appropriate ones need to be selected based on the management objectives, fishery types and level of exploitation. For example, the fishery on the subpopulation of sea cucumbers in coral reef areas is controlled, but not so in seagrass habitats. The subpopulation in the soft bottom and mudflats of inshore waters is supposed to be conserved, but encroachment of trawlers into these areas does not make conservation effective. Thus the type and scale of regulatory and recovery programmes have to be different between these habitats.

Ecosystem approach to fisheries management (EAFM):

In this background, it is suggested that effective management of sea cucumber fishery could be achieved by following an ecosystem approach, in which multiple regulatory measures and management actions could be agreed upon and applied in a participatory manner in full consideration of the sea cucumber stocks, the ecosystems in which they live and the socio-economic systems that drive exploitation. In the ecosystem approach, it is crucial to get the commitment of governments, fishery managers and scientists to develop, apply and strictly enforce the management measures to sustain sea cucumber populations for current and future generations (Purcell, 2010). Ecosystem approach attempts to achieve ecological well-being and human well-being through good governance.

Ecosystem approach would typically start with start-up task for preparing the ground to (i) identify the project team and facilitators, (ii) identify the management area, (iii) coordinate with other

agencies and government, (iv) identify stakeholders and organisations, (v) establish key stakeholder group, and (vi) determine legal basis for ecosystem approach.

Step 1. Define and scope the management unit and geographical area

After preparing the ground and a series of on-going processes in the start-up, step 1 of the EAFM process should start. The management unit should be defined. While the key management unit in this case is the sea cucumber, the geographical area of the ecosystem to be managed should be clearly defined based on the distribution of the resource and the geographical extent of the fishery. The final choice of the geographic area for the management plan will depend on a number of factors, covering all harvest sub sectors, both small-scale artisanal (dive fishing, minitrawl) and large vessels (trawlers). After agreeing to the management unit and geographical area, the stakeholders have to agree on a vision to the EAFM plan, which is a long-term statement of the aspirations of the stakeholders. For scoping the management unit, background information on the sea cucumber resources, gears, people and information relating to economic, social, environmental and governance factors need to be collected.

Step 2.Identify and prioritise threats and issues to the sea cucumbers in Palk Bay and Gulf of Mannar

The next step is for stakeholders to undertake an initial evaluation of threats and issues associated with the sea cucumber resources. These threats and issues should be summarised into three categories: ecological well-being, human well-being and governance. Often, a large number of issues will be identified by the stakeholders that need to be prioritised so that a manageable number of addressable issues could be short listed. The short listed issues are of high priority and therefore need to be managed directly.

While considering the issues, it is useful to group them into separate themes (for example, those concerned with fishing, environment, trade, communities etc.). After this, a goal may be developed for each theme that would relate to the overall vision of the plan. A reality check needs to be undertaken at this stage to decide whether the goals are really achievable.

Step 3. Develop the EAFM plan

Clear and appropriate management objectives should be developed for all high priority issues requiring management. It is also important to develop indicators and benchmarks for the objectives to enable the stakeholders to assess whether the objectives are being achieved. The management actions needed to meet each specific objective and how the actions will be complied with, should be discussed with the stakeholders. Collectively, the objectives, indicators, benchmarks and management actions provide a means to communicate with decision makers on how management is performing and will influence future changes in management. After identifying financing to support implementation of the plan, the plan can be finalised.

Step 4. Implement the plan

A simple work plan should be developed that outlines who does what tasks during implementation, and by when. The plan should be formalised so that it has authority and backing. A communication strategy needs to be developed to inform the stakeholders. The appropriate governance arrangement needs to be clearly defined. The implementation may establish co-management arrangements. This will take time and require strengthening institutions and developing human capacity.

Step 5. Monitor, evaluate and adapt

Monitoring the indicators and benchmarks allows management to see if the plan is on track and to take remedial action if necessary. Reference points give the management plan pre-defined limits by which management effectiveness can be gauged during, and at the end of a management cycle (FAO, 2010). Hence, indicator information should be collated and reviewed periodically to assess whether the management actions are meeting the objectives as planned.

By monitoring data, the plan can be adapted if there is sufficient evidence to indicate that a change is necessary. A long-term review also should take place to assess how the plan is performing. In the light of long-term data and reviews, the plan may need to be adapted considerably to allow unforeseen elements and to incorporate lessons learned.

Co-management:

Monitoring and enforcement costs and the sheer number of fishers make it impossible to curtail illegal fishing practices with a centralized management system. During the interview surveys and stakeholder consultations, the fishermen and traders showed keen interest in co-management of the sea cucumber fishery. Whereas participation and co-management is enshrined in the principles of EAFM, and the two approaches are complementary, it is thought worthwhile to emphasise the importance of increased participation in managing and conserving sea cucumber in Palk Bay and Gulf of Mannar. In co-management of sea cucumber resources, both the communities of local resource users and the government (Government of India and Government of Tamil Nadu) share the responsibility and authority for managing and determining the goals of the fishery, with various degrees of power sharing. Stakeholders will be the central part of the management process. Stakeholders and resource users include number of users who interact with and care about the fishery and the associated ecosystems; for example, fishermen of different sub sectors (dive, trawl, indigenous craft etc.), traders and middlemen, processors, exporters, department of fisheries, department of environment, district level administration, coast guard, marine police, crime control bureau, Gulf of Mannar Biosphere Trust, non-governmental organisations, scientists, conservationists, etc. In co-management, the rights and degree of empowerment of stakeholders have an important role on decision making and implementation process. In Palk Bay and Gulf of Mannar, the fishery is operated by a defined group of people in a defined geographical area. It is believed that in fisheries of this nature, it is possible to target the communities and communicate and engage with them.

Institutional requirements:

For effective implementation of EAFM, a governing or advisory council consisting of important players from fishing to export may be constituted. Establishment of institutions for resource management by fisher groups is part of co-management and community-based management and encouraged within an ecosystem approach to fisheries. The management decisions and outcomes have to be vested with fishers or fishing communities who value the long-term benefits of a sustainable resource. Self-regulation by fishing groups and co-management can help to reduce the burden of conflict management that generally resides with management agencies. The government and non-government agencies in the governing council will play important roles in conflict resolution and ensure that the governing process is proceeding in the right direction.

To establish institutional mechanism, different types of fisher's organizations or stakeholders need to be listed and a plan drawn to show how they are structured or linked within the current management institution. Other management activities like monitoring, surveillance and enforcement should be devolved with the governing council. Government agencies may monitor the fisheries, and regularly arrange meetings and operationalise management decisions, and engage with scientists and NGOs and conservationists.

It is important to describe the legal frameworks. These would include processes by which management decisions are placed into law or customary regulatory systems, overarching national or international regulations and the process by which offenders are prosecuted for breaching fishery regulations.

Capacity development:

Capacity development at all levels, from fishermen to government officials is necessary to promote the skills and knowledge for development and implementation of sustainable management

approaches and conservation of sea cucumber populations. It is necessary to improve the capacity for management including increasing resources for surveillance, enforcement and training. In particular, capacity is required in ecosystem approach to management, co-management and inspection of trade, data collection and monitoring, and the use of scientific information to implement management interventions. Capacity development programmes within the fishery create an enabling environment for better management decisions, through consensus building. Informed stakeholders are in a better position to manage their resources in co-management and community-based management systems.

Regional cooperation:

Sea cucumbers in Palk Bay and Gulf of Mannar are shared stocks between India and Sri Lanka. While there is a moratorium on sea cucumber fishery and trade on the Indian side, there is no restriction on the fishery on the Sri Lanka side. As the sea distance between the two countries is very short (18 to 42 km), the sea cucumbers removed illegally along the Indian side are taken through Sri Lanka for finding overseas market. Without bilateral cooperation between the two countries, any conservation effort would be ineffective. It has been realised that bilateral consultations and/or agreements are now needed, given the geographical distribution of the species. It is important that binding or non-binding arrangements are established between governments that promote cooperation towards common interests and objectives of conservation and sustainable use of sea cucumber resources. Joint Indian and Sri Lankan sea cucumber resources conservation and management could be established in collaboration with and support from the second phase of the BOBLME Project.

Ecosystem approach to management of Palk Bay and Gulf of Mannar:

Palk Bay and Gulf of Mannar are biodiversity hotspots. This area consists of three critical habitats, namely coral reefs, seagrass beds, seaweeds and mangrove forests. This area is also home for several endangered and vulnerable species such as dugong, dolphins, turtles, whale shark, sea cucumbers, seahorses, sponges, sea fans, urchins etc. Considering the importance of these habitats and species, it is worthwhile considering managing the entire area through ecosystem approach jointly by the two countries. It is recommended that a holistic approach for the management of Palk Bay and Gulf of Mannar may be followed by (i) setting up of a cooperative mechanism within the existing bi-lateral framework of the Governments of India and Sri Lanka, (ii) enhancing knowledge on ecological characters and conducting impact assessments, (iii) ensuring conservation of resources and restoring fisheries habitats, (iv) ensuring effective stakeholder participation, (v) promoting livelihood options, and (vi) strengthening institutions and capacities.

The above recommendations are generic but if appropriately implemented they should assist in conservation and sustainable use of the habitats and biodiversity in Palk Bay and Gulf of Mannar. The solutions need to be tailored to the specific context within which the challenges occur.

6. References

Al-Rashdi, K.M., Claereboudt, M.R. and Al-Busaidi, S.S. 2007. Density and size distribution of the sea cucumber, *Holothuria scabra* (Jaeger, 1935), at six exploited sites in Mahout Bay, Sultanate of Oman.*Agricultural and Marine Sciences.* 12:43–51.

Asha, P.S.2005. Reproductive aspects, larval and juvenile rearing of *Holothuria* (Theelothuria) *spinifera*Theel.PhD thesis Manonmaniam Sundarnar University, TamilNadu, India, 120 pp.

Asha, P.S and Muthiah,P. 2002. Spawning and larval rearing of sea cucumber *Holothuria* (*Theelothuria*) *spinifera. SPC Beche-de-mer Inform. Bull.*, 16: 11-15.

Asha, P.S., Diwakar K., Santhanavalli G., Manisseri Mary, K. 2015.Comparative distribution and habitat preference of the sea cucumber *Holothuria atra* Jaeger at protected and unprotected sites in Thoothukudi region of Gulf of Mannar, south-east coast of India.*Indian J. Fish,* 62 (1).pp. 52-57.

Bell, J.D., Purcell, S.W. and Nash, W.J. 2008.Restoring small-scale fisheries for tropical sea cucumbers. Ocean and Coastal Management, 51: 589–593.

Birkeland, C.1989. The influence of echinoderms on coral-reef communities. In: Echinoderm Studies 3, volume 3 (eds M. Jangoux and J.M. Lawrence). A.A. Balkema, Rotterdam, Netherlands, pp. 1–79.

Birkeland, C., Dayton, P.K. and Engstrom, N.A. 1982. A stable system of predation on a holothurian by fourasteroids and their top predator.*Australian Museum Memoir* 16, 175–189.

Buckius, C., Albert S., Tibbetts I.and Udy,J. 2010.Effect of diel activity patterns and harvesting pressure on the diversity and biomass of sea cucumbers in Marovo Lagoon, Solomon Islands. *Environ. Manage,* 45: 963–973.

Bruckner, A.W.2006.The proceedings of the technical workshop on the conservation of sea cucumbers in the families Holothuriidae and Stichopodidae. NOAA Technical Memorandum NMFSOPR 44, Silver Spring, 239 pp.

Chao,S. M.,Chen,C.P.and Alexander,P.S.1994.Reproduction and growth of *Holothuria atra* (Echinodermata: Holothuroidea) at two contrasting sites in southern Taiwan. *Mar. Biol.,*119: 565-570.

Conand, C.1989.The Holothurians Aspidochirotida the lagoon of New Caledonia: Biology, ecology and exploitation. Studies &Theses, O.R.S.T.O.M., Paris, 393 p.

Conand, C. 1990. The fishery resources of Pacific island countries. Part 2: Holothurians. In: FAO Fisheries Technical Paper, Geneva: FAO. p. 143.

Conand, C.1993. Ecology and reproductive biology of *Stichopus variegatus* and Indo-Pacific coral reef sea cucumber (Echinodermata: Holothuroidea). *Bull Mar Sci* 52:970–981.

Conand, C. 2004. Present status of world sea cucumber resources and utilization: an international overview. In: Advances in sea cucumber aquaculture and management. A. Lovatelli, C. Conand, S. Purcell, S. Uthicke, J.-F. Hamel and A. Mercier, (Eds.). FAO, Rome. (Present document).

Conand, C. 2008. Population status, fisheries and trade of sea cucumbers in Africa and the Indian Ocean. In: Toral-Granda, V., Lovatelli, A. and Vasconcellos, M. (Eds.), *Sea cucumbers - A global review of fisheries and trade.FAO fisheries and aquaculture technical paper, No. 516*, FAO, Rome, p. 143–193.

Conand, C. Polidoro B., Mercier A., Gamboa R., Hamel J.F and Purcell S. 2014.The IUCN Red List assessment of aspidichirotid sea cucumbers and its implications.*SPC Beche-de-mer Inform. Bull.*, 34: 3-7.

Cone, R.S. 1989.The need to reconsider the use of condition indices in fishery science. Trans. Am.Fish.Soc.118: 510-514.

Dissanayake, D.C.T. and Stefansson,G. 2010. Abundance and distribution of commercial sea cucumber species in the coastal waters of Sri Lanka.*Aquat. Living Resour.,*23: 303–313.

Dissanayake, D.C. T. and Stefansson, G. 2012. Present status of the commercial sea cucumber fishery off the north-west and east coast of Sri-Lanka. *J. Mar. Biol. Ass. U. K.*, 92: 831-841.

Eriksson, H. 2006. Sea cucumber abundance, diversity and fishery in Samoa: an assessment of lagoon occurring Sea cucumbers Uppsala University. M.Sc in Biology.Department of Animal Ecology. Uppsala, Sweden, 51pp.

FAO, 2008. Sea cucumbers: A Global Review of Fisheries and Trade. Technical Report 516, Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO, 2010.Putting into Practice an Ecosystem Approach to Managing sea cucumber Fisheries.Food and Agriculture Organization of the United Nations, Rome. 81pp.

FAO, 2013. Report on the FAO Workshop on sea cucumber fisheries: An Ecosystem Approach to Management in the Indian Ocean (SCEAM Indian Ocean), Mazizini, Zanzibar, the United Republic of Tanzania, 12–16 November 2012. FAO Fisheries and Aquaculture Report, 1038: 92 pp.

Francour, P. 1997. Predation on holothurians: a literature review. *Invertebrate Biology* 116, 52–60.

Friedman, K., Eriksson H., Tardy E.and Pakoa K. 2011. Management of sea cucumber stocks: Patterns of vulnerability and recovery of sea cucumber stocks impacted by fishing. *Fish and Fisheries* 12:75–93.

Garrett, H.E. and Woodworth, R.S. 1969. Statistics in Psychology and Education, Vakils, Feffer and Simons Pvt. Ltd., Bombay.pp. 329.

Gonzalez-Wanguemert., M Aydin,M. and Conand, C. 2014. Assessment of sea cucumber populations from the Aegean Sea (Turkey): First insights to sustainable management of new fisheries. *Ocean & Coastal Management*. 92: 87-94.

Hamel, J.-F., Conand C., Paeson D.L. and Mercier A. 2001. The seacucumber *Holothuria scabra* (Holothuroidea: Echinodermata): its biology and exploitation as *beche-de-mer*. Advances in Marine Biology. 41, 129–223.

Hasan, M. H. 2005. Destruction of a *Holothuria scabra* population by overfishing at Abu Rhamada Island in the Red Sea.*MarineEnvironmental Research.* 60: 489–511.

Herrero-Perezrul,M.D and Reyes-Bonilla, H. 2008.Weight-Length relationship and relative condition of the holothurian *Isostichopus fuscus* at Espiritu Santo Island, Gulf of California, México.*Int. J. Trop. Biol*. 56, 273-280.

Hickman, C.P., Roberts, L.S., Larson,A., Anson,H. and Eisenhour D.J. 2006.Integrated Principles of Zoology, 13th edn.McGraw-Hill, New York, NY, USA.

IUCN (International Union for Consrvation of Nature). 2013. Guidelines for using the IUCN Red List Categories and Criteria. Version 10.Prepared by the Standards and Petitions Subcommittee. http://www.iucnredlist.org/documents/RedListGuidelines. pdf Accessed March 4, 2013.

James, D.B.1994. Ecology of commercially important holothurians of India. Bull. Cent. Mar, Fish. Res. Inst., 46: 37-38.

James, D.B. 1995. Taxonomic studies on the species of Holothuria (Linnaeus, 1767) from the seas around India. Part 2.*J. Bombay Nat. Hist. Soc*., 92: 190-204.

James, D.B. 2004.Lessons to India from Chinese multi-million dollar sea cucumber industry. *Fishing Chimes*. 24(1):136-138.

James, D.B, Rajapandian, M.E., Baskar, B.K., and Gopinathan, C.P. 1988. Successful induced spawning and rearing of the Holothurian *Holothuria* (matriatyla) *scabra* Jaeger at Tuticorin. *Mar Fish Inf Serv Tech Ext Ser* 87:30–33.

James, D.B. and Baskar, B.K. 1994. Present status of the beche-de-mer industry in Palk Bay and the Gulf of Mannar. *Bull.Cent.Mar.Fish.Res.Inst*., 46: 85-90.

James, D.B., Gandhi, A.D., Palaniswamy, N. and Rodrigo, J.X. 1994. Hatchery techniques and culture of sea cucumber Hatchery-produced juveniles of commercial sea cucumber *Holothuria scabra*Central Marine Fisheries Research Institute, Kochi, India. Special Publication 57,1-40.

Jones,O.A. and Endean, R. 1973.The biology and ecology of tropical holothurians, vol. ii, biology i. In:Biology and Geology of Coral Reefs (Eds O.A. Jones and R. Endean). Academic Press, New York, pp. 325–367.

Kinch,J., Purcell, S., Uthicke, S. and Friedman, K. 2008. Population status, fisheries and trade of sea cucumbers in the Western Pacific. In: Toral Granda, V., Lovatelli, A. and Vasconellos, M. (Eds.), Sea cucumbers: a global review on fisheries and trade. FAO fisheries and aquaculture technical paper, No.516. FAO, Rome, p. 57-77.

Klinger,T. S. and Johnson, C. R. 1998. Spatial and temporal distribution of feeding of Aspirochirotida (Holothuroidea) on Heron Island, Great Barrier Reef. In: David, B., Guille, A., Feral, J. P. and Roux, M. (Eds.), *Proceedings of the 9th International Echinoderms Conference*. Balkema, San Francisco, p. 467-471.

Lampe, K. 2013. Holothurian density, distribution and diversity comparing sites with different degrees of exploitation in the shallow lagoons of Mauritius.*SPC Beche-de-mer Inform. Bull.*, 33: 2–29.

Lawrence, J. 1987. A Functional Biology of Echinoderms.Croom Helm, London & Sydney.340 pp.

Long, B.G., Skewes T.D., Dennis D.M., Poiner I.R., Pitcher C.R., Taranto T., Manson F., Polon P., Karre B, Evans C. and Milton D. 1996.Distribution and abundance of*beche-de-mer* on Torres Strait reefs.CSIRO Division of Fisheries Final Report, March 1996, 99 pp.

Lovatelli, A., Conand, C., Purcell, S., Uthicke, S., Hamel, J.F and Mercier, A. 2004.Advances in sea cucumber aquaculture and management. FAO Fisheries Technical Paper no. T 463: 425pp.

Massin, C.1982. Effects of feeding on the environment: Holothuroidea. p. 193–197. In: Jangoux M. and Lawrence J.M. (Eds). Echinoderm nutrition.Rotterdam, Netherlands: Balkema A.A. Publication.

Mercier, A., Battaglene, S.C. and Hamel, J-F. 1999. Daily burrowing cycle and feeding activity of juvenile sea cucumbers *Holothuria scabra* in response to environmental factors. Journal of experimental Marine Biology and Ecology 239:125–156. Mercier A., Battaglene S.C.and Hamel J-F. 2000a

Mercier, A.,. Battaglene, S.C and Hamel, J.-F. 2000a. Settlement preferences and early migration of the tropical sea cucumber *Holothuria scabra*. *J. Exp. Mar. Biol. Ecol.*, 249: 89-110.

Muthiga,N., Ochiewo, J.and Kawaka, J.2010.Strengthening capacity to sustainably manage sea cucumber fisheries in the western Indian Ocean. *SPC Beche-de-mer Inform. Bull.*, 30: 3-9.

Pitt, R. and N.D.Q. Duy. 2004. Length-weight relationship for sandfish, *Holothuria scabra*. *SPC Beche-de-mer Inform. Bull.*, 19 : 39-40.

Pauly, D.1980.A selection of simple methods for the assessment of tropical fish stocks.FAO Fish. Circ., (729): 54 p. Issued also in French. Superseded by Pauly.D., 1983.FAO Fish. Tech. Pub., 234, 52 pp.

Purcell, S.W**.** 2010. *Managing sea cucumber fisheries with an ecosystem approach*. Edited/compiled by A. Lovatelli, M. Vasconcellos & Y. Yimin. FAO Fisheries and Aquaculture Technical Paper No. 520. Rome, FAO. 157 pp. (also available at www.fao.org /docrep/012/i1384e/i1384e.pdf).

Purcell, S.W. 2014. Value, market preferences and trade of *beche-de-mer* from Pacific Island sea cucumbers. PLoS One 9: e95075.

Purcell, S.W., Gossuin, H., Agudo, N.N., 2009, Status and management of the sea cucumber fishery of la Grande Terre, New Caledonia. Programme ZoNéCo. WorldFish Center Studies and Reviews No. 1901.The WorldFish Center, Penang, Malaysia.136 pp.

Purcell, S.W.,.Samyn, Y and Conand, C. 2012.Commercially important sea cucumbers of the world. FAO Fisheries and Aquaculture Technical Paper No. 463 Rome: FAO Species Catalogue for Fishery Purpose. 150 pp.

Purcell, S.W., Mercier, A., Canand, C., Hamel, J.F., Toral-Granda, V., Lovatelli, A. and Uthicke, S. 2013. Sea cucumbers fisheries: Global analysis of stocks, management measures and drivers of overfishing, Fish and Fisheries 14: 34-59.

Robinson,G. and B. Pascal. 2009. From hatchery to community – Madagascar's first village-based holothurian mariculture programme. *SPC Beche-de-mer Inform. Bull.*, 29: 38–43.

Sastry, D.R.K.1998. Faunal diversity in India, In: J.R.B. Alfred., A.K.Das., A.K. Sanyal (Eds.). A commemorative volume in the 50th year of India's Independence, Zoological Survey of India, 308-403.

Shepherd,S., Martinez, P., Toral-Granda, M. and Edgar, G.2004. The Galapagos sea cucumber fishery: management improves as stocks decline. *Environmental Conservation,* 31, 102–110.

Skewes,T. D., Dennis, D. M., Jacobs, D. R., Gordon, S. R., Taranto, T. J., Haywood, M., Pitcher, C. R., Smith, G. P., Milton, D. and Pioneer, I. R. 1999. Survey and stock size estimates of the shallow reef (0-15 m deep) and shoal area (15-50 m deep) marine resources and habitat mapping within the MOU74 box. Volume 1.*Stock estimates and stock status, CSIRO Final Report to the FRRF,* 88 pp.

Skewes,T. D., Dennis, D. M., Wassenberg, T., Austin, M., Moesender, C. and Koutsoukos, A. 2002. Surveying the distribution and abundance of *Holothuria scabra* (sand fish) in Moreton Bay.*CSIRO Division of Marine Research Final Report,* 20 pp.

Skewes, T., Smith L., Dennis D., Rawlinson N., Donovan, A. and Ellis N. 2004.Conversion ratios for commercial beche-de-mer species in Torres Strait.Torres Strait Research Program Final Report R02/1195, Australian Fisheries Management Authority.

Sloan, N.A. 1984. Echinoderm fisheries of the world: a review. In: Proceedings of the Fifth International Echinoderm Conference (eds B.F. Keegan and B.D.S. O'Connor).A.A. Balkema, Rotterdam, Netherlands, pp. 109–124.

Toral-Granda,V., Lovatelli A. and Vasconcellos, M. 2008. Sea cucumbers: A global review on fishery and trade. FAO Fisheries Technical Paper no. 516. Rome, Italy: Food and Agriculure Organization. 319 p.

Uthicke,S. and Conand C. 2005. Amplified fragment length polymorphism (AFLP) analysis indicates importance of both asexual and sexual reproduction in the fissiparous holothurian *Stichopus chloronotus* (Aspidochirotida) in the Indian and Pacific Ocean. *Coral Reefs.*24(1):103–111.

Venkitaraman, C. 2007. Present status of population of holothurians in India. Report submitted to Ministry of Environment and Forests, New Delhi, 58 pp.

Venkataraman K., C Venkitaraman. and Rajkumar Rajan. 2012. Status assessment of sea cucumber species in Palk Bay and Gulf of Mannar. Report submitted to Gulf of Mannar Biosphere Reserve Trust, Ramanathapuram, Tamil Nadu 55 pp.

Vivekanandan, E. 2005.Stock assessment of tropical marine fishes.Indian Council of Agricultural Research, New Delhi, India, 115 p.

Appendix I Tables

Table 17 GPS readings of trawl survey sites in Gulf of Mannar

Station code	Year	Month	Day	Long	Lat
GOMT1	2015	January	30	78°18.846'E	8°46.555'N
				78°20.318'E	8°48.171'N
GOMT2	2015	January	30	78°20.495'E	8°48.502'N
				78 22.185'E	8°49.446'N
GOMT3	2015	January	30	78°24.478'E	8°49.570'N
				78°19.480'E	8°48.795'N
GOMT4	2015	February	5	78°59.209'E	9°16.016'N
				78°58.029'E	9°15.910'N
GOMT5	2015	February	5	78°56.917'E	9°15.964'N
				78°55.588'E	9°15.583'N
GOMT6	2015	February	5	78°56.376'E	9°14.185'N
				78°55.280'E	9°13.558'N
GOMT7	2015	March	3	78°48.608'E	9°12.596'N
				78°49.801'E	9°12.912'N
GOMT8	2015	March	3	78°48.848'E	9°12.906'N
				78°47.394'E	9°12.892'N
GOMT9	2015	March	3	78°47.222'E	9°12.227'N
				78°45.481'E	9°11.175'N
GOMT10	2015	March	3	78°45.409'E	9°11.353'N
				78°45.004'E	9°12.281'N
GOMT11	2015	March	4	79°10.532'E	9°14.707'N
				79°11.511'E	9°15.313'N
GOMT12	2015	March	4	79°06.309'E	9°13.429'N
				79°05.158'E	9°13.080'N
GOMT13	2015	March	4	79°04.448'E	9°15.062'N
				79°04.037'E	9°15.548'N

Table 18 GPS readings of dive survey sites in Gulf of Mannar

Station code	Year	Month	Day	Long	Lat
GOMD1	2015	January	13	79°2.261'E	9°14.577'N
GOMD2	2015	January	31	78°33.277'E	8°59.372'N
GOMD3	2015	February	3	78°51.573'E	9°10.606'N
GOMD4	2015	February	3	78°50.974'E	9°11.997'N
GOMD5	2015	February	3	78°49.220'E	9°11.347'N
GOMD6	2015	May	16	78°20.252'E	8°45.188'N
GOMD7	2015	May	16	78°22.262'E	8°51.958'N
GOMD8	2015	May	16	78°16.002'E	8°54.400'N
GOMD9	2015	May	16	78°16.238'E	8°49.622'N

Table 19 GPS reading of trawl survey sites in Palk Bay

Station code	Year	Month	Day	Long	Lat
PBT1	2015	March	5	78°59.855'E	9°29.735'N
				78°59.855'E	9°28.268'N
PBT2	2015	March	5	78°59.407'E	9°28.138'N
				78°59.420'E	9°26.664'N
PBT3	2015	March	5	78°59.261'E	9°26.782'N
				78°59.624'E	9°27.524'N
PBT4	2015	March	6	79°04.888'E	9°41.838'N
				79°04.936'E	9°41.367'N
PBT5	2015	March	6	79°04.924'E	9°41.406'N
				79°04.622'E	9°41.759'N
PBT6	2015	March	6	79°03.853'E	9°38.887'N
				79°02.513'E	9°39.159'N
PBT7	2015	March	6	79°02.218'E	9°39.175'N
				79°01.259'E	9°39.259'N
PBT8	2015	March	24	79°20.382'E	9°15.941'N
				79°20.499'E	9°15.684'N
PBT9	2015	March	24	79°20.470'E	9°15.861'N
				79°20. 514'E	9°16.123'N
PBT10	2015	March	24	79°20.792'E	9°16.849'N

				79°20.524'E	9°17.694'N
PBT11	2015	March	24	79°19.492'E	9°17.006'N
				79°19.873'E	9°16.676'N
PBT12	2015	March	26	79°20.123'E	10°15.371'N
				79°19.335'E	10°14.506'N

Table 20 GPS reading of dive survey sites in Palk Bay

Station code	Year	Month	Day	Long	Lat
PBD1	2015	March	25	78°59.359'E	9°37.750'N
PBD2	2015	April	16	79°10.874'E	9°17.591'N
PBD3	2015	April	16	79°15.256'E	9°18.515'N
PBD4	2015	April	16	79°90.258'E	9°18.028'N
PBD5	2015	April	17	78°58.627'E	9°23.432'N
PBD6	2015	April	17	79°40.106'E	9°18.797'N
PBD7	2015	April	17	79°60.399'E	9°18.127'N
PBD8	2015	April	18	79°22.111'E	9°14.814'N
PBD9	2015	April	18	79°21.564'E	9°15.777'N
PBD10	2015	April	18	79°20.180'E	9°16.018'N
PBD11	2015	April	21	78°55.188'E	9°26.990'N
PBD12	2015	April	21	78°55.530'E	9°26.616'N
PBD13	2015	April	21	78°55.793'E	9°26.205'N
PBD14	2015	April	21	78°55.312'E	9°27.829'N

Table 21 Mean (±SE) biomass (kg ha^{-1}) of bottom biota (other than sea cucumbers)

S. no.	Components	Biomass (kg ha^{-1})	
		Gulf of Mannar	Palk Bay
1	Sea cucumber	3.28.43±1.36	2.59±0.50
2	Osteichthyes	3.43.13±0.91.88	4.9819±1.2545
3	Chondrichthyes	0.8462±0.4205	00.00
4	Molluscs	1.86.37±1.03.56	9.525±4.418
5	Crustacean	2.9.5±0.1826	0.0762±0.0734
6	Other echinoderms	7.7274±3.6356	21.908±9.2436
7	Sponges	3.553±1.236	12.1739±6.9812
8	Dead coral and shells	5.1627±2.899	00.00
9	Seagrasses	96.13.88±23.8846	42.9141±13.7774

Table 22 Organic carbon content and texture of sediments collected from selected dive survey sites of gulf of mannar and Palk Bay

S. No	Station code	% of organic carbon	% of organic matter	% of organic N_2	% of silt	% of clay	% of fine sand	% of coarse sand
1	GOMD9	1.3425	2.3158	0.11579	8.46	8.46	20.094	44.296
2	GOMD8	0.72	1.242	0.0621	8.2489	4.1201	6.515	65.309
3	GOMD6	0.7125	1.229	0.061453	0	7.755	10.22	57.54
4	PBD4	0.2025	0.34931	0.017465	7.6	3.8	54.302	4.674
5	GOMD3	0.7425	1.28081	0.06404	0	4.7945	12.4658	75.6987
6	GOMD4	0.81	1.39725	0.0698625	0	3.455	23.3558	35.0337
7	PBD2	0.2025	0.34931	0.017465	0	7.6	36.001	27.306
8	PBD3	0.0825	0.14231	0.007115625	0	8.4	2.478	69.426

Table 23 Garrett's score table

Percent	Score	Percent (contd.)	Score	Percent (contd.)	Score	Percent (contd.)	Score
0.09	99	11.03	74	52.02	49	90.88	24
0.20	98	12.04	73	54.03	48	91.67	23
0.32	97	13.14	72	55.03	47	92.45	22
0.45	96	14.25	71	58.03	46	93.19	21
0.61	95	15.44	70	59.99	45	93.86	20
0.76	94	16.65	69	61.94	44	94.03	19
0.97	93	19.01	68	63.85	43	95.08	18
1.20	92	19.20	67	65.75	42	95.62	17
1.42	91	20.33	66	67.43	41	96.11	16
1.63	90	22.32	65	69.39	40	96.57	15
1.90	89	23.63	64	71.14	39	96.99	14
2.03	88	26.43	63	72.85	38	97.37	13
2.63	87	27.16	62	74.52	37	97.72	12
3.01	86	28.66	61	76.12	36	98.04	11
3.43	85	30.61	60	77.68	35	98.32	10
3.89	84	32.42	59	79.17	34	98.68	9
4.38	83	34.25	58	80.61	33	98.82	8
4.92	82	35.15	57	81.99	32	99.03	7
5.51	81	38.06	56	83.31	31	99.22	6
6.14	80	40.01	55	84.56	30	99.39	5
6.81	79	41.97	54	85.75	29	99.55	4
7.55	78	42.97	53	86.89	28	99.68	3
8.33	77	45.97	52	87.95	27	99.80	2
9.17	76	47.98	51	88.97	26	99.91	1
10.06	75	50.00	50	89.94	25	100.00	0

Appendix II Photographs

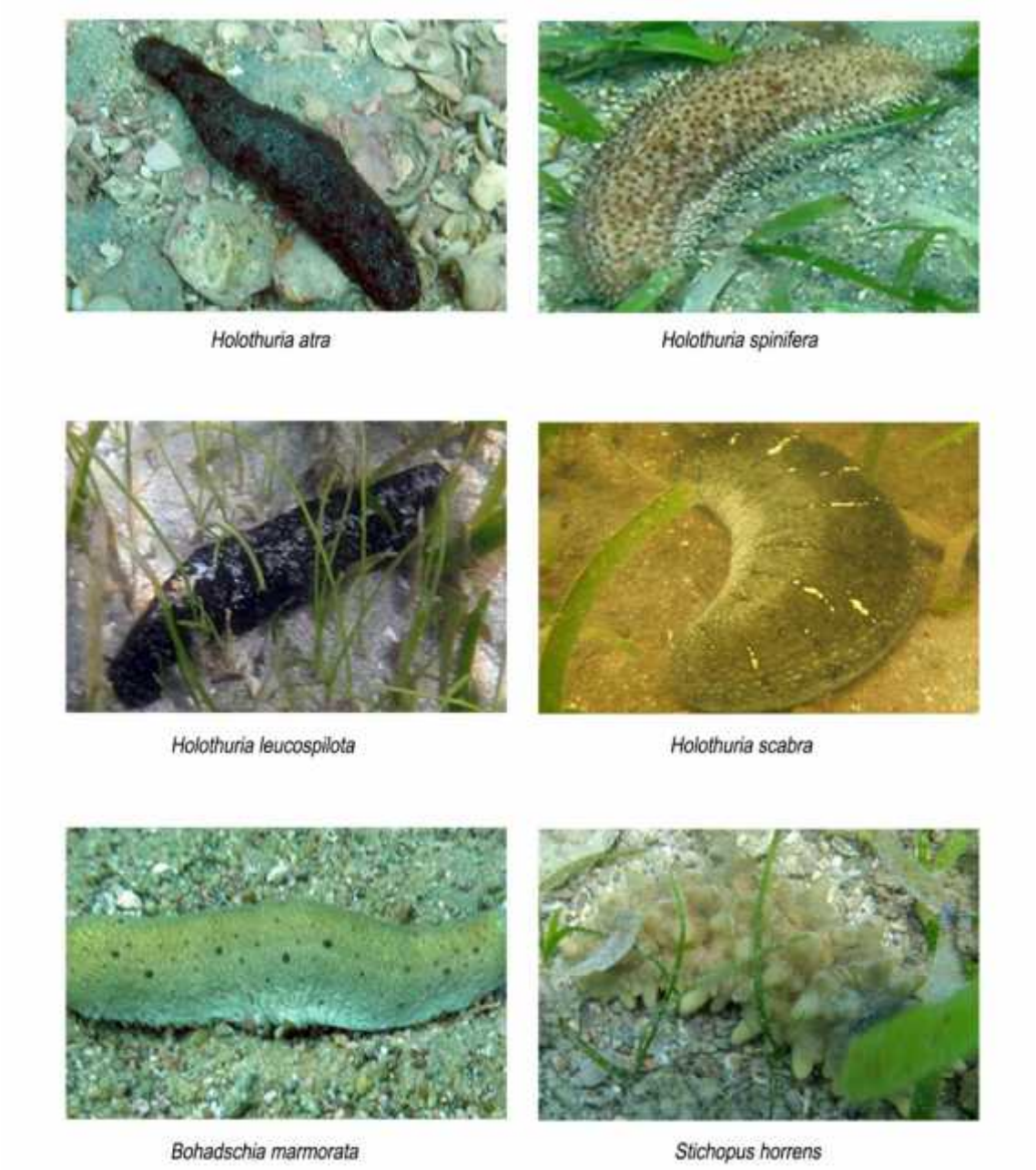


Figure 24 Photographs of sea cucumbers collected from Gulf of Mannar during the project

Colochirus quadrangularis

Holothuria edulis

Bohadschia sp.

Figure 25 Photographs of sea cucumbers collected from Gulf of Mannar and Palk Bay during the project

Attai madi -modified prawn trawl net

Shooting of attai madi from trawler

Hauled trawl content

Trawl component with sea cucumbers

Field identification of sea cucumbers

Biometric measurement of sea cucumbers

Figure 26 Photographs on trawl survey conducted along Gulf of Mannar and Palk Bay

Figure 27 Photographs on dive survey conducted along Gulf of Mannar and Palk Bay

Figure 28 Photographs on interview survey along Gulf of Mannar and Palk Bay

Appendix III Questionnaire for socio economic survey

Questionnaire for socio-economic survey

"An evaluation of the current conservation measures on sea cucumber stocks in Palk Bay and Gulf of Mannar of India"

1. Name:
2. Age:
3. Address:
4. Level of education:
5. Experience in fishing (in years):
6. Perception on sea cucumber biology, ecology and population

Statement	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Sea cucumbers are regarded as sedentary					
Sea cucumbers are nutritious food					
Medicines are prepared from sea cucumbers					
Sea cucumbers can be easily exploited					
Holothurians help to recycle the detritus					
Sea cucumbers are fully buried					
Sea cucumbers are half buried					
Sea cucumbers appear during dawn					
Sea cucumbers appear during dusk					
Others (specify if any)					

Before sea cucumber ban

7. Experience in sea cucumber fishing (in years):
8. Were you exclusively fishing/dependent on sea cucumber fishery for income? **Yes/No**
9. Mode of fishing of sea cucumbers:

Skin diving/trawling/*chanku madi*/*thallumadi*/other (specify if any)

10. Economics of sea cucumber fishing

Mode of fishing sea cucumber	**Expenditure incurred**	**Income**
Skin diving		
Trawl		
Chanku madi (bottom set gillnet)		
Thallumadi (mini-trawl)		
Other (specify if any)		

11. Depth of collection of sea cucumbers:
12. How many species of sea cucumber do you used to get?
13. Which species of sea cucumber was preferred for fishing?
14. In which habitat and location do you used to get sea cucumber :
15. Season of maximum abundance :
16. Whether it is abundant at fishing grounds and reserves: **Yes/No**
17. Do you process sea cucumbers yourself: **Yes/No**
18. If yes, how many days are required for *beche-de-mer* preparation?
19. To whom do you used to sell the sea cucumber?
20. Expenditure incurred for processing?
21. How you are packing it for selling to exporter?
22. How much you were given by the exporters?
23. If you sell to middlemen/traders in what form do you used to sell the sea cucumber: **Fresh/Processed**
24. What price do you get per kilogram?

S. no	**Sea cucumber variety**	**Fresh (`)**	**Processed (`)**
1.			
2.			
3.			
4.			
5.			

25. Whether there was any community initiative for sustainable sea cucumber fishing

After sea cucumber ban

26. Do you think sea cucumber ban is necessary?
27. Status of sea cucumber population (Increase/Decrease/Do not know)

Change/status in Sea cucumber population	**Before ban**	**After ban**
Numerical density (Nos/m^2)		

28. If the sea cucumber population is reduced, what are the major reasons for reduction?
29. After sea cucumber ban, what type of activity you are involved:
30. What is your monthly income in that activity?
31. Whether sea cucumber fishing is continued after ban? (Yes/No/Do not know)
32. If yes,

Type of gear	**Quantity**	**Rs./kg**

33. During regular fishing whether do you get sea cucumber incidentally: **Yes/No**
    i) If yes how much quantity:
    ii) What you do with that catch:

Give to the forest officials/put in the sea back/destroying it/sell it

34. Whether sea cucumber ban affected your livelihood: **Yes/No**

    If Yes, what way it affected your livelihood:

35. If a decision to lift the blanket ban is made in future, what effective management measures do you suggest for sustaining the stocks?

Management measures	**Whether it can be implemented (Yes/No)**	**If yes, give your suggestion**
Size restriction		
Gear limitation		
Effort and capacity control		
Seasonal closure/closed season		
Catch quotas		
Rotational harvest closures		
No-take zone		
Stock enhancement through sea ranching		
Licensing		
Reporting the catches		
Others (specify if any)		

36. Do you suggest hatchery production for farming/ranching?
37. Scope for participatory management and how it can be done?

Middlemen (Processors)

38. In what form do you sell sea cucumbers: **Fresh/Processed**
39. If you process, how many days are required for *beche-de-mer* preparation?
40. Expenditure incurred for processing?
41. How you are packing it for selling to exporter?
42. How much you were given by the exporters?
43. To which market do you export:
44. What price do you get per kilogram?

S.no	**Sea cucumber variety**	**Fresh (`)**	**Processed (`)**
1.			
2.			
3.			
4.			
5.			

45. How sea cucumber ban affected your activity?
46. What type of activity you are involved after sea cucumber ban?
47. Opinion about blanket ban on sea cucumber:

Exporters

48. To which market do you export:
49. What price do you get per kilogram?

S. no	**Sea cucumber variety**	**Fresh (`)**	**Processed (`)**
1.			
2.			
3.			
4.			
5.			

48. How sea cucumber ban affected your activity?
49. What type of activity you are involved after sea cucumber ban?
50. Opinion about blanket ban on sea cucumber:

Appendix IV Report of the finalization workshop on FAO BOBLME Project

Report of the finalization workshop on FAO-BOBLME Project

"An evaluation of the current conservation measures on sea cucumber stocks in Palk Bay and Gulf of Mannar of India"

30 June 2015

Tuticorin Research Centre of CMFRI
South Beach Road, Near Roche Park
Tuticorin, Tamil Nadu – 628 001

Table of contents

1.	Background	92
2.	Technical session	93
3.	Plenary session	93
4.	Appendices	
5.	Appendix-I. List of participants	95-97
6.	Appendix-II. Agenda of the programme	98-99
7.	Appendix–III	
	i. Photographs on inaugural session	100
	ii. Photographs on technical session	101
	iii. Photographs on plenary session	102

Background

An evaluation of the current conservation measures on sea cucumber stocks in Palk Bay and Gulf of Mannar of India

Sea cucumber fisheries are one of the top non-finfish income streams for coastal peoples throughout the Indian Ocean, Southeast Asia and the Pacific. Inadequate fishery management along with certain biological traits have caused overexploitation of this resource and fishery is showing the signs of severe depletion in many producing countries. The fishing pressure on sea cucumber population has been extraordinarily intense in recent decades placing species and coastal livelihood at risk.

In India, sea cucumber fishery was not organized and hence management measures could not be effectively implemented. The industry came to a standstill until the ministry imposed a total ban on sea cucumber fishery in June 2001 and listed all holothurians as protected animals along with 50 other marine species under the Indian Wild Life Protection Act, 1972. The enforcement of ban on the capture and trade of sea cucumbers for the last ten years might have helped in reviving their population; at the same time, the ban would possibly have a social and economic impact on scores of people, particularly the fishers, who were dependent on the sea cucumber fishery. No assessment has been made yet on whether the protection of sea cucumbers by India alone has yielded the desired results. Hence through the proposed project, studies were made to generate information on the stock status of sea cucumber species along Gulf of Mannar and Palk Bay and the effectiveness of current conservation measures on sea cucumber stock and as well on socio-economic and livelihood status of fishermen engaged in the fishery, thereby to suggest effective, renewed management strategies for its conservation.

Objectives of the workshop

- To discuss the present status of sea cucumber stocks in the Gulf of Mannar and Palk Bay.
- To discuss the impact of ban on the livelihood of local communities and also on conservation of sea cucumbers.
- To evolve effective recommendations for conservation and sustainable use of sea cucumbers along the region.
- To discuss on management measures for developing a framework for conservation action plan for sea cucumber along the Gulf of Mannar and Palk Bay.

The important delegates for the workshop were Dr P.S.B.R. James (former Director, CMFRI), Dr D.B. James (Rtd.Principal Scientist, CMFRI), Dr E.Vivekanandan (Emeritus Scientist, CMFRI), Dr A.P.Lipton (Rtd.Principal Scientist,CMFRI), Dr A.K. Abdul Nazar (Scientist in charge, Mandapam Regional Research Centre of CMFRI), Shri.C.M.Muralidharan (Project Manager, BOBLME); Dr T.S.Dange,IFS (Director,GOMBRT), Dr C.S. Shine Kumar(Deputy Director, MPEDA), Shri. T.P.Pradeep (Inspector, Wildlife Crime Control Bureau), Dr N.Venugopalan (International Collective in Support of Fish workers), Shri.J.Vincent Jain (Association of Deep Sea Going ArtisanalFishermen), Shri.Arul Ananadam (Alliance for Relief of Innocent Fishermen), Shri.IssacJayakumar (Assistant Director of Fisheries,Thoothukudi) representatives from MPEDA, NETFISH, NGOs like DHAN foundation; scientists and researchers from CMFRI, Annamalai University, Bharatidasan University, Madurai Kamaraj University, Bharathiyar University, Fisheries College & Research Institute, Tuticorin, fishermen and fishermen leaders who belong to various associations.

The workshop was inaugurated by Dr P.S.B.R. James, Former Director of CMFRI by lighting the traditional lamp and delivered the presidential address.The felicitation address was given by MrC.M.Muralidharan, Project Manager, BOBLME, DrT.S. Dange, Director, GOMBRT and Dr K.K. Joshi, Head, Marine Biodiversity Division, CMFRI, Kochi. DrP.P. Manojkumar,Principal Scientist and Scientist-in-charge, TRC of ICAR-CMFRI welcomed the participants.

Technical session

The technical session was chaired by Dr E. Vivekanandan, former Principal Scientist, CMFRI & Senior Advisor of the Projects and he gave an overview of the projects. A brief summary of BOBLME Project findings on sea cucumber was presented by Dr P.S. Asha, Principal Scientist. The major finding of stakeholder survey was presented by Dr B. Johnson, Scientist. Dr D. B. James, former Principal Scientist, CMFRI delivered a lecture on conservation of sea cucumbers in India.

Shri.Issac Jayakumar,Assistant Director of Fisheries, Thoothukudi explained about the challenges and opportunities on conservation of endangered species, while Shri.T.P.Pradeep, Inspector, Wildlife Crime Control Bureau (WCCB) made a presentation on role of WCCB in the Gulf of Mannar.

The importance of conservation and sustainable use of sea cucumber was discussed. If a decision to lift the blanket ban is made in future, some effective management measures for this resource were also discussed.

After talks, the participants interacted with the resource persons. The fishermen and traders voiced their concern that the ban on sea cucumber fishery has affected their livelihood and wanted the ban to be lifted. They also expressed that the ban has increased their indebtedness level and they were not able to give quality education to their children.

Plenary session

In the plenary session there was a panel discussion, it was moderated by Dr P. S. B. R. James, former Director of CMFRI. The panellists were Shri.C.M.Muralidharan (Project Manager, BOBLME), Shri. Issac Jayakumar (Assistant Director of Fisheries, Thoothukudi),Shri. Arul Ananadam (Alliance for Relief of Innocent Fishermen), Dr N. Venugopalan (International Collective in Support of Fish workers) and Dr E. Vivekanandan, former Principal Scientist, CMFRI & Senior Advisor of the Projects. Each panellist expressed their views followed by participant's interaction with the panellists.

The workshop was attended by stakeholders who are involved in fishery, trade, management, crime control, research and education of sea cucumbers. The fishermen and traders unanimously and sternly voiced their concern on continuation of ban on sea cucumbers, which, according to them, has severely affected their livelihood. They also told that a relaxation of ban, but allowing fishery with restricted removal and trade is acceptable to them. They also showed keen interest in co-management of the fishery along with government organisations.

The major recommendations from the panel discussion were:

- Organization of continuous scientific survey on distribution and stock status of sea cucumber species in Gulf of Mannar and Palk bay is necessary to sustain the resource.
- Based on the results of re-examination of the natural stock availability, breeding population assessment, fishing season and size at first maturity, initial steps can be taken for delisting and later it can be recommended for the partial ban lifting.
- Seasonal ban, spatial closure, release of spawners, minimum legal size and categorization of species for conservation and management can be adopted as effective biological management measures.
- Standardized technology for the mass production of juveniles through hatchery system for sea ranching and trade should be implemented with the funding from state government with the involvement of fisher families for grow-out farming techniques.
- Ecosystem based approaches for the conservation of resources should be adopted with special emphasis on habitat protection especially the sea grass beds and measures for reducing the incidental capture of sea cucumbers.
- Participatory co-management approaches engaging communities will be more effective in managing the resources.
- Establishing a governing council with government institutions, civil societies and communities for conservation and sustainable utilization of the resource.

- Establishing a system for continuous monitoring and certification programme.
- Regional co-operation is required from the neighbouring countries for transboundary cooperation and coordination.
- State government should co-operate and play their own role in policy matters.

Appendix I List of participants

S.no	Name and address	Contact numbers
1	Dr Nilesh Anil Pawar, Sr.T.O, Mumbai RC of CMFRI, Mumbai.	9224753075
2	DrT. Thangaradjou, Asst. Professor, CAS, Annamalai University, Parangipettai.	9486388791
3	Dr P. Santhanam, Asst. Professor, Dept of Marine Science, Bharadhidhasan University, Trichy.	9894223482
4	Dr E. Vivekanandan, Former Principal Scientist, CMFRI, Chennai.	9444238648
5	Dr K. K. Joshi, HOD & Principal Scientist, CMFRI, Cochin.	9447209179
6	Mr P. Makkuvater Durai, Tuticorin.	9688930409
7	Mr M. Esakkimuthu, Sangukuli Sanga Thalaivar, Tuticorin.	9791422183
8	Dr K. Vinod, Principal Scientist, Calicut Research Centre of ICAR-CMFRI, Calicut.	7200449596
9	Mr R. Saravanan, Scientist, Mandapam Regional Centre of CMFRI.	9994290450
10	Dr P. S. B. R. James, Former Director, Bangalore.	9986881706
11	Mr N. Venugopalan, ICSF, 27 Colleges, Chennai.	9940466380
12	Dr D.B. James, Former Principal Scientist, Chennai.	04423745351
13	Mr C. M. Muralidharan, BOBLME, Phuket, Thailand.	9840859888
14	Mr T.P. Pradeep, Inspector, RBO,WCCB(SR) Ramanad.	8903137550
15	Mr M.S. Badrudheen, Fish Traders Union, Chennai.	9841021202
16	Mr B.Johnson, Scientist, CMFRI, Mandapam.	8870380782
17	Mr V.J.Thomos, Tech.Assist., CMFRI, Cochin.	9847480445
18	Mr C. Kalidas, Scientist, CMFRI, Tuticorin.	9791548799
19	Mr S. Chinnadurai, Scientist, CIFT, Cochin.	9567538185
20	Mr A.K. Abdul Nazar, S.I.C, CMFRI, Mandapam.	9443541632
21	Mr Rireegan, GOMBRT.	9486147076
22	Mr R.Senthil Kumar, GOMBRT.	9003804222
23	Mr N.Anbalagan, GOMBRT.	9750640660
24	Dr P.Jawahar, TNFU, Tuticorin.	9487078758
25	Mr J.Vincent, Chief Execute, ADSGAF, Nagercoil.	9585615351
26	Dr A. P.Lipton, Principal Scientist (Redt) CMFRI.	9843281969
27	Dr M.Thangarj, Asst.Professor, CAS in Marine Biology, Annamalai University, Parangipettai.	9486133396
28	Mr Roja Raj, Tuticorin.	9940767129
29	Mr L.Ranjith, Scientist, CMFRI, Tuticorin.	8144701198
30	Mr S.M.Sadhakadhullah, Sr. Tech. Assist, CMFRI, Tuticorin.	8344257120

31	DrShine Kumar, DD, MPEDA, Tuticorin.	9940804398
32	Mr K.Murugan, Tech. Assist., CMFRI, Tuticorin.	8754711829
33	Mr A. Savariaandham, EDC Leader, Vellappatti.	9245489031
34	Dr .A.Murugan, State Co-Ordinator, NETFISH-MPEDA, Tuticorin.	8220211770
35	Mr B.Ramkumar, MKU, Madurai.	9940181115
36	Mr S.Shankar, 59.W.G.C.Road, Tuticorin.	9444310756
37	Mr M.Vetriselvan, CMFRI, Tuticorin.	9944376547
38	Mr S.Alagesan, CMFRI, Tuticorin	9677984212
39	Mr N.Jesuraj, CMFRI, Tuticorin.	9043111192
40	Dr P.T.Sarada, CMFRI, Tuticorin.	9442538777
41	Mr S.Willigton, CMFRI, Tuticorin.	9677516140
42	Mr Subramanian, CMFRI, Tuticorin.	9751919605
43	Mr K.P. Kanthan,Tech.Assist., CMFRI, Tuticorin.	9677872417
44	Mr M.Sathiyavan, CMFRI, Tuticorin.	9688209254
45	Mr A.Paulpandi, CMFRI, Tuticorin.	9442886376
46	Mrs C. Puspharani, CMFRI, Tuticorin.	9442552593
47	Mr J.Padmanathan, CMFRI, Tuticorin.	9788694530
48	Mr A.Dickson, CMFRI, Tuticorin.	9942203070
49	Mr M.Kalimthu, CMFRI, Tuticorin.	9994090781
50	Mr I.Raveendran,CMFRI, Tuticorin.	9443527981
51	Mr K.Marudapan, AD, GOMBRT, Tuticorin.	
52	Mr J.Vinoth, CMFRI, Tuticorin.	9865106912
53	Mr Soundrapandi, CMFRI, Tuticorin.	9245376708
54	Mr Sekar V Rayar, CMFRI, Tuticorin.	9940893767
55	Mr K.Johnjames, CMFRI, Tuticorin.	9442886297
56	Mr C. Sivakumar, MSSRF	
57	MrsT. Mahalakshmi,CMFRI, Tuticorin.	9442925545
58	Mr M.Kannan, CMFRI, Tuticorin.	
59	Mrs R.Anantharani, CMFRI, Tuticorin.	9488637684
60	Mrs C.Rajeswari, CMFRI, Tuticorin.	8870401830
61	Mrs A.Usharani, CMFRI,Tuticorin.	9597093555
63	Mr K.R. Samy, Tuticorin	
64	Mr R.Rajkumar, CMFRI, Mandapam.	
65	Mrs C. Sathiya, CMFRI, Mandapam.	
66	Mr R.Saravanakumar, CMFRI, Mandapam.	
67	Mrs B.Konciesmary, CMFRI, Tuticorin.	9442279001
68	Mr J. Jensiponmalar, CMFRI, Tuticorin.	

69	Mrs S.Saradha, CMFRI, Tuticorin.	9442585980
70	Mr K.Kannan, CMFRI,Tuticorin.	9790155073
71	Dr R.Saravanan, CMFRI, Mandapam.	
72	Mr B.Vijayakumar, CMFRI, Tuticorin.	8220346196
73	Dr I. Jagadis, CMFRI, Tuticorin.	9443734521
74	DrC.P.Suja, CMFRI, Tuticorin.	9443871024
75	Mr S.Mariappan, CMFRI, Tuticorin.	9442886772
76	Mr P. Issac Jeyakumar, AD Fisheries, Tuticorin.	9442331537
77	Dr P.P.Manojkumar, CMFRI, Tuticorin.	9488676193
78	Mr K.Suresh Kumar, CMFRI, Tuticorin.	9443896601
79	Mr K.Divakar, CMFRI, Tuicorin.	9443005795
80	Mr P.Jesuraj, CMFRI, Tuicorin.	9003748417
81	Mr M.Nottan, Tuicorin.	9943410255
82	Dr Vinoth S Ravindran, MKU, Madurai.	9655638373
83	Mr V.Arulanantham, Mandapam.	9994629470
84	Mr Ahamed Ibrahim, Mandapam.	9840506303
85	Mr K. Madasamy, Mandapam.	9944013884
86	Mr H.Akbar John, Periyapatnam.	7200629843
87	Mr M.Seidahamed, Periyapatnam.	8015534200
88	Mr S. Arbudham, Keezhakarai.	
89	Mr M.Shiek Mohamed, CMFRI, Mandapam.	9600488880
90	Mr P. Raja Kumaran, CMFRI, Mandapam.	7708495830
91	Mr Y.Anthony Jacob,Rameshwaram.	7373441944
92	Mr MDavid Prisan, Rameshwaram.	8220457916
93	Mr R. Bala, Rameshwaram.	7200921579
94	Mr K.Senthoor, Rameshwaram.	9500986378
95	Mr A.Janal, Rameshwaram, Mandapam.	9788209555
96	Mr L.K. Lakshmi Narayanan	948660083
97	Mr T.Moskieh, Mandapam.	8903515434
98	Mr J. Muthukumar, CMFRI, Tuticorin.	7502995734
99	Mr Ponnusamy, CMFRI, Tuticorin.	
100	Mr S.Shankar, Mandapam.	9444510750
101	Mr Mahesh, Mandapam.	
102	Mr K.Subramaian, CMFRI, Tuticorin.	9751919605
103	Mr N.Anto Machado,CMFRI, Tuticorin.	
104	Mr V.Ramasamy, CMFRI, Tuticorin.	9443005956
105	Mr S.Enastein, CMFRI, Tuticorin.	9442507358

106	Mr R.Sekar, CMFRI, Tuticorin	7418726058
107	Mr W.Sathyavan, CMFRI, Tuticorin.	
108	Dr Asha.P.S, CMFRI, Tuitocorin.	9445111189
109	Mr C.S. Subin, SRF, CMFRI, Mandapam.	8089566852
110	Mr K. Abdul Kadhar, Therespuarm, Tuticorin.	9944439216
111	Mr Amal Raj, Tuticorin.	
112	Mr S.Vimal, Tuticorin.	
113	Mr K.M. Sree Kumar, Tuticorin.	8089685008
114	Mr H. Sivanesh, CMFRI, Tuticorin.	9003356976
115	Mr Pickson, Mandapam	9677938098

Appendix II Agenda

Project report finalisation workshop of FAO-BOBLME Project

"An evaluation of the current conservation measures on sea cucumber stocks in Palk Bay and Gulf of Mannar of India"

Venue: Bell Hotel

23 - South Beach Road, Tuticorin -628 001

Date: 30June 2015

Time: 09.00-17.00 hrs

Inaugural function

Schedule	Programme
09.00 hrs	Registration
09.30-09.40 hrs	Welcome address -Dr P.P Manojkumar, S.I.C, Tuticorin RC of CMFRI
09.40-09.45 hrs	Lighting of the lamp
09.45-09.55 hrs	Presidential address – DrP.S.B.R James; Former Director of CMFRI
09.55-10.05 hrs	Remarks – Mr C.M. Muralidharan, Project Manager, BOBLME
10.05-10.10 hrs	Remarks – Shri Dr T.S. Dange, Director, GOMBRT
10.10-10.15 hrs	Remarks – Dr K.K. Joshi, Head, Marine Biodiversity Division, CMFRI, Kochi
10.15-10.20 hrs	Vote of thanks – Mr L. Ranjith, Scientist, Tuticorin RC of CMFRI
10.30–10.45 hrs	Tea

Technical session

Schedule	Programme
10.45–10.55 hrs	An overview of the Projects -DrE. Vivekanandan, Former Principal Scientist, CMFRI & Senior Advisor of the Projects
10.55-11.20 hrs	A brief summary of BOBLME Project on sea cucumber - Dr P.S. Asha
11.20-11.45 hrs	Major findings of stakeholder survey – Dr B. Johnson
11.45-12.05 hrs	Conservation of sea cucumbers in India – Dr D.B.James

12.05-12.25 hrs	Challenges and opportunities of conservation of endangered species-Shri. Issac Jayakumar, AD, Fisheries, Tuticorin
12.25-12.45 hrs	Role of Wildlife Crime Control Bureau in Gulf of Mannar - Shri. T.P. Pradeep, Inspector, Wildlife Crime Control Bureau
12.45-13.00 hrs	Photo session
13.00-14.30 hrs	Lunch

Plenary session

Schedule	Programme
14.30–14.50 hrs	Opening remark- Dr E.Vevekandan., Former Principal Scientist, CMFRI
14.50–15.10 hrs	Remark-V.Arulanantham, ARIF trust, Pamban
15.10–15.30 hrs	Remark – N.Venugopal, Consultant , ICSF
15.30–15.50 hrs	Remarks – Mr C.M. Muralidharan, Project Manager, BOBLME Tea break
15.50–16.10 hrs	Remarks – Mr Shri. Issac Jayakumar, AD, Fisheries, Tuticorin
16.10–16.30 hrs	Remarks –DrP.S.B.R James, Moderator Former Director of CMFRI
16.45–17.00 hrs	Concluding session

Co-ordinators:

Dr P.S. Asha

DrK. Vinod

Dr B.Johnson

Mr R. Saravanan and

MrL. Ranjith

Rapporteurs:

DrB.Johnson

MrC. Kalidas

Mr L. Ranjith and

Mr R. Saravanan

Appendix III Photographs

Welcome address by Dr.P.P.Manojkumar
(SIC,TRC of CMFRI,Tuticorin)

Lighting of the lamp
by Shri. Mr. C.M. Muralidharan,
Project Manager BOBLME

Inaugural address by Dr.P.S.B.R James,
(former Director, CMFRI)

Felicitation address by Dr.T.S. Dange,
Director, GOMBRT

Felicitation address by Dr.K.K.Joshi.,
Head, MBD, CMFRI, Kochi

A view of the workshop participant

Figure 29 Photographs of inaugural session

Presentation by Dr.E.Vivekandan.,
Former Principal Scientist,
CMFRI & Senior Advisor of the Projects

Chair with rapporteurs

Presentation by Dr. P.S Asha Principal
Scientist, CMFRI, Tuticorin

Presentation by Dr. B. Johnson, Scientist
CMFRI, Mandapam

Presentation by Dr. D.B.James ,
Former Principal, Scientist, CMFRI

Interaction by fisherman

Figure 30 Photographs of technical session

Panellist of the plenary session

Remark by Mr. Shri. Issac Jayakumar
AD, Fisheries, Tuticorin

Remark by N.Venugopal, Consultant ,
ICSF

Remark by V.Arulanantham,
ARIF trust, Pamban

Concluding the plenary session
by Dr.P.S.B.R James (former Director CMFRI)

Group photo of the workshop participants

Figure 31 Photographs of plenary session