Survey and assessment of seagrass beds in the Gulf of Mannar and Palk Bay to support strategy to conserve and manage seagrass habitats

Suganthi Devadason Marine Research Institute (SDMRI)

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A Cuttlefish swims amongst the seagrass beds in Palk Bay © MFF/SDMRI

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Contents

Introduction

Seagrass meadows are specialized marine flowering plants that have adapted to near shore underwater environments. Forming extensive meadows, they support high levels of biodiversity, stabilize sediments and trap heavy metals and nutrient rich runoff, thereby improving the water quality for large numbers of associated coral reef communities. They are important nursery habitats for fishes and feeding grounds for endangered species such as turtles and dugongs, the latter for who the presence of seagrass is highly correlated with its ability to survive. Additionally, seagrass rhizome systems bind and stabilize bottom sediments and provide habitats for hundreds of in-faunal organisms.

Seagrasses are amongst the least understood marine ecosystems in India. Seagrass beds in the country are predominantly found in mudflats and sandy regions along open shores and in island lagoons, from the lower intertidal zone to a depth of approximately 10–15m (Jagtap, 1991, Ramamurthy et al., 1992). The major seagrass meadows are distributed amongst the Lakshadweep and Andaman and Nicobar Islands and along the southeast coast of India, in the Gulf of Mannar and Palk Bay. It is estimated that the maximum extent (3,000ha) of seagrass are found in the latter region; fourteen species of seagrass have been conclusively identified in the region (Jagtap and Inamdar, 1991).

The Gulf of Mannar extends from Rameswaram Island in the north to Kanyakumari in the south. It consists of a chain of 21 islands stretching from Mandapam to Tuticorin. The islands are located approximately 2 - 10km from the mainland and are classified based on their proximity to mainland into four major groups Tuticorin, Vembar, Keezhakkarai and Mandapam groups. The region was declared a Marine Biosphere Reserve in 1989 under the Man and Biosphere Programme of UNESCO in lieu of its invaluable biodiversity and multiple use status. The 21 islands are protected under the Gulf of Mannar Marine National Park. In previous years, area estimates of seagrass beds from different regions were generally made from aerial photographs, ground survey, and naval hydrographic charts, whereas standing crop was calculated by using biomass data collected by line transect and quadrat methods.

By comparison to the adjacent Gulf of Mannar, the Palk Bay region has not been paid much attention and most of the available literature and studies do not reflect the current scenario. In general, the distribution pattern of seagrass has been observed to be relatively close to that of most tropical and subtropical regions in terms of distribution and abundance (Jagtap and Untawale, 1989, Jagtap, 1987, 1991).

Globally, there has decrease in seagrass abundance and associated organisms, mainly due to anthropogenic activities (Kemp 2000). A number of countries have given high priority to conserving seagrass ecosystems, and rehabilitation programs have been implemented since 1945 in some areas (Thorhaug 1986). Seagrass beds from India have been included as ecologically sensitive regions and are protected by the Coastal Regulation Zone Act. Despite this seagrasses, and associated fauna like dugongs (a highly endangered Sirenian species, dugongs are afforded the highest protection under the Wildlife Protection Act, 1972, in India; very little is known about

them), have been largely left out of education, research, and management consideration, as compared to other ecologically sensitive habitats such as mangroves and coral reefs.

The objectives of this project are to develop a long-term strategy for seagrass conservation in the Gulf of Mannar and Palk Bay and to enhance knowledge of dugongs in the region. This will be achieved through

- Assessment of current status of seagrass habitats in Gulf of Mannar and Palk Bay
- Informal discussions to identify fishery-related threats to seagrass habitats
- Stakeholder discussions and capacity building of fisher folk, in particular youth, in reporting dugong sightings
- Documenting threats to Dugongs through targeted surveys
- Development of knowledge products on dugongs and seagrass

Methodology

Assessment of current status of seagrass habitats in Gulf of Mannar and Palk Bay

Study sites

A preliminary visual survey was carried out to identify the location and extent of sea grass meadows in the Gulf of Mannar, in the area outside of the Marine National Park between Rameswaram and Tuticorin,(please refer to Figure 2). Similar surveys were conducted in Palk Bay from Thondi to Athiramapattinan (please refer to Figure 3). The Palk Bay area was demarcated using GPS coordinates, into eleven separate sites, in relation and close proximity to villages along the coastline. For a table of GPS coordinates of all sites and associated maps, please refer to Annex 1.

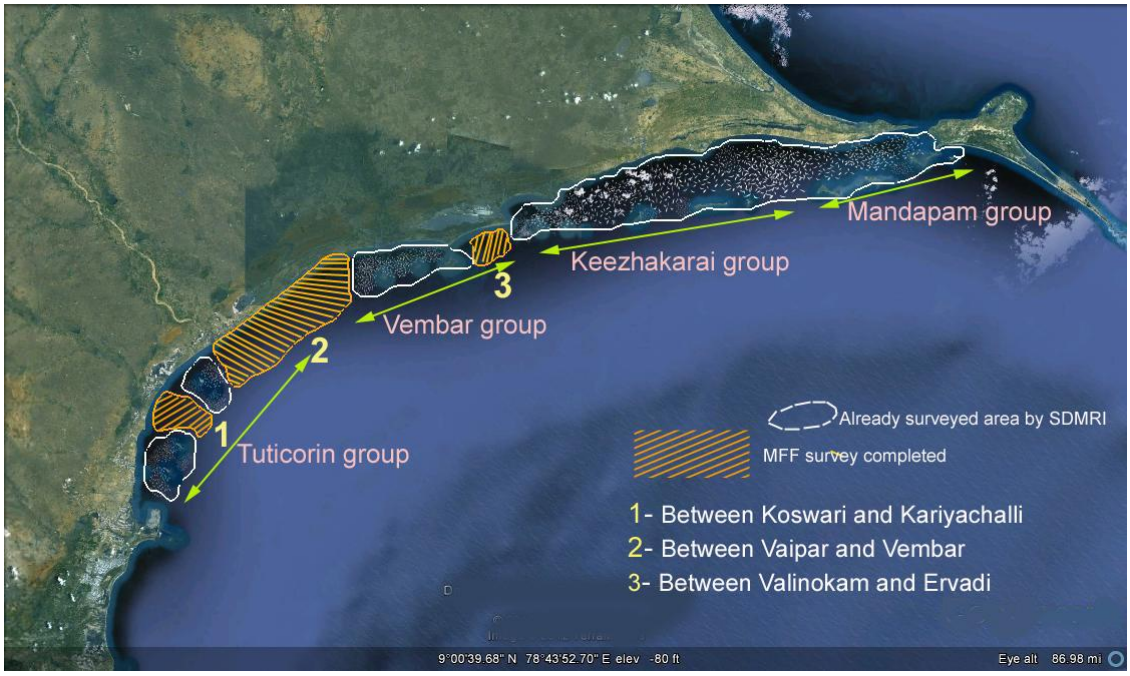

Figure 1. Surveyed sites for MFF project in the Gulf of Mannar

Figure 2. Surveyed sites for MFF project in Palk Bay

Seagrass assessments

Assessments of the seagrass beds were conducted as per the methodology detailed in English et al. (1997). 100m Line Intercept Transects (LIT) were laid down perpendicular to the shoreline and parallel to each other at a distance between 50 – 100m. 1 x 1m quadrats (with 10cm grids) were placed along either side of each transect at 5m intervals. Percentage seagrass species composition and density, shoot density and seagrass biomass were assessed. Number of transect differed between sites depending on the extent of seagrass beds. For more detailed information please refer to Annex 2.

Assessments in the Gulf of Mannar were conducted from January to April 2012. Assessments in Palk Bay were conducted from June to September 2012. This was timed as such because rough weather prevails in the Gulf of Mannar between April and September and in Palk Bay between October and March, that endangers divers.

Shoot density

Shoot density was measured by counting the number of leaf meristems (points of leaf initiation on the shoot) of individual seagrass species within each of the afore-mentioned quadrats. The shoot density was averaged along each transect.

Above ground biomass

Leaves, roots and rhizomes were collected by hand from within 4 random quadrats per transect. The samples were rinsed clean of adhering debris, sand and epiphytes and separated species-wise. Each set of species samples were divided into leaves, rhizomes and roots for the biomass study. Each portion was blotted to remove excess water and dried at 30°C to a constant weight. The biomasses were weighed for each species and averaged along each transect.

Research was further simultaneously carried out on the % composition and biomass of specific species of bottom dwelling fauna, epifauna and epiphytes, as well as fish densities. Although this does not form part of the project activities and this report, as it requires long term data collection which will continue to be collected beyond the scope of this small grant project, whatever raw data was collected within the period of the project has been provided to MFF India and IUCN India Country Office. It is envisioned that in combination with the data collected through this project and the data collected previously by SDMRI, a comprehensive understanding of the seagrass habitats within the entirety of the Gulf of Mannar and Palk Bay ecosystem can be developed and subsequent scientific papers published.

Informal discussions to identify fishery-related threats to seagrass habitats

Informal discussions were had with all encountered active fishermen at all of the study sites in Gulf of Mannar and Palk Bay to identify what they regarded as most threatening to the seagrass beds. The recorded list is provided in Annex 3.

Stakeholder discussions and capacity building of fisher folk, in particular youth, in reporting dugong sightings

Trainings were conducted in four coastal villages (two in Palk Bay and two in Gulf of Mannar). The trainees were youth from fisher communities, predominantly males, as they are the most active fishers in these coastal regions. In MunaiKadu, a few fisherwomen also participated in the training as they are involved in the seaweed collection around the island areas.

	Village	**Date of Training**	**No. of participants**
1.	MunaiKadu (Palk Bay)	26.02.2013	25
2.	VadaKarai (Palk Bay)	26.02.2013	28
3.	Vethalai (Gulf of Mannar)	27.02.2013	29
4.	IyanarKoil (Gulf of Mannar)	27.02.2013	25

The training was designed to ensure that a data base of dugongs in the region is maintained by involving the local fishing communities. It is envisioned that the data can be accessed to estimate dugong population size and status and to identify possible management techniques that can be adopted to protect this critically endangered and iconic animal. The following was taught during the training:

- How to gather and store relevant information pertaining to sightings of marine mammals, particularly dugongs, on their daily fishing outing whilst maintaining a mandated 2m distance from the animal so as not to stress it out.
- How to record, location of sighting, individual animal size, sex, scars and period of time that the animal spent submerged.
- Recording the behavior of sighted dugongs as per the following classifications:

1. Feeding (movement of muzzles over sea grass resulting in ingestion of food)
2. Idling (seemingly undirected activity on a small area).
3. Resting (absence of any kind of movements)
4. Communicating (Sound emissions in form of squeaks and barks)
5. Direct behavior to observer

Documenting threats to Dugongs through targeted surveys

Communities from coastal villages and hamlets were selected for the survey based on previous research documentation of dugong occurrence, and comprehensive discussions with fisheries scientists and experts. As such, 46 coastal villages were selected and surveyed from Tuticorin to Rameswaram in the Gulf of Mannar, and from Mandapam up to Adhirampattinam in Palk Bay. Interviews were conducted randomly with ten individuals at each village or hamlet. Of the 460 interviewees, 98% were active fishermen (of ages ranging from 19 to 74 years) and 2% were officials from the State Fisheries Department, fish buyers and vendors. A standard semi-structured questionnaire including both closed and open-ended questions was designed (adapted from Hines 2002, please refer to Annex 4 for the survey) and translated into local languages for the interviews. The survey was conducted during the month of February 2013.

Development of knowledge products on dugongs and seagrass beds

A brochure to raise awareness of dugongs was developed in the Tamil and distributed to all surveyed villages. A copy has been attached to this report.

Results and Discussion

Assessment of current status of seagrass habitats in Gulf of Mannar and Palk Bay

The seagrass beds at the study sites in the Gulf of Mannar comprised of eight species (Figure 1, Annex 5). In three of the study sites (between Vipar and Periyasamipuram, between Periyaswamipuram and Vembar, and between Valinokam and Ervadi), *Cymodocea serrulata* was by far the most dominant species (ranging from 36 -38%) with *Thalassia hemprichii* following behind. *Halophila ovata* was the least dominant (ranging from 0 – 3.24%); the species was not found between Valinokam and Ervadi. The two Halodule species were found in exceeding low abundance (ranging from 4.5 – 6.9%). By stark contrast, between Koswari and Kariyachalli, the seagrass compositional structure differed varied to the other three sites. Three species dominated *Cymodocea serrulata*, *Halophila ovalis* and *Halodule pinifolia* (at approximately 20% each). An eighth species, *Enhalus acoroides* (not found in any other of the other sites) was also observed. *Halodule uninervis* had the least coverage in the site (at 2.2%).

Between Koswari and Kariyachalli shoot density was highest for the species *Cymodocea serrulata* with 183.65 m^{-2} followed by *Thalassia hemprichii* with 56.39 m^{-2}. Biomass was also highest for the species *Cymodocea serrulata* with 101.14 g dry

weight m^{-2} followed by *Thalassia hemprichii* with 24.31 g dry weight m^{-2}. Between Vipar and Periyasamipuram shoot density was highest for the species *Cymodocea serrulata* with 180.41 m^{-2} followed by *Thalassia hemprichii* with 52.07 m^{-2}. Biomass was also highest for the species *Cymodocea serrulata* with 112.03 g dry weight m^{-2} followed by *Syringodium isoetifolium* with 28.79 g dry weight m^{-2}. Between Periyaswamipuram and Vembar shoot density was highest for the species *Cymodocea serrulata* with 159.23 m^{-2} followed by *Thalassia hemprichii* with 62.75 m^{-2}. Biomass was also highest for the species *Cymodocea serrulata* with 99.49 g dry weight m^{-2} followed by *Thalassia hemprichii* with 23.82 g dry weight m^{-2}**.** Between Valinokam and Ervadi shoot density was highest for the species *Cymodocea serrulata* with 136.5 m^{-2} followed by *Thalassia hemprichii* with 56.64 m^{-2}. Biomass was also highest for the species *Cymodocea serrulata* with 94.98 g dry weight m^{-2} followed by *Thalassia hemprichii* with 22.92 g dry weight m^{-2} (Figure 3, Annex 5)

Previous studies indicate (Japtap, 1996) that species of *Halodule* and *Halophila* occurred in higher frequencies in the intertidal and shallow seagrass beds of the Gulf of Mannar, whereas *Cymodocea serrulata*and *Thalassia hemprichii* showed greater frequencies in the depth range of 3 – 5m and 7 – 8m respectively. This contrasted with the results of the present study in that it was observed that *Cymodocea serrulata* was consistently present in all seagrass beds regardless of depth or distance from shore of the seagrass bed. However, the pattern that Jagtap (1996) found, appears to be consistent with seagrass composition in Koswari and Kariyachalli. This could attributed to the fact that since the site is not as exposed to the open sea, it is protected from strong waves and currents, enabling a greater diversity of seagrass to grow (Manikandan et al., 2011).

The seagrass beds at the study sites in Palk Bay comprised of six species (Figure 2, Annex 5)). *Cymodocea serrulata* had the most dominant coverage followed by *Syringodium isoetifolium*, at all eleven sites. *Halophila decipiens* has the least coverage in all sites. Moving from east to west along the coast, there is decreasing presence of *Halodule pinifolia* and *Halophila ovalis*. At the majority of the 11 sites the shoot density and biomass for *Cymodocea serrulata* was the highest, followed by *Thalassia hemprichii* (Figure 4, Annex 5)

It is important to note that although the majority of species are the same between the Gulf of Mannar and Palk Bay there are a few species that differ. *Halophila decipiens* was only found in Palk Bay. *Holophilia ovate, Halodule univeris* and *Enhalus acoroides* were found in the Gulf of Mannar but not Palk Bay. This insinuates that the management plans for the region will need to differ in some aspects with regard to ensuring that the varied floral diversity of the two regions is conserved. There are a range of factors including depth, distance from shore, temperature and salinity, that have not been investigated through this study, and that have been shown to affect the distribution, diversity (seagrass species assemblage) and abundance.

Recommendations for a strategy for conservation and management of seagrass beds in the Gulf of Mannar and Palk Bay

The short term and long term management strategies need to be implemented for the conservation and management of seagrass beds in Gulf of Mannar and Palk Bay.

Short-term objectives

Short-term objectives include identification of immediate threats / issues responsible for degradation of the seagrass beds, which could be considered on priority for conservation.

Long-term objectives

Long-term objectives include consideration all the issues / threats responsible for degradation of the seagrass beds and action to be taken accordingly for conservation.

Strategies for achieving the objectives

Management Action Plan

Strategies to achieve short-term and long-term objectives should help in the preparation of holistic integrated management action plan, which should clearly bring out work plan for 5 or 10 years for effective implementation in order to meet out objectives for conservation. A tentative list of actions required for corals are briefly given hereunder for illustrative purposes.

Protection

- Survey and mapping
- Restriction on boat anchoring
- Restriction on destructive fishing practices like trawling, shore seine and push net operation
- Regulation of coastal development activities on a scientific basis

Management

- Regular survey and assessment of seagrass beds and associated resources to update the status
- Regulation of fishing activities
- Monitoring of seagrass beds, associated resources and threats
- Preparation of monitoring protocol

Rehabilitation

- Rehabilitation of degraded seagrass area using native species with appropriate low tech methods.
- Protection of seagrass and associated faunal & floral diversity
- Monitoring of rehabilitated areas
- Community involvement in rehabilitation and monitoring

Pollution control

- Regulation of industrial effluent discharges
- Regulation of land based domestic sewage discharges.

- Regulation of fishing harbor activities
- Regulation of coastal developmental activities
- Regulation of aquaculture and slat pan waste discharges

Environmental Monitoring

- Monitoring of environmental parameters (Water and Sediment Quality) in seagrass bed areas
- Monitoring of pollution level

Socio-economic development through community participation

- Skill development programmes to local community
- Training in Eco-friendly fishing practices
- Regular surveys to be conducted on the socioeconomics of the local people
- Viable and site additional livelihood options to seagrass dependent coastal community
- Formation of village level conservation and management committees

Awareness building

- Local workshop to create awareness among coastal community
- Publication of brochures, posters and education materials to make aware all stakeholders including conservation managers, administrators, judiciary, political leaders etc.
- Awareness creation through electronic media.

Capacity building

- Training of management staff
- Capacity building of local research institutions for assessment, and monitoring
- Capacity building of local community in seagrass rehabilitation

Legislative and administrative measures

- Steps to provide appropriate conservation status to seagrass bed areas in Palk Bay and Gulf of Mannar

Documenting threats to Dugongs through targeted surveys

Based on the data collected, it is evident that the dugong population in the Gulf of Mannar still persists; the offshore waters of Mottaigopuram, Vellaipatti, Sippikulam, Vaipar, Vembar, Erwadi, Keezhakarai, Pamban, Mandapam, Vedhalai, Muthupet, Periyapatnam in particular were identified as important nursing and feeding grounds. Please refer to Annex 6 for more details. When respondents were asked if the local dugong population was increasing, declining or stable, 60% of the respondents based in the Gulf of Mannar were of the opinion that population was declining; some further elaborated that there is a visible decline in dugong occurrence in areas where they were commonly found as early as 15-20 years ago. 50% of the respondents attributed the decline in population to trawling. A further 4% attributed the decline to the destruction of seagrass habitat and 4% to natural disasters like tsunamis and

cyclones. 12% of the interviewed fishermen admitted that they had caught an animal in their gill nets and deliberately killed it; 8% set the caught animal free, although whether the animal survived or not is unknown. The majority of the respondents were hesitant to answer questions related to the catching and killing of the animal, it was observed that a significant number knew that the dugong was protected by law.

Based on the data collected, it is evident that the dugong population in Palk Bay (Thoppukaadu to Adhirampatinm) still persists although 80% of the respondents within Palk Bay agree that the population has dropped significantly in the past decade. Please refer to Annex 6 for more details. Thoppukaadu, Uppur, Mullumunai, Solaiyakudi, Thondi, Ammanisathiram and Mallipatinam were identified as having the highest frequency of visiting dugongs and are believed to be key feeding grounds for mothers and calves in particular. Dugongs have also been sporadically observed in the offshore waters of Pirappannavalasai, Panaikulam, Palanivalasai, Muthuregunathpuram, Nambuthalai, Kottaipatinam, Sethuvapatinam and Senthalaivayal. The respondents attributed the decline in population to trawling (60%), usage of large sized gill nets like shark nets (10%), hunting (20%), natural disasters like tsunami and cyclones (5%) and destruction of seagrass habitats (5%). 8% admitted to catching dugongs in their gill nets and killing them; 2% claimed to have freed caught animals. As in the Gulf of Mannar the majority of the respondents were hesitant to answer questions related to the catching and killing of the animal, it was observed that a significant number knew that the dugong was protected by law

Attitudes to the need for conservation and sustainable use of natural resources, specifically dugongs and seagrass, differed between the two regions Gulf of Mannar and Palk Bay, with respondents from the latter believing it was more important. When questioned as to what they thought should be done to conserve natural resources, the majority suggested a decrease in trawling. Please refer to Annex 6 for more details.

Challenges

Due to time constraints and unavailability of local authorities and state forest officials to attend meetings, it was impossible to conduct stakeholder discussions to finalise the draft the strategy plans for conservation of seagrass in the region. It is intended that the data collected through this study will be published in an accredited scientific journal to further support the strategy document, following which SDMRI with support from MFF India will officially disseminate the document to relevant stakeholders for review.

There were some delays in data collection due to rough weather. In Gulf of Mannar, Rough weather prevails between April and September and this will have hindrance in data collection in the field. In Palk Bay, Rough weather prevails between October and March and this will have hindrance in data collection in the field.

Recommendations for future research

The overall results of this study indicate the need for rehabilitation of the once abundant seagrass meadows in this region. As the coastal population grows with a marked increase in dependence on marine and coastal resources, we must restore these valuable nurseries for commercially important organisms, to serve our own needs and the needs of some of the poorest communities in south India. As such comprehensive research must be conducted, where lacking on the following aspects:

- Fishing patterns in the region (both artisanal and mechanized), with particular relevance to the exploitation and stress of their impact on seagrass and related fauna.
- The effects of patch size on diversity, abundance and composition of fauna. Whilst continuous, extensive seagrass meadows are recognized for their importance in providing refuge for a variety of organisms, vegetated patches have not been widely investigated. Habitat patch size can be an important determinant influencing species diversity and biological interactions among species.
- Seasonal differences can strongly influence the salinity, temperature and other abiotic factors within the seagrass habitat. As such, the diversity, composition and abundance of seagrass beds within the region could be constantly (and perhaps naturally) changing over time; this will likely require differing management efforts and actions at different periods of time.
- Identification of suitable sites for rehabilitation and plantation of seagrass and established protocols for the same.

References

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2. Ramamurthy, K., N.P. Balakrishnan, K. Ravikumar and R. Ganesan, 1992. Seagrasses of Coromandel coast, India. Flora of India – Series 4, Botanical Survey of India, 80 p.

Annex 1

GPS coordinates and maps for surveyed project sites in Gulf of Mannar and Palk Bay (2007 - 2012)

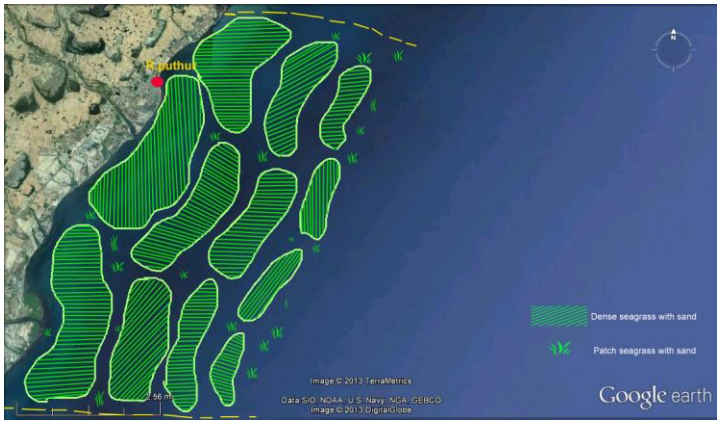
Gulf of Mannar

	Name of the area	**GPS Mark**
1.	Vaan	08^0 50.223'N 78^0 12.089'E
2.	Koswari	08^0 52.336'N 78^0 13.039'E
3.	Kariyachalli	08^0 57.359'N 78^0 14.424'E
4.	Vilanguchalli	08^0 56.222'N 78^0 15.589'E
5.	Upputhanni	09^0 05.446'N 78^0 29.701'E
6.	Puluvinichalli	09^0 06.200'N 78^0 32.046'E
7.	Nallathanni	09^0 06.468'N 78^0 34.408'E
8.	Anaipar	09^0 09.269'N 78^0 41.464'E
9.	Valimunai	09^0 09.379'N 78^0 43.536'E
10.	Poovarasanpatti	09^0 09.373'N 78^0 45.145'E
11.	Appa	09^0 10.084'N 79^0 49.186'E
12.	Thalayari	09^0 11.059'N 78^0 54.514'E
13.	Valai	09^0 11.184'N 78^0 56.246'E
14.	Mulli	09^0 11.262'N 78^0 57.515'E
15.	Hare	09^0 12.233'N 79^0 04.118'E
16.	Manoli	09^0 13.077'N 79^0 07.476'E
17.	Manoliputti	09^0 13.164'N 79^0 09.007'E
18.	Poomarichan	09^0 14.350'N 79^0 10.480'E
19.	Pullivasal	09^0 14.380'N 79^0 11.449'E
20.	Krusadai	09^0 14.588'N 79^0 12.423'E
21.	Shingle	09^0 14.449'N 79^0 14.141'E

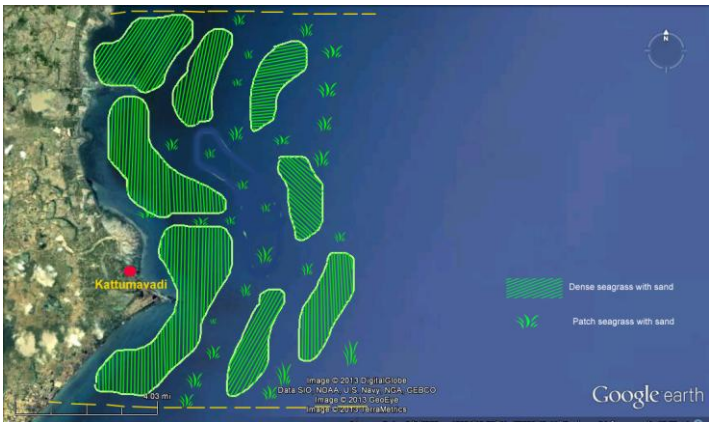
Palk Bay

	Name of the area	**GPS Mark**
1.	Pasipattinam	09^0 47.426'N 79^0 04.183'E
2.	R. puthur	09^0 53.132'N 79^0 07.267'E
3.	Kottaipattinam	09^0 58.284'N 79^0 11.502'E
4.	Kattumavadi	10^0 03.307'N 79^0 15.098'E
5.	Sampaipattinam	10^0 13.202'N 79^0 16.189'E
6.	Senthalaivayal	10^0 12.261'N 79^0 16.242'E
7.	Ammanisathiram	10^0 14.199'N 79^0 16.212'E
8.	Kaarankuda	10^0 14.414'N 79^0 16.405'E
9.	Sethupavasathiram	10^0 15.016'N 79^0 17.046'E
10.	Mallipattinam	10^0 16.455'N 79^0 19.135'E
11.	Athiramapattinam	10^0 18.368'N 79^0 22.478'E

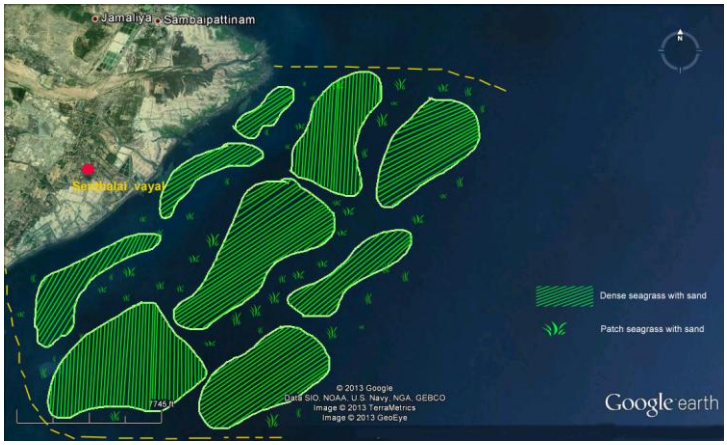

Pasuipattinam
Dense seagrass with sand
Patch seagrass with sand
Google earth


K puthur
Dense seagrass with sand
Patch seagrass with sand
Google earth


Kottaipattinam
Dense seagrass with sand
Patch seagrass with sand
Google earth


Kattumavadi
Dense seagrass with sand
Patch seagrass with sand
Google earth

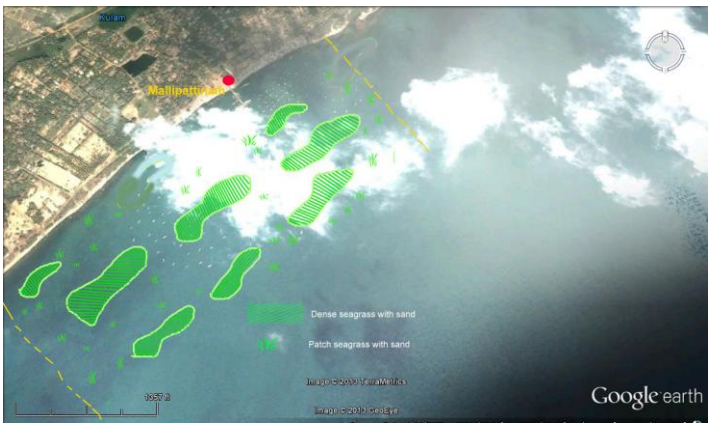

Sambaipattinam
Dense seagrass with sand
Patch seagrass with sand
Google earth

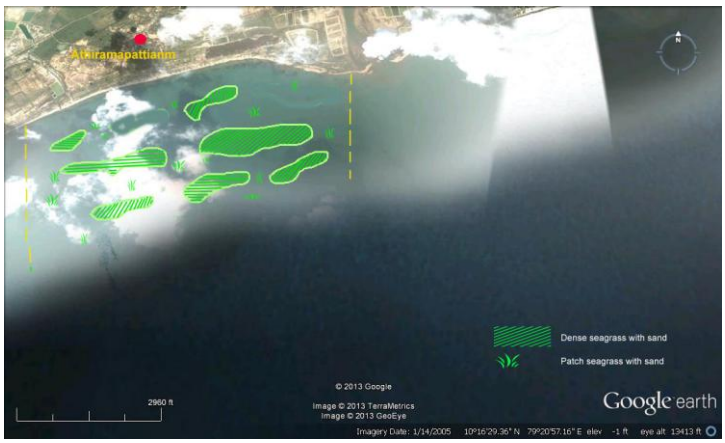

Jamaliya
Sambaipattinam
Dense seagrass with sand
Patch seagrass with sand
Google earth


Ammani sathiram
Dense seagrass with sand
Patch seagrass with sand
Google earth


Kattaguda
Dense seagrass with sand
Patch seagrass with sand
Google earth


Sethupayasathiram
Dense seagrass with sand
Patch seagrass with sand
2206 ft
Image © 2013 TerraMetrics
Image © 2013 GeoEye
Google earth


Mallipattinam
Dense seagrass with sand
Patch seagrass with sand
Google earth


Athiramapattianm
Dense seagrass with sand
Patch seagrass with sand
2960 ft
© 2013 Google
Image © 2013 TerraMetrics
Image © 2013 GeoEye
Google earth

Annex 2

Transects conducted within each site

Gulf of Mannar

	Name of the area	**Total**
1.	Between Koswari and Kariyachalli Islands	120
2.	Between Vipar and Periyasamipuram	135
3.	Between Valinokam and Ervadi	144
4.	Between Periyaswamipuram and Vembar	154

Palk Bay

	Name of the area	**Total**
1.	Pasipattinam	130
2.	R. puthur	156
3.	Kottaipattinam	158
4.	Kattumavadi	119
5.	Sampaipattinam	128
6.	Senthalaivayal	111
7.	Ammanisathiram	137
8.	Kaarankuda	102
9.	Sethupavasathiram	86
10.	Mallipattinam	119
11.	Athiramapattinam	64

Annex 3

Fishery-related threats to seagrass habitats

Gulf of Mannar

Between Koswari and Kariyachalli Islands
Inshore trawling
Shore seine operation
Bottom gill net operation
Boat anchoring
Sedimentation

Between Vipar and Periyasamipuram
Inshore trawling
Shore seine operation
Bottom gill net operation
Boat anchoring
Sedimentation
Grazing

Between Valinokam and Ervadi
Inshore trawling
Shore seine operation
Bottom gill net operation
Boat anchoring
Sedimentation

Between Periyaswamipuram and Vembar
Inshore trawling
Shore seine operation
Bottom gill net operation
Boat anchoring
Sedimentation

Palk Bay area

Pasipattinam
Inshore trawling
Bottom gill net operation
Boat anchoring
Sedimentation

R. puthur
Inshore trawling
Bottom gill net operation
Boat anchoring
Sedimentation

Kottaipattinam
Inshore trawling
Bottom gill net operation
Boat anchoring
Sewage disposal
Sedimentation

Kattumavadi
Inshore trawling
Bottom gill net operation
Boat anchoring
Sewage disposal
Solid waste dumping
Sedimentation

Sampaipattinam
Inshore trawling
Bottom gill net operation
Boat anchoring
Sewage disposal
Solid waste dumping
Sedimentation

Senthalaivayal
Inshore trawling
Bottom gill net operation
Boat anchoring
Sedimentation

Ammanisathiram
Inshore trawling
Bottom gill net operation
Boat anchoring
Sewage disposal
Sedimentation

Kaarankuda
Inshore trawling
Bottom gill net operation
Boat anchoring
Solid waste dumping
Sedimentation

Sethupavasathiram
Inshore trawling
Bottom gill net operation
Boat anchoring
Sedimentation

Mallipattinam
Inshore trawling
Bottom gill net operation

Boat anchoring	Inshore trawling	Sedimentation
Sedimentation	Bottom gill net operation	
Athiramapattinam	Boat anchoring	

Annex 4

Dugong questionnaire (adapted using UNEP-CMS guidelines)

Name:
Age:
Gender:
Area:
Topography:
Demography:
Population size of the village:
Education of the respondent:
Occupation of the respondent:

- Fishing labourer/Owner
- Wage labourer
- Skilled worker
- Petty Trader
- Self employed

No. of own boats:

- More than 100 boats
- 50-100 boats
- Less than 50 boats

Ports nearby(in nos.)
Large
Medium
Small

Fishing activities: (specification to Fishing depth, fishing grounds (past & now), time and season)

Fishing activity (Past)
Fishing ground
Depth
Time & season

Fishing activity (Present)
Fishing ground
Depth
Time & season
Remarks

Fishing activity - Past	
Fishing Activity - Present	

Fishing resources caught (sps. and tonnes/day)

Area code:
Fishing Effort:

- Days of fishing:
- Caught /day:

Habitat
e.g: Fishing areas, seagrass areas
Animals you have seen:

- Turtles
- Dugongs
- Cetaceans

Describe what you saw of the animal/s (e.g. shape of muzzle/beak/dorsal fin, flank markings, size or other distinguishing features)
How many individuals did you see
Live/ Dead
If dead, what is the reason of death and explain the observed condition
Size: Small /Large
If alive,
No. of adults
No. of juveniles (75-100%) Adult Size)
No. of calves/pups (50-75%) Adult Size)
What was/were the animal/s doing?

- ☐ Resting
- ☐ Feeding
- ☐ Breaching (jumping)
- ☐ Swimming
- ☐ Interacting
- ☐ Stranded
- ☐ Not sure
- ☐ Other

If other, please specify

If swimming, how fast was/were the animal(s) moving?

- ☐ Fast
- ☐ Medium
- ☐ Slow

If swimming, in what direction was/were the animal(s) moving?

If interacting, what was it with?

- ☐ People
- ☐ Vessels
- ☐ Fishing gear

If swimming, how fast was/were the animal(s) moving?

- ☐ Fast
- ☐ Medium
- ☐ Slow

If interacting, what was it with?

- ☐ People
- ☐ Vessels
- ☐ Fishing gear

Date of Sighting:

Time and duration of sighting:

Were you ...

- ○ On land
- ○ On a vessel

If on a vessel, what type was it?

Reported: Yes / No

Any further notes

Date of Survey:

Annex 5

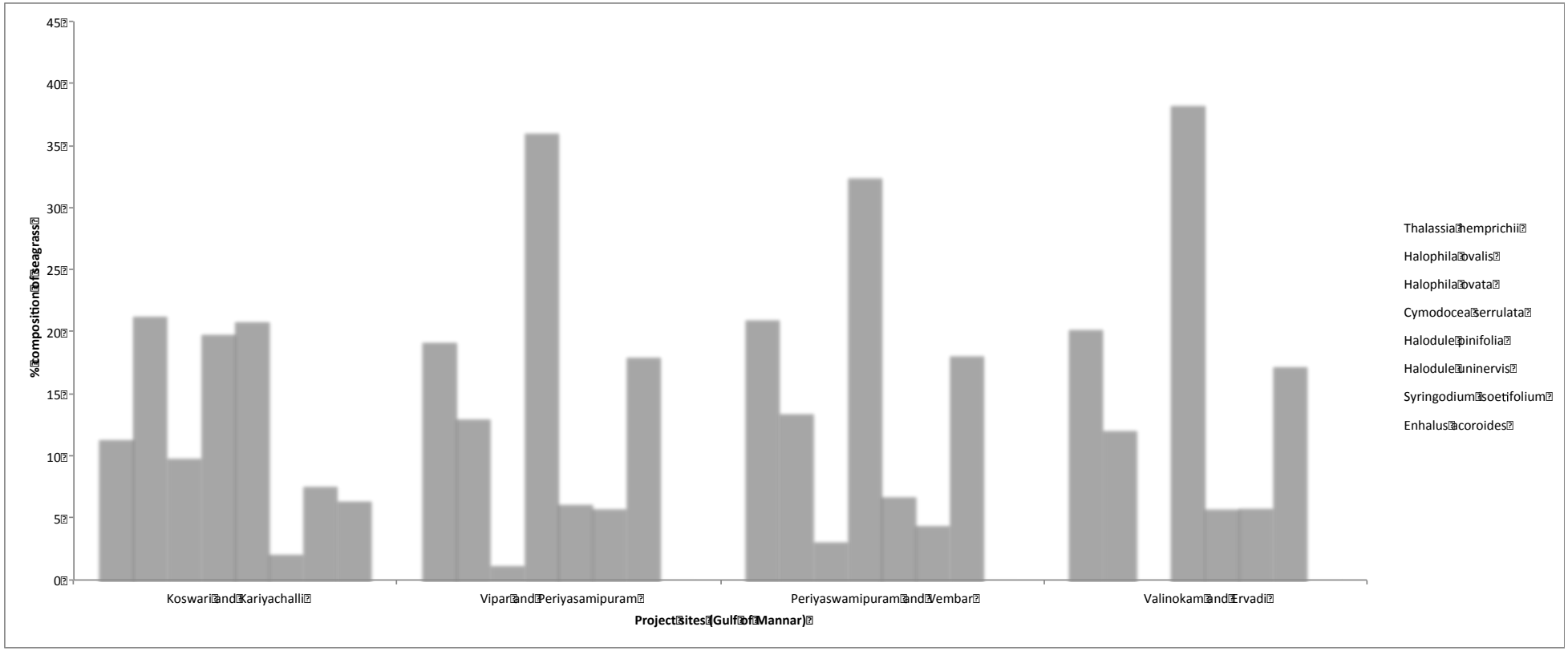


Figure 3. Diversity and % composition of seagrass in Gulf of Mannar

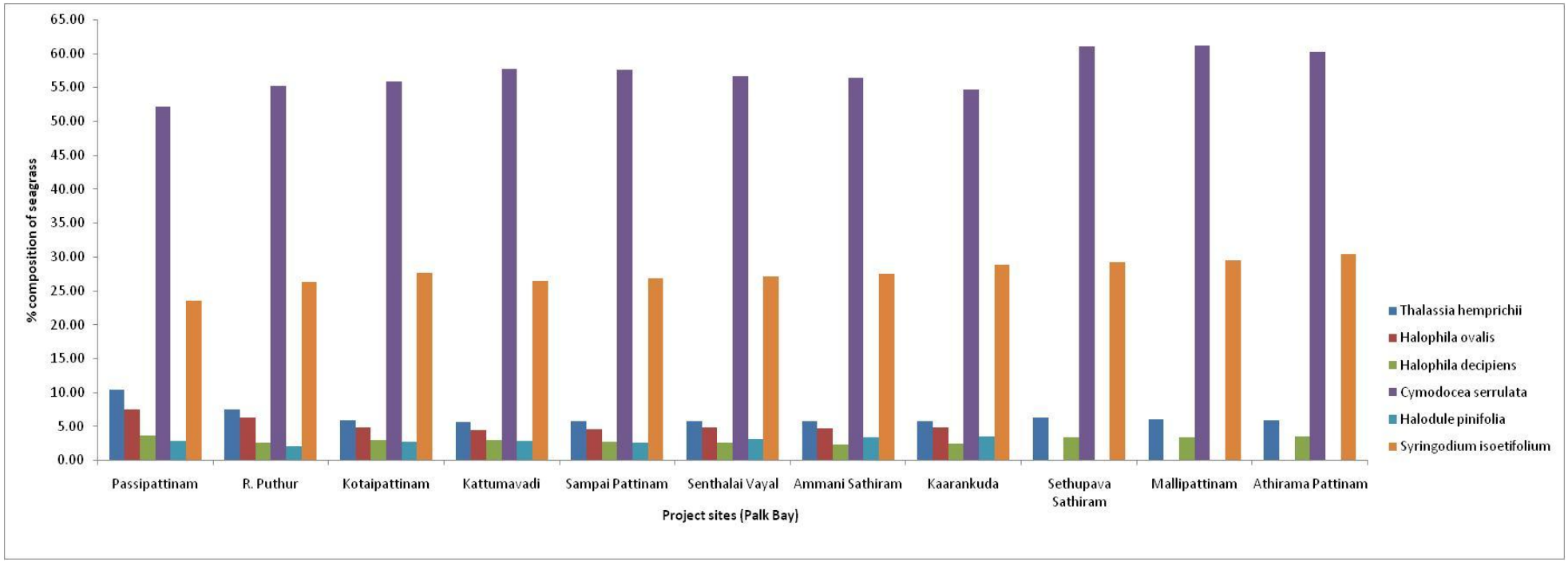


Figure 4. Diversity and % composition of seagrass in Palk Bay

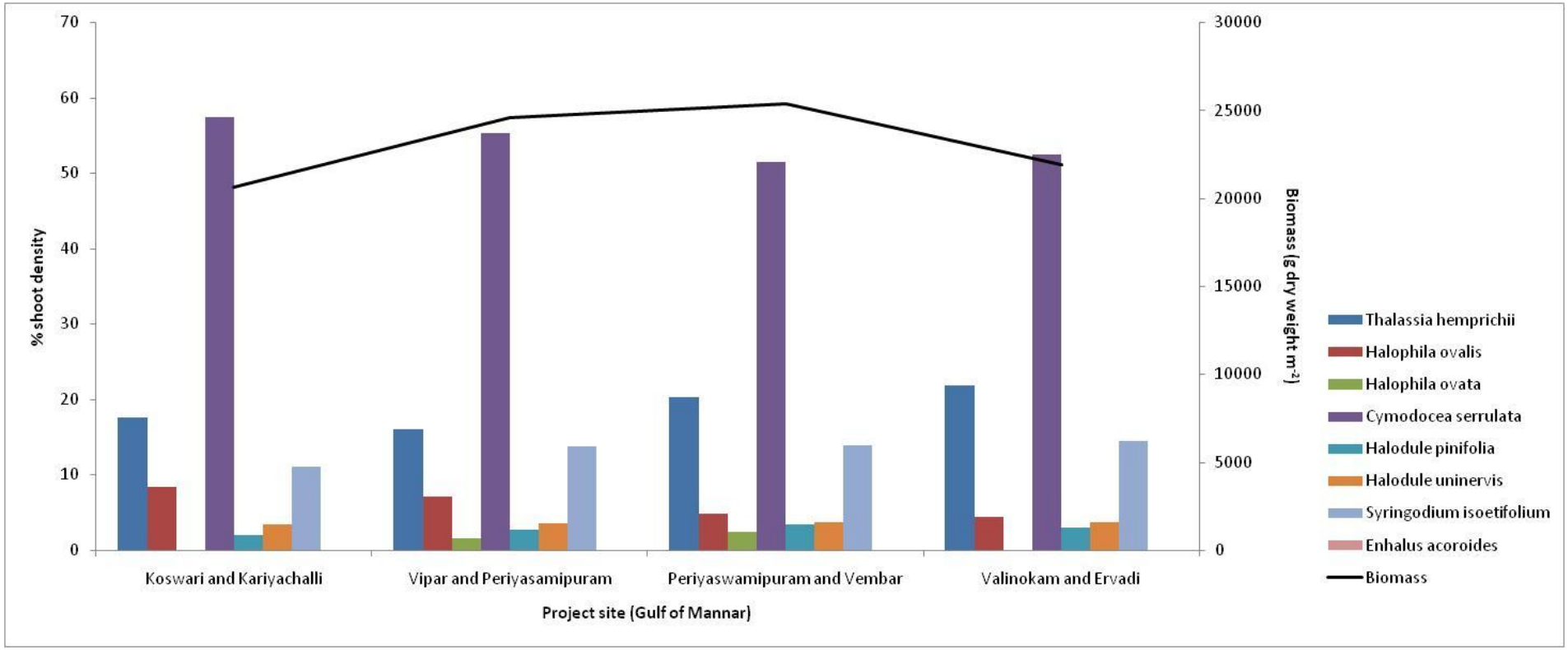


Figure 5. Biomass and shoot density of seagrass in the Gulf of Mannar

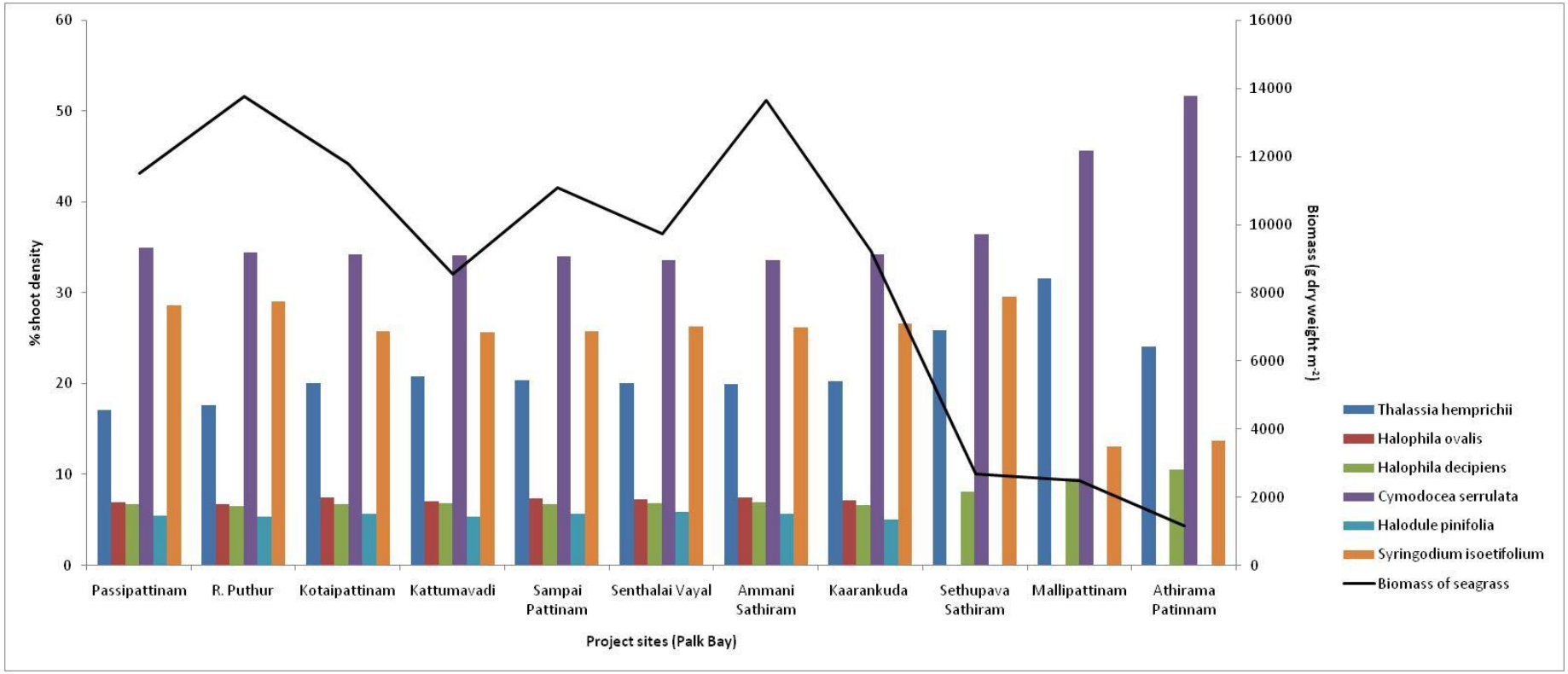


Figure 6. Biomass and shoot density of seagrass in Palk Bay

Annex 6

Distribution and sightings of dugongs

Gulf of Mannar

S.No.	Study area Gulf of Mannar	Population freq (in nos.)
1	Thirespuram	2
2	Mottaigopuram	6
3	Vellaipatti	5
4	Tharuvaikulam	1
5	Pattinamaruthur	1
6	Sippikulam	4
7	Veipar	3
8	Vembar	3
9	Erwadi	4
10	Keezhakarai	2
11	Muthupettai	4
12	Periyapattinam	2
13	Vedhalai	8
14	Puthumadaam	1
15	Mandapam	5
16	Pamban	2

Palk Bay toAdhirampatinam

S.No.	Study area Palk Bay - Adhirampatinam	Population size (in nos.)
17	Thoppukaadu	12
18	Pirappannavalasai	3
19	Aathankarai	2
20	Panaikulam	3
21	Iraniyanvalasai	1
22	Palanivalasai	3
23	Muthuveerampatinam	2
24	Poosarinagar	2
25	Illanthakootam	2
26	Devipatinam	2
27	Muthuregunathapuram	3
28	Pathananthal	2
29	Karankadu	1
30	Thirupallakudi	1
31	Uppur	10

32	Mullumunai	5
33	Solaiyakudi	5
34	Nambuthalai	3
35	Thondi	8
36	Pasipatinam	1
37	R.puthur	3
38	Kottaipatinam	3
39	Kattumavadi	3
40	Sambaipatinam	3
41	Sethalaivayal	2
42	Ammanisathiram	5
43	Karankuda	2
44	Sethuvapatinam	2
45	Mallipatinam	8
46	Adirampatinam	3

Attitudes towards conservation of seagrass habitats and dugongs

	Positive		**Neutral**		**Negative**	
Study area	**Sea grass**	**Dugong**	**Sea grass**	**Dugong**	**Sea grass**	**Dugong**
Gulf of Mannar	100 (62.5%)	120 (75%)	50(31.25%)	30(18.75%)	10 (6.25%)	10(6.25%)
Palk Bay	275 (76.38)	300(83.33%)	15(4.17%)	45(12.5%)	70(19.45%)	15(4.17%)