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Acoustic survey of seagrass beds in northern Palk Bay, India

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Present study consists the acoustic survey of sea grass beds carried out in 220 sq.km along the coast of northern Palk Bay. In total 865,440 acoustic pings were recorded along the transects. The study showed that the seagrass beds spread along the shore of Thanjavur district in Tamil Nadu up to 12,243 hectares reaching up to eight kilometers from the coast and 8 m depth. Seven species of seagrasses were found in the area. Of these, ***Cymodocea serrulata*** was the dominant species, which occupies a depth ranging between 2 m and 5 m. Shoreward edge of the seagrass meadow was not in healthy condition showing physical damages and wide algal cover. Seaward edge of the meadow was dense and probably feeding ground for dugongs.

[**Keywords:** acoustic, sea grass, Palk bay, GIS, bathymetry]

Introduction

Seagrasses are marine flowering plants that complete the whole life cycle underwater environment[1]. So far, sixty species of seagrasses, belonging to 12 genera, four families and one order have been recorded across the world[2]. Seagrass meadows are highly productive plant community providing habitats for feeding and breeding for many marine species[3,4,5,6,7]. Seagrasses while helping in the diversity of associated marine organisms[8, 9,10] greatly support commercial, artisanal and recreational fisheries[11,12].

Palk Bay is a shallow tropical marine water body wedged between Sri Lanka and India. It is connected to the Arabian Sea on its west through the Gulf of Mannar, and with the Bay of Bengal directly on its east. So far, 14 species of seagrasses are recorded from the area[13]. Palk Bay is also reportedly a habitat for Dugong (***Dugong dugon***)[14], an endangered herbivorous marine mammal belonging to the family ***Dugongidae*** and the order ***Sirenia***. Sivakumar and Nair (2013)[15] stated that the Gulf of Mannar and Palk Bay have comparatively more dugong occupancy as well as mortality. Several studies have recorded the occurrence of dugongs across the Indian coastal waters including islands, west and east coasts of the subcontinent[16, 17,18,19,20]. While a recent study among fisher folk reveals the status of the species in Indian waters[15], and there is serious dearth of field data on the species.

Seagrass meadows play a major role on fishery production in the coastal area. It is also well recognized that effective management practices of natural resources essentially requires baseline information[21]. Palk Bay lacks quantitative information on the seagrass meadows due to technical and logistic difficulties. Thus, significance of the Bay from ecological, conservational and livelihood perspectives is much less recognized than the coral reefs of Gulf of Mannar located adjacent to the west.

Acoustic techniques help to study the underwater vegetations in vast areas within limited time. The techniques in sub-aquatic environments have been used since 1980s to study fresh water as well as salt-water vegetations[22, 23, 24]. The method is based on the principle that underwater plants are acoustically visible due to their difference in acoustic impedance with that of water. Present study made use of the acoustic and video techniques to document distribution of seagrasses in potential dugong feeding areas.

Materials and Methods

The study area is located in Thanjavur district, northern Palk Bay of southeast coast of India (Figure 1). Near-shore area of northern Palk Bay is shallow with a gentle seaward slope. Dead algae and seagrass spread all over the seashore and near-shore waters. Mallipattinam and Sethubhavachattiram are the two major fish landing centers located in coastal region of Thanajvur district. Thousands of fishers depend on Palk Bay for their livelihood, and especially the small-scale artisanal fishers in near-shore seagrass beds.

The seagrass survey was carried out on pre-determined equally distanced line-transects (Figure 2) from April to October 2014. Thirty one straight transect lines were marked on the geo-referenced satellite image of the study area using Global Mapper software. Each transect, 8 km long, was drawn perpendicular to coastline since we have already confirmed visually by scuba diving, that seagrasses are not found growing beyond ~8 km from the coast due to depth, muddy and murky waters.

This was also re-confirmed by the local fishers who has traditional knowledge about seaward boundary of seagrass beds. Hence, the line-transects were designed to end approximately one kilometer beyond the seagrass seaward edge, again confirmed visually by scuba diving.

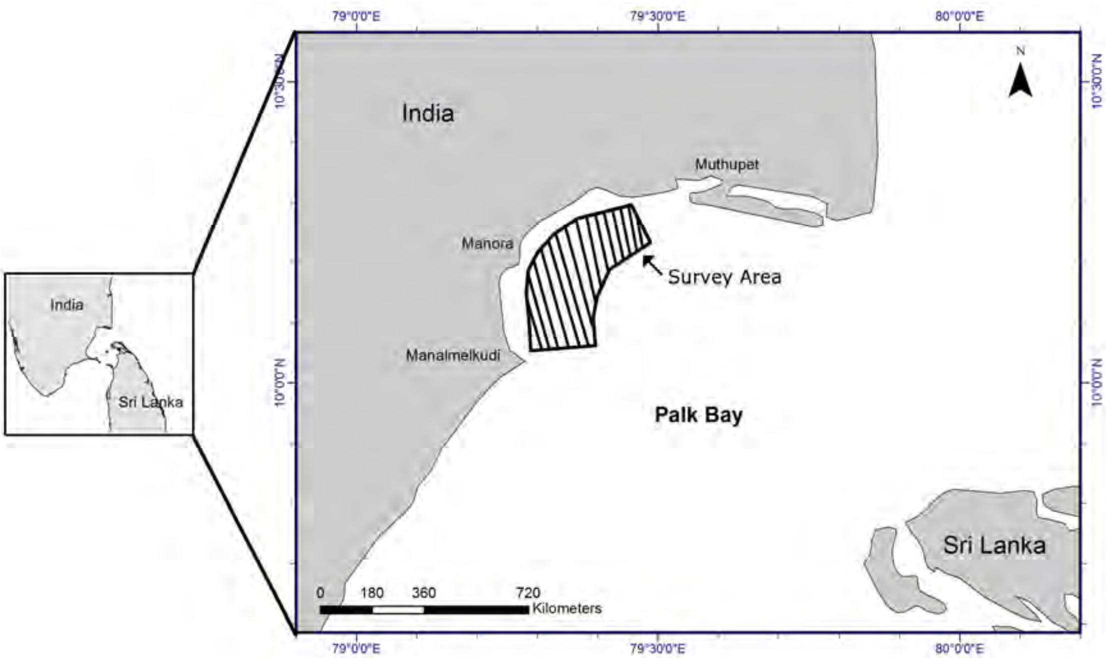

Fig. 1 — Location of Survey area in Palk Bay Southeast coast of India

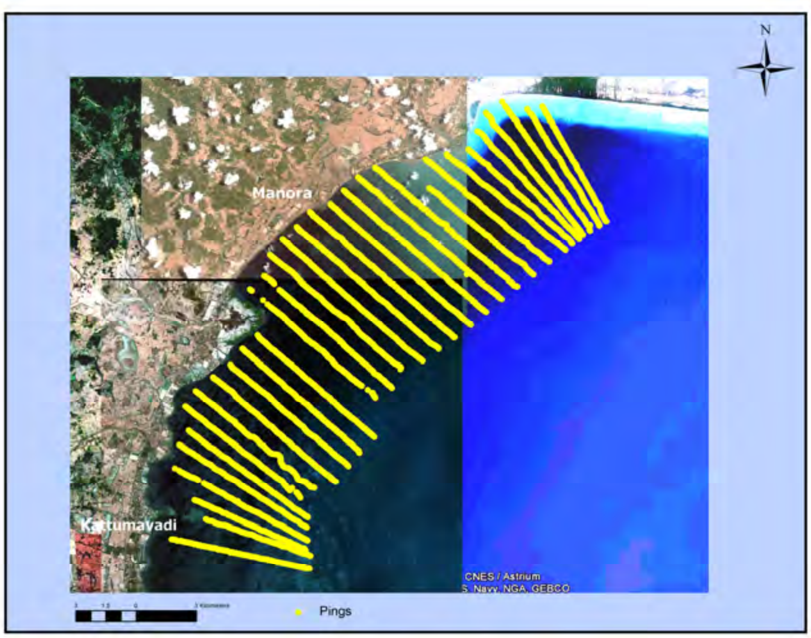

Fig. 2 — The transects along which the survey was conducted in the study area

To conduct the acoustic survey along the line-transects, a 33-feet survey boat, fitted with Biosonic MX Habitat Mapping equipment, was used. The survey gear involved three components namely a transducer, DGPS and a laptop. The 204.8 kHz single beam transducer with a beam width of 8.6 degree was fixed on the side of the boat on to an iron rod. Transducer was connected using a 10-meter BNC cable with a DGPS unit coupled with a laptop through a RS 232 cable. The transducer recorded data samples (pings) at rate of 10 pings/second. Data from the transducer along with the respective geographic coordinates from the DGPS was forwarded to the laptop. Biosonic Visual Acquisition software, which also imaged real time graphics with depth in the monitor, was used to record real-time data from the DGPS.

Along with the acoustic survey as described earlier, based on contour variations in seagrass distribution and depth in GIS thematic maps, 3 sites (Site i. shoreward side of seagrass bed, Site ii. Middle of seagrass bed, and site iii. Seaward side of seagrass bed) were randomly selected along the transects for video sampling. For navigation, the geographical coordinates of these locations were transferred to a hand-held GPS. Seagrass field video sampling was carried out in those selected sites using Seaviewer© underwater CCTV drop camera on September 2014 and January 2015. The camera, fitted at the tip of an iron rod to keep it sufficiently above the seafloor to observe seagrass species, was connected with digital video recorder unit linked with GPS through a 20 m long cable. Live view of seagrass beds were watched in a monitor and recorded with the respective geographical coordinates, while the boat moved at very slow speed (1.3 nautical miles / hour) within a radius of 500 m around each sampling site. The video records were later analyzed in the laboratory and .jpeg images were generated at each notable change in seagrass species composition in the image / video stream.

The acoustic data for each transect was separately transferred to an external hard disks in **.dt4** and **.rtpx** formats, which contains latitude, longitude, depth, density and percentage cover of seagrass. Subsequently, this data was used for appropriate geo-statistical analysis using Biosonic Visual Habitat and Surfer software. The .dt4 and .rtpx files, after conversion into .csv (comma separated value) files by Biosonic visual habitat software, were again checked for errors and then converted into three columns (x, y and z) format for each parameter (e.g., latitude, longitude and depth) into grid files (.grd) to create thematic maps using the surfer software.

Table 1 — Description of the variables graded from the video frames

Variable	Grades	Descriptions
Sea grass Density	0	No sea grass
	1	Sparese coverage (only a few shoots with served video frames
	2	of sea grass patches) Patchy coverage (and sand or intermediate density
	3	Dense sea grass but seabed visible (cover % 100>)
	4	% 100) Continous sea grass canopy (cover
Algae Index	0	No alge
	1	Algae present
	2	Abundant algae
Bottom Type	0	Bottom not visible/covered by algae or sea grass
	1	Clay bottom
	2	Sand bottom-Clay
	3	Sand bottom

Later in the laboratory, the video records were examined at slow speed for the details in the captured video. Seagrass density was categorized from 0 to 4, algal density from 0 to 2 and the bottom type (substrate) was categorized into 1 to 3 (Table 1). The category 0 denotes absence while other numbers denotes grades in density of seagrass, or category of substrate. Video stream was paused every 10 seconds to create an image file to observe seagrass density, algal cover, sea floor type, latitude and longitude.

Results

Acoustic survey was carried out in 220 sq.km covered by 31 transects in the coastal area of Thanajvur district in Tamil Nadu. This study explored seagrass meadows of 12,243 hectares using hydro-acoustic techniques along the coast of Thanajvur District in northern Palk Bay (Figure 6). A total number of 8,65,440 acoustic pings were recorded during the survey. The acoustic survey backscatter clearly showed the difference between seafloor with no vegetation (Figure 3), seafloor with continuous seagrass (Figure 4) and seafloor with patchy seagrass (Figure 5).

In total, seven species were recorded during the present study (Table 2). Of these, ***Cymodocea serrulata*** was found to be the most predominant one

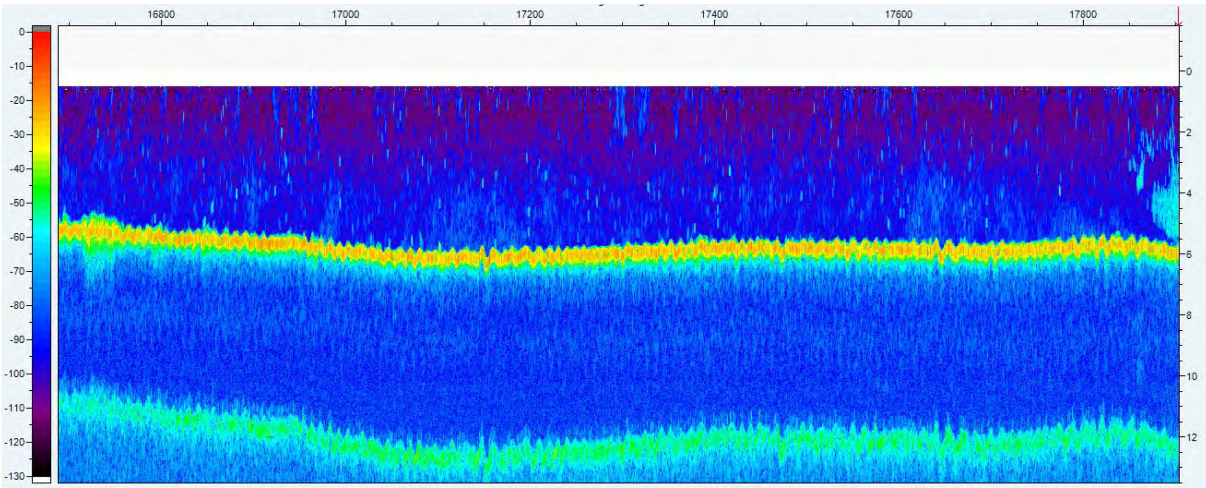

Fig. 3 — Acoustic data 30 log R echogram view on a seafloor with no seagrasses at 6m depth.

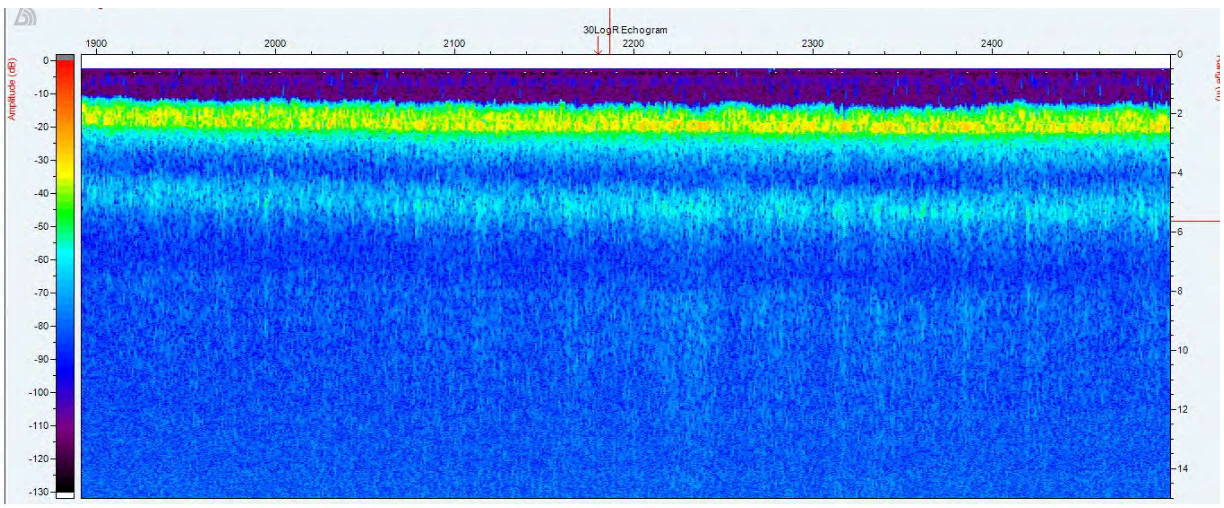

Fig. 4 — Acoustic data 30 log R echogram view on a seafloor with continuous seagrasses at 2.1m depth.

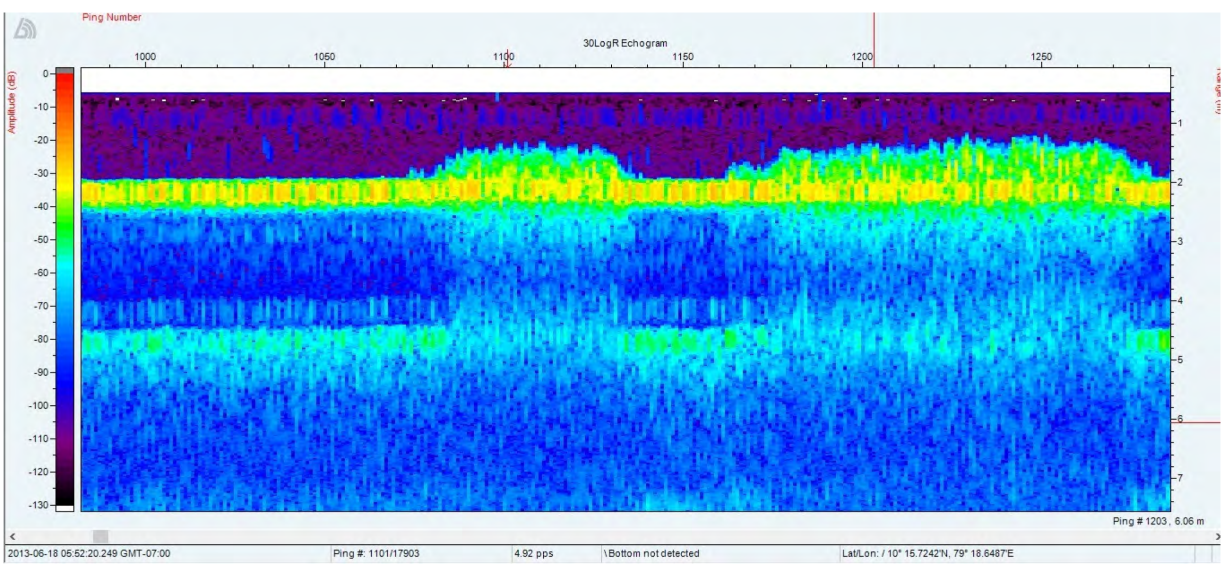

Fig. 5 — Acoustic data 30 log R echogram view on a seafloor with patchy seagrasses at 2m depth.

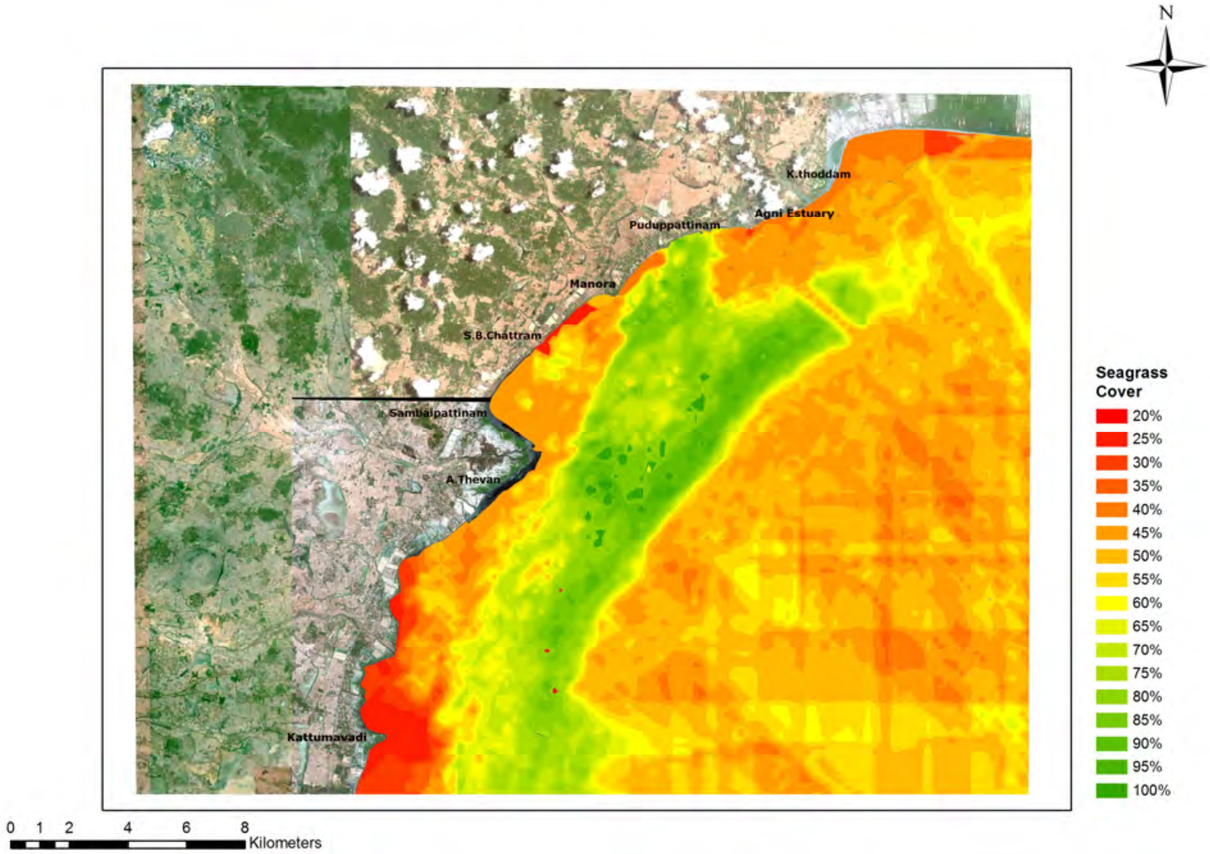

Fig. 6 — Showing 12,243 hectares of seagrass beds in Thanjavur District.

Table 2 — Seagrass distribution in three sites as observed by Video Survey

Location	Seagrass Species	Number of video images in which sea grass species recorded	Depth (m)	Bottom Type	Seagrass Density	Algae Index
Shoreward side of sea grass bed	***Cymodocea serrulata***	24	1-3	0	1	2
	Syringodium isoetifolium	17	1-3	0	1	2
	Halodule uninervis	28	1-3	0	3	1
	Halodule pinifolia	12	1-3	0	2	1
	Halophila ovalis	0	1-3	1	0	1
	Enhalus acoroides	16	1-3	0	1	1
	Thalassia hemprichii	0	1-3	2	0	1
Middle of sea grass bed	***Cymodocea serrulata***	116	4-5	0	4	1
	Syringodium isoetifolium	61	4-5	0	3	1
	Halodule uninervis	0	4-5	2	0	0
	Halodule pinifolia	0	4-5	2	0	0
	Halophila ovalis	0	4-5	2	0	0
	Enhalus acoroides	0	4-5	2	0	0
	Thalassia hemprichii	12	4-5	0	2	0
Seaward side of sea grass bed	***Cymodocea serrulata***	22	6-8	0	3	0
	Syringodium isoetifolium	59	6-8	0	3	0
	Halodule uninervis	0	6-8	2	0	0
	Halodule pinifolia	0	6-8	2	0	0
	Halophila ovalis	42	6-8	2	2	0
	Enhalus acoroides	0	6-8	3	0	0
	Thalassia hemprichii	0	6-8	3	0	0

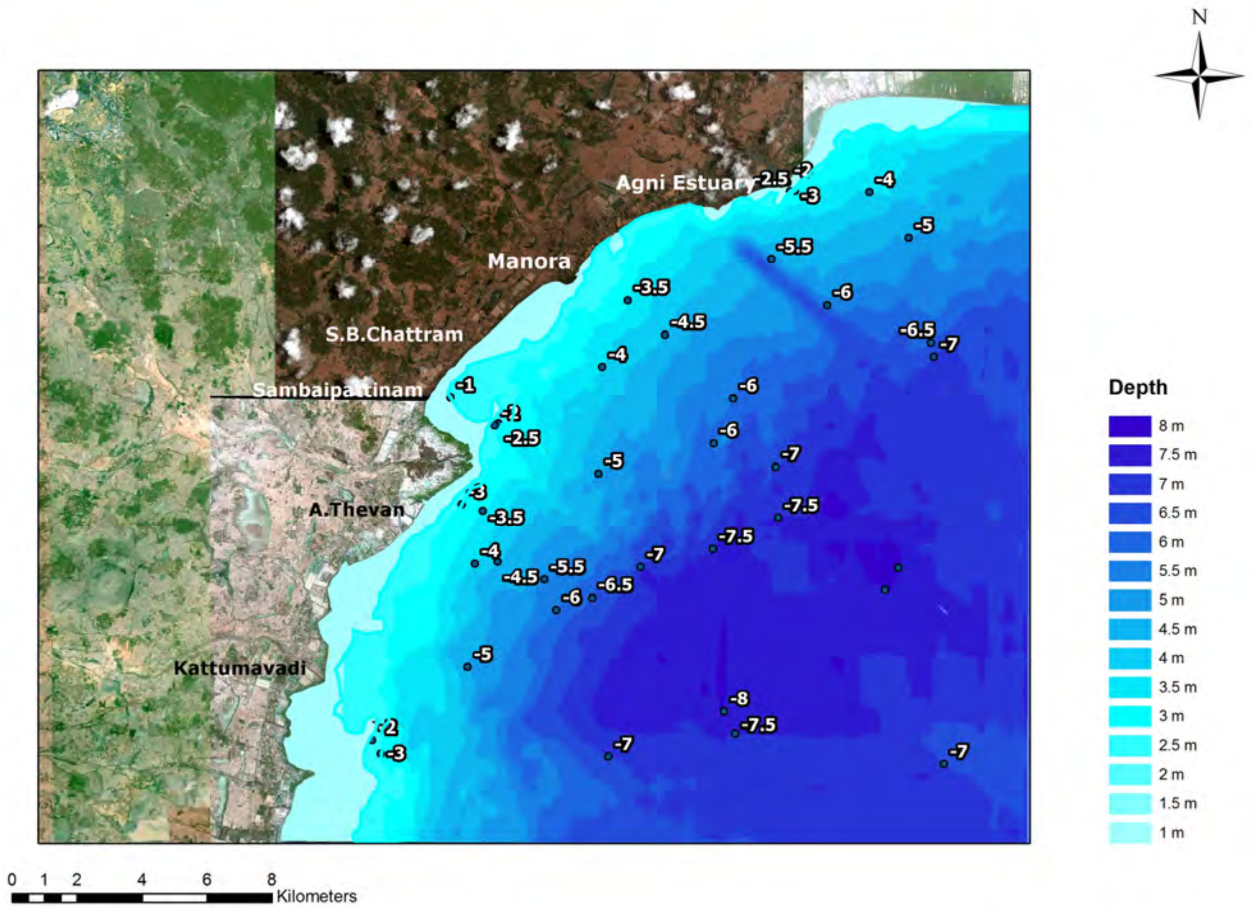

Fig. 7 — Showing bathymetric map of Thanjavur District.

forming extensive meadows. A large number of young and adult sea cucumbers ***(Holothuria scarba*)** were found opposite to the place Manora, where an extensive large seagrass meadow comprising of ***Cymodocea serrulata*** and ***Syringodium isoetifolium*** was found.

Three video transects at the shoreward edge (~1 km from the shore), seaward edge (~8 km from the shore) and middle of seagrass bed (~4 km from the shore) showed obvious differences in vegetation and sea floor. No seagrass was found opposite to Agni estuary, where depth is up to 2 meter deeper than other areas along the coast (Figure 7). This deeper site is about 750 m wide and 5.6 km long, formed due to fast discharge from the Agni River. Such eroding seafloor does not support growth of aquatic vegetation. The Video survey showed that the shoreline edge of the seagrasses in all transects was covered by algae (Figure 12), with obvious physical damage on seagrasses as well as the sea floor. Such damages may be due to fishing using trap-nets and anchors. The video and acoustic survey confirmed that among the seagrass species, ***Cymodocea serrulata*** was the most dominant and widely distributed species in different depths (Table 2). ***Cymodocea serrulata*** was recorded in 29 transects out of 31 total transects surveyed. Both video and acoustic surveys showed that the algal bed was predominantly spread out up to two km from the shore through the coastal area of northern Palk Bay (Figure 8). Near-shore areas of Sethubhavachattiram, Sambaipattinam, and Adaikkathevan area are completely covered by algae, except for the patchily distributed seagrass ***Enhalus acoroides***.

In the southern side of Thanajvur district, there is a long sand bar extending from the shore up to two kilometers in to the sea. This shallow sand bar is perpendicular to the coast and is exposed during low tides. Both the immediate sides of this sand bar are not suitable for acoustic survey due to shallowness. Moreover, explicitly no living seagrass patches were visible here. In Adaikkathevan and Ammapattinam areas, some fishers used mangrove branches and tie them together floating on the seagrass bed for few days to attract squids and cuttlefishes. These animals are known to attach their egg masses on the floating mangrove vegetation traps to actively protect them, making the fishers easy for harvest. This kind of fishing technique destroys mangroves on the coastline as well as smothers seagrass beds in southern side of Thanjavur district. Shore seining is a routine fishing method in some villages in northern side of Thanjavur district coastal areas such as Keezhathoddam and Velivayal, where patchy near-shore seagrass beds are subject to physical damage by the net. Harsh physical damage on wide area of seagrass beds was observed in some sites during the survey, where the seagrasses were found uprooted and scattered on the sea floor. Trawlers are not permitted to operate inner shore areas, but the fishers during the survey reported that the trawlers were operated in midnights in those areas. During northeast monsoon, several small fiber boats, with sail drawing power from the northeast winds, are used in deploying and retrieving seine nets, a major cause of seagrass damage during October to January.

Discussion

Hydro-acoustic techniques to study underwater vegetation have been used for the past 30 years[25] and it is proved as a technique to survey large areas within short time. The signals in the water column from vegetations and sediments differentiate underwater meadows [26]. In India, the present survey is a pioneer attempt using the technique for seagrass mapping. Extensive seagrass meadows are found in near shore tropical water throughout the world[1]. However, the rapid loss of seagrass habitats in coastal waters has also been reported[27]. In the present study, continuous seagrass meadows were recorded very close to the shoreline only in the area between Manora and Pudhupattinam (Figure 6)

The bathymetric map created during this survey showed that the study area had very shallow seafloor with gentle slope seawards (Figure 7) and the seagrass beds found spreading up to 8 m depth. Most of the near shore areas were covered by algae (Figure 8), which may be due to release of nutrients from the nearby areas and probably eutrophication.

Of the 7 genera of seagrasses reported from India, 6 genera and 11 species are recorded from Palk Bay of Tamilnadu. Of the 11 species earlier reported only 7 could be recorded during the present survey. Of these, ***Cymodocea serrulata***, ***Halophila ovalis***, ***Halodule pinifolia*** and ***Syringodium isoetifolium*** are common in northern Palk Bay. ***Among the species recorded, Cymodocea serrulata*** was the most dominant species that occurs in the depth ranging from 2 m to 5 m. No sea grass was observed beyond 8 m depth in the study area. Light and turbidity are the major environmental factors that control seagrass distribution[28]. The turbid waters of muddy bottom with strong currents in the depths more than 8 m in the Palk bay are not conducive for seagrass growth. ***Enhalus acoroides*** was rare in the present study area**.**

Fig. 8 — Showing algal cover in nearshore areas up to 1.5 km from the shoreline.

Fig. 9 — Showing mixed seagrass bed of ***Halodule pinifolia*** and ***Halodule uninervis*** on the shoreline.

It is usually found in the sub-tidal zone and is slow to produce new shoots but produces high biomass, being a very large plant with long leaves. This slow-growing, persistent species has poor resistance to perturbation[29]. It is the only species that releases pollen to the surface of the water for reproduction,and that feature restricts its distribution to intertidal and

Fig. 10 — Showing mixed seagrass bed of ***Cymodacea serrulata*** and ***Syringodium isoetifolium*** at 4.5 m to 5 m depth.

Fig. 11 — Showing ***Halophila ovalis*** at at depth of 7m to 8m depth.

shallow sub-tidal areas. ***Halodule pinifolia*** and ***Halodule uninervis*** were observed close to shoreline as patches in intertidal areas (Figure 9). ***Syringodium isoetifolium*** was also found along with ***Cymodocea serrulata*** in the depth ranging from 4.5 m – 5 m depth (Figure 10).

The ***S. isoetifolium*** inhabits clear waters and prefers sandy substrates and is usually found in shallow water in the lower, inter and sub-tidal areas[30]. ***Thalassia hemprichii*** is a climax seagrass species in the Indo-Pacific region[31], which can tolerate high temperature and low salinity. In the present study, the species was observed at 3 m to 4 m depth in the middle of seagrass meadow. ***Halophila ovalis*** is susceptible to elevated temperatures; therefore, it was not found healthy in the shoreward side of the sea[28]. In the present study, ***Halophila ovalis*** was found in deeper areas at a depth of 7 m to 8 m (Figure 11). Beyond the depth of 8 m, there was a flat and wide sandy substratum running parallel to the coast (Figure 12).

Fig. 12 — Showing sandy substratum without seagrasses at a depth of 8m.

During this study, healthy, dense and continuous distribution of seagrass was seen on the seaward edge all along the coast, while the shoreward edge of seagrass bed were widely covered by algae and damaged by fishing activities. No dugongs were observed throughout the study period; the last report of a dead dugong from the area was in June 2006. Dugongs may not feed close to the shore in the study area due to the thick algal cover, boat traffic, pollution and physical damage by fishing activities. The present study suggests that the possible dugong feeding ground in northern Palk Bay may be on the seaward edge of seagrass bed at a depth range of 4 m to 5 m, which is about 5 to 7 km from the coast. The seagrass beds play key role in ecological setup of the area and fishery productivity with special reference to squids and cuttlefish (e.g. ***Cymodocea serrulata, Syringodium isoetifolium***) and the local artisanal fishers depend largely on such areas for their livelihood.

Conclusion

The present study documented seven species of seagrasses in the study area. Of these, ***Cymodocea serrulata*** was the predominant one. Continues meadows were seen from Kollukkadu to Kattumavadi of coastal length of Thanjavur District %80covering . Algal growth possibly promoted by release of nutrients from domestic wastes was common in near-shore areas, where seagrass beds were disturbed by fishing activities. Study showed no seagrass beds above 8 m depth in the Palk bay, probably due to high turbidity in water. The healthy undisturbed seaward edge may be the probable feeding ground for dugong. Thousands of fishers depend on seagrass beds in northern Palk Bay for their daily livelihood. Hence, participatory management of seagrass beds of northern Palk Bay deserves due attention for conservation and sustainable management of the resources.

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