Seagrass Diversity and Influence of Beach Erosion in Palk Bay and Gulf of Mannar Seagrass Beds

Bindu Sulochanan[1]*, A.K. Kumaraguru[2] and Grace Mathew[3]

[1] Mandapam Regional Centre of Central Marine Fisheries Research Institute, Mandapam Camp - 623 520, Ramanathapuram, Tamil Nadu, India

[2] Centre for Marine and Coastal Studies School of Energy, Environment and NaturalResources, Madurai Kamaraj University, Madurai 625 021, Tamil Nadu, India

[3] Central Marine Fisheries Research Institute Post Box No. 1603, Ernakulam North P.O., Cochin-682 018, Kerala, India

**Email: binduchaithanya@yahoo.co.in*

Introduction

Seagrasses are an important link in the critical chain of habitats required for sustainable fisheries production (Cappo *et al.*, 1995). They form an ecosystem which has great value in stabilizing and protecting coastlines from erosion (Ginsburg and Lowenstam, 1958; Scoffin, 1970). In recent decades, destruction of seagrass meadows has occurred world wide (Kemp *et al.*, 1983; Orth and Moore, 1983; Cambridge *et al.*, 1986). The loss may result from natural events such as high energy storms, sea level rise and coastal erosion. The actual rise of the sea level along the Indian coast varies widely at different places. Habitats may be smothered where sediment is deposited more rapidly than tolerated by benthic communities (Hancock *et al.*, 2001). But most seagrass loss has resulted from human activities such as eutrophication (Orth and Moore, 1983; Cambridge *et al.*, 1986) and land reclamation and change in land use pattern (Kemp *et al.*, 1983). Palk Bay has a maximum depth of 13 m. The Gulf of Mannar has 21 islands with seagrass beds and coral reefs are present in most of the islands. Mixing of both Palk Bay and Gulf of Mannar waters takes place at Pamban and at Adam's Bridge. In India, large regions and major stretches of coastline of the country are still not surveyed for seagrasses (Das, 1996).

The present study on the seagrass diversity and the influence of beach erosion in the seagrass beds of Palk Bay and Gulf of Mannar was

undertaken, in view of the growing impact of human activities on the seagrass beds.

Materials and Methods

The study area was selected based on its variability in current pattern with the change of season, topography and anthropogenic activity (Fig.1). Sangumal situated in Rameswaram island is located in Palk Bay (9°17' N lat; 79°19' E long). As it is near the temple of Rameswaram, it attracts a lot of tourists round the year. There is a sewage outlet adjacent to this site which brings in effluent from the habitation in the island. The seagrass beds located here are exposed during the lowest low tide in the southwest monsoon season up to a distance of 1-2 km from the shore, while during northeast monsoon season the current is in the reverse direction towards the coast from Bay of Bengal, hence there will be no exposure of seagrass beds even during low tide. Thonithurai, in mainland, is located in Gulf of Mannar (9°16' N lat; 79°10' E long). There is seaweed cultivation activity in an area of about 1000 m^2. The coast will be more exposed during the northeast monsoon season and hence seagrass beds will be exposed to 600-800 m during the lowest low tide. Farm pond in mainland located in Palk Bay (9°17' N lat.; 79°07' E long.) is adjacent to Pillaimadam lagoon which receives freshwater runoff during northeast monsoon season. The seagrass bed is located at a distance of 400 to 500 m away from the mouth of the lagoon. The observations were conducted during 2007-08, covering post-monsoon (January to March), summer (April to June), pre-monsoon (July to September) and monsoon (October to December) seasons.

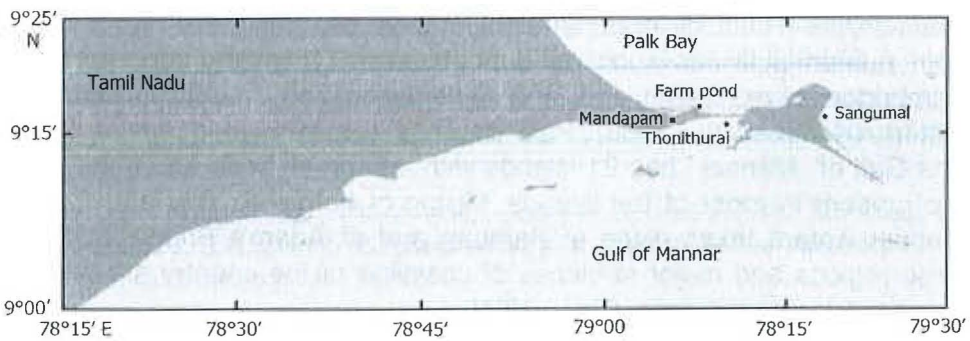


Fig. 1. Location of study area

affects the seagrass bed displaying alternate bands of decaying and healthy leaves. *Halodule uninervis* was found in all the three sites. Narrow leaf is more prevalent than the broad leaf. Plants of broad leaf were observed in Thonithurai. It is usually the first to appear in newly formed sediment along the shoreline. In some places it was seen along with *Halophila ovalis*. Where the seabed is rarely exposed *Cymodocea rotundata* was observed. In Sangumal, some plants were noticed with lesser inter-node spacing and it broke quickly at the rhizome when digging out from the soft sediment. This variation in inter-node spacing was not observed for specimens from other sites. This could be due to more nutrient load.

Table 1. Seagrass species occurring in Palk Bay and Gulf of Mannar

Phylum	**Magnoliophyta**
Class	**Monocots**
Order	**Potamogetonales**
Family:	**Cymodoceaceae**
1.	*Syringodium isoetifolium* (Ascherson) Dandy 1939
2.	*Halodule pinifolia* (Miki) den Hartog 1964
3.	*Halodule uninervis* (Forsskål) Ascherson 1882
4.	*Cymodocea serrulata* (R. Brown) Ascherson & Magnus
5.	*Cymodocea rotundata* Ehrenberg & Hemprich ex Ascherson 1870
Order	**Hydrocharitales**
Family:	**Hydrocharitaceae**
6.	*Halophila ovalis* (R. Brown) J.D. Hooker 1858
7.	*Halophila beccarii* Ascherson 1871
8.	*Halophila stipulacea* (Forsskål) Ascherson 1867
9.	*Halophila decipiens* Ostenfeld 1902
10.	*Enhalus acoroides* (Linnaeus f.) Royle 1839
11.	*Thalassia hemprichii* (Ehrenberg) Ascherson 1871

At Thonithurai, *Cymodocea serrulata* was observed near the shore along with *Syringodium isoetifolium*, *Cymodocea rotundata* and *Enhalus acoroides* and at other places it was mostly seen away from the shore.

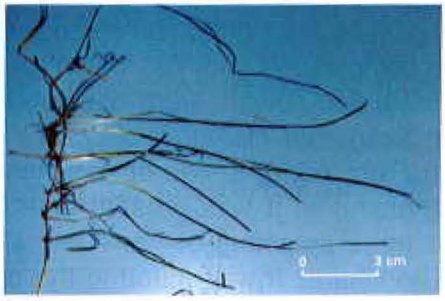
Large quantity of this seagrass along with other species gets uprooted during the rough season of southwest monsoon at Thonithurai. While in Sangumal and Farm pond seagrass was seen uprooted forming a thick bed in the northeast monsoon season. In shallow as well as deeper regions *Halophila ovalis* was observed. Occasionally, it was seen along with *Halophila uninervis* or *H. pinifolia* bed near the shore line. It can survive when covered by mud and sand or even other seagrass species. The rhizomes are brittle. The stabilization of the substratum is usually by other accompanying species, which grow faster shoots and cover this species. Fruits and flowers were observed during the southwest monsoon season in Sangumal. *Halophila decipiens* is found in soft mud in all the three sites. In Farm pond, it was absent near-shore but present in deeper areas. In Thonithurai, it was present near the shoreline where the depth of water is more than that of Farm pond. *Halophila stipulacea* was found only in Thonithurai. It was found in the depths rarely exposed. *Halophila beccarii*

Table 2. Percentage cover of seagrasses in Thonithurai, Sangumal and Farm pond, in different zones from shorelines

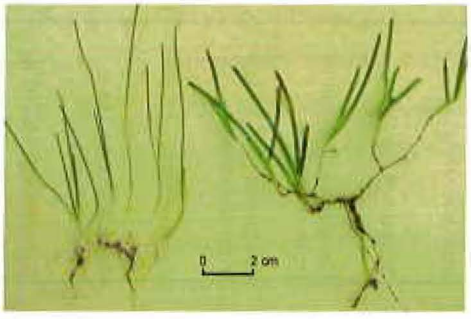
Categories	Thonithurai	Thonithurai (1-20 m from shoreline)	Thonithurai (20-300 m from shoreline)	Sangumal	Sangumal (120-260 m from shoreline)	Sangumal (260-400 m from shoreline)	Farm pond	Farm pond(60-240 m from shoreline)	Farm pond(240-700 m from shoreline)
Syringodium isoetifolium	13	12	22	8	0	10	0	0	0
Halodule pinifolia	13	17	7	5	6	0	6	0	6
Halodule uninervis	19	11	15	16	15	20	6	3	6
Cymodocea serrulata	9	14	14	14	13	22	27	32	27
Cymodocea rotundata	3	5	4	6	8	6	4	2	6
Halophila ovalis	8	11	0	10	11	17	4	2	5
Halophila beccarii	2	2	0	4	6	0	0	0	0
Halophila stipulacea	6	6	0	0	0	0	0	0	0
Halophila decipiens	4	7	5	7	9	0	6	0	6
Enhalus acoroides	6	0	9	0	0	0	0	0	0
Thalassia hemprichii	0	0	0	6	0	7	0	0	0
Seaweeds	4	5	0	11	15	3	16	29	13
Area without seagrass	13	10	24	13	17	15	13	32	31
Total	100	100	100	100	100	100	82	100	100

was observed in Sangumal and Thonithurai in muddy and sandy substratum but not in Farm pond. *Enhalus acoroides* was present in Thonithurai in depth exceeding 20 cm during the lowest low tide but absent in Sangumal or Farm pond. Ramamurthy *et al.* (1992) had recorded 12 and 10 species of seagrass from Gulf of Mannar and Palk Bay, respectively. The species recorded by them was the same as that observed in the

Syringodium isoetifolium **at Thonithurai**



Halodule pinifolia



Halodule uninervis

Cymodocea rotundata

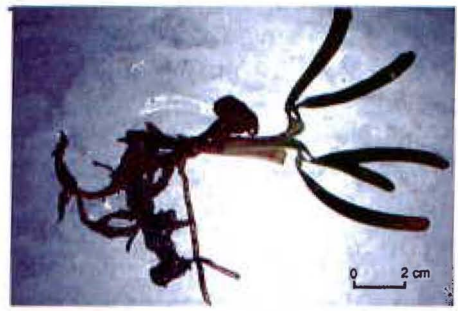
Cymodocea serrulata

Halophila ovalis **along with** ***Halodule uninervis***

Fig. 2a. Selected seagrasses from the study area

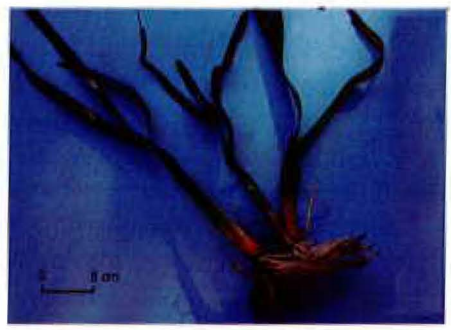
present study except for that of *Halophila ovata*. *Thalassia hemprichii* was found with an open fruit, near the disintegrating coral reef and sand stone of Sangumal area but was not found in other sites. Hartog (1970) has also observed that this species occurs on coral debris.

***Halophila decipiens* (left) and *Halophila ovalis* (right)**



***Thalassia hemprichii* with fruit**

Halophila beccarii



***Enhalus acoroides* with rhizome**

Fig. 2b. Selected seagrasses from the study area

Eleven species were found at Thonithurai, out of which *Halodule uninervis* accounts for 19% coverage of the area. At a distance of 1-20 m from the shoreline at the site, the water depth varied from 5 to 45 cm during the lowest low tide. The highest water depth beyond 20 m from the shoreline was 110 cm. The average water depth during low tide in the zone was 80 cm. The number of species was less in the deeper zone. The overall percentage coverage of seagrass was 83%. The maximum coverage of 85% was in the 1-20 m zone and 76% in 20-300 m zone. At Sangumal, nine species of seagrasses were observed. The overall percentage coverage of seagrasses was 76%. In 120-260 m zone, the coverage was 82%, at an average water depth of 23 cm. In the area surveyed, the maximum water depth was 160 cm. The seagrass

percentage coverage of 85% was observed in 260-400 m zone with an average water depth of 62 cm. At Farm pond, six species of seagrasses were observed. The overall percentage coverage of seagrass was 53%. In 60-240 m zone, the seagrass coverage was 39%, at an average water depth of 55 cm. The maximum water depth of 210 cm was observed in the area surveyed. The percentage coverage of 56% was observed in 240-700 m zone at an average water depth of 133 cm. The average length variation in *Halodule pinifolia* bed in Thonithurai was high during pre-monsoon (14.4 cm) and less during monsoon (2.12 cm). The biomass was the highest during pre-monsoon, 0.29 kg.m^{-2} followed by that during summer, 0.178 kg.m^{-2} and the least was observed during monsoon 0.025 kg.m^{-2} (Fig. 3).

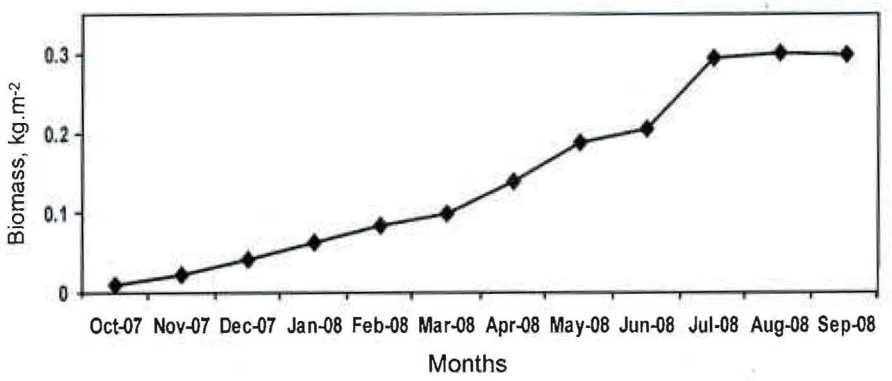


Fig. 3. Variation in biomass of *Halodule pinifolia* at Thonithurai, during 2007-08

The presence of rocky beach in sections of Thonithurai beach caused less erosion compared to the section near the Pamban pass which was subjected to erosion during the seasonal changes in current pattern as well as heavy rainfall during the northeast monsoon season. Eroding sand dunes buried the near-shore seagrass bed of *Halodule pinifolia*. Some part of the eroded soil was brought back during the calm season. The seagrass beds in the downstream offers resistance to erosion as well as aids in trapping the suspended particles. The profile of the beach was taken up to a water depth of 77.5 cm. The width of the beach varied between 20 and 50 m. The presence of sand dune vegetation on the beach also helped to bind the soil. The average erosion rate was 0.86 m^3.m^{-2}.year^{-1}. At Sangumal, during the northeast monsoon the beach area exposed was less and the water depth at a distance of 40 m from the foreshore dune was 0.6 m. Here, due to the construction of roads and cultivation of coconut plantations, the foreshore dune height has been reduced and varied

between 0.5 m and 1.6 m. The beach is almost stabilized and the water depth during low tide in the seagrass bed varied between 0.5 and 1m during northeast monsoon. The volume of soil eroded at Sangumal was estimated as 0.33 $m^3.m^{-2}.year^{-1}$ during 2006-07. The beach profile in Farm pond was highly variable up to a distance of 60 to 120 m from the shoreline with the seasonal influx of freshwater from the lagoon. Hence, seagrasses were located 120 m from the shoreline. The beach profile was taken up to a depth of 77 cm during the lowest low tide. Severe erosion at the rate of about 2.25 $m^3.m^{-2}.day^{-1}$ was noticed near the mouth of the lagoon during the northeast monsoon in 2007. Due to low sediment stability near the lagoon, the establishment of seagrass was found to be 200 to 300 m away from the mouth of the lagoon. The eroded sediment accumulated at a distance of 50-60 m away from the shoreline. This is again spread out during the southwest monsoon when calm currents carry the flow away from the lagoon and the most part of it remains dry. The average erosion rate for the beach was estimated as 0.97 $m^3.m^{-2}.year^{-1}$.

Coles *et al.* (1987) noted three general depth zones of seagrass species composition for tropical waters: (i) a shallow zone less than 6 m deep with high species diversity, likely to include all species found in a region; (ii) a zone between 6 and 11 m, where the most commonly found seagrasses were *Halodule* and *Halophila* species; and (iii) a zone deeper than 11 m where only species of genus *Halophila* were commonly found. In the present study, Thonithurai had a higher water depth beyond 20 m from the shoreline compared to Sangumal and Farm pond which influences the growth of species such as *Cymodocea rotundata*, *Cymodocea serrulata*, *Enhalus acoroides* and *Syringodium isoetifolium*. Ramamurthy *et al.* (1992) observed that the marginal zones are dominated by *Halodule* spp. and *Halophila* spp. The same trend was observed here also. The presence of rubbles and stones was found to restrict the growth of seagrasses as it hinders root penetration. Anchor stones of seaweed culture raft left at Thonithurai prevent the growth of seagrass though it encouraged seaweed growth. Sangumal is shallower compared to Thonithurai. Hence, for a distance of 120 m from the shoreline, there was no seagrass. But when compared to Farm pond, the inter-tidal area and the beach of Sangumal had lesser sediment transport and, hence, the number of species was more. The highest growth rate in *Halodule pinifolia* bed at Thonithurai was during summer (southwest monsoon) and the least during monsoon (northeast monsoon), though the season was rough in Gulf of Mannar. This implies that the sediment bank formed during the northeast monsoon serves a seed bank for the growth during subsequent

months and, depending on the stability of the sediment bank, seagrass growth occurs. The first species observed in the newly formed sediment bank, in Thonithurai and Farm pond, were *Halodule pinifolia* and *Halodule uninervis*.

The first author is thankful to Dr. G. Syda Rao, Director CMFRI and Dr. G. Gopakumar, Scientist-in-Charge, Mandapam Regional Centre of CMFRI, for the facilities and support provided. The diving assistance provided by Mr. Laxman Shankar Korabu and Mr. M. Ganesh Pandian and the field assistance given by Mr. M. Govindaraj are also acknowledged. The support of the local fisherman in facilitating the study is gratefully acknowledged.

References

Cambridge, M.L., Chiffings, A.W., Brittan, C., Moore, L. and McComb, A.J. (1986) The loss of seagrass in Cockburn Sound, Western Australia. II. Possible causes of seagrass decline, Aquat. Bot. 24: 269-285

Cappo, M., Alongi, D.M., Williams, D. and Duke, N. (1995) A review and synthesis of Australian Fisheries Habitat Research : Major threats, issues and gaps in knowledge of coastal and marine fisheries habitat, Fisheries Research and Development Corporation, http://www.aims.gov.au/pages/ research/afhr/ afhr-00.html

Coles, R.G., Long, W.J.L, Squire, B.A., Squire, L.C. and Bibby, J.M. (1987) Distribution of seagrasses and associated juvenile commercial prawns in northeastern Queensland waters, Australia, Aust. J. Mar. Freshwater Res. 38: 103-120

Das, H.S. (1996) Status of seagrass habitats of the Andaman and Nicobar Coast, SACON Technical Report No. 4, Salim Ali Centre for Ornithology and Natural History, Coimbatore, India: 33 p.

Ginsburg, R.N., and Lowenstam, H.A. (1958) The influence of marine bottom communities on the depositional environments of sediments, J. Geol. 66(3): 310-318

Hancock, G.J., Olley, J.M. and Wallbrink, P.J. (2001) Sediment transport and accumulation in Western port, CSIRO Land and Water, Environmental Hydrology, Canbera Report 47/01, www.clw.csiro.au/publications/ technical2001/tr47-01.pdf

Hartog, C.D. (1970) The Seagrasses of the World, North-Holland, Amsterdam: 272 p.

Ibe, A C and Quelennec, R E (1989) Methodology for the assessment and control of coastal erosion in West and Central Africa, UNEP Regional Seas Reports and Studies No. 107, UNEP, Nairobi.

Kemp, W.M., Boynton, W.R., Twilley, R.R., Stevenson, J.C. and Means, J.C. (1983) The decline of submerged vascular plants in upper Chesapeake Bay: Summary of results concerning possible causes, Mar. Tech. Soc. J. 17:78–89

McKenzie, L.J. and Campbell S.J. (2002) Seagrass-watch: Manual for Community (citizen) Monitoring of Seagrass Habitat, Western Pacific Edn., QFS, NFC, Cairns: 43 p.

Orth, R.J., Moore, K. A. 1983 Chesapeake Bay USA: an unprecedented decline in submerged aquatic vegetation, Science 222 (4619): 51-53

Ramamurthy. K., Balakrishnan N. P., Ravikumar K. & Ganesan R. (1992) Seagrasses of Coramandal coast India, Botanical Survey of India, Coimbatore, Flora of India. Series 4: 1-79

Scoffin, T. P. (1970) The trapping and binding of subtidal carbonate sediments by marine veg- etation in Bimini Lagoon, Bahamas, J. Sed. Petrol. 40(1): 249-273