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Assessment of seagrass biomass and coastal land forms along palk strait

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Present study was made an attempt to assess the onshore seagrass biomass and off shore seagrass deposition. Maximum total biomass of *Cymodocea serrulata* (571.2±78.94 g.dry wt/m^2) and *Syringodium isoetifolium* (240 ± 24.92 g.dry wt/m^2) were recorded in Thondi during the month of December-2011. Maximum total biomass of *Halodule pinifolia* (145.6 ± 57.41 g.dry wt/m^2) and *Halophila ovalis* (142.4 ± 21.83 g.dry wt/m^2) were recorded in Manamelkudi during the month of December-2011. Several seagrass parameters *viz.,* above ground biomass, below ground biomass, canopy height, percentage coverage, above and below ground biomass ratio were also examined in this study. Maximum deposition of *Cymodocea serrulata* (10.73±0.08 Kg.drywt/m^2) and *Syringodium isoetifolium* (7.93±0.03 Kg.drywt/m^2) were recorded at Thondi coastal area during the month of May-2012. The survey provides enormous information on the seagrass biomass and seagrass deposition along the Palk Strait coast.

[Keywords: Coastal Landforms, Seagrass biomass, Seagrass deposition, *Cymodocea serrulata, Syringodium isoetifolium,* Palk Strait]

Introduction

Ecology is often referred as the study of distribution and abundance of an organisms or group of organisms. Field survey is essential to identify the habitats present in a study area and to locate representative areas of each feature. Seagrass are difficult to see or identify in turbid water. The survey data is used to ensure that all restoration and mitigation requirements are required. Generally, the survey provides the details about the seagrass percent cover, shoot counts and height and species composition etc. Of these, shoot density is a key parameter which is responsible for the meadows health [1]. Several factors have affected the seagrass meadows including anthropogenic activity. For the seagrass recovery, several monitoring and surveying strategies have been properly assessed all over the world especially in Portugal, Spain, Australia, the Galapagos Islands, Costa Rica, Puerto Rico and the United States for the restoration and mitigation of seagrass loss. The surveys are accomplished using a variety of monitoring tools including quadrat, line transects, video transect and photo interpretation. Among them, quadrat method is widely used which is economically feasible. This method is appropriate for estimating the abundance of plants and other organisms and this approach allows estimation of absolute density. Seagrass are flowering plants uniquely adapted for survival in coastal waters. About 58 species belonging to 13 genera are recognized worldwide. Of these, six genera *viz., Amphibolis, Heterozostera, Phyllospadix, Pos idonia, Pseudalthenia* and *Zostera* are mostly restr ictedto temperate seas. The seven generaincluding *Cymodocea, Enhalus, Halodule, Halophila, Syrin godium, Thalassia* and *Thalassodendron* are distributed in tropical seas. About 15 species belonging to 7 genera are recognized in India. The major seagrass meadows in India are Gulf of Mannar, Palk Bay, Andaman and Nicobar and the islands of Lakshadweep [2]. Seagrass biomass is the prime factor influencing the organization of marine macro-faunal communities [3, 4]. Seagrass contribute significantly to the productivity of coastal areas of both temperate and tropical waters [5]. Therefore, seagrass beds served as good indicators in monitoring the health of the surrounding environment. Several authors assessed the live seagrass distribution in Gulf of Mannar [6, 7], Andaman and Nicobar [2] and such studies are still lacking in the Palk Strait region. Hence, the present study made an attempt to

assess the offshore seagrass biomass and onshore seagrass deposition along Palk Strait coast of South India.

Materials and Methods

The Palk Strait is situated in the Southern part of the peninsular India. The survey was conducted eight different stations from Point calimer to Thondi between September-2011 to August-2012. The Palk Strait region gets the maximum rainfall mainly due to the North East and South West monsoon (Fig. 1).

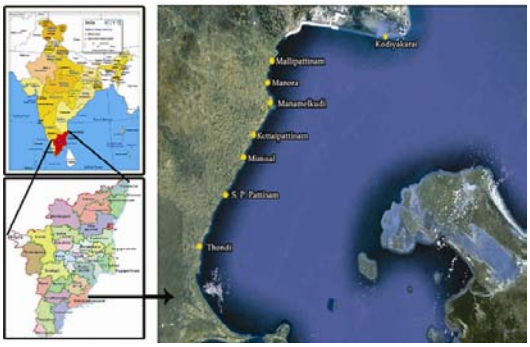

Fig.1-Map showing the study area

Monthly samplings were carried out from eight different stations *viz.,* Kodiyakarai (Lat. 10° 16' N; Long. 79° 49' E), Mallipattinam (Lat.10°16'N; Long.79°19'E), Manora (Lat.10°15'N; Long.79°18'E), Manamelkudi (Lat.10°02'N; Long.79°15'E), Kottaipattinam (Lat.09°59'N; Long.79°13'E), Mimisal (Lat.09°54'N; Long.79°08'E), S.P.Pattinam (Lat.09°51'N; Long.79°05'E) and Thondi (Lat.09°44'N; Long.79°01'E) along Palk Strait from September-2011 to August-2012 for the assessment of seagrass biomass. For the estimation, the seagrass were collected during the low tide from the intertidal and sub-tidal regions. The collected seagrass were manually separated based on the genus and taxonomically identified by standard identification manual [8]. About 1M×1M size quadrat was placed around ten different places randomly at each site. The quadrat was divided into 16 squares and each square consists of 0.25 m^2. The seagrass which found inside the single square were collected by hand and the substratum should be excavated well so as to enable to collect all the underground parts. Then, they were washed thoroughly with the seawater for the removal of debris and stored in the previously unused polythene bags. After that, the collected seagrass were treated with 10% v/v orthophosphoric acid to remove the epiphytes and calcareous substances. Further, they were washed 5-10 times with tap water for the removal of acid and the moisture content was removed using the blotting papers. Finally, the samples were oven dried at 60°C for 48 hrs. After 48 hrs, the samples were weighed for the estimation of total biomass. In addition to that, the above ground biomass, below ground biomass, shoot density, canopy height, above and below ground biomass ratio and the percentage of seagrass were also calculated by using the standard protocol [1].

The distribution of seagrass accumulation was also estimated along the Palk Strait. The quadrat (1M×1M) was thrown 5 times randomly within each 50 meters interval at each site. Then the samples were collected from the single square and carefully washed with seawater and transported to the laboratory. After that, the collected samples were washed with tap water and separated based on the morphology. Finally, the samples were dried at room temperature for 72 hrs to the complete removal of water. The mean of five quadrat samples were considered as seagrass accumulation. The seagrass accumulation was calculated with standard deviation and the unit is expressed as kg.dryweight/m^2.

The coastal land forms, which include beach, beach ridges, sand dune, spit, lagoon, heavy mineral deposition and river were recorded during the field survey. Climatological data such as, rain fall, wind speed and wind direction were also obtained from the meteorological department.

Results and Discussion

The ocean covers more than 70% of the earth surface. The marine environment is frequently recognized as the largest potential sources of biodiversity such as seaweeds, seagrass, invertebrates and microbes which proved their potential in several fields. Among the biological sources, seagrass are one of the rich biological resources which protect several marine organisms and used in many ways to human being. They also control the habitat complexity, species diversity, abundance of associated invertebrates and thereby shaping the structure of marine communities. Several activities are

responsible for the seagrass detachment from the substratum. The accumulation of beach cast is a result of the interaction between dense near shore seagrass meadows and physical factors such as; wind, tide and currents. In the present study, the above ground biomass of the four seagrass species, *Cymodocea serrulata* (166.4 ± 36.72 g.dry wt/m^2), *Syringodium isoetifolium* (84.8 ± 22.46 g.dry wt/m^2), *Halodule pinifolia* (68.8 ± 13.93 g.dry wt/m^2) and *Halophila ovalis* (62.4 ± 17.45 g.dry wt/m^2) were exhibited maximum biomass at Mimisal, S.P. Pattinam, Manora and Manamelkudi during the month of November-2011. However, the *Cymodocea serrulata* (16.0±16.0 g.dry wt/m^2), *Syringodium isoetifolium* (16±14.6 g.dry wt/m^2), *Halodule pinifolia* (11.2±2.8 g.dry wt/m^2) were recorded minimum biomass during the month of May-2012 at Manora, Mimisal and Kottaipattinam.

But, the minimum biomass of *Halophila ovalis* (11.2±9.9 g.dry wt/m^2) was observed at Manamelkudi during the month of April and May-2012 (Fig. 2).

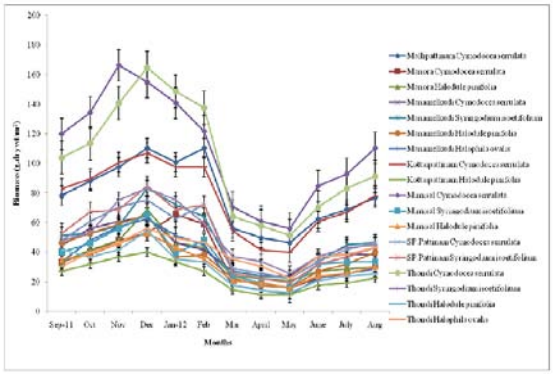

Fig.2 Monthly occurrence of above ground biomass of chosen seagrass species along Palk Strait. *Values are found significant ($p<0.05$) between months and stations.

The maximum (406.4 ± 114.5 g.dry wt/m^2) below ground biomass of *Cymodocea serrulata* was recorded at Thondi during the month of December-2011 and the minimum (33.6 ± 20.63 g.dry wt/m^2) was recorded during the month of April-2012 at Manora. Maximum below ground biomass of *Syringodium isoetifolium* was recorded (156.8 ± 37.37 g.dry wt/m^2) at Thondi during the month of December-2011 and the minimum (24 ± 21.81 g.dry wt/m^2) was recorded at Mimisal during the month of May-2012. The below ground biomass of *Halodule pinifolia* suggested that, the maximum level (80 ± 22.5 g.dry wt/m^2) was recorded during the month of November-2011 and December-2011 at Manamelkudi and the minimum value (11.2 ± 16.2 g.dry wt/m^2) was recorded at Kottaipattinam during the month of April-2012. The *Halophila ovalis* showed maximum (80 ± 22.9 g.dry wt/m^2) and minimum (14.4 ± 22.9 g.dry wt/m^2) below ground biomass in Manamelkudi during the month of December-2011 and May-2012 respectively (Fig.3).

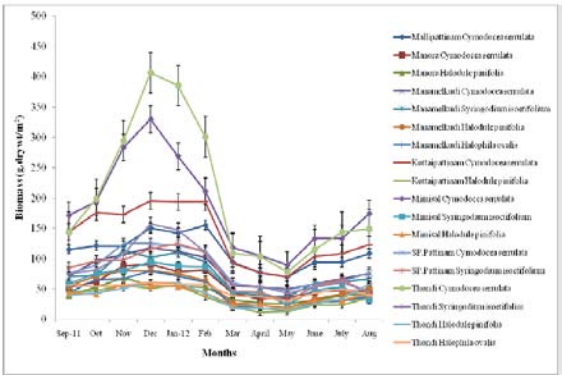

Fig.3 Monthly occurrence of below ground biomass of chosen seagrass species along Palk Strait. *Values are found significant ($p<0.05$) between months and stations.

The below ground biomass was found maximum than the above ground biomass and this might be due to the presence of all the essential micro and macro elements which are highly accumulated in the root system. Similarly, the author's [9] reported that, the below ground biomass of the seagrass was found maximum than the above ground biomass in Costa Rica coast. Moreover, the author's [10] reported that, the level of below ground biomass was found maximum due to C, N and P accumulation in the alphine steppe root system.

The present study also made an attempt to identify the total biomass of the various seagrass species at selected coastal areas. Of the selected four seagrass species, the maximum total biomass were recorded with *Cymodocea serrulata* (571.2 ± 78.94 g.dry wt/m^2), *Syringodium isoetifolium* (240 ± 24.92 g.dry wt/m^2), *Halodule pinifolia* (145.6 ±

57.41 g.dry wt/m^2) and *Halophila ovalis* (142.4 ± 21.83 g.dry wt/m^2) respectively during the month of December-2011 at Thondi and Manamelkudi stations. But, the minimum total biomass were recorded in *Cymodocea serrulata* (52.8 ± 8.92 g.dry wt/m^2), *Syringodium isoetifolium* (49.6 ± 21.83 g.dry wt/m^2), *Halodule pinifolia* (22.4 ± 6.27 g.dry wt/m^2) and *Halophila ovalis* (25.6 ± 7.42 g.dry wt/m^2) at Manora, Mimisal, Kottaipattinam and Manamelkudi stations respectively during the month of May-2012. Minimum (22.4 ± 6.27 g.dry wt/m^2) total biomass of *Halodule pinifolia* was recorded during the month of April-2012 at Kottaipattinam (Fig.4).

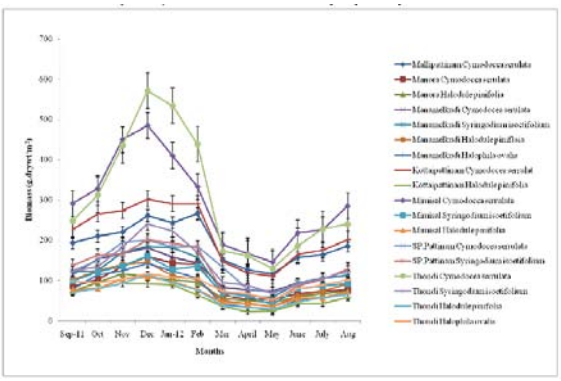

Fig.4 Monthly occurrence of Total biomass of chosen seagrass species along Palk Strait. *Values are found significant ($p<0.05$) between months and stations.

The maximum total biomass was recorded during the month of December-2011 at Thondi and Manamelkudi which might be due to the sedimentation pattern and environmental parameters of the study sites. The author's [9] reported that, the higher biomass in Puerto vargas could be attributed to the sediment structure and environmental condition. The author's [11] reported that, higher biomass are due to the presence of liquid mud. However, the total biomass was not recorded in Kodiyakarai and this might be due to the coarse sand. This is agreeing with the previous observation of Estaction and Fortes (1988)[11].

The shoot density of the C*ymodocea serrulata*, *Syringodium isoetifolium*, *Halodule pinifolia* and *Halophila ovalis* seagrass species suggested that, of the four different species, *Cymodocea serrulata* (1068.8 ± 46.09 shoots/m^2), *Syringodium isoetifolium* (488 ± 12.09 shoots/m^2) and *Halophila ovalis* (427.2 ± 24.82 shoots/m^2) showed the maximum shoot density at Thondi and Manamelkudi during the month of December-2011. Maximum (387.2 ± 34.62 shoots/m^2) shoot density of *Halodule pinifolia* was recorded at Manamelkudi during the month of January-2012. But, the minimum shoot density was recorded in *Cymodocea serrulata* (57.6 ± 3.45 shoots/m^2), *Syringodium isoetifolium* (33.6 ± 1.45 shoots/m^2) and *Halophila ovalis* (56 ± 3.73 shoots/m^2) at Manora, Mimisal and Manamelkudi during the month of May-2012. The minimum level (51.2 ± 4.55 shoots/m^2) of *Halodule pinifolia* was recorded at Kottaipattinam during the month of April-2012 (Fig. 5).

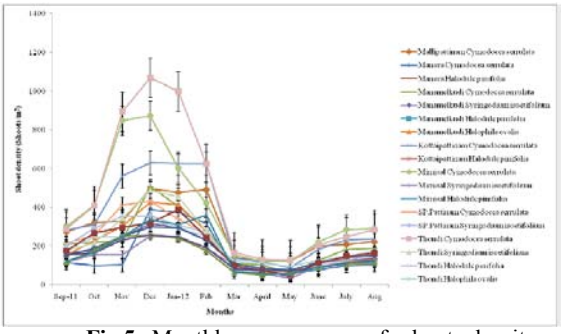

Fig.5 Monthly occurrence of shoot density of chosen seagrass species along Palk Strait. *Values are found significant ($p<0.05$) between months and stations.

The canopy height of the *Cymodocea serrulata* suggested that, the maximum (27.3 ± 0.89 cm) canopy height was observed at Thondi during the month of December-2011 and minimum (10.6 ± 0.82 cm) was observed during the month of March-2012 at Mallipattinam. The canopy height of the *Syringodium isoetifolium* suggested that, the maximum (34.7 ± 1.94 cm) canopy height was recorded at S.P.Pattinam during the month of October-2011, but the minimum (15.7 ± 0.52 cm) canopy height was recorded at Manamelkudi during the months of July and August-2012. Canopy height of the *Halodule pinifolia* suggested that, the maximum (9.4 ± 0.61cm) and minimum (2.5 ± 0.04 cm) canopy height were recorded at Kottaipattinam during the month of December-2011 and November-2011. Similarly, the *Halophila ovalis* canopy height was found maximum by 7.1 ± 1.2 cm and minimum by 2.3 ± 0.7 cm at Manamelkudi during the months of March-2012 and September-2011 (Fig.6).

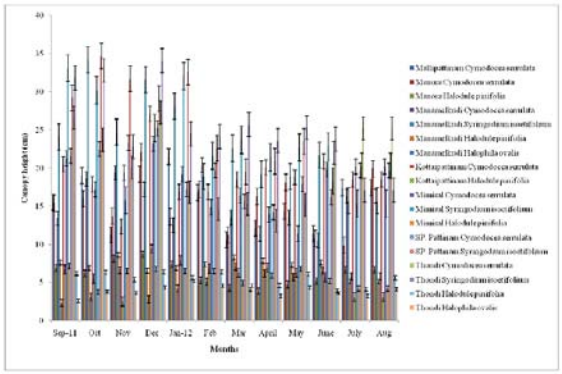

Fig.6 Monthly occurrence of canopy height of chosen seagrass species along Palk Strait. *Values are found significant ($p<0.05$) between months and stations.

Of the four seagrass species, the maximum above and below ground biomass ratio of *Cymodocea serrulata* (0.83±0.l) was recorded at Manora and minimum (0.38±0.1) ratio was observed at Thondi in January-2012, the maximum (0.81 ± 0.08) ratio of *Syringodium isoetifolium* was observed at Manamelkudi during December-2011 and minimum (0.44±0.09) ratio of *Syringodium isoetifolium* was observed at Mimisal during the month of January-2012. The maximum (1±0.1) *Halodule pinifolia* was recorded at Kottaipattinam during April-2012 and minimum (0.59±0.09) was observed at Thondi during the month of January-2012 and the *Halophila ovalis* (0.91 ± 0.09) was recorded at Thondi during March-2012 and minimum (0.59±0.09) was recorded at Thondi during the month of January-2012 (Fig.7).

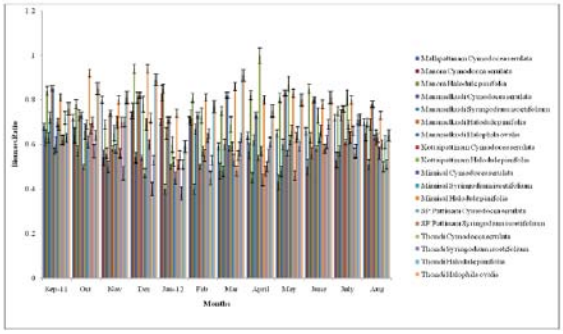

Fig.7 Monthly occurrence of above and below ground biomass ratio of chosen seagrass species along Palk Strait. *Values are found significant ($p<0.05$) between months and stations.

The percentage occurrence of *Cymodocea serrulata* revealed that, the maximum (100%) was recorded at Mallipattinam throughout the year. But, the minimum (27.69%) was recorded at Manamelkudi during the month of September-2011. Percentage occurrence of *Syringodium isoetifolium* revealed that, the maximum (52.76%) percentage was recorded at S.P.Pattinam during the month of September-2011. But, the minimum (15.37%) was recorded at Thondi during the month of January-2012. Similarly, the percentage occurrence of *Halodule pinifolia* was found maximum (48.94%) during the month of August-2012 at Manora. But, the minimum (9.74%) percentage occurrence was recorded during the month of February at Thondi. The percentage occurrence of *Halophila ovalis* revealed that, the maximum (21.98%) percentage was recorded at Manamelkudi during the month of October-2011 but the minimum (11.19%) percentage was recorded at Thondi during the month of January-2012 (Fig.8).

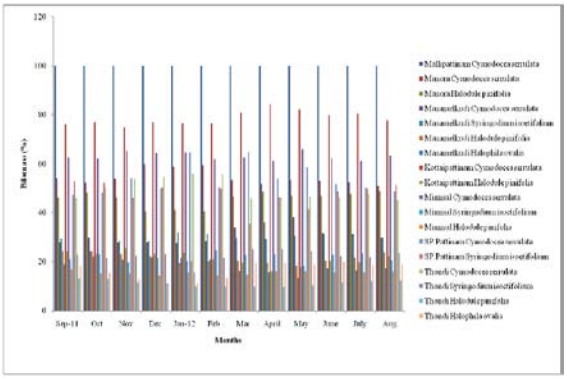

Fig.8 Percentage occurrence chosen seagrass species along Palk Strait. *Values are found significant ($p<0.05$) between months and stations.

The deposition of *Cymodocea serrulata* and *Syringodium isoetifolium* revealed that, the maximum deposition of *Cymodocea serrulata* (10.73±0.08 Kg.drywt/m^2) and *Syringodium isoetifolium* (7.93±0.03 Kg.drywt/m^2) were recorded at Thondi during the month of May-2012. But, the minimum deposition of *Cymodocea serrulata* (0.624±0.002 Kg.drywt/m^2) and *Syringodium isoetifolium* (0.688±0.001 Kg.drywt/m^2) were recorded at Mimisal and Thondi during the month of November-2011. None of the coastal area showed the seagrass

deposition during the month of December-2011. But, the deposition of *Syringodium isoetifolium* was not recorded at Mallipattinam and Manora coastal areas throughout the year (Fig.9).

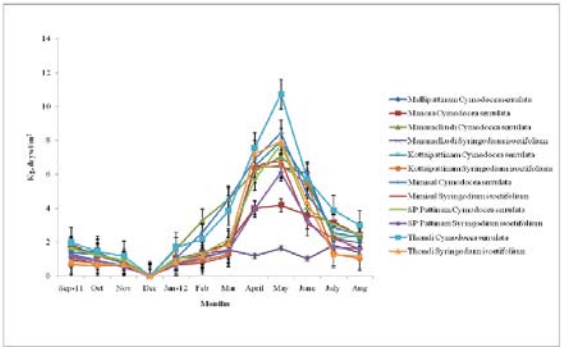

Fig.9 Monthly deposition of *Cymodocea serrulata* and *Syringodium isoetifolium* seagrass species along Palk Strait. *Values are found significant ($p<0.05$) between months and stations.

Deposition of *Cymodocea serrulata* and *Syringodium isoetifolium* reveals that, the maximum deposition of seagrass was observed during the month of May-2012. The maximum beach cast deposition might be due to the Southern wind with the speed of 12/06 KmPH/Knots and low level of rainfall. It is therefore clear that, hydrodynamics play a major role in the process of detachment and deposition [12]. The author's[13] reported that, the high amount of beach cast accumulation due to the wind speed. But, the minimum deposition was identified during the month of November-2011 and this might be due to the low wind speed. In addition, none of the coastal area showed the seagrass deposition during the month of December and this could be due to the calm wind. However, the Kodiyakarai coastal area, neither seagrass standing crop nor deposition was recorded throughout the year and this might be due to the coarse sandy particles.

Several coastal landforms *viz.,* beach, ridges, Lagoon etc. were recorded in the chosen collection sites. The result of the coastal landforms revealed that, the beach is short lined deposits of fine and medium size sands on the shore. It covers the sea shore between the high and low water level of the tides. Sandy beaches were observed in all the study area. Sandunes were poorly distributed in most of the survey site. The sand dunes were observed in Kodiyakarai and Mimisal. The spit growth was observed in Kottaipattinam, Manamelkudi and Mimisal. The beach ridges were observed in Kodiyakarai. The shallow stretch of sea water behind the barrier is called lagoon. Coastal lagoons were observed in Manamelkudi and S.P. Pattinam. Black colour sand was deposited in the shore line indicates the presence of heavy minerals. It was highly observed in Kodiyakarai, Mimisal and S.P.Pattinam. Small rivers namely, Puthu aaru and Pambaru were observed in Kodiyakarai and Mimisal respectively (Table 1).

Table 1- Occurrence of geographical coastal landforms along Palk Strait coast

Station	Beach	Sand une	Spit	Beach ridges	Lagoon	Heavy mineral deposition	Name of the River present
Kodiyakarai	✓	✓	-	✓	-	✓	Puthu aaru
Mallipattinam	✓	-	-	-	-	-	-
Manora	✓	-	-	-	-	-	-
Manamelkudi	✓	-	✓	-	✓	-	-
Kottaipattinam	✓	-	✓	-	-	-	-
Mimisal	✓	✓	✓	-	-	✓	Pambaru
S.P.Pattinam	✓	-	-	-	✓	✓	-
Thondi	✓	-	-	-	-	-	-

*✓- Present; - absent

Table 2- Climatological data observed during September 2011–August 2012

Month	Total rainfall (mm)	Avg. wind Speed (KmPH/Knots)	Wind direction
September	22.6	06/03	NorthEast
October	384.5	03/01	NorthEast
November	433.5	01/00	NorthEast
December	55.9	02/00	Calm
January	0.00	06/00	NorthEast
February	1.2	07/00	East
March	3.6	09/05	Southern wind
April	39.7	11/06	Southern wind
May	2.0	12/06	Southern wind
June	0.00	10/05	Southern wind
July	39.7	04/08	Southern wind
August	47.0	08/04	South SouthEast

The climatological data suggested that, the maximum rainfall (433.5 mm) was recorded during the month of November-2011 and minimum (1.2 mm) was recorded during the month of February-2012. However, no rainfall was recorded in January-2012 and June-2012 respectively. In addition to that, the maximum 12/06 (KmPH/Knots) wind speed was recorded during the month of May-2012 and the direction was Southern wind. The minimum wind speed was recorded during the month of November-2011. The speed was 01 KmPH/00 Knots and the wind direction was North East (Table 2).

The climatological parameters such as, wind, rainfall, wave and tides plays a major role in the formation of coastal landforms. Small river is responsible to deliver the sediments to the coast and it can be re-modified as beach, dunes and deltas by the influence of climatological parameters [14]. Moreover, the pollution free estuaries provide many nutrients for most of the marine organisms. Salt marshes and beaches also support the marine flora and fauna diversity. Generally, seagrass grow in healthy estuaries, lagoon and shallow areas where the light can readily penetrate. Hence, the coastal landforms can also be used to understand about the health of the seagrass meadows.

Conclusion

In conclusion, the present study provides detailed information on the abundance, species composition and distribution of seagrass meadows along the Palk Strait coast. Seagrass meadows play an important ecological role, particularly food for the endangered and threatened species such as dugong and turtles. Moreover, they are providing the nursery grounds for commercial fisheries and substantial component of the primary productivity for the marine ecosystem. Therefore, this data can be used as a basis for the future survey to compare and monitor the health of the seagrass meadows along the Palk Strait coast.

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