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Full Length Research Paper

Interrelation among coral reef and sea-grass habitats in the Gulf of Mannar

R. Uma Maheswari[1]*, V. Naganathan[2] and J. K. Patterson[3]

[1]Arulmigu Palaniandavar, Arts College for Women, Chinna Kalayamputtur, Palani – 624 601, Tamil Nadu, India.
[2]District Forest, Atthur District, Salem – 636121, Tamil Nadu, India.
[3]SDMRI, Tuticorin, Tamil Nadu, India.

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The Gulf of Mannar consists of ecologically sensitive important habitats such as: coral reef and seagrass. Though each has its own function and importance, two are closely interrelated and supporting each others in function. The majority of the reefs are formed around the 21 islands, while vast sea grass beds are seen in the shoreward side of each islands. In most cases the seagrasses bordering the coral reefs play important role in limiting sedimentation on the coral reefs and help in protection. The coral reefs help in controlling erosion of islands and thereby protecting destruction.
These habitats are highly productive and so economically important. The physical, chemical and biological data collected from Manoli Island of Mandapam group of the Gulf of Mannar clearly reveal the interrelationship in enhancing the associated resources, particularly fishes and other invertebrates due to constant supply of nutrients and other favourable environmental factors. The 'transient' coral and seagrass associated fishes use these habitats for shelter, food and breeding. During windy and turbulent period in the Gulf of Mannar (April to August), the water is highly turbid and most dense seagrass beds are disturbed because of strong wave action and this period the nearby reefs act as major shelter point to the associated fish resources of seagrass areas. The ecological and economical use of these two important habitats stresses the need for their proper conservation and management to sustain the benefits.

Key words: Gulf of Mannar, interrelation among coral reef and sea-grass habitats, physical, chemical and biological data.

INTRODUCTION

India has a coastline of about 7500 km including that of island territories and comprises 60 coastal districts. The coastal environment is very dynamic with much cyclic and random process owing to a variety of resources and habitats. Further the coastal ecosystems are the most productive ecosystems on earth. India is one of the twelve – mega biodiversity areas of the world with 4500 wild species of plants and over 7700 wild species of animals. There are about 448 wildlife sanctuaries, 8 biosphere reserves and 85 national parks in India. Three biosphere reserve, three national parks and 13 wild life sanctuaries are located on the coastline (Krishnamoorthy, et al., 1995). A number of coastal areas along the Indian coast are rich in marine biodiversity and have unique flora and fauna that needs to be preserved as live natural heritage. Marine environment accounts for 71% of the earth's surface and play an important role in the sustenance of life. Vegetation growing along the coast such as: mangroves, macro algae, seagrass and sand dune plants play an important ecological role in the maintenance of the coastal ecosystem and their productivity. In the first instance, the organic matter produced by such vegetation enhance the biological productivity of the coastal ecosystem (Wafar, 1988). Many food webs include components that encompass multiple habitats, implying spatial and tropic linkages between these habitats. Tropic linkages between spatially discrete habitats can occur due to movement of food

*Corresponding author. E-mail: drsumamaheswari@gmail.com.

resources (for example, nutrients, detritus and prey) and movement of consumers (Polis et al., 1997). These cross habitat linkages can have important ecological consequences, especially by increasing productivity in the recipient area. In some cases, this maintains higher populations of consumers than would otherwise be supported (Bustamante et al., 1995). The filter feeders create extra levels in aquatic food chains that tends to be more complex than terrestrial ones (Margulis and Schwartz, 1988; UNEP, 1992).

Nearly 60% of the human population which occupy the coastal zone, exploit the coastal resources (Kathiresan and Rajendran, 1996). Among the islands of Gulf of Mannar, only the Manoli Island shows rich diversity and density of coral. The Hare Island supports extensive corals on the southern west end, but not as much in comparison to Manoli Island (Jeyabaskaran and Lyla, 1996; Kannaipar, 1997). Coral reef fish in tropical waters can move between different marine habitats in close proximity, including mangroves and seagrasses (Cocheret de la Moriniere et al., 2002).

Coral reefs and seagrasses are fundamentally connected ecosystems. Seagrasses provide spawning and nursery ground for many of the species of animals who spend their adult lives on the reefs. In return, the coral reefs provide shelter for the sea grasses and their inhabitants, while the calcium carbonate eroded from the reef provides sediment from which the sea grasses grow. However, the reciprocity of these linked ecosystems is not limited to benefits, threats to one have consequences to both.

Tropical seagrasses are important in their interactions with coral reefs. All these systems exert a stabilizing effect on the environment, resulting in important physical and biological support for the other communities (Amesbury and Francis, 1988). Barrier reefs protect coastlines, and the lagoon formed between the reef and the mainland is protected from waves, allowing the seagrass communities to develop. Seagrasses trap sediment and slow water movement, causing suspended sediment to fall out. This trapping of sediment benefits coral by reducing sediment loads in the water.

Study area

The Gulf of Mannar (GoM) is one of the four major coral reef areas of India, covering an area of approximately 10,500 sq. km from Rameswaram to Kanyakumari (Map 1). The area includes a chain of 21 coral islands surrounded by fringing reefs and patch reefs rising from the shallow sea floor. The interrelationship between these two potentially dynamic habitats was studied in Manoli Island of Mandapam group of the Gulf of Manna. The physico-chemical parameters of the sea water around the islands were analyzed, qualitative and quantitative analyses of plankton, primary productivity, macro benthos and fin fishes were carried out. The assessments on the benthic categories are also discussed subsequently.

METHODOLOGY

The Gulf of Mannar is one of the coral reefs rich areas of India situated in the southeast coast of India. The coral reef needs the following for their perfect growth. They are: constant salinity, warm water between 27 and 30°C, clear and clean water and sufficient nutrient levels. The highest atmospheric temperature recorded was 32°C and the lowest was 30°C. Due to rains, land run – off and sewage input, salinity level at Rameswaram showed the lowest level of 28%. The highest level of salinity was observed in places were land drainage was limited. The pH level was similar in all the selected locations. The study was carried out in Manoli Island of the Gulf of Mannar. A permanent monitoring site has been fixed for the monitoring. The site was selected according to the presence of all two habitats nearby. The Manoli Island (N 09013.300'E 079008.592') is rich in corals and seagrass beds. In the permanent monitoring site, physic - chemical and biological parameters were analyzed separately for reef area and nearby seagrass area.

The chemical analysis was carried out by following APHA (1992). Acid and double distilled water washed ploythene plastic bottles were used for collection of water. Temperature and PH was measured *in situ*. Dissolved oxygen and salinity were estimated in the laboratory immediately after collection on the same day. Measurement of nitrite, nitrate, phosphate were made by Colorimetry methods using HITACHI U – 2000 UV – VIS Spectrophotometer within 24 h period. The water samples were collected every month and the physico-chemical parameters such as: temperature, salinity, transparency, pH, dissolved oxygen, TSS, turbidity and nutrients were analyzed using standard methods. Plankton samples were collected from surface water using plankton nets, biomass, density and primary productivity were measured using standard methods. Macro benthos was collected from the bottom using grab and the densities of the major groups were analyzed. The aforesaid parameters were analyzed separately in coral and seagrass areas.

The benthic cover assessment was carried out in October 2007, January 2008, April 2008 and July 2008. The benthic cover around the islands was assessed by Line intercept transect (LIT) method (English et al., 1997). The fish diversity and abundance was assessed visually through belt transect method. Before, starting the in-depth study, a general preliminary survey was conducted to assess and observe the benthic community using manta tow method (Done et al., 1982). The assessment in the seagrass area was carried out with the use of 0.5 x 0.5 m^2 quadrates (Saito and Atobe, 1970).

RESULTS

Physico-chemical parameters

In Manoli Island, temperature level was between 27.1 and 32.6°C in the reef area and between 27.3 and 32.8°C in the seagrass area with the maximum in June 2008 and minimum in January 2008. Salinity did not show much difference as it ranged between 34.7 and 36% during the study period. pH was between 7.8 and 8.2 in all the months in both the habitats. Turbidity ranged between 2.9 and 11.6 NTU with the maximum record in July 2008 and minimum in October 2007 in both reef and seagrass

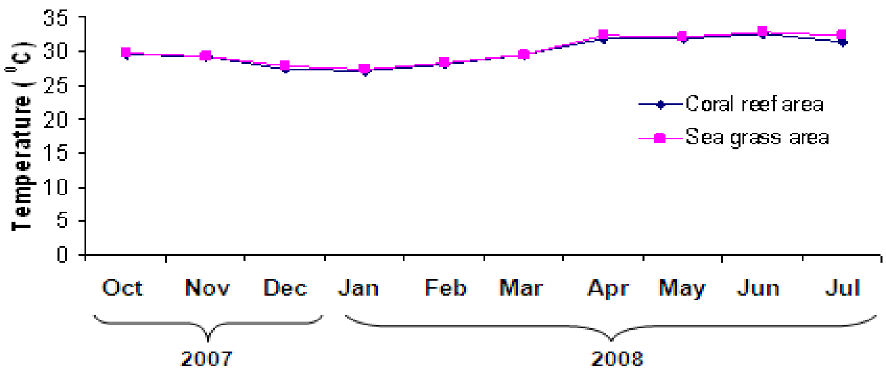

Figure 1. Temperature.

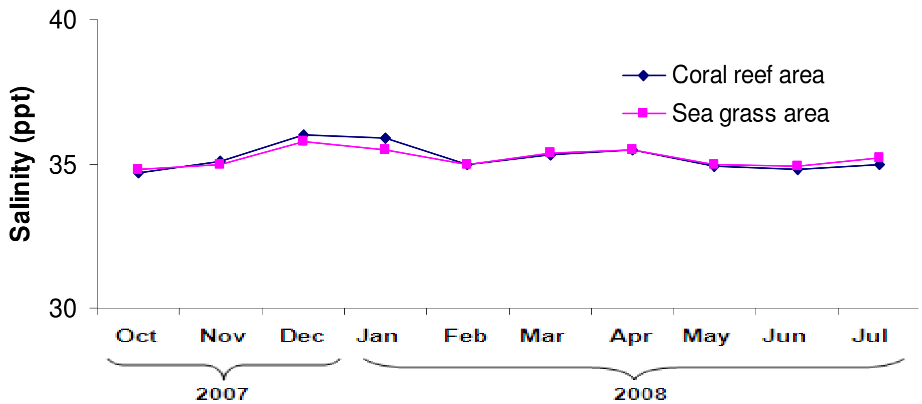

Figure 2. Salinity.

areas. TSS was highest in June 2008 with 105 mg/l and lowest in October 2007 with 51 mg/l in the reef area and it was between 53 and 115 mg/l in the seagrass area. Transparency was highest in December 2007 with 3.8 m and lowest in the month July 2008 with 1.1 m in the reef area and it was between 1 and 3.5 m in the seagrass area. Dissolved oxygen values in all the months ranged between 4.65 and 4.96 mg/l in both ecosystems. Calcium values ranged between 400 and 560 mg/l with the highest in July 2008 and lowest in November 2007 in the reef area and between 440 and 600 mg/l in the seagrass area. Magnesium values between 1140 and 1526 mg/l with the maximum in April 2008 and minimum in November 2007 were obtained in the reef area and between 1250 and 1612 mg/l in the seagrass area. Phosphate values ranges between 2.15 and 3.28 µg/l with the highest in June 2008 and lowest in January 2008 in the reef area and between 2.45 and 3.81 µg/l in the seagrass area. Nitrate concentrations ranged between 0.36 and 0.54 µg/l with the maximum in May 2008 and minimum in June 2008 in the reef area and between 0.42 and 0.71 µg/l in the seagrass area. The values of nitrite ranged between 0.02 and 0.08 µg/l in both the habitats.
The details of physico-chemical parameters are given in the Figures 1 to 12.

Biological parameters

Phytoplankton density in Manoli Island ranged between 53486 and 63542 cells/l, with the maximum in April 2008 and minimum in June 2008 in the reef area, and between 54120 and 64250 cells/l in the seagrass area. Zooplankton density ranged between 10306 and 15245 cells/l, with the maximum in June 2008 and minimum in November 2007 in the reef area, and between 11240 and 15950 cells/l in seagrass area. Plankton biomass ranged between 2.3 and 4.9 g/m^3 with the highest in the month April 2008 and lowest in June 2008 in reef area and between 2.5 and 5.2 g/m^3 in the seagrass area. Primary productivity ranged between 3.6 and 6.5 g/m^3 with the maximum in April 2008 and minimum in June 2008 in the reef area, and between 3.9 and 6.7 g/m^3 in seagrass area. The details of plankton assessments are given in the Figures 13 to 16.

Among the macrobenthic communities, gastropods formed the dominant major group and it was between 5.03 and 6.31/m^2 in the reef area and between 6.03 and 7.62 m^2 in the seagrass area. This was followed by bivalves, with a density of 1.96 and 4.02 m^2 in the reef area and between 1.95 and 4.53 m^2 in seagrass area. The densities of polychaetes, echinoderms, scaphopods

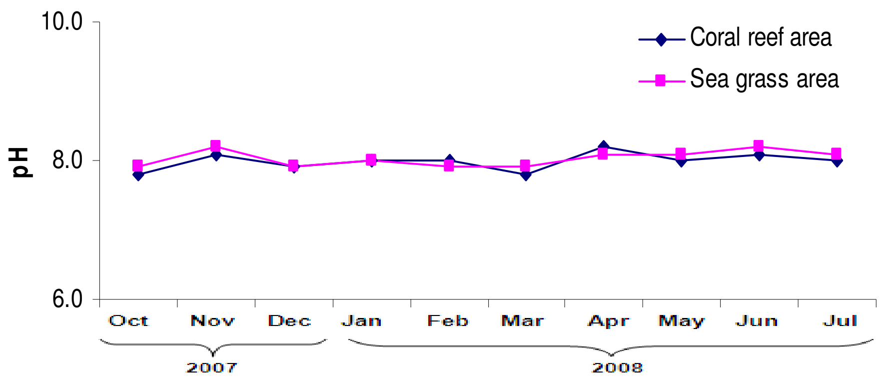

Figure 3. pH

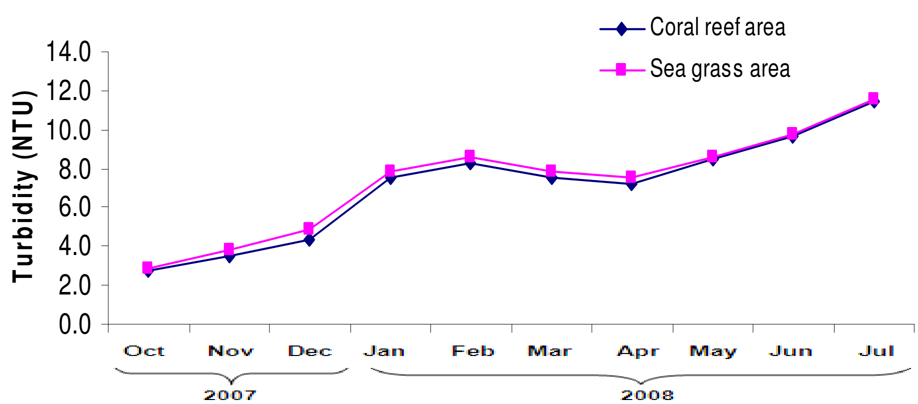

Figure 4. Turbidity.

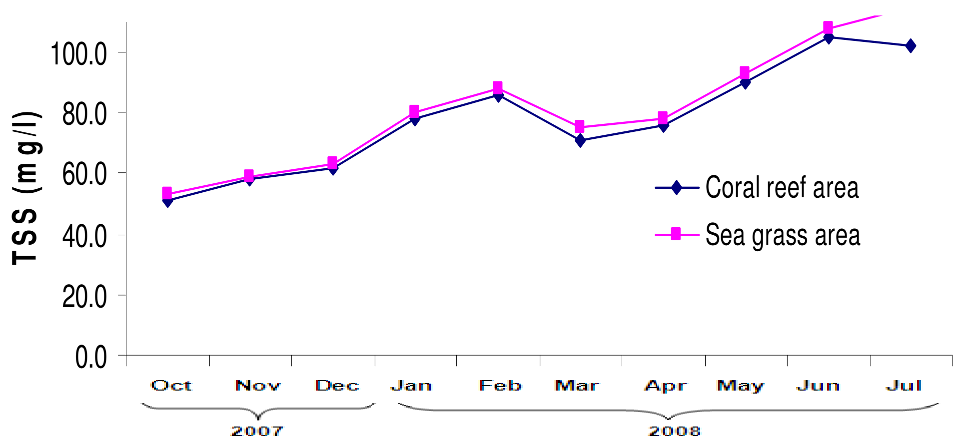

Figure 5. Total suspended solids (TSS).

and crustraceans were not high. The details of macrobenthos densities are given in the Figures 17 and 18.

Benthic community structure of reef area

Percentage of live coral cover during October 2007 was 42.25 and it increased to 43.25% in ten months. The percentage DCA (Dead coral with algae) was between 12.87 and 16.25%, while the percentage abiotic factors were between 15.23 and 18.44%. The percentage algae was between 12.25 and 13.85 and others were between 9.22 and 14.77%. *Acropora* branching corals were the dominant coral type with around 12% followed by massive corals and *Acropora* foliose corals. The details

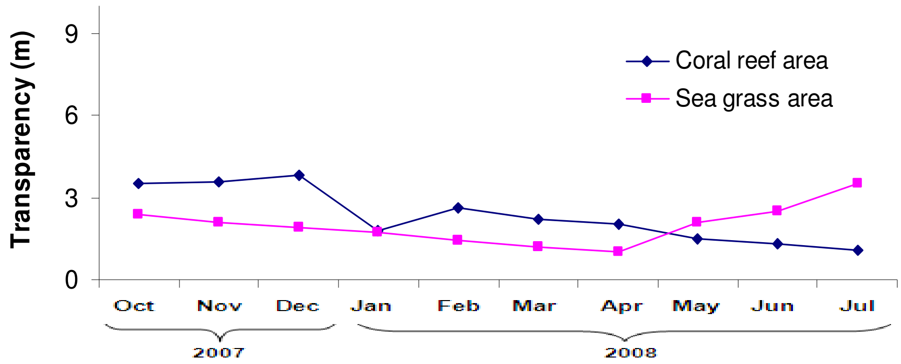

Figure 6. Transparency.

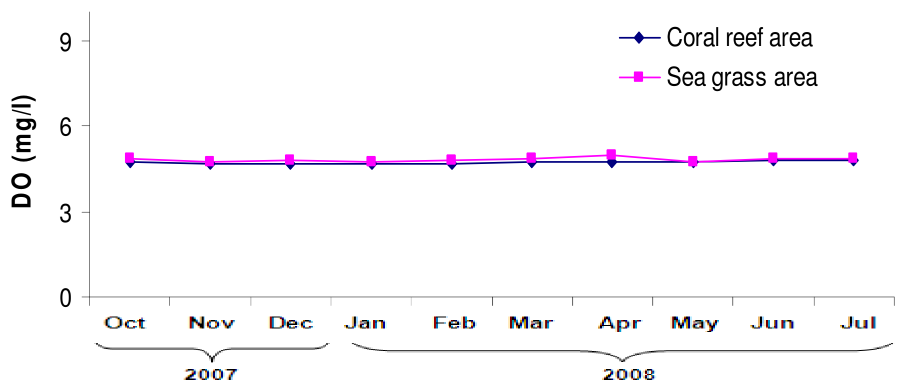

Figure 7. Dissolved Oxygen (DO).

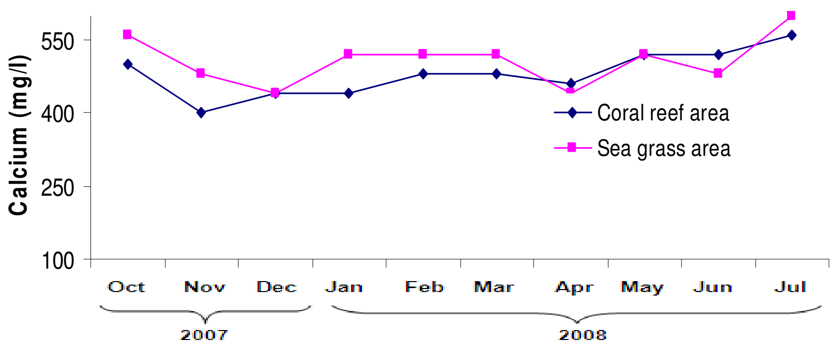

Figure 8. Calcium.

are given in Figures 19 and 20.

Benthic community structure of seagrass area

In Manoli Island, the percentage of seagrasses near the permanent study site was 45%. Totally 8 species of seagrasses were recorded, they are as follow: *Thalassia hemprichii, Halphila ovalis, Halophila decipiens, Cymodocea serrulata, Halodule pinifolia, Halodule uninervis, Syringodium isoetifolium* and *Enhalus acoroides*. Among these, *C. serrulata* was dominant with 31.05% followed by *T. hemprichii* with 20.9%. Shoot density was high for *C. serrulata* (124.35 shoot/m^2) followed by *T. hemprichii* with 78.62 shoot/m^2. Biomass was also high for *C. serrulata* with 95.61 g dwt/m^2 followed by *T. hemprichii* with 54.02 g dwt/m^2 (Figures 21 to 23).

Abundance of fish

The abundance of fish was random and reasonably high during the study period. The most abundant fish species

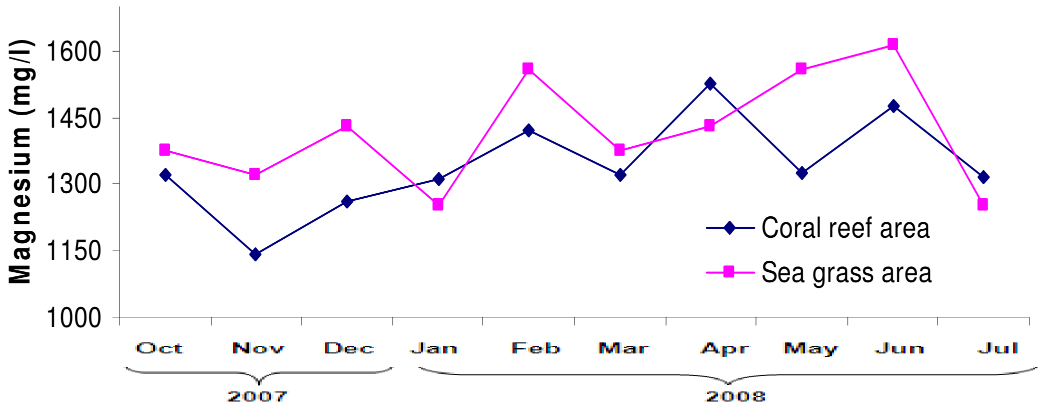

Figure 9. Magnesium.

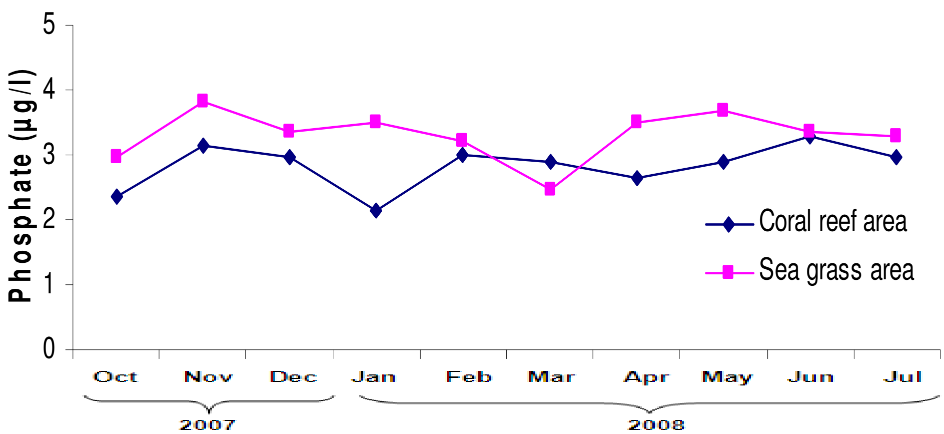

Figure 10. Phosphates.

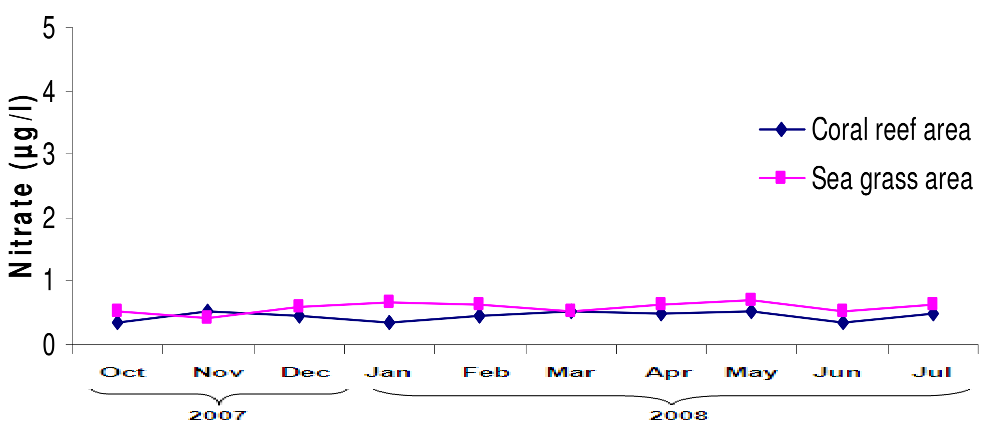

Figure 11. Nitrates.

recorded in the reef area were *Lethrinus nebulosus, Lethrinus microdon, Lethrinus ornatus, Lutjanus lunulatus, Lethrinus lutjanus, Lethrinus malabaricus, Lethrinus fulviflamma, Carangoides malabaricus, Chaetodon* sp., *Scarus, Siganus ghobban*, *Sardinella gibbosa* and *Odonus niger*. The most common fish species recorded in the seagrass area were *Lutjanus lutjanus, L. malabaricus, Terapon* sp., *Amphiprion* sp.,

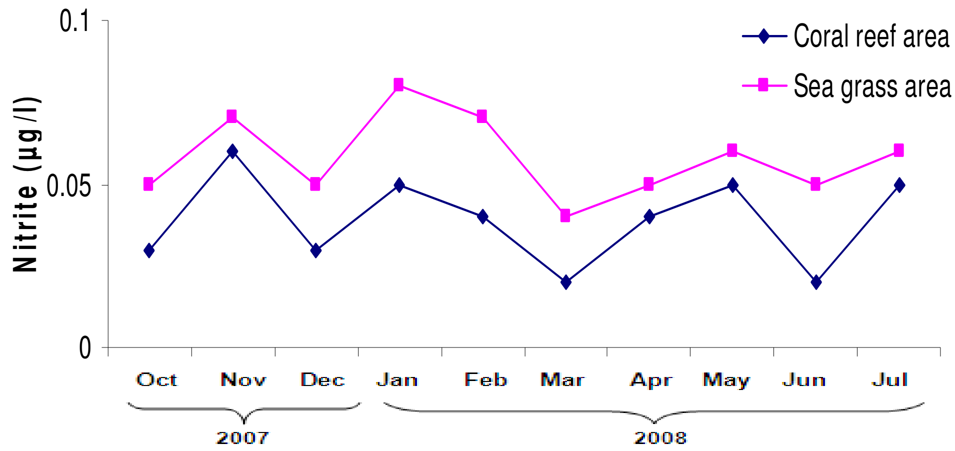

Figure 12. Nitrites.

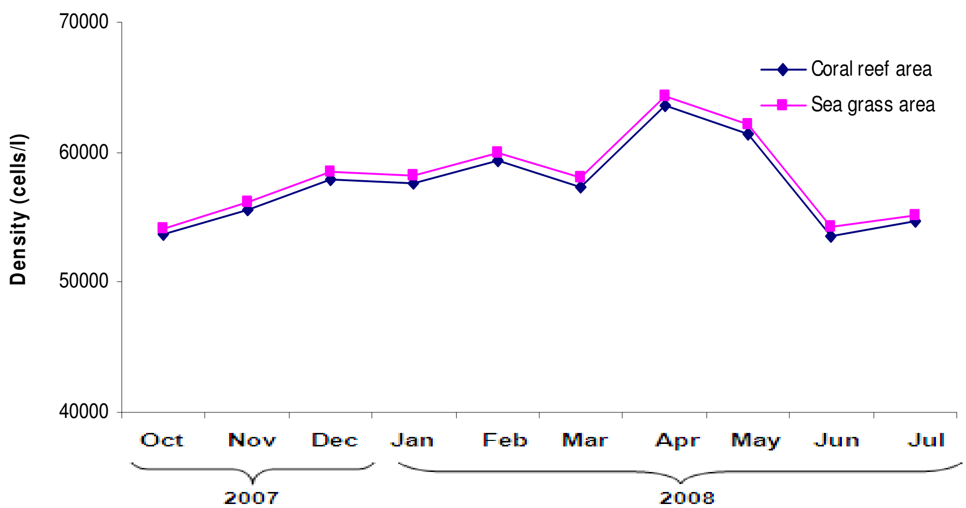

Figure 13. Phytoplankton density.

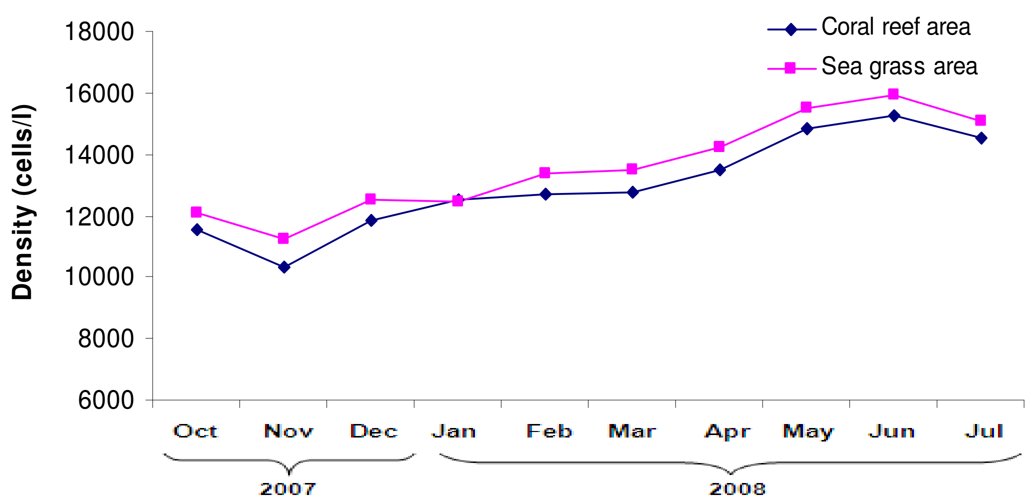

Figure 14. Zooplankton density.

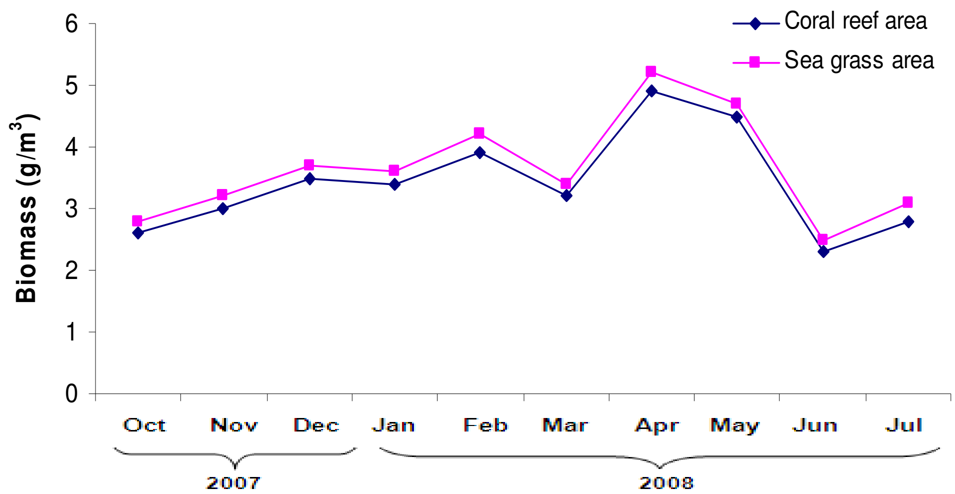

Figure 15. Plankton biomass.

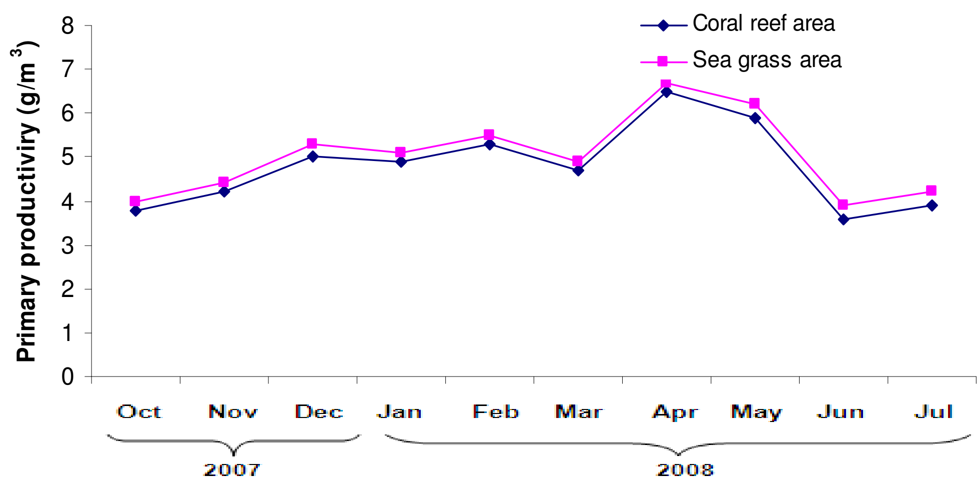

Figure 16. Primary productivity.

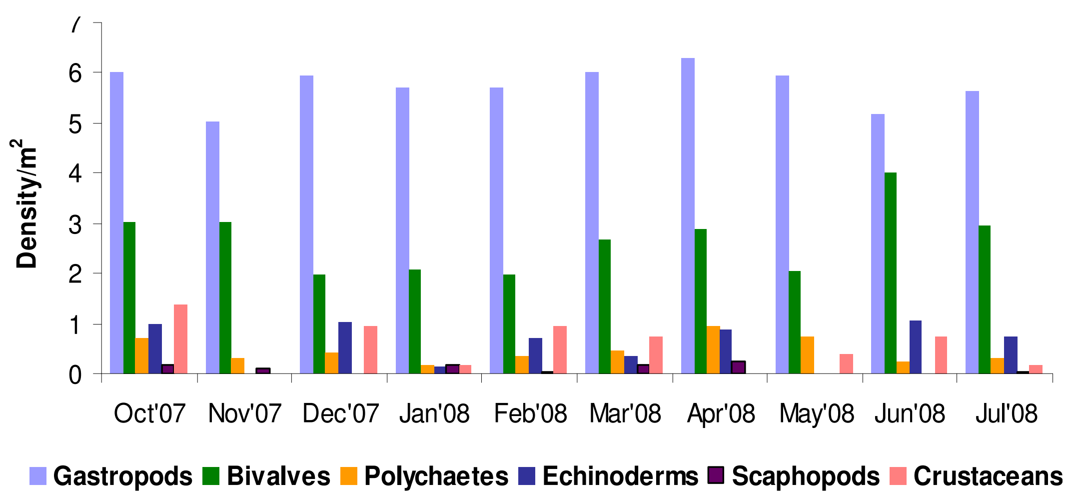

Figure 17. Macrobenthos in Coral reef area.

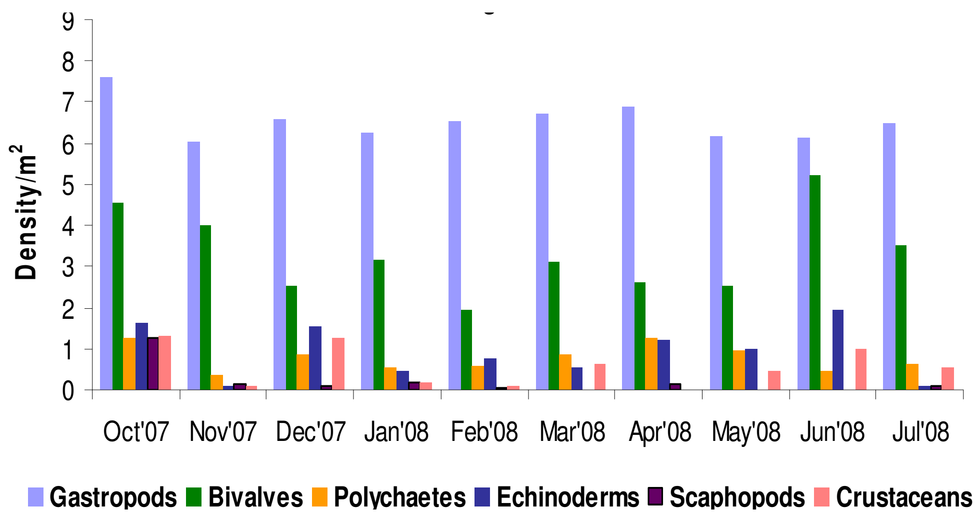

Figure 18. Macrobenthos in Seagrass area.

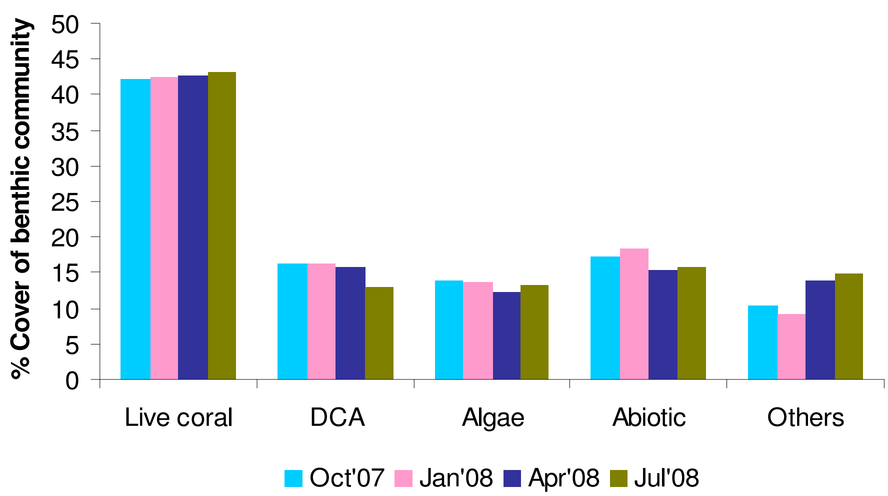

Figure 19. Benthic community structure of reef area.

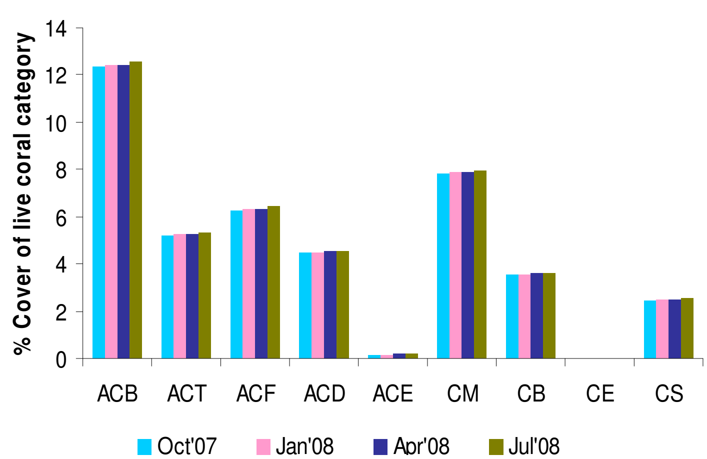

Figure 20. Coral types.

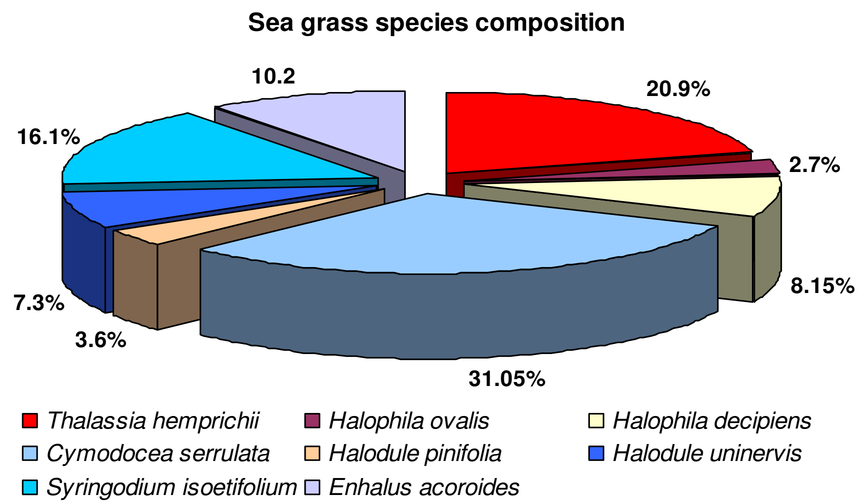

Figure 21. Percentage distribution of seagrass species.

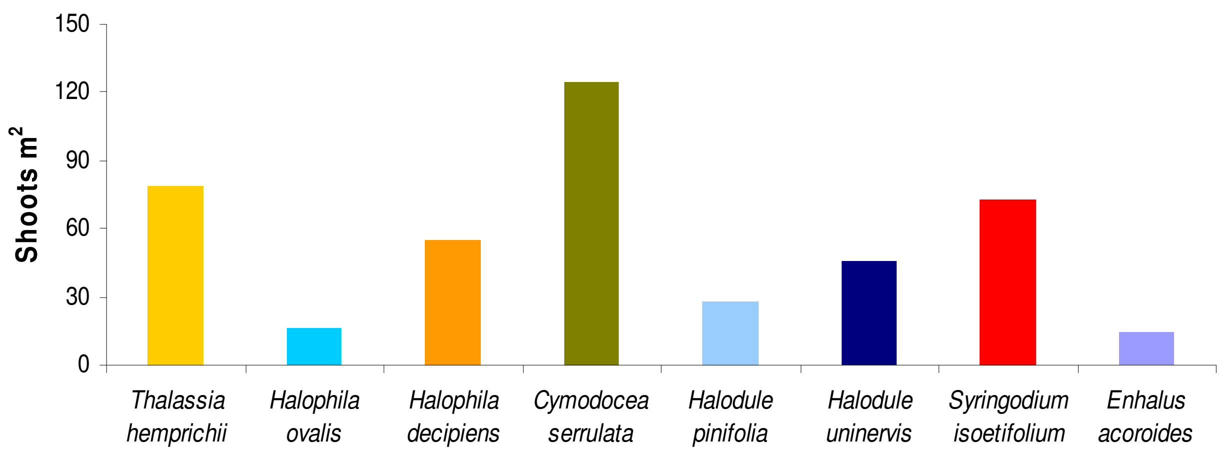

Figure 22. Seagrass shoot density.

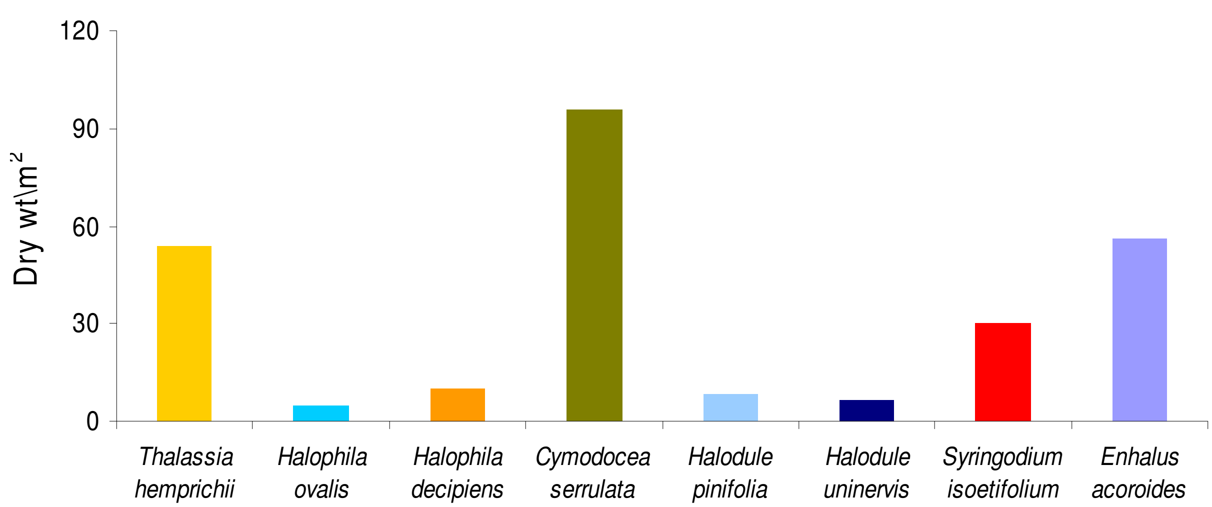

Figure 23. Seagrass biomass.

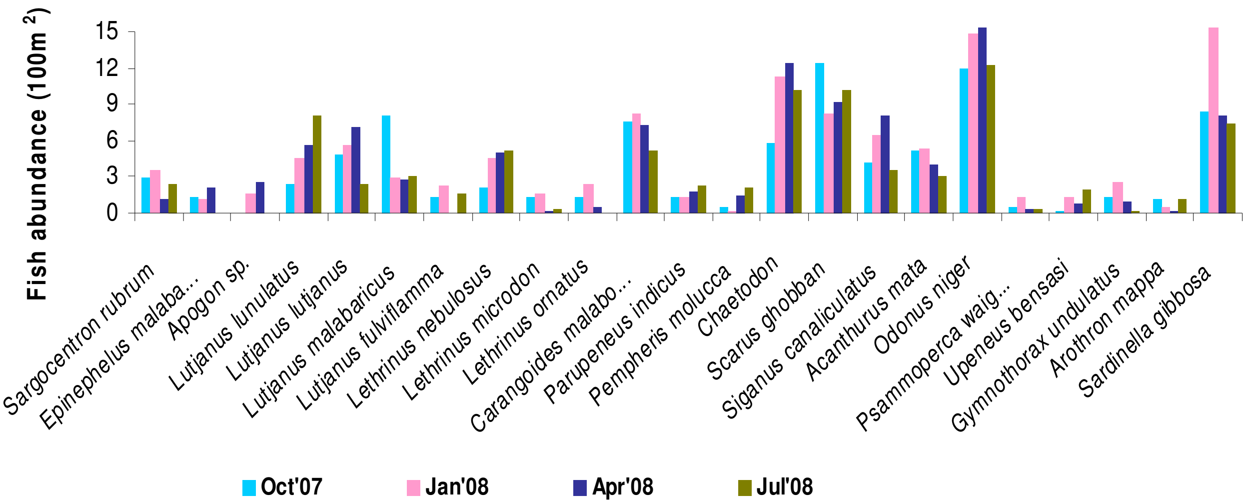

Figure 24. Abundance of fish in the reef area.

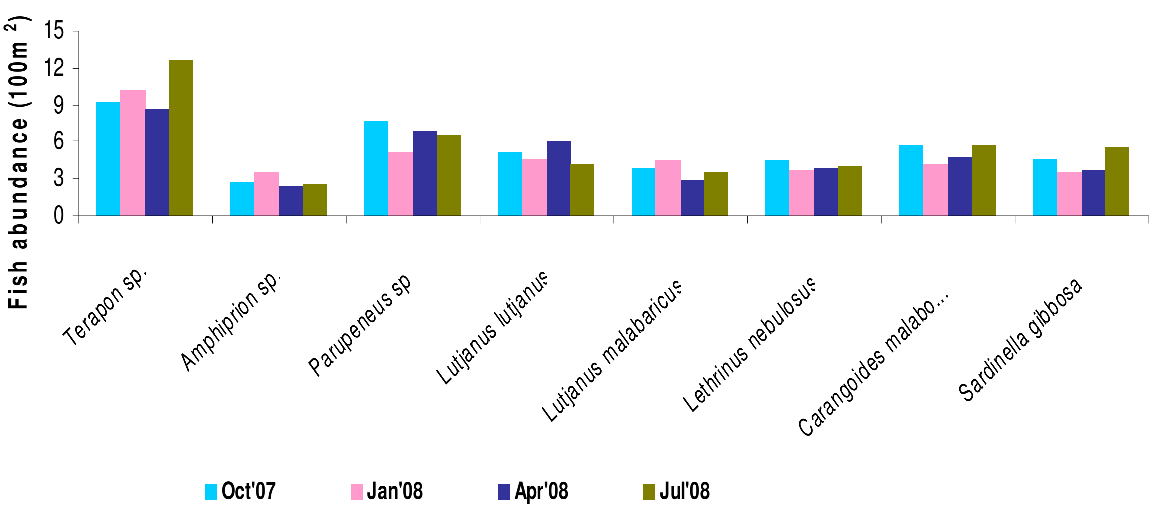

Figure 25. Abundance of fish in the reef area.

C. malabaricuss, S. gibbosa and *Parupeneus* sp. The details are given in the (Figures 24 and 25).

DISCUSSION

In the present study, the temperature recorded that the summer season was maximum. The increasing trend of temperature found confirms that the life of the corals in this part of the sea is going to be challenging in the year to come. It was observed in windy and turbulent period (April to August) the water is highly turbid and most the dense sea grass beds are disturbed because of strong wave action and this period, the nearby reefs act as major shelter point to the associated fish resources of seagrass areas. There was also no much difference in the pH level. The dissolved oxygen concentration was higher in the coral reef environment. The low level of dissolved oxygen was recoded during summer season due to the higher surface water temperature. The nutrient level can also have consistent impact on both the coral reef and sea grass ecosystem. The coral reefs are more sensitive to the changes in the nutrient level in the ambient environment, especially nitrogen and phosphorous which have limiting nutrient for coral growth. The seagrass ecosystem is capable of withstanding higher nutrient levels when compared to the coral reef ecosystem.

A dense vegetation of seagrass in Manoli Island produces a great quantity of organic material, and offers a good substrate for epiphytic small algae, micro flora, and sessile fauna. The vegetation plays the role of sediment trap, and minute suspended particles, both organic and inorganic, are deposited in this biotope, thus increasing water clarity (Smith, 1984). It also creates unique microhabitats for small animals. In the case of an animal assemblage, epifauna attached to the seagrass may have close correlation with the seagrass bed, but some infauna may be a part of the benthic community of the surrounding area and not positively correlated with the seagrass bed. Regarding nekton, some fishes are permanent residents, some reside there only seasonally, and for some the seagrass bed is only a part of their daily foraging area. Nevertheless, these various components are linked together by tropic interrelationships. The increasing trend of temperature and nutrient level in both the coral reef and seagrass environment has to be checked otherwise such climatic change, eutrophication and food web alterations have independent effect and potential for synergistically enhancing the development of macro- algae blooms in coastal ecosystem.

The coral reefs and sea grasses are characterized by high biodiversity, productivity and provide a wide spectrum of services to coastal communities, especially in relation to fisheries and coastal protection. The seagrasses and mangroves frequently exist in close association with coral reefs and often interact through exchanges of biodiversity and productivity. Shallow, coastal areas with coral reefs and sea grasses are among the most diverse and productive in the world (Beck et al., 2001; Valiela et al., 2001).

Coral reef and seagrass habitats are juxtaposed in many areas of the world. Bensan and Udayasankar (1990) have attempted the colonization and growth of seagrass *H. uninervis* and *H. ovalis* in the marine culture ponds of Mandapam. Kannan (1997) and Kannan and Thangaradjou (1999) are the very few attempts made in creation of awareness about the seagrass resources and their need of conservation, have also developed a simple economically feasible tank culture technique for *E. acoroides* through which they could able to get 100% germination rate which would help in producing large number of seedlings at any given time at low cost.

In warmer waters, such as the Caribbean and Indo-Pacific, coral reefs are often found adjacent to seagrass beds, and strong linkages have been observed between these two habitats. For example, reef associated consumers forage in adjacent seagrass meadows, often exerting a strong influence on community structure in the meadows (Randall 1965; Eggleston et al., 1988). In turn, the consumers bring organic matter and nutrients back to the reefs, where they can increase productivity (Meyer and Schultz, 1985).

The patterns of distribution of fishes in seagrass beds and shallow-water coral reefs may result either from behavioral responses to habitats, in terms of resource availability for example, space, shelter, food, (Jones, 1991) and reproduction (Robertson, 1991), or ecological interactions, such as differential survival among different habitats through predation and competition (Hixon, 1991; Roberts, 1996).

Conclusion

The present study showed that Manoli Island is rich in all the two dynamic habitats like coral reef and seagrasses. Plankton density, biomass and primary productivity were also high in the seagrass area than the reef area and this richness can be transported to the nearby reef through consumers. The temperature and the nutrient concentration level have increased compared to the previous year. The temperature would directly affect these environments. The increase nutrient level in the coral water would affect the coral skeleton formation and causes the micro and macro – algal blooming. The previous process would affect the coral reefs by decreasing the light availability to the zooxanthellae. The increase in the nutrient levels in the seagrass environment would favour the growth and effect of epiphytes. It was observed that the fish diversity was high in the reef area than the sea grass area and few common species were present in both ecosystems indicating migration and adaptability. There must be a strong relationship between these two habitats, in exchange of nutrients and organisms in this Island. The study concludes that, if these habitats are present near to each other the diversity and abundance of fish and other organisms will be great because they aid each other. The Gulf of Mannar is rich with these two important habitats and since each habitat is dependent on other, it is essential to protect these habitats with utmost care.

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