PRIMARY PRODUCTIVITY OF SOME FRINGING REEFS OF SOUTH-EAST INDIA

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ABSTRACT

Primary productivity of two fringing reefs in south-east India was studied from the diurnal curve method. The rate of production in the waters around the reef was determined by ^{14}C uptake and chlorophyll-*a* estimation. The rates of production and consumption in individual sea-grasses were determined by the light and dark bottle oxygen method. Gross production of the Palk Bay reef ranged from 4.86 gC/m^2/day in March to 9.5 gC/m^2/day in May. In the Kurusadai island reef the rate of gross production was 2,39 gC/m^2/day in November. Phytoplankton production in the Palk Bay reef area ranged from 0.51 gC/m^2/day to 1.62 gC/m^2/day and chlorophyll-*a* values from 0.177 µg/l to 0.695 µg/l. In the Kurusadai reef the phytoplankton production was 0.17 gC/m^2/day and the chlorophyll-*a* was 0.163 µg/l. Oxygen production and consumption in individual corals and sea grasses indicate that the individual species is autotrophic with P/R ratios exceeding 1.

INTRODUCTION

Earlier works have shown that the coral reefs are highly productive communities (Odum and Odum, 1955; Kohn Helfrich, 1957; Qasim *et al.*, 1972; Nair and Pillai, 1972.) However, most of the information available is on the reefs of the Pacific and Atlantic oceans. Little data have been collected on the productivity of coral reefs from the Indian Ocean except for the studies by Qasim *et al.* (1972) and Nair and Pillai (1972). Qasim *et al.* (1972) have studied the productivity of the reef on Kavaratti Atoll. Their observations covered the production by reef, lagoon, individual corals, plants and phytoplankton. A similar study has not been carried out on any of the fringing reefs. The present study was taken up to investigate the total production by the fringing reefs at Mandapam and the contribution of corals and phytoplankton in the overall productivity.

MATERIALS AND METHODS

The reef selected for this study was in the Palk Bay. It lies in an east-westerly direction running parallel to the shore (Long. 79° 17'40" E–79°8 ' E and

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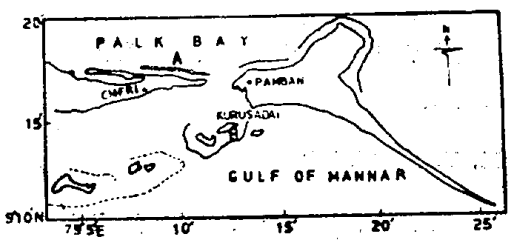

Fig. 1 Map showing location of reefs studied A. Palk Bay Reef B. Kurusadai Reef.

Lat. 9°17 ' N) upto a distance of about 5 km (Fig. 1). The average depth over the reef is about 2 m. A narrow navigational channel at about the middle of the reef separates it into an eastern half called *Kathuvalimuni reef* and a western half called *Vellapertumuni reef*. However, both the reefs are structurally and faunistically similar and are considered as a single biotope (Pillai, 1969). Among the 63 species of corals belonging to 22 genera recorded from this reef (Pillai, 1969), the common species are of *Favia, Favites, Goniastrea, Goniopora, Acropora, Pocillopora, Porites* and *Symphillia*. The other reef studied is at Kurusadai which is one of the islands in the Gulf of Mannar. It runs parallel to the Mandapam peninsula (Fig. 1). The reef is located in the eastern part of this island. The corals found in this reef are species of *Pocillopora, Madripora, Montipora, Porites* and *Acropora*.

Diurnal curve method of Odum and Hoskin (1958) was employed to study the community metabolism of these reefs. The flow respirometry method of Sargent and Austin (1949, 1954) was found unsuitable in these fringing reefs as the fluorescein dye tended to sink and failed to move properly, probably due to the shallowness of the reef. Replicate samples for the determination of the oxygen were, therefore, taken over a fixed station in the reef at 3-hourly intervals for a period of 27 hours and the measurements were averaged to get one value of oxygen which is representative of the entire water mass. A curve for the rate of change was prepared from these values after correcting for diffusion of oxygen. Gross production and respiration were calculated following the method of Odum and Hoskin (1958).

Phytoplankton production was measured by ^{14}C technique and chlorophyll estimation. Incubations with ^{14}C were carried out at intervals of 3 hours, over a period of 24 hours at the reef itself by suspending the bottles from a moored buoy. Chlorophyll estimations were made according to the method suggested by UNESCO (1966). Changes in the oxygen were also measured with individual corals and plants commonly found in the reef and lagoon, using light and dark bottles to get some idea of their oxygen balance. All necessary precautions were taken to ensure maximum accuracy of the experimental and analytical methods.

RESULTS

Measurements of community metabolism were made in March, April, May, July and August 1973 in the Palk Bay reef. The curves for community metabolism are given in Fig. 2 and the values of gross production and consumption in Table I. Gross production in

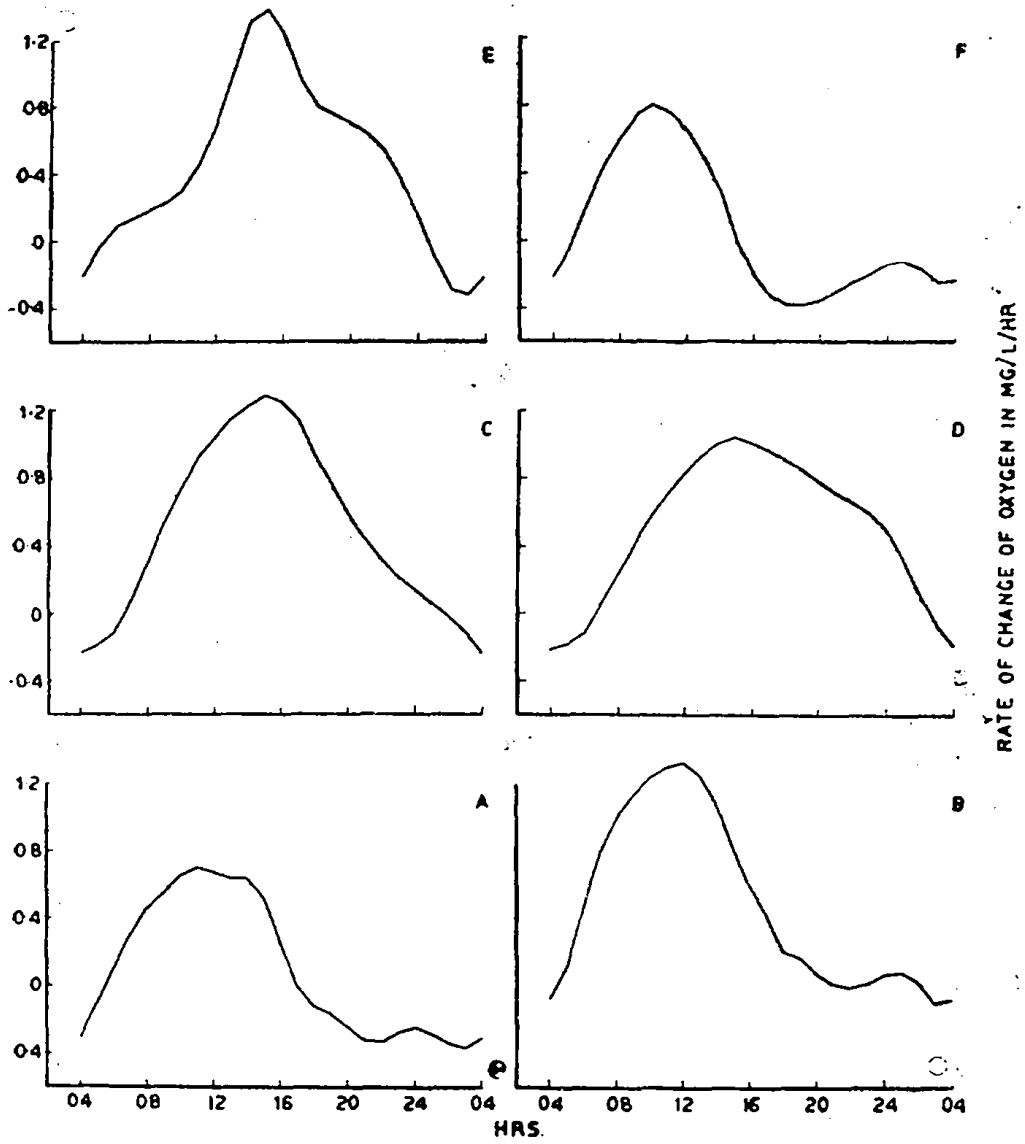

Fig. 2 Community metabolism curves

A-E Palk Bay Reef in March, April, May, July and August respectively.

F. Kurusadai Reef in November.

the Palk Bay reef ranged from 4.86 gC/m^2/day in March to a maximum of 9.5 gC/m^2/day in May. Phytoplankton production ranged from 0.51 gC/m^2/day to 1.62 gC/m^2/day (Table II). The pigment values available for all the 12 months indicate that the chlorophyll-*a* concentration in the reef waters is low (0.177 – 0.695 mg/m^3).

TABLE I

Gross production and respiration values for the Palk Bay and Kurusadai Reefs.

Location	Gross production ($gC/m^2/day$)	Respiration ($gC/m^2/day$)	P/R
Palk Bay Reef			
March	4.86	2.26	2.15
April	6.30	2.30	2.74
May	9.50	3.30	2.90
July	8.94	2.63	3.40
August	8.73	3.13	2.80
Kurusadai Reef			
November	2.39	2.01	1.19

The community metabolism curve for the Kurusadai reef in November 1973 is given in Fig. 2. Gross production was found to be 2.39 $gC/m^2/day$ and consumption 2.01 $gC/m^2/day$. The phytoplankton production was 0.17 $gC/m^2/day$. Chlorophyll-*a* in the water around this reef was 0.163 mg/m^3.

Oxygen balance of individual corals which are the dominant reef builders in this area has been studied earlier (Pillai and Nair, 1972). The oxygen balance of individual sea-grasses found in the lagoons were studied and the results are given in Table III. The sea-grasses were found to be autotrophic.

TABLE II

Phytoplankton production values for Palk Bay and Kurusadai reefs.

Location	Production ($gC/m^2/day$)
Palk Bay Reef:	
March	1.15
April	1.62
May	0.51
August	1.10
Kurusadai Reef:	
November	0.17

DISCUSSION

The Palk Bay reef undergoes marked changes in two seasons during the year, one from April to August and the other from September to March. From April to August, the Palk Bay is relatively calm, with abundant sunlight and temperature characteristic of the summer months. From September onwards, when the north-east monsoon sets in, the sea becomes turbulent, rendering diurnal studies difficult. Rough conditions during NE monsoon coupled with decreasing temperature and salinity lead to some mortality of corals. However, once the calm conditions begin to prevail, the corals start budding-off rapidly and growth season begins to commence.

TABLE III

Ratios of gross production to respiration in some of the sea grasses found in the lagoon of both reefs.

Species	P/R
Cymodocea isoetifolia	1.00
C. serrulata	1.00
Diplanthera uninervis	2.17
Halophyla ovalis	2.35
H. stipulacea	2.61

Proliferation of corals, to gether with favourable conditions markedly enhances the productivity. This is reflected from the gross production values obtained in March, April and May. Gross production in March (at the end of the rough season) is 4.86 gC/m^2/day but it increases to 6.3 gC/m^2/day in April and 9.5 gC/m^2/day in May. Thereafter, it almost records similar values (8.94 gC/m^2/day in July and 8.78 gC/m^2/day in August) until the next NE monsoon. Thus a seasonal variation in productivity becomes quite apparent although we have no data for comparison during the rough season. However, as the data for March indicate, it may be reasonably assumed that the production during the NE monsoon will be low due to decline in salinity and temperature and because of some mortality of corals.

The reported values of gross productivity of coral reefs fall within the range of 8 to 12 gC/m^2/day. The coral reef in a nearby island (Manauli Reef) is reported to have a productivity of 7.3 gC/m^2/day (Nair and Pillai, 1972). Qasim *et al.* (1972) have observed a gross production value of 12.92 gC/m^2/day in the reef on Kavaratti Atoll. But in spite of the high production rate all the reefs are not self supporting. The heterotrophic reefs largely include fringing reefs (Qasim *et al.*, 1972).

In the present study, both the fringing reefs at Mandapam have been found to be clearly autotrophic. The Palk Bay reef is highly productive in summer months with a P/R of 3.4 in July. The lowest gross production and P/R ratio were found in March. Allowing a decrease in the photosynthetic rate during the NE monsoon months, the production might still possibly be higher than the consumption. Further, the reef has shown a rapid growth since its partial destruction by a severe cyclonic storm which hit the coast in 1964. However, the Kurusadai reef is dying as evidenced by the sparse population of corals and its low gross production value (2.39 gC/m^2/day). Nevertheless, it is interesting to note that the reef is still self supporting as shown by the P/R ratio (1.19). Abundance of seaweeds of the genera *Caulerpa* and *Turbinaria* in this reef also contributes to the production of the reef. The low production rate in some fringing reefs observed by some authors may be because the measurements were made at a time when the rate of production was at its seasonal minimum (Qasim *et ol.*, 1972).

Dead corals of Mandapam area are being removed for the carbide industry. However, no discrimination is shown between living and dead ones and hence a fast destruction of the reef is taking place. This may be the cause of

low production observed for this reef. In spite of strict government regulation to remove only the coral debris, the reefs of Kurusadai and nearby islands are being destroyed with the result that the coral population has become sparse.

The Palk Bay reef, on the other hand, is seldom subjected to any exploitation. The reef is thus thriving well and has a reasonably good growth of corals and algae. The need for conservation of coral reefs has been emphasized by Yonge (1969) in general and by Mahadevan and Nagappan Nair (1972) with special reference to the Gulf of Mannar reefs. Unless suitable measures are urgently taken, the reefs of Gulf of Mannar will soon be completely destroyed.

The phytoplankton production values in both reefs were lower than the average values reported by Nair (1970) for the continental shelf stations of Palk Bay (2.24 $gC/m^2/day$) and Gulf of Mannar (1.2-1.5 $gC/m^2/day$). Qasim *et al.* (1972) have found that the phytoplankton productivity in the reefs at Kavaratti Atoll was low and agreed in general with the rate of production of the western Indian Ocean. Chlorophyll-*a* values found in both the reefs were low. Low photosynthetic pigment values were observed in other reefs also (Jeffrey, 1963; Qasim and Sankaranarayanan, 1970; Sournia and Ricard, 1974, 1976); Thus it appears that the contribution of phytoplankton to the overall productivity of the reef is not significant and it represents only the production rates of the surrounding waters.

Pillai and Nair (1972) showed in ten species of corals collected from the Palk Bay that they are autotrophic with P/R ratios varying from 1.97 in *Goniastrea pectinata* to 3.58 in *Porites solida*. The present study on oxygen balance of seagrasses found in these reefs shows them to be autotrophic. Earlier works on oxygen balance of corals and benthic macro-algae show almost all of them to be autotrophic (Muscatine, 1973; Kanwisher, 1966; Qasim and Bhattathiri, 1971). Production and consumption values of individual corals and plants from the two reefs are in consistence with those of the available data.

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REFERENCES

Jeffrey, S. W., 1968. Photosynthetic pigments of the phytoplankton of some coral reef waters. *Limnol. Oceanogr.*, **13**(2) : 350-355.

Kanwisher, J. W., 1966. Photosynthesis and respiration in some seaweeds. In *Some contemporary studies in Marine Science*, Harold Barnes (Ed.,) George Allen and Unwin, London: 407-420.

Kohn, A J. and P. Helfrich, 1957. Primary organic productivity of a Hawaiian coral reef. *Limnol. Oceanogr.*, **2** : 241–251.

Mahadevan, S. and K. Nagappan Nair, 1972. Distribution of coral reefs in the Gulf of Mannar and Palk Bay and their exploitation and utilization. *Proc. Symp. Corals and Coral Reefs*, C. Mukundan and C. S. Gopinatha Pillai (Ed.,) Marine Biological Association of India, Mandapam Camp. : 181–190.

Muscatine, L., 1973. Nutrition of corals. In *Biology and Geology of Coral Reefs*, Vol. 2, O. A. Jones and R. Endean (Ed.,) Academic Press, : 77–115.

Nair, P. V. R., 1970. Primary productivity in the Indian Seas. Bull. Central Marine Fisheries Researeh Institute, India, **22**

Nair, P. V. R. and C. S. G. Pillai, 1972. Primary productivity of some coral reefs in the Indian Seas. *Proc. Symp. Corals and Coral Reefs.*, C. Mukundan and C. S. Gopinatha Pillai (Ed.,) Marine Biological Association of India, Mandapam Camp : 33–42.

Odu n, H. T. and E. P. Odum, 1955. Trophic structure and productivity of a windward coral reef community of Eniwetok atoll. *Ecol. Monogr.*, **25**: 291–320.

Odum, H. T. and C. M. Hoskin, 1958. Comparative studies on the metabolism of marine watets. *Publs. Inst. Mar. Sci. Univ. Texas*, **5** : 16–46.

Pillai, C. S. G., 1969. The distribution of corals on a reef at Mandapam (Palk Bay), S. India. *J. mar. biol. Ass. India.* **11** : 62–72.

Pillai, C. S. G. and P. V. R. Nair, 1972. Productivity studies on some hermatypic corals by means of both oxygen and ^{14}C method. *Proc. Symp. Corals and Coral Reefs*, C. Mukundan and C. S. Gopinatha Pillai (Ed.), Marine Biological Association of India, Mandapam Camp : 43–58.

Qasim, S. Z. and V. N. Sankaranarayanan, 1970. Production of particulate organic matter by the reef on Kavaratti atoll (Laccadives). *Limnol Oceanogr.*, **15** : 574–578.

Qasim, S. Z. and P. M. A. Bhattathiri, 1971. Primary production of a seagrass bed on Kavaratti Atoll (Laccadives). *Hydrobiologia*, **38** : 29–38.

Qasim, S. Z., P. M. A. Bhattathiri and C. V. G. Reddy, 1972. Primary production of an atoll in the Laccadives. *Int. Revue. ges. Hydrobiol.*, **57**: 207–225.

Sargent, M. C. and T. S. Austin, 1949. Organic productivity of an atoll. *Trans. Am. Geophys. Un.*, **30** : 245–249.

Sargent, M. C. and T. S. Austin, 1954. Biologic economy of coral reefs. *Prof. Pap. U. S. Geol. Surv.*, **260**-E: 293–300.

Sournia, A. and M. Ricard, 1974. Production primaire planctonique dans deux lagons de Polynesie francaise (ile de Moorea et atoll de Takapoto) *C. R. Acad. Sci.* Paris. *t* **280**(10 fevrier 1975) Serie D : 741–743.

Sournia, A. and M. Ricard., 1976. Phytoplankton and its contribution to primany productivity in two coral reef areas of French Polynesia. *J. exp. mar. Biol. ecol*, **21**.

UNESCO, 1966. Determination of photosynthetic pigments in sea waters. *Monographs on Oceanographic methodology*, **1**: 1-69.

Yonge, C. M., 1969. Conservation of coral reefs. *Micronesica*, **5**: 307-310.