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PRIMARY PRODUCTION IN COASTAL WATERS

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INTRODUCTION

The data on primary production from the Bay of Bengal and the Andaman Sea are very meagre. The Danish Galathea Expedition during her round-the-world cruise, made some measurements across the Indian Ocean through the equatorial current system and in the Bay of Bengal, of which two stations were from the Andaman Sea. It was observed that in the eastern part of Bay of Bengal, the lower bound ry of the photosynthetic layer was between 84-99 m and the stations located on the shelf were characterised by a high rate of production. In the Galathea report (Steemann Nielsen and Jensen, 1957), it was concluded that the monsoon shift has some influence on the rate of production in the Bay of Bengal and that extensive investigations during the different seasons are necessary in order to get a true picture of the production of organic matter.

Galathea was followed by R.V. *Vityaz* in 1956-60 and a few measurements were taken during her 31st-33rd cruises in the Bay of Bengal and Andaman Sea. Immediately following *Vityaz*, the International Indian Ocean Expedition (IIOE) started its programme and collected extensive data relating to various biological and hydrological parameters with a few observations on phytoplankton productivity. Other measurements of primary production were those of Nair *et al.* (1968) and Nair and Pillai (1972) which also do not cover the different seasons but the pre-monsoon season only.

In view of the vast potential for mariculture activities in the coastal areas of Andaman-Nicobar Islands, it was decided to cover the entire stretch of islands from Diglipur (North Andaman) to Campbell Bay (Great Nicobar). This account embodies the results of productivity measurements made during the pre-monsoon period of 1978.

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BRIEF REVIEW OF EARLIER WORKS

The major factor limiting the production is the depth of the euphotic zone which has been found by Galathea to be rather low in the northern regions, presumably due to the organic and inorganic material conveyed by the Ganges, Brahmaputra and other river systems. Around the Andamans, on the other hand, there is an increase in the depth of the euphotic zone which is between 65-75 m during the pre-monsoon period and 75-90 m during the monsoon period. Further, in the offshore regions it exceeds 90 m indicating clear oceanic condi ions, while for the major part of the Bay of Bengal, towards the coast, it is less than 50 m. The other important factor governing the production is the depth of the mixed layer which is around 60 m during most part of the year, while in the central part of the bay it exceeds 80 m.

The Galathea measurements showed that the vicinity of the western side of Andamans had a rate of production of 0.31 $gC/m^2/day$ (Steem nn Nielsen and Jensen 1957). Nair (1970) calculated the production rate for the offshore waters of the Bay of Bengal as 0.19 $gC/m^3/day$. Radhakrishna's (1978) recent measurements also give a comparable average of 0.16 $gC/m^2/day$. Nair and Pillai (1972) observed that the annual production of the reef area in the Andaman Sea was 1200 gC/m^2, which is of a lesser order than that of similar reef areas. Kabanova (1964) during the 33rd cruise of *Vityaz* found that the primary production in the central part of the Andaman Sea was 114-176 $mgC/m^2/day$ and that the area was characterised by greater concentration of nitrates than the other regions. According to this author, in the Bay of Bengal and in the Andaman Sea, phosphates were almost exhausted by the production of phytoplankton. The surface production of the Bay of Bengal is less when compared to the Arabian Sea, This can be attributed to the greater cloud cover over the Bay of Bengal, as compared to Arabian Sea, which reduces the incident radiation and inhibits primary production at the surface and also due to the heavy load of nitrogen and phosphorus brought about by rain runoff (Qasim, 1977).

The primary production value for the Andaman Sea during the monsoon period averaged for 0-50 m depth is over 50 $mgC/m^3/hr$ which would amount to nearly 2 $gC/m^2/day$. This is comparable to the high production in some of the regions of the Arabian Sea. So it can be reasonably inferred that the production rate of Andaman Sea in the upper 50 m is of a higher order equal to the northern regions of the Bay of Bengal Rest of the Bay especially the western half during the corresponding period exhibits a low rate of production (2 $mgC/m^3/hr$ (Krey and Babenard, 1976).

Results and Discussion

The temperature of the coastal waters during the period of observations ranged from 27-32°C and salinity 27-33‰. The pH ranged from 7-8.5, especially in the mangrove areas investigated and the dissolved oxygen content was 4.0-5.5 ml/l. Due to lack of facilities, the nutrient analysis of the water could not be carried out.

Phytoplankton

During the present investigation, the phytoplankton samples were collected by means of a ½ metre bolting nylon net (mesh size-0.069 mm) by surface haul of 10 minutes duration. Altogether 39 samples were collected from the Andaman-Nicobar Islands. Since the samples were obtained by means of a net, the quantitative estimation of the organisms could not be made. The qualitative studies reveal that 56 species of phytoplankters occur: 22 species of Diatomaceae, 33 species of Dinophyceae and one species of Myxophyceae (blue-green algae). The inshore samples were dominated by Dinophyceae especially species of *Ceratium, Peridinium, Ornithocercus, Dinophysis, Phalacroma, Pyrocystis* and *Pyrofacus* and the near shore samples predominantly contained Diatomaceae such as *Rhizosolenia* spp., *Guinardia flaccida, Biddulphis sinensis, Streptotheca indica* and *Chaetoceros* spp. The blue-green alga *Trichodesmium thiebautii* was present in all the inshore samples collected from the Nicobar group of islands. The Silicoflagellates and Coccolithophores were totally absent in these samples.

During the 31st cruise of *Vityaz*, Sukhanova (1962) found that in the Indian Ocean region near Nicobar Islands, the phytoplankton component was dominated by dinoflagellates. This feature reveals a ' basic Indo-Oceanic complex ' as suggested by Sukhanova. During the 33rd cruise of *Vityaz*, Zernova (1962) made a study of the quantitative distribution of the phytoplankton of the Bay of Bengal and Andaman Sea and she found that the total quantity of phytoplanton was high (6100 cells/m^3) in the Andaman Sea compared to the low values (1200 cells/m^3) of Arabian Sea. However, Zernova and Ivanov (1964) found that in the Bay of Bengal phytoplankton number did not exceed 500 cells/m^3. According to them, a higher phytoplankton number (> 5000 cells/m^3) was found to the south-west of the Nicobar islands and in the Andaman Sea.

Chlorophyll

The chlorophyll values also indicate a high seasonal variability in the Andaman Sea. The values as reported in the IIOE Atlas (Krey and Babenard, 1976) are considerably higher during the November-April period. A zone of higher phytoplankton production near the Nicobar islands is evident reaching upto 300-500 $\mu g/m^2$. Values ranging between 200-300 $\mu g/m^3$ have also been observed near Car Nicobar, Little Andaman and part of South Andaman. This high density of chlorophyll is observed in the Andaman Sea even upto 75 m depth in certain regions. But in May-October period, the values are considerably less. This is in contrast to a higher concentration of chlorophyll observed during May-October period in the Arabian Sea.

Primary production

The primary production measurements by ^{14}C technique were carried out at 42 stations in the Andaman-Nicobar islands. Of these 26 stations are from typical coastal waters and 16 stations from the mouth of the mangrove areas. The results of the present investigations are given in Table 1. The results indicate that there is considerable variation in unit volume production ($mgC/m^3/day$) as well as the production per unit area ($gC/m^2/day$). The mangrove areas, in general, contrast with the mangrove swamps of the mainland, being less productive. The reason for this low production may perhaps be due to the less light penetration and greater quantity of detritus reducing the oxygen content. The phytoplankton is predominantly of Dinophyceae and quantitatively of much less magnitude. The Diatomaceae in general was found to be very poor. The production rate ranges from 0.07 to 3.6 $gC/m^2/day$. The main centres where production rate exceeds 0.5-1 $gC/m^2/day$ are Mayabunder, Rangat, Chiriyatapu, Havelock, Corbyn's Cove, Navy Bay, Phoenix Bay and Shoal Bay regions of Andamans, Hut Bay of Little Andaman, Kimios and Sawai Bay of Car Nicobar, East Bay of Katchall and Spiteful Bay of Nancowry. The depth of the euphotic zone ranges 30-50 m depending on the depth of the area. This is in contrast to the open ocean area of Andaman Sea where the euphotic zone extends from 75-90 m.

It has been generally observed that as the continental shelf margins of the oceans are approached, the standing crop will increase. The same increase is presumed to exist with nearness to island shores. This hypothesis has been tested by Doty and Oguri (1956) in the Hawaiian waters which has been termed as 'Island Mass Effect'. This phenomenon could be applicable in the case of Andaman Sea as well. These authors noted a consistent increase in carbon fixation as shore is approached. The values obtained by Galathea, IIOE and other expeditions show that the deeper water stations between 1000-3000 m have on the whole a production rate of 0.1 to 0.2 $gC/m^2/day$ whereas the shallow water stations, both in the continental shelf and near island masses, have a production rate exceeding 0.5 $gC/m^2/day$. Doty and Oguri (1956) have attributed this increase in production due to runoff from high islands and percolation

TABLE 1. *Primary production values of Andaman-Nicobar coastal waters*

		$mgC/m^2/day$	$gC/m^2/day$	Nature of ecosystem
Andaman Islands				
1. Table Islands			0.86	Rocky shore
2. Diglipur (surface)		169		Creek muddy
3. Mayabunder :	North		2.7	Rocky and sandy
	Middle Channel		2.3	Sandy and marshy
	Oyster point		0.57	Rocky
	Mayabunder jetty		2.16	Boulders with sandy
4. Rangat (surface)		923		Mangrove fringed shallow
	Mangrove area		0.32	Marshy bottom
	Jetty		0.61	Marshy and sandy
5. Shoal Bay			0.57	Muddy exterior deep
6. Havelock Island			1.47	Rocky intertidal
7. North Bay (Port Blair)			0.18	Reef
8. Navy Bay (Port Blair)			2.09	Muddy shallow
9. Phoenix Bay (Port Blair)			2.09	Slushy mangrove shore
10. Sesostris Bay (Port Blair)			1.7	Mangrove fringed sandy
11. Ross Island (Port Blair)			0.23	Fouled reef
12. South Point (Port Blair)		1040		Rocky reef
13. Corbyn's Cove South			3.6	Muddy flat with creeks
14. Burmanalla		375		Sand stone flat
15. Wandoor		470		Slushy mangrove
16. Chiriyatapu			0.57	Sandy reef
17. Macpherson strait			0.85	Deep water
18. Rutland Island			0.14	Rocky area deep water
19. North Cinque			1.07	Sandy shore
20. Little Andaman ;	Hut Bay		0.54	Sandy
	Butler Bay		0.48	Rocky intertidal sandy
Nicobar Islands				
1. Car Nicobar :	(i) Hog point		1.63	Sandy
	(ii) Sawai		1.02	Sandy and rocky
	(iii) Tee-Top jetty	140		Sandy and rocky
	(iv) Passa	1370		Sandy
	(v) Malacca	230		Reef
	(vi) Kimios Backwater		0.51	Marshy mangrove
	(vii) Arong	1010		Rocky rough
2. Katchall ;	East Bay		2.35	Sandy reef
	West Bay	340		Rocky rough
3. Camorta :	Jetty (Cross Harbour)		0.22	Marshy reef
	Kakana		0.27	Sandy reef
	Beresford Channel	280		Deepwater
4. Nancowry :	Champin jetty		0.39	Sandy calm
	Spiteful Bay		0.56	Calm mangrove fringed
	Mangrove area	280		Marshy
5. Trinkat Island (west side)		230		Thick reef
6. Great Nicobar ;	Campbell Bay		0.17	Sandy area with dead corals
	Vijaynagar	980		Sandy reef

from low islands. It is also postulated (Doty, 1954) that the benthic algae as well as endozoic species and those found in the reef regions accumulate inorganic nutrients from the passing waters which are relatively poor in nutrients which will in turn be leached out making it available to planktonic algae. Thus there is overwhelming evidence to conclude that as island masses are approached, productivity increases. The higher values noted on the eastern side of the Andaman Islands by Nair *et al.* (1968), as compared to the values observed offshore, could be due to this process of local enrichment.

According to Nair and Pillai (1972), the Andaman reef areas have an annual production of 1200 gC/m^2 and the respiratory requirements of the organisms in the reefs far exceed production and hence the reef in the South Andaman at least is non-autrotrophic. The efficiency of gross production is also low here because of the relative sparseness of phytoplankton and paucity of benthic algae. Further they stated that the reefs of the Andaman Sea especially of the Nicobar islands may be having a different level of total community metabolism. Though the organic production of the waters of Nicobar islands is comparatively high due to luxuriant growth of corals, it lends support to the contention raised by Gorden and Kelly (1962) that there is considerable variability between different coral reefs at the level of total community metabolism.

For determining the potential for mariculture activities, it may be more advantageous to assess the potential productivity of the surface waters for the different seasons. It would appear that the potential productivity of the surface waters is distinctly higher during the May-October period and the integrated values of daily production of the euphotic layer is also higher during the same period. However, all data indicate that though the waters of the Nicobar islands seem to be highly productive, larger part of the production is consumed by the reef fauna leaving very little surplus for the ecosystem. Therefore, in certain regions of Andamans, it is likely that the potential productivity of the ambient waters may not be available to the ecosystem as a whole.

References

Doty, M. S. 1954. Floristic and ecological notes on Raroia. *Atoll. Res. Bull.*, **33** : 1-41.

Doty, M. S. and M. Oguri. 1956. Island Mass Effect. *J. cons. Int. Explor. Mer.*, **22** : 33-37.

Gorden, M. S. and H. M. Kelly. 1962. Primary production of an Hawaiian coral reef. A critique of flow respirometry in turbulent waters. *Ecology*, **43** : 474-480.

Krey, J. and B. Babenard. 1976. Phytoplankton production. Atlas of the International Indian Ocean Expedition. *Inst. Meer. Kiel Univ.*, 1-70.

Kabanova, Ju. G. 1964. Primary production and nutrient salts content in the Indian Ocean waters in October-April 1960-61. *Trud. Inst. Okeanol.*, **44** : 85-93.

Nair, P. V. R. 1970. Primary productivity of the Indian Seas. *Bull.* 22, CMFRI, 1-56.

Nair, P. V. R. and C. S. G. Pillai. 1972. Primary production of some coral reefs in the Indian Seas. *Proc. Symp. corals and coral reefs*, 33-42. Mar. biol. Ass. India.

Nair, P. V. R., Sydney Samuel, K. J. Joseph and V. K. Balachandran. 1968. Primary production and potential fishery resources in the seas around India. *Proc. Symp. Living Res. Seas around India*, Cochin, 184-198.

Qasim, S. Z. 1977. Biological productivity of the Indian Ocean. *Indian J. Mar. Sci.*, **6** (2) : 122-137.

Radhakrishna, K. 1978. Primary productivity of the Bay of Bengal during March-April 1975. *Indian J. Mar. Sci.*, **7** (1) : 58-60.

Steemann Nielsen, E. and E. A. Jensen. 1957. Primary oceanic production. *Galathea Rept.*, Copenhagen, **1** : 49-136.

Sukhanova, I. N. 1962. On the specific composition and distribution of the phytoplankton in the northern Indian Ocean. *Trud. Inst. Okeanol.*, **48** : 27-39.

Zernova, V. U. 1962. Quantitative distribution of the phytoplankton in the Northern Indian Ocean. *Trud. Inst. Okeanol.*, **48** : 45-53.

Zernova, V. U. and Ju. A. Ivanov. 1964. On the distribution of phytoplankton as depending from hydrological conditions in the northern part of the Indian Ocean. *Trud. Inst. Okeanol.*, **44** : 257-264.