

Food Components of the Andaman Sea

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Detrital carbon in the Andaman Sea constitutes about 92% of the total particulate carbon while phytoplankton and zooplankton constitute small fractions of the total suspended matter. Latitudinal relationship between phytoplankton and zooplankton is inverse. The Andaman Sea is oligotrophic in nature with low primary and secondary productivity and hence the production of large quantities of detritus appears to supplement the nutritional inadequacy of these waters.

Particulate material, forming the food, in the open ocean consists of both living (phytoplankton and zooplankton) and non-living (detritus) components. The techniques for the estimation of living matter in the sea are fairly well known but the detritus is largely estimated as the difference between the total suspended material and the living matter, generally in terms of organic carbon. In these estimations, the total bacteria and other microflora present in the water are not taken into account as living matter separately.

Recent studies on the energy pathways of the Laccadive Sea have indicated that the contribution of detritus to the total suspended matter is very high¹. During the 4 cruises of *RV Gaveshani* in the Andaman Sea (51 and 52 in Feb. 1979 and 67 and 68 in Jan./Feb. 1980), the detrital part along with the other food components, was estimated.

The Andaman Sea is perhaps one of the least known areas of the Indian Ocean. Apart from the observations by Sewell² on the oceanographic conditions of this area and a few remarks on the thermal structure³, some physical and chemical features, deduced from the data collected during the IIOE^{4, 5}, are available. The Andaman Sea extends to about 650 km east from the Malaysian Peninsula to about 1200 km southwards from the Irrawaddy delta in Burma⁷. It has a total area⁸ of about 0.602×10^6 sq km, volume 0.660×10^6 cubic km and mean depth of 1096 m. Two major rivers—Irrawaddy and Salween—from Burma drain into the Andaman Sea. The former⁹ has an average discharge of $13560 \text{ m}^3/\text{second}$ or $426 \text{ km}^3/\text{yr}$ and from this river alone the Andaman Sea receives 250 million tonnes of sediments/yr. Other major rivers, the Ganga, Brahmaputra, Mahanadi, Godavari and Krishna¹⁰ collectively discharge on an average $40749 \text{ m}^3/\text{second}$ or $1300 \text{ km}^3/\text{yr}$ of fresh water into the Andaman Sea.

Thus, the large quantities of sediments and other materials brought to the Andaman Sea from outside make the study of particulate material in this region of the Bay of Bengal particularly important.

Materials and Methods

Detrital content of the particulate matter was studied at 36 stations during the 4 cruises (Fig. 1). Of these, 19 were occupied during Feb. 1979 and 17 during Jan./Feb. 1980. The total number of deep

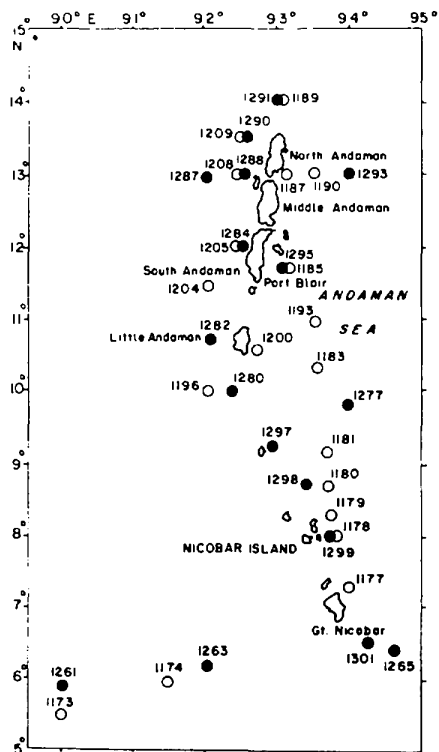


Fig. 1—Position of stations occupied during the 4 cruises of *RV Gaveshani* in the Andaman Sea ([O, Feb. 1979 cruises; ●, Jan./Feb. 1980 cruises])

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stations, where observations were made was 27 and the rest were shallow stations (Table 1). From each station water samples were collected using van Dorn Sampler at 5 depths within the water column of 0-200 m at deep stations and at 3 depths or more between 0-100 m at shallow stations. From each depth, 5-10 litre of water was filtered through preweighed GF/C Whatman glass filter pads and the pads were dried to constant weight and weighed again. The total suspended matter in terms of dry weight was estimated from the difference in the 2 weights. Particulate organic carbon (POC) of the settled material was determined by Bhattathiri and Devassy¹¹, chlorophyll (Chl) *a* at each depth was measured fluorometrically on board the ship and all the values were integrated for the column of water to calculate per square metre. Chlorophyll values were converted to carbon using the well known conversion factor 1 mg chlorophyll = 50 mg carbon. Zooplankton samples from the entire column of water were obtained by vertical hauls of IOSN and the total biomass values were converted to dry weight and carbon using the conventional conversion factors given earlier¹. The carbon values of both phytoplankton and zooplankton thus known, the detrital carbon was determined by the difference from POC. Detrital energy was calculated from carbon using the conversion factor 1 mg carbon = 10 calories¹.

Results and Discussion

Suspended and particulate organic matter—At deep stations, within 0-200 m column of water, the total suspended matter varied very little quantitatively (Table 1). It ranged from 135 to 212 g dry wt./m² at 14 deep stations worked in Feb. 1979 and from 160 to 263 g dry wt./m² in Jan./Feb. 1980 at 13 deep stations. At the 5 shallow stations, on the other hand, the range was from 55 to 146 g dry wt./m² during Feb. 1979 and from 108 to 193 during Jan./Feb. 1980. In Jan./Feb. 1980, the total suspended matter was relatively higher than in Feb. 1979.

The particulate organic carbon also showed significant differences between the deep and shallow stations (Table 1). The average value for the deep stations was 12 g C/m² whereas for the shallow stations it was 6 g C/m² during Feb. 1979. In Jan./Feb. 1980, the mean values for deep and shallow stations were almost similar (17.3 and 17.4 g C/m² respectively; Table 1).

Living matter—Phytoplankton carbon varied widely both at deep and shallow stations, the mean values for all the stations being 353 mg/m² and 440 mg/m² during Feb. 1979 and Jan./Feb. 1980 respectively. Zooplankton carbon also showed a large variation during Feb. 1979 and had an average value of 207 mg/m². Much higher values of zooplankton

carbon were recorded in Jan./Feb. 1980 (av. 793 mg/m² for deep stations and 610 mg/m² for shallow stations). Both phytoplankton carbon and zooplankton carbon were significantly higher in Jan./Feb. 1980 than in Feb. 1979.

Fig. 2 shows the latitudinal variation in phytoplankton and zooplankton carbon. Relation between the 2 appears to be inverse, i.e. where the phytoplankton carbon was high, zooplankton carbon was low and vice versa. Maximum phytoplankton carbon was observed between lat. 5° and 8° N, whereas zooplankton carbon was maximum at 11°, 14° and 7° N, during Feb. 1979. In Jan./Feb. 1980, zooplankton carbon was 5-10 times higher than in Feb. 1979 at all stations, although its latitudinal relationship was similar to that of the latter (Fig. 2).

Detritus—In Feb. 1979, except for a single value at 1173, where the detritus, like POC, was exceptionally high, the range in values was small and did not vary significantly in relation to latitudes at all the other stations (Fig. 2). In Jan./Feb. 1980 the detrital values were much higher and there was a significant difference in the values between the latitudes. Lowest values were recorded from 7 to 9° N and high values at all other latitudes (Fig. 2). Detrital carbon constituted about 92% of the total POC in the suspended matter and there was practically no difference in this value between the cruises. Detrital energy varied from 25 to 479 kcal/m² (av. 111.5 kcal/m²), at deep stations and about 52.3 kcal/m² at shallow stations during Feb. 1979 (Table 1). The values were higher in Jan./Feb. 1980 (av. 165.7 kcal/m²) and there was no difference between the deep and shallow stations (Table 1).

In the Laccadive Sea, the average contribution of detritus is of the order of 97%. The average phytoplankton carbon is 213 mg/m², zooplankton carbon 450 mg/m² and the detrital carbon 2932 mg/m² (see ref. 1).

Both Laccadive and Andaman Seas are oligotrophic in nature with low primary and secondary productivity. The former is a coral sea with an archipelago of 24 atolls and many submerged banks of coral origin scattered in between. The Andaman Sea, on the other hand, has 15 islands of volcanic origin with luxuriant fringing coral reefs around many of these islands. Presumably the large quantities of organic detritus present in the suspended matter in the 2 seas is to supplement the nutritionally inadequate food in these waters. However, what could possibly be the source of detritus in the open ocean and where does it come from? Some explanation of the possible source of detritus from the organic pool existing in the ocean has been given earlier¹. The contribution made by heterotrophic bacteria and other microflora to the quantity of organic matter present in the sea appears to

Table 1—Integrated Values of Different Living and Non-Living Components in the Andaman Sea and the Percentage of Detrital Carbon and Detrital Energy during Feb. 1979 and Jan./Feb. 1980

| St No. | Total suspended matter g dry wt./m ² | POC gC/m ² | Chl <i>a</i> mg/m ² | Phytoplank- ton carbon mg/m ² | Zooplank- ton dry wt mg/m ² | Zooplank- ton carbon mg/m ² | Detrital carbon g/m ² | Detrital carbon % | Detrital energy kcal/m ² |
|--------------------------------|--|--------------------------|-----------------------------------|--|--|--|--|-------------------------|---|
| Feb. 1979 | | | | | | | | | |
| Deep stations (depth: 0-200m) | | | | | | | | | |
| 1173 D | 205.2 | 48.9 | 7.45 | 372.5 | 740 | 253.08 | 47.9 | 98.02 | 479 |
| 1174 D | 195.5 | 7.41 | 7.45 | 372.5 | 300 | 102 | 6.93 | 93.5 | 69.3 |
| 1177 D | 223. | 8.45 | 10.8 | 540 | 740 | 253.08 | 7.65 | 90.6 | 76.5 |
| 1178 N | 185.5 | 8.25 | 10.7 | 535 | 440 | 150.48 | 7.56 | 95 | 75.6 |
| 1179 D | 197 | 7.47 | 15.3 | 765 | 320 | 109.44 | 6.59 | 94.2 | 65.9 |
| 1180 D | 188 | 2.95 | 3.4 | 170 | 600 | 205.2 | 2.57 | 87.2 | 25.7 |
| 1181 D | 135 | 5.11 | 1.35 | 67 | 740 | 253.08 | 4.79 | 92.4 | 47.9 |
| 1183 N | 187.5 | 3.36 | 6.45 | 322.5 | 900 | 307.80 | 2.88 | 85.7 | 28.8 |
| 1189 N | 212.5 | 7.35 | 4.97 | 248.5 | 725 | 247.95 | 6.55 | 93.2 | 68.5 |
| 1190 D | 185 | 8.43 | 10.42 | 521 | 320 | 109.44 | 7.78 | 92.4 | 77.8 |
| 1193 D | 184 | 11.25 | 4.15 | 207.5 | 1640 | 560.88 | 10.48 | 93.2 | 104.8 |
| 1196 D | 156.5 | 17.46 | 4.75 | 237.5 | 530 | 181.26 | 16.76 | 96.1 | 167.6 |
| 1204 D | 193.2 | 17.53 | 2.25 | 112.5 | 740 | 253.08 | 16.86 | 96.2 | 168.6 |
| 1209 D | 205.5 | 11.55 | 9.3 | 465 | 1340 | 458.28 | 10.62 | 92 | 106.2 |
| Shallow stations | | | | | | | | | |
| 1185 D ^a | 55 | 0.98 | 2.13 | 106.5 | 315 | 107.73 | 0.76 | 77.5 | 7.6 |
| 1187 N ^b | 132.5 | 10.8 | 7.92 | 396.5 | 450 | 153.9 | 10.28 | 95.2 | 102.8 |
| 1200 D ^c | 80 | 2.59 | 1.32 | 66 | 150 | 51.3 | 2.47 | 95.4 | 24.7 |
| 1205 N ^d | 145.5 | 7.8 | 1.48 | 74 | 150 | 51.3 | 7.67 | 98.3 | 76.7 |
| 1208 D ^e | 145 | 5.47 | 3.45 | 259.5 | 360 | 123.12 | 5.08 | 92.9 | 50.8 |
| Jan./Feb. 1980 | | | | | | | | | |
| Deep stations (depth: 0-200 m) | | | | | | | | | |
| 1261 N | 195.9 | 20.04 | 7.7 | 385 | 2550 | 872.4 | 18.74 | 93.7 | 187.4 |
| 1263 N | 240.2 | 11.26 | — | — | 3600 | 1231.2 | — | — | — |
| 1265 D | 205.2 | 26.76 | 18.32 | 915 | 1600 | 547.2 | 24.8 | 94.4 | 248 |
| 1277 D | 263.3 | 23.16 | 16.2 | 810 | 1540 | 526.6 | 21.32 | 92 | 213.2 |
| 1280 D | 214.5 | 12.38 | 10.25 | 512.5 | 1960 | 670.3 | 11.2 | 90.7 | 112 |
| 1282 N | 209.8 | 19.44 | 8.55 | 427.5 | 2500 | 855 | 18.16 | 93.4 | 181.6 |
| 1287 D | 205.2 | 19.4 | 2.5 | 125.2 | 3020 | 1032.8 | 18.24 | 94 | 182.4 |
| 1290 D | 226.4 | 17.14 | — | — | 2650 | 906.3 | — | — | — |
| 1291 D | 216.2 | 22.24 | 3.6 | 180 | 2300 | 786.6 | 21.17 | 95.6 | 211.7 |
| 1297 N | 246.4 | 11.22 | 2.72 | 136 | 2500 | 855 | 10.13 | 91 | 101.3 |
| 1298 D | 243.2 | 8.96 | 6.23 | 311 | 1430 | 489 | 8.16 | 91 | 81.6 |
| 1299 N | 227.5 | 9.9 | 14.25 | 712.5 | 2560 | 875.5 | 8.3 | 83.7 | 83 |
| 1301 N | 160.6 | 23.1 | 6.55 | 327.5 | 1940 | 663.4 | 22.11 | 95.7 | 221.1 |
| Shallow stations | | | | | | | | | |
| 1284 D ^a | 160.6 | 19.48 | 4.3 | 135 | 1575 | 538.6 | 18.81 | 96.5 | 188.1 |
| 1288 D ^c | 110.5 | 13.52 | 9.01 | 450.5 | 1645 | 562.5 | 12.42 | 91.9 | 124.2 |
| 1293 D ^b | 108.9 | 16.18 | 2.38 | 119 | 1500 | 513 | 15.55 | 96.1 | 155.2 |
| 1295 N ^b | 193.3 | 20.72 | 0.46 | 23 | 2425 | 826.3 | 19.87 | 95.8 | 198.7 |

Depth (m): a = 0-30, b = 0-100, c = 0-50, d = 0-80 and e = 0-75

D = Day station and N = Night station

be far greater than the contribution of phytoplankton and zooplankton. Detritus appears to originate from the dissolved organic matter as flakes or flocculent particles which remain suspended enriching the food value of the water column.

Recent studies on the hand-collected samples of 'marine snow' or 'macroscopic organic aggregates' by

SCUBA diving from the shallow neritic waters have indicated that marine snow occurs in the sea in large quantities as amorphous and fragile particles. The organic matter contained in the marine snow forms a potential source of food to other animals¹². The snow is composed of passively sinking particles such as faecal pellets, thick-walled diatoms, frustules of

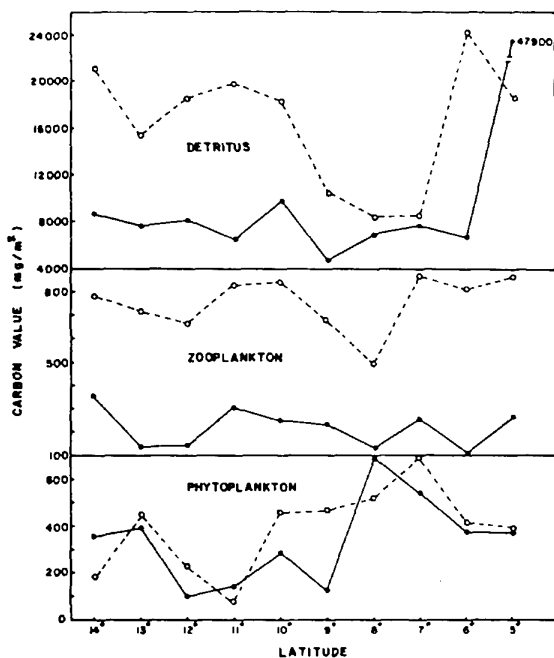


Fig. 2—Carbon values of phytoplankton, zooplankton and detritus in relation to latitudes [—, 1979 cruises; ----, 1980 cruises]

diatoms, microflora, etc., and motile organisms such as dinoflagellates and ciliates. The particles constituting marine snow range from 0.05 to 10 cm and these are of much ecological significance as microhabitat and pelagic food sources¹³. The snow contains nutrients in much greater concentrations than the surrounding waters¹⁴. The sinking rate of large particles of marine snow is about 68 m/day and as a result of sinking about 4% of particulate organic carbon and nearly 15% of particulate organic nitrogen are removed by marine snow from the surface water¹⁵. Although no detailed studies have been carried out so far on the snow of the open ocean, it is of common occurrence in the sea and has been reported from the atolls of the Laccadives¹⁶ and also from the deeper waters of the Caribbean Sea¹⁷. Possibly, the occurrence of this type of material in suspension increases the detrital content of the water column.

Primary production—Average primary production of the Andaman Sea¹¹ has been estimated to be 273 mg C/m²/d. At this rate, the primary production of the entire Andaman Sea (area 0.602 × 10⁶ km²) would be approximately 6 × 10⁷ tonnes of carbon/year.

Secondary production—Average zooplankton biomass¹⁸ of the Andaman Sea estimated as zooplankton carbon is 288.8 mg C/m². Assuming that about 50% of the biomass gives rise to daily rate of secondary

production, the total production of the next trophic level for the entire area of the Andaman Sea would be of the order of 3.173 × 10⁷ tonnes of carbon/yr. The 50% figure is based on a series of conversions from biomass values to secondary production which range from 3-98%¹⁹.

Tertiary production—As given elsewhere^{1, 20} for the open ocean 0.1% of primary production and 1% of secondary production are to be taken for calculating the tertiary production. The mean of the 2 gave a value of 18.70 × 10³ tonnes of carbon/year. In terms of live weight the figure would be 18.70 × 10⁴ tonnes/year (using factor 10). In the Andaman Sea, like the Laccadive Sea, the major exploited stocks largely include long-lived tuna, bill fishes, etc. Therefore, 25% of potential yield could be taken as the exploitable stock. This would amount to 470.00 tonnes of fish/year. The average fish landings in Andaman and Nicobar islands during 1975-1979 were about 1500 tonnes each year. Hence, a considerable increase in the total yield appears to be possible.

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