

ANDAMAN SEA - ITS PHYSICAL, CHEMICAL AND BIOLOGICAL CHARACTERISTICS

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The Andaman and Nicobar group of Islands are located in the south-eastern part of the Bay of Bengal. The two groups are comprised of 325 islands of which only a few are inhabited. The islands are of volcanic origin. Most of these islands are surrounded by fringing reef on their eastern side and barrier reef on their western side. It harbours a rich population of corals, molluscs and are surrounded by thick mangrove vegetation. Geographically the sea on the east of these groups of islands is termed as Andaman Sea. This sea on the north form a part of the Bay of the Bengal through the Prepara channel and on the south it is connected with the South China sea through the Malacca strait. The Andaman sea occupies an area of 6.02×10^5 sq km and has average depth of 1096 meters.

INTRODUCTION

Andaman sea is one of the least investigated regions of the Indian Ocean. Oceanographic research in the Andaman sea dates back to 1869 when Francis Day visited these islands. Thereafter a number of investigations were carried out in the region. The most comprehensive and outstanding study of the Andaman sea was carried out from 1913 to 1925 by Seymour Sewell and published in the memoirs of the Asiatic Society of Bengal. In the recent past the important ships which carried out oceanographic surveys in the Andaman sea were INS Kistna and R.V. Anton Bruun during the International Indian Ocean Expedition. However, the comprehensive investigations on many aspects of oceanography were carried out only during 1979-80 by R.V. Gaveshani. Two major rivers draining into the Andaman sea are the Irrawaddy and Salween with the former having an average discharge of $13560 \text{ m}^3/\text{sec}$ (Coleman, 1968). The quantity of sediment carried by Irrawaddy is estimated to be approximately 363 million tonnes annually (Groves and Hunt, 1980). The Andaman sea and Bay of Bengal are separated by three channels. From north to south the Prepara channel divides the region at 20°N depth. The depth of the ten degree channel between Andaman and Nicobar islands has a depth of 1800 m. Great channel between great Nicobar islands and Sumatra has a depth of 1800 m. Exchange of water between the two regions occurs through these channels.

PHYSICAL PROPERTIES OF THE ANDAMAN SEA

The Andaman sea is influenced by large quantities of freshwater runoff from the perennial rivers of Burma, Thailand and Malaysia. This runoff largely influences the topmost

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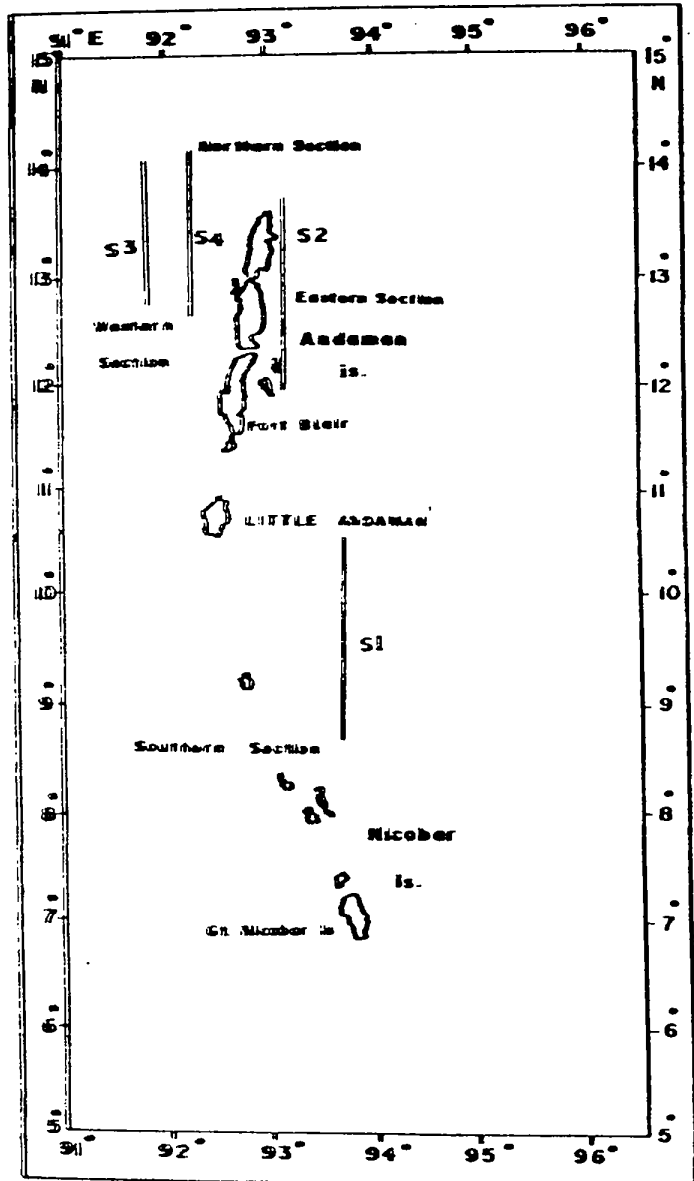


Fig. 1 Sections around Andaman and Nicobar Islands

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layers by reducing the salinity of the surface water. Below the surface layer oceanic conditions prevail. There are some reports available on the physical and hydrographical features of the waters of the Andaman sea (Gangadhar Rao and Jayaraman, 1968; Garg et al., 1968; Wyrki, 1971, Maslennikov, 1973; Rao, 1981, Gouveia et al., 1981, Bhattathiri, 1984). Most of the authors have described the hydrographic features sectionwise in the Andaman sea as is shown in Fig. 1.

TEMPERATURE

The depth of the mixed layer is reported to vary from 44 to 58 m along western section and along eastern section it is 50 to 75 m. In section I the surface temperature is 28.07 to 28.65°C with decreasing trend showing against increase in depths. The thermocline was found between 180 to 280 m in this section. In section II the surface temperature variation is 27.0 to 28.5°C. Similarly on section three and 4 the surface temperature variation was narrow. Vertically the temperature profile is reported to show a decrease upto 3°C to a depth of 500 m with little variation between the observation point. Overall the surface temperature in the Andaman sea vary within the narrow limit (Bhattathiri, 1984). During the north-east monsoon the surface temperature slightly drops with values of 25 to 28°C are reported. Some temperature inversions are also reported in the northern region of the Andaman sea. The thermocline is demarcated by a 12°C isotherm in the Andaman sea. In the eastern section the temperature profile below 1500 m has been reported to show an increasing trend, a feature not found in the other parts of the Andaman sea. Such a phenomenon has been reported to be due to heat flow from beneath or with volcanic activity associated with the islands and sea mounts (Ramaraju *et al.*, 1981). There is another explanation for these higher temperature in these basins. Ramesh Babu and Sastry (1976) attributed it to the enclosed nature of the basin with depths around 1300 m above which the temperature distribution is similar on either side of the island chain.

SALINITY

The dynamic of the upper layer of the Andaman sea is controlled by the salinity. The thickness of the freshened water on the western side is greater than on the eastern side. The basic feature of the distribution of salinity is the development of fairly strong vertical and horizontal gradients in the near surface layer (0-100 m) in the Andaman sea. Surface water salinity shows wide variations (11.06 to 32.0×10^3) as reported by Bhattathiri, (1984). The surface salinity values are higher towards southern side. The low salinity of the surface water are reported to be due to the high river discharges during the northeast monsoon season and the Irrawaddy runoff. Below surface the salinity increases rapidly resulting in the development of a strong halocline in the top layer. Below halocline gradual increase in salinity are reported with maximum values in the region of 75 to 100 m in the eastern section (Bhattathiri, 1984). Like temperature, salinity inversions are also reported from the eastern section of the Andaman sea. Gangadhar Rao and Jayaraman (1968) and Rao (1981) have reported strong vertical and horizontal gradients of salinity particularly in the upper layer of the Andaman sea.

It may be inferred that the surface water in the Andaman sea behaves more like an estuarine water while the sub-surface water represents typical marine conditions.

DISSOLVED OXYGEN

Andaman sea surface water is super-saturated upto 115%. At depths of 100 m the oxygen saturation varies from 14 to 28%. Dissolved oxygen in the surface water is uniformly distributed with the values from 4.42 to 5.54 ml/l, reported by Bhattathiri (1984). Ramesh Babu and Sastry (1976) reported a uniform value of surface oxygen at 4.6 ml/l. In the vertical distribution Garg *et al.*, (1968) reported less thickness of oxygen rich layer in the Andaman sea which was further confirmed by Bhattathiri (1984). Gangadhar Rao and Jayaraman (1968) concluded that spreading of the river discharge from Irrawaddy influences the distribution of oxygen in the upper 75 m during the pre-monsoon season. Oxygen values in the section I and II decreased to 0.94 ml/l at 100 m. In the northernmost section the oxygen minimum layer was found between 200 and 300 m. Along the north-south section IV and V the oxygen saturation was found to vary from 107 to 127% at the surface. Highest level of saturation was found at the eastern most region. The supersaturation of oxygen was found at depths varying from 53 to 78 m in the western section.

CHEMICAL PROPERTIES

Studies on the chemistry of waters in the Andaman sea have been few and far between. One of the earliest efforts involved gas chromatographic measurements of nitrogen and oxygen (Swinerton, 1962), this incidentally was among the first reports of its kind from the ocean. The results showed that seawater was nearly saturated with respect to oxygen at all the depths. In the foregoing accounts the oxygen data agreed reasonably well with the Winkler values.

An incidence of abnormally high phosphate concentrations ($>12 \mu\text{mole dm}^{-3}$) was reported by Reddy *et al.*, (1968) from some stations located closer to the islands, occupied by INS Kistna as a part of the IIOE. This was thought to result from a possible calcium phosphate precipitation. Subsequent studies undertaken in the same region, however, failed to confirm this feature (Sengupta *et al.*, 1981). Naik and Reddy (1983) examined the calcium phosphate saturation levels within the Andaman sea, but did not find any appreciable supersaturation, nor were the calcium and phosphorus contents of the sediments.

Perhaps the most comprehensive study dealing with the chemistry of Andaman sea has been that of Sen Gupta *et al.*, (1981). Based on an intensive geographical coverage achieved during 1979-80 cruises of R.V. Gaveshani, these authors presented vertical profiles of several properties and studied relationships between oxygen and nutrients. Their results suggested the following ratio:

$\Delta \text{AOU} : \Delta \text{C} : \Delta \text{Si} : \Delta \text{N} : \Delta \text{P} = 252 : 98 : 29 : 14 : 1$. These probably reflect lower silicate concentrations and somewhat different stoichiometric composition of organic matter

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as compared to the Arabian sea.

A contemporary investigation undertaken by Noronha *et al.*, (1981) dealt with the major ions, calcium, magnesium and fluoride. The high Ca : Cl ratio reported by them (0.02224) is among the highest observed in the oceans, resulting perhaps, from large runoff from Irrawaddy. High calcium enrichment in near-bottom water was also observed; this was attributed to intense solution of CaCO_3 (aragonite) supplied by the numerous coral reefs. Ratios of magnesium and fluoride to chlorinity (0.04455 and 7.15×10^{-5}), on the other hand, agreed fairly well with the oceanic averages.

BIOLOGICAL PROPERTIES

Chlorophyll a and Primary Production - Primary productivity in the Andaman sea has been studied from the time of IIOE by Kabanova (1964). More recently Qasim (1977), Bhattathiri and Devassy (1981), Devassy and Bhattathiri (1981) and Bhattathiri (1984) have given a good account of the primary production in the Andaman sea. Andaman sea is less productivity than the Bay of Bengal. Observation of the chlorophyll 'a' shows great deal of variation in the surface layer. The values varied from 0 to 0.098 mg/m^3 during January/February. The average value for the entire area is 0.03 mg/m^3 . Chlorophyll 'a' concentration at 60%, 30%, 10% and 1% light depths was 0.044, 0.039, 0.043 and 0.057 mg/m^3 respectively in the Andaman sea. The chlorophyll 'a' in the water column varied from 0 to 11.0 mg/m^2 averaging 2.33 mg/m^2 . These values are lower than those reported from the Laccadive seas.

The phytoplankton count in the Andaman sea is reported to range from 1200 to 4000 in the surface water. Genera like *Navicula* sp., *Coscinodiscus* sp., *Denticula* sp., and *Trichodesmium thiebautii* are the most abundant phytoplankton species reported from the Andaman sea (Devassy and Bhattathiri, 1981). The primary production values at the surface reported by various authors shows higher magnitude of variation. The primary production at the surface in the Andaman sea varies between 1.25 to $67.31 \text{ mg C/m}^3/\text{day}$ with an average value of $12.13 \text{ mg C/m}^3/\text{day}$. At 60%, 30%, 10% and 1% light depths the production values varied from 3.21 to 67.31, 1.08 to 42.59, 1.88 to 20.24 and 0.66 to $8.46 \text{ mg C/m}^3/\text{day}$ respectively. The column production rates in the area ranged from 196 to $1218 \text{ mg C/m}^2/\text{day}$ with an average column production of $426 \text{ mg C/m}^2/\text{day}$. The average primary production for the entire region was $272 \text{ mg C/m}^2/\text{day}$ (Bhattathiri, 1984). The magnitude of primary production in the Andaman sea as given by Qasim (1977) is found to be within 250 to $500 \text{ mg C/m}^3/\text{day}$. Earlier report indicated a production of 114 to $117 \text{ mg C/m}^3/\text{day}$ by Kabanova (1964).

The concentration of particulate organic carbon has been studied by Bhattathiri (1984). Values at the surface varied from 0 - 465 mg/m^3 . Generally the values were lower in the western section than in the eastern section. POC concentration at 60, 30, 10 and 1% light depth varied from 0-315, 0.210, 0.195 and 0-195 mg/m^3 . Column values of POC were varying from 7.19 to 25.69 g/m^2 with an average value of 16.40 g/m^2 .

In discussing the primary production it is important to mention about the extracellular production and its role in the Andaman sea. The only data available on this aspect is by Pant (1981). The extracellular production by phytoplankton is low in the Andaman sea compared to Laccadive sea and varies from 1.79 to 0.18 mg C/m³/h. Its column production values are between 80.3 mg C/m²/day to 766 mg C/m²/day. Glycollate, one of the products, is reported to be in the range of 370 to 150 µg/l. The extracellular production was high at the surface and decreased to 0% at the bottom of the euphotic zone.

Zooplankton : Before IIOE virtually nothing was known about the zooplankton standing crop of Andaman sea. Even during IIOE this area had been scantily studied as far as zooplankton are concerned. It was during the 51, 52, 67 and 68 cruise of R.V. Gaveshani, in the year 1979-80 that a comprehensive study, covering the entire geographical area, was conducted. The data of these cruises are published by Madhupratap *et al* (1981a, 1981b) and Nair *et al* (1981).

The biomass of the zooplankton in the Andaman sea is reported to be poor (Fig.2). The average value is in the order of 5.6 ml/100m³. The most dominant groups are copepoda, chaetognatha and tunicata. The average standing crop is 288.8 mg C/m³ in the upper 200 m collection. From the IIOE collection the biomass in this area is reported to be 1 to 12.4 ml/100 m³. The total zooplankton count ranged between 760 to 13900/100 m³. In general the composition of zooplankton is constituted by a mixture of neritic and oceanic species with euryhaline marine forms dominating the zooplankton. The diversity is uniformly high in the Andaman waters. 13 species of chaetognaths are reported (Nair *et al*, 1981) from the Andaman sea. Similarly 48 species of copepods, 16 species of ostracods and 11 species of euphausiids are reported besides the decapod larvae in the zooplankton samples (Madhupratap *et al* 1981a).

Many of the Zooplankton distribution in the Andaman sea are related to thermocline structure. Groups like chaetognatha, Appendicularia, Decapoda, Thaliacea and Euphausiacea showed high aggregation above the thermocline layer while the ostracods and many of the less common forms were usually in great abundance below the thermocline. It has been reported that discontinuity layer may act as barrier to any species of zooplankton as far as their vertical migration is concerned.

Biochemical constituents of zooplankton were worked out by Goswami *et al* (1981). Protein was the dominant constituent in the biochemical composition. The overall mean values of protein was 45.14%, lipids 10.6% carbohydrates 4.2%, organic carbon 33.5% and total nitrogen 7.2%.

Benthos - Bottom fauna of the Andaman sea has been studied in details by Parulekar and Ansari (1981) and Ansari and Parulekar (1981). Earlier reports are based on scanty material and mainly relate to trophic structure (Sokolova and Pastenak, 1964; Neimann, 1973).

Sediment Characteristics - Sediment distribution in the Andaman sea, as reported by Parulekar and Ansari (1981), is given in Fig. 3. The substratum presents a composite picture

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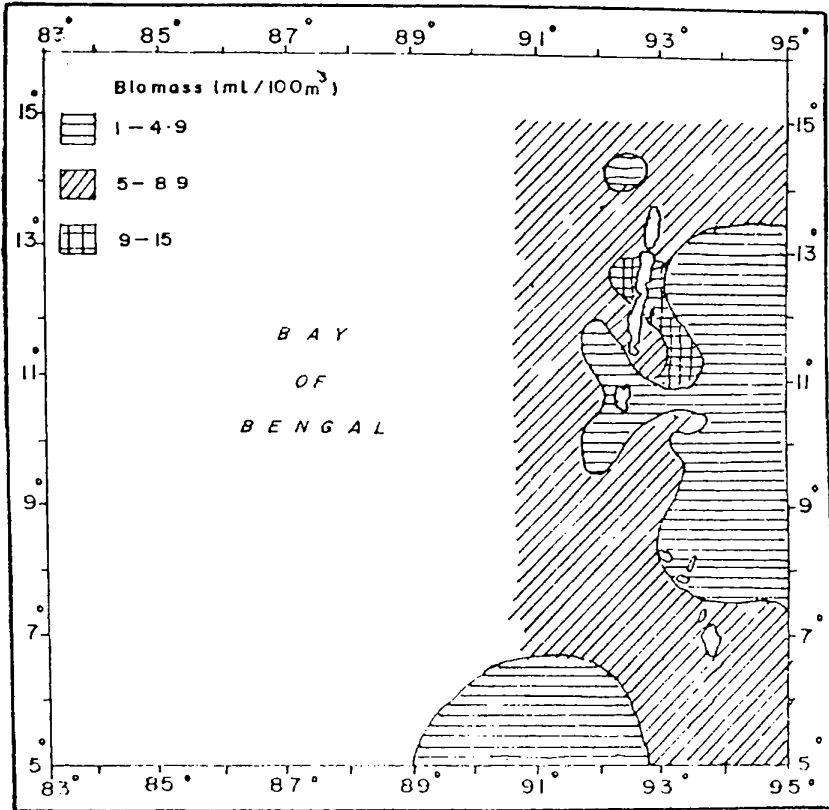


Fig. 2 Distribution of zooplankton biomass in the Andaman sea

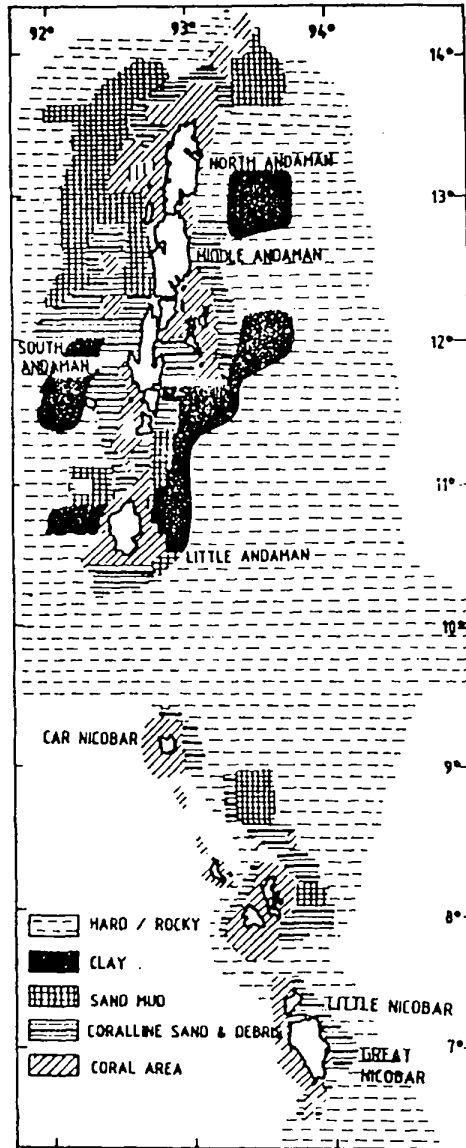


Fig. 3 Bottom sediments in the Andaman sea
(Numbers indicate the depth (m) distribution)

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of sea bottom with sediment ranging from hard rock to sandy mud and coralline sand. The western section is dominated by sandy mud in the northern region and coralline sand in the southern region. On the eastern section the sediment is more of clay type and coralline sand. The deeper section of the sea is mostly hard and rocky.

Among benthos the macrofauna comprised of 22 faunal taxa. Of these the polychaetes were the most dominant contributing 76% of the fauna. Macrofaunal density in the Andaman sea varies from 80 to 998/m² with a fairly high average of 406/m². Mean standing stock biomass varied from 0.3 to 74.4 g/m² with an average of 6 g/m². One of the features of the distribution of macrobenthos in the Andaman sea is a well demarcated depth zonation. Seventeen

	depth (m)			
	0-200	200-1000	1000-2000	>2000
faunal group	17	9	6	1
mean density (m ²)	460	241	468	764

taxa were found on 0-200 meters while only one group was observed in the deepest zone. The macrofauna showed a distinct substrate specificity. In muddy deposit of sand and silt the density is maximum followed by coralline sand.

The meiobenthic density was in the range of 68 to 438/10 cm² with average value of 247/10 cm² and the biomass was within the range of 3.557 and 32.8 mg/10 cm². Faunal components were maximum in sandy desposits and diminished in coarse coralline sand. In their vertical distribution the meiofauna is reported to be mostly restricted to the top 2 cm layer of the sediment at all water depths and showed highly contageous distribution.

Average benthic production in the Andaman sea is reported to be in the range of 0.39 and 1.9 C/m²/year with an average value of 1.27 g C/m²/year. The annual biomass production for the Andaman sea as a whole is 0.2 x 10⁶ tonnes/year. Benthic production in the Andaman sea is higher than in the Laccadive sea.

The Andaman sea is oligotrophic in nature with low primary (273 mg/m²/day) and secondary production (288.8 mg C/m²). The production of detritus therefore appears to supplement the nutritional inadequacy of these waters. The detrital carbon constitute about 92% of the total particulate carbon in the Andaman sea (Qasim and Ansari, 1981).

Tertiary production - The Andaman sea is known to be rich in marine wealth. Based on the primary and secondary production in the Andaman sea the tertiary production has been estimated. Qasim (1977) has used 0.1% of primary production and 1% of secondary (zooplankton) production for calculating tertiary production in Indian Ocean. Qasim and Ansari (1981) calculatted 18.7x10³ tonnes of carbon per year as a mean of the primary and secondary production in the Andaman sea. Using a factor of 10 they estimated 18.7x10⁴ tonnes/year as live weight. The major exploited stock in the Andaman sea largely include long lived

tuna, bill fishes etc. Therefore 25% of the potential yield could be taken as the exploitable stock. This would amount to 47000 tonnes of fish per year. The average fish landing in Andaman and Nicobar islands is about 6587 tonnes during 1984-85.

Based on benthic secondary production the potential yield of demersal catch estimated is about 158 kg/ha. Considering 60% as the harvestible yield, it would amount to 94.8 kg/ha as against the present catch of about 5 kg/ha. These figures indicate that there is possibility of increase in the total yield, both pelagic and demersal, fish catch of the Andaman sea.

Among other investigations carried out in the Andaman sea, studies on microbiology were reported for the first time by Matondkar (1981). He reported bacterial counts of 2.1×10^7 to 3.7×10^6 in the sediment. Phenolic degraders were present in high concentration in the southern region of sea. Majority of the organisms were gram-negative and non motile. Other studies of importance is on nannoplankton (Pant and Misra, 1976). Gupta (1981) reported 38 species of nannoplankton from recent sediment of which 14 are modern and 24 are the reworked fossil. Solimabi *et al* (1981) have reported 38 species of nannoplankton from recent sediment of which 14 are modern and 24 are the reworked fossil. Solimabi *et al* (1981) have reported bromine and iodine in some marine organisms from Andaman and Nicobar islands. Kureishy *et al* (1981) reported mercury concentration in fishes of the Andaman sea.

Overall the Andaman sea is poorly investigated inspite of the fact that it has rich and varied resources of living and non-living origin. Attempts are being made by the National Institute of Oceanography to collect more data on various aspects of oceanography from this region and increase our present state of knowledge.

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