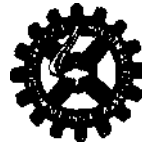


**national institute of  
oceanography, India**

**1973**



# **ANNUAL REPORT**

**1973**



**NATIONAL INSTITUTE OF OCEANOGRAPHY**

( Council of Scientific & Industrial Research)

DONA PAULA, GOA

INDIA

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## general introduction

During the year under report, 45 projects were under investigations. Of these, 5 projects were sponsored by the Government and private bodies.

Physical oceanographic studies were made largely on the coastal problems. These were conducted on harbours, beaches and nearshore waters off Goa, Cochin and Bombay.

The investigations made on the chemical aspect were largely concerned with the distribution of inorganic nutrients and trace elements, physico-chemical factors responsible for fouling etc. Chemical aspects of pollution in the waters of Bombay were also studied.

The areas covered under marine geological studies were on the shelf and slope, coastal and nearshore waters and estuaries. The studies made were on sedimentological, geochemical, mineralogical and micropalaeontological aspects.

The biological work was carried out on almost all the levels of trophic chain and the studies included productivity, zooplankton and benthos. Some efforts were also made on the development of aquaculture in coastal waters. While most of these studies were conducted in the estuarine and nearshore waters, a new project, entitled, oceanography

of the waters around Lakshadweep (Laccadives Sea) was also initiated. Special efforts will shortly be made to explore the possibilities of algal farming, turtle farming and oyster culture on the atolls of Laccadives.

Two sponsored projects were continued from the previous year, and three new projects were undertaken during the current year on specific problems specified by the sponsors.

The projects on instrumentation have made a considerable headway towards the fabrication of salinometer, current-meter and on the development of marine electronic system for the acquisition of oceanographic data through telemetry. The workshop and maintenance, servicing and calibration facilities of oceanographic and electronic instruments are now available at the Institute.

Planning and Data Division has continued to offer data and information service to the users of oceanographic data and information pertaining to the Indian Ocean.

Shri V. V. Giri, the President of India, laid the corner stone of the buildings of the Institute, and Shri C. Subramaniam, Minister for Industrial Development, Science and Technology,

laid the foundation stone of the buildings of Regional Centre of the Institute at Cochin, during the current year.

Work on to the modifications, conversion and refitting of the R. V. *Gaveshani*, continued during the year at the Garden Reach Workshop, Calcutta.

Dr. N. K. Panikkar, the founder Director of the Institute received the Chandrakala Hora Memorial Medal for Fisheries. He retired on 17th August 1973.

Scientists of the Institute participated in the MONEX-73 cruises planned under

the Global Atmospheric Research Programme (GARP). Many young scientists of the Institute also participated in the INS *Darshak* Oceanographic Expedition to the north-eastern Indian Ocean sponsored by the Indian Naval Hydrographic Office, Dehra Dun. The six-month participation in the expedition is likely to produce interesting results.

The Institute published the IIOE Plankton Atlases Vol. IV and V, and the Volumes IV and V of the Handbook to the International Zooplankton Collections.

— *DIRECTOR*

# 2

## research activities

### 2.1

#### physical oceanography

##### 2.11 Oceanic Properties

1. Oceanographic Studies at Mormugao and Cochin Harbours

##### 2.12 Physical Processes

1. Beach Studies along the Goa and Kerala Coasts
2. Physical Studies of the Estuaries of Goa
3. Studies on Aguada Bar
4. Studies on the Beach Sediments along the Goa Coast

##### 2.13 Waves

1. Wave Studies off Goa using Wave Recorders

##### 2.14 Circulation

1. Circulation in the Shelf Waters off Goa

##### 2.15 Tides and Sea Level

1. Studies on Variation in Mean Sea Level

##### 2.16 Marine Geophysics

1. Gravity and Magnetic Anomalies
2. Studies on Geo Acoustics
3. Studies on Bottom Sediments

##### 2.17 General

1. "Monex-1973"
2. Cruises of INS *Darshak* in the N. E. Arabian Sea
3. IGOSS Programme
4. Hydrographic Survey off the Central West Coast of India

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The Physical Oceanography Division continued to operate the existing programmes of the coastal and nearshore environment. Thus oceanographic studies of Mormugao and Cochin harbours, physical and geochemical studies on the beaches of Goa and Kerala, physical studies on the estuaries of Goa, studies on Aguada Bar, circulation of shelf waters, studies on mean sea-level variations and wave studies using wave recorders were continued.

Scientists from the Division participated in the Monex-73, planned under GARP and conducted physical oceanographic observations on board INS *Darshak*.

Synoptic observations on the short wave radiation, wind speed and direction, sea surface temperature and salinity, light penetration, etc. were started as part of the IGOSS Programme.

The Geophysics Section conducted studies on the gravity and magnetic anomalies, geo-acoustics and bottom sediments of the Mormugao harbour.

A detailed report of the Divisional projects is given in the following paragraphs, the findings of the 'sponsored projects' undertaken during the year are given separately.

## **2.11 Oceanic Properties**

### **1. Oceanographic Studies at Mormugao and Cochin Harbours**

Based on the data collected at the Mormugao Harbour and in the adjoining Sea in 1972, a paper entitled "Hydrography and suspended sediment load of the oceanic and estuarine waters adjoining Mormugao Harbour during early summer" is prepared and submitted for publication.

Similar studies in the neighbouring region were conducted during August - September 1973 at the request of Captain of Ports, Goa and Mormugao Port Trust. The observations at orxel point (in Aug. '73) indicated currents with speeds upto 25 cm/sec and waves of the order of 2.5 m height.

The studies carried out in the region of the Cochin harbour approach channel with a view to examine the variations in the pattern of siltation revealed that there are two distinct zones, one between 2000 to 6000 ft (610 to 1830 m) and the other beyond 6000 ft (1830 m) in the approach channel, of homogeneous bottom sediments, but with different sedimentation rates. The 2000 - 6000 ft (610-1830 m) zone showed a lesser rate of sedimentation compared with the other.

## **2.12 Physical Processes**

### **1. Beach Studies along the Goa and Kerala Coasts**

Along the Goa coast, the studies carried out on a macro scale at Baina beach with special reference to the effects of dumping dredged material from the Mormugao harbour area indicated progressive build up of the beach and shallowing up of the nearshore zone at the place of discharge owing to the slow rate of littoral movement. The details of the findings have been incorporated in a paper entitled, "Effects of artificially dumped material on the configuration of the Baina beach, Goa."

Along the Kerala coast, the regular observational programme on the beach changes was continued. In all a total of 50 beach profiles were taken. All along the beaches studied, there was a general trend of accretion or stability. At Purakkad, the presence of the mudbank created a calm zone aiding the build up of the beach. The width of the beach extended from 60 m to nearly 100 m during the year.

### **2. Physical Studies of the Estuaries of Goa**

The data collected for studying the physical aspects of the Mandovi - Zuari estuarine system with a view to understand the circulation and salinity patterns and the mixing processes in the estuaries are being processed and analysed.

Studies on the data collected in the upstream region of Chapora estuary during the post-monsoon period in 1972,

at the request of Government of Goa, Daman and Diu, revealed the following salient features.

The temperature shows a characteristic diurnal variation attaining a maximum in the afternoon hours. The salinity increases from surface to bottom and in general varies between 18‰ and 4‰. Maximum currents of the order of 60 cm/sec are encountered during peak ebb. The sediment load and turbidity of the waters are generally low. A linear relationship between turbidity and attenuation coefficient is inferred.

### **3. Studies on Aguada Bar**

The observational programme carried out towards an understanding of the formation and maintenance of the Aguada bar has been completed. The results of sediment movements along-shore inferred from dyed sand tracers are being finalized. Preliminary studies indicate that there is a circular flow pattern within a part of the Caranzalem bay that replenishes the Aguada Bar with sediment whereas on the navigation channel side of the bar the sediment is transported away from there by the river flow or the tidal flood and ebb.

### **4. Studies on the Beach Sediments along the Goa Coast**

*Geochemical* : The concentrations of iron, manganese, titanium, cobalt and organic carbon in 11 beach and 58 marginal sediments off Calangute and Colva were estimated. The results indicate that the concentrations of these elements are low in the beach and surf zone sediments compared to the corresponding marine sediments. The percentages of iron, manganese, titanium and cobalt

range from 1.0 to 8.9, 0.01 to 0.11, 0.50 to 0.93 and 0.001 to 0.009 respectively. The low values are found to be associated with coarse grained sediments. Further, the elements are concentrated in clays and silt and clay fraction of the sediments. The organic carbon content of the sediments varied between 0.05 to 4.30%.

## **2.13 Waves**

### **I. Wave Studies off Goa using Wave Recorders**

The observational programme on wave characteristics, namely, period, height and direction, was continued during the year under review, barring the monsoon season. These studies will help in understanding the land-sea interaction. Problems like beach erosion and form the basis for coastal engineering. Future requirements may include wave energy tapping and offshore operations like oil drilling, structures etc. The results obtained from the earlier observations were incorporated in a paper entitled, "Fair weather wave characteristics off Goa."

## **2.14 Circulation**

### **1. Circulation in the Shelf Waters off Goa**

This study was being carried out by using sea-bed drifters which were made indigenously following Woodhead's design. These studies are oriented towards a better understanding of sediment transport and upwelling which has an important bearing on fisheries.

Some of the preliminary studies carried out were presented in a paper



entitled, "Circulation in the shallow waters of the shelf region using sea-bed drifters."

## **2.15 Tides and Sea Level**

### **1. Studies on Variation In Mean Sea Level**

Analysis of tide data for the period 1965-70 for Mormugao Port indicated the following :

During the course of each year, the mean sea level at Mormugao is subjected to consistent seasonal rises and falls, reaching its lowest value during the south-west monsoon and the highest during the north-east monsoon. The annual maximum occurs during December/January and minimum during August/September. A secondary maximum in June and a secondary minimum in May are also noticed. The average annual range of the mean sea level is about 18 cm. The study is in progress.

## **2.16 Marine Geophysics**

### **1. Gravity and Magnetic Anomalies**

Aeromagnetic data for the North Arabian Sea and Bay of Bengal were obtained on our request from the U. S. Coast and Geodetic Survey, USA.

In Bay of Bengal the total magnetic field data are available along four profiles in the form of analogue records. The length of each profile extends more than 1000 miles across the Bay of Bengal. All the data were digitized for each half a mile and the anomalies were computed by Least Square method. Analysis and interpretation of the data to estimate the depth and the intensity of magnetization of the anomalous crustal features is in progress.

In the North Arabian Sea the data are available in the form of contour map covering an area between 20° to 24°N and 60° to 75°E. The area was divided into 91 profiles in North-South direction with the profile length extending more than 300 miles. The data was digitized for each mile for all the profiles. Computation of anomalies by least square method is in progress.

### **2. Studies on Geo-Acoustics**

Forty sediment core samples were collected over the inner shelf between Karwar and Vengurla. The length of each sample varied between 2 and 3 ft. Physical properties of the sediments like grain density, bulk density, porosity and moisture content were determined. Longitudinal wave velocities and the acoustic impedance of the sediments at different depths were estimated with the help of ultra-sonic flow detector, which was obtained on loan from NPOL, Cochin. Studies on the inter-relationship of the physical and acoustic properties and the formulation of mathematical models are in progress.

### **3. Studies on Bottom Sediments**

Studies on the grain size distribution of the Mormugao Bay surface sediments collected in 1972 were completed. These studies have revealed that the sediments along the Bay Margins are predominantly sands, well to moderately sorted, positively skewed and leptokurtic. From the Bay margins to the Central Bay and Eastern Bay the sediments are mainly silts and clays, poorly to very poorly sorted, negatively skewed and platikurtic. The transportation and deposition of sediments inside the Bay are believed to be mainly due to the subaqueous erosion by the waves and currents along the Bay margins and by the process of silting

of suspended load as well as the silting of material brought by river Zuari in the centra) and eastern parts of the Bay. Near Bay mouth, the regional distribution of sands indicates a patch of coarse material which suggests that the sediments are being carried into the bay in NW-SE direction. But the topographic data do not indicate any surface relief in the bottom topography. It is therefore concluded that the deposition of material in this region due to the incoming waves, and currents is much less and does not contribute for the silting at the Bay mouth.

## 2.17 General

### I. "Monex-1973"

The monsoon experiment was planned as a programme of Global Atmospheric Research Programme. Scientists from Physical Oceanography Division participated in the cruises of Soviet Research Vessel "*Ocean*" and the Indian-Naval Ships under Indo-USSR Joint Expedition for studying the Indian Summer Monsoon during May-July 1973. Some results of the analysis of the data collected on board Soviet Research Vessel are incorporated in a paper entitled, "Preliminary studies on hydrographical features of the Northwestern Indian Ocean in May during Monex-1973" in the Seminar held at Cochin on 11-7-1973.

Studies on the data on thermal structure, collected on board Indian Naval ships, indicated the following features :

Along 20° N latitude, thickness of the mixed layer varied between 20 and 43 m, during the premonsoon - period. In July when the monsoon was fully developed

mixed layer thickness of 53 m, was observed. Thickness of the order of 80 m or more was generally observed in the Arabian Sea during the southwest monsoon. The marked increase in the mixed layer thickness appears to be a result of the intense mixing caused by wind. The studies are in progress.

### 2. Cruises of INS "Darshak" in the N. E. Arabian Sea

During these cruises, temperature and salinity structures and light penetration in the sea were studied. Observations on light penetration in January indicated the depth of occurrence of 1% light intensity to vary from about 1.5 m in the coastal waters off Bombay to 60 m in the deeper waters of the northwestern Arabian Sea.

### 3. IGOSS Programme

As a part of the IGOSS (Integrated Global Ocean Station System) Programme, synoptic observations on short wave radiation, wind speed and direction, sea surface temperature and salinity, water transparency dry and wet bulb temperatures were initiated during February 1974. Regular observations are being carried out at 0830 hrs and 1730 hrs at a fixed station near Dona Paula.

### 4. Hydrographic Survey off the Central West Coast of India

The data collected at monthly intervals on board *Arjun Prasad* on the physical parameters during the fair weather season along the central west coast of India were processed. The results are being incorporated in a paper entitled, "Hydrographical features of the inner shelf waters along the central west coast of India during the premonsoon period."

## 2.2

### chemical oceanography

#### 2.21 Composition of Sea Water and Estuaries

1. Iron Cycle in the Mandovi and Zuari Estuaries and the Coastal Waters off Goa
2. Copper Concentrations in the Mandovi and Zuari Estuaries and in the Coastal Waters of Goa
3. Distribution of the Arsenic in the Inshore and Estuarine Waters around Goa
4. Biogeochemistry of Phosphorus and Nitrogen Compounds in the

Estuarine and Nearshore Waters of Goa

5. Carbon-dioxide System in the Estuarine, Inshore and Offshore Waters
6. Studies on Inorganic Nutrients, their Stoichiometry and Trace Metals of the Arabian Sea
7. Carbohydrate Concentration in the Waters of Goa Coast

#### 2.22 Marine Fouling and Pollution

1. Marine Fouling
2. Marine Pollution (Chemical)

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Investigations carried out during the year under review can be broadly classified into three categories: (i) distributional aspects of inorganic and organic constituents and their inter-relationship in the estuarine and coastal waters of Goa and in the Arabian Sea, (ii) chemical aspects of marine pollution and fouling and (iii) apparatus and methods.

Studies were continued on the distribution of inorganic nutrients and trace elements (Iron, Copper and Arsenic) in the coastal waters and estuaries of Goa. Work on biogeochemical cycle of phosphorus and nitrogen compounds carbohydrate concentrations and carbon-dioxide system in the estuarine and coastal waters of Goa was continued during the year. Under the NIO programme of participation in INS *Darshak* Oceanographic Expedition, studies were initiated on the Chemical Oceanography of the northern Arabian Sea, with emphasis on inorganic nutrients, stoichiometry and trace metals.

Preliminary work on the physico-chemical factors of fouling has been completed and studies on the efficiency of commercial anti-fouling paints were started. The effectiveness of cashew-nut shell liquid as a antifouling coat for wooden structures is also being tested.

An improved form of Secchi disc for measurements of light penetration in water was developed and tested. A new type of liquid dispenser to deliver an specific volume of water directly from the bottle was developed and completed, specifications were submitted to the Controller of Patents.

## **2.21 Composition of Sea Water and Estuaries**

### **1. Iron Cycle in the Mandovi and Zuari Estuaries and the Coastal Waters of Goa**

Iron is an essential growth promoting trace element for the marine organisms, and is an active element involved in the geochemical processes, controlling the concentration of many other elements of biogeochemical importance. In view of specific importance of Goa coast, being rich in iron ore deposits, studies on the cyclic changes of various factors of iron existing in the estuarine and coastal waters are undertaken to understand its biological and geochemical involvement.

Total soluble iron in the estuarine and coastal waters of Goa showed very high concentrations. The values in the inshore waters varied between 43-600 $\mu\text{g/l}$ , in the Zuari estuary between 68-527  $\mu\text{g/l}$  and in the Mandovi estuary between 113-865  $\mu\text{g/l}$ . These high values in these waters are generally due to the effect of leaching from iron ore rich terrain of Goa. Unlike the total iron concentration which was maximum during the monsoon period, the total soluble iron found to attain its peak during the month of December and this feature is mainly due to the decomposition of organic iron complexes by the bacterial action. The variations within the two estuaries suggest significant biochemical differences in the nature of the waters and the sediments. The observed high concentration of total soluble iron in coastal waters are mainly contributed by the rivers.

### **2. Copper Concentrations in the Mandovi and Zuari Estuaries and in the Coastal Waters of Goa**

The general distribution and seasonal variations of ionic copper in the inshore and the estuarine waters are highly erratic. In general, the levels are high in all the seasons with maximum during the monsoon period due to the effect of land run off. The range of variation in the coastal waters is between 3 to 44  $\mu\text{g/l}$  at the surface and 11 to 25  $\mu\text{g/l}$  at the bottom. The variations in the Mandovi estuary are from 6 to 36  $\mu\text{g/l}$  at the surface and 5 to 59  $\mu\text{g/l}$  at the bottom and in the Zuari estuary the surface values ranged between 11 to 36  $\mu\text{g/l}$  and the bottom values between 8 to 28  $\mu\text{g/l}$ .

### **3. Distribution of the Arsenic in the Inshore and Estuarine Waters around Goa**

Arsenic is toxic to man and marine organisms. It is a cumulative poison and marine organisms concentrate it providing a pathway to reach the human system through consumption of fishes and other edible marine biota. The present study enables to understand the limits of natural levels of arsenic occurring in the sea and estuarine waters with space and time, hitherto not investigated and also to have regular check on the probable elevated levels of arsenic due to pollution.

Total ionic arsenic concentrations in the inshore waters off Goa Coast are generally low (<1 $\mu\text{g/l}$ ) excepting the nearshore regions wherein the surface

values are between 2 and 10  $\mu\text{g}/\text{l}$  and bottom waters around 12  $\mu\text{g}/\text{l}$ . High values in the nearshore region are attributed to the proximity to the land which is also of ore bearing nature. In the estuarine waters (Zuari River) the arsenic concentrations are highly variable and are relatively higher than the inshore waters, ranging between 3 to 67  $\mu\text{g}/\text{l}$ . The higher values in the estuarine waters appear to be associated with the leaching from the ore bearing terrain.

#### **4. Biogeochemistry of Phosphorus and Nitrogen Compounds in the Estuarine and Nearshore Waters of Goa**

Dissolved inorganic phosphorus and the particulate phosphorus in the waters are generally low ( $< 0.6 \mu\text{g at}/\text{l}$  during the pre- and post-monsoon months in the inshore and estuarine systems of Mandovi and Zuari. High concentrations occur ( $>1 \mu\text{g at}/\text{l}$ ) during the monsoon period. During the same period particulate phosphorus forms the major portion of the total phosphorus as compared to the surface waters in all the seasons.

The different forms of inorganic nitrogen compounds, viz,  $\text{NH}_4^+ -\text{N}$ ,  $\text{NO}_2^- -\text{N}$  and  $\text{NO}_3^- -\text{N}$  also show the same trend as phosphorus compounds.  $\text{NH}_4^+ -\text{N}$  is found to be dominant form during the entire period. Bottom concentrations are always high.

#### **5. Carbon-dioxide System in the Estuarine, Inshore and Offshore Waters**

Carbon-dioxide system in the natural

waters, apart from controlling the biological productivity of the waters, is largely responsible for controlling the pH of the waters and affects the chemical equilibrium in the sea. This study is undertaken to understand the temporal and regional changes in different components of the carbon-dioxide system and their probable influence on the biological and geochemical conditions of the waters around Goa.

Total  $\text{CO}_2$  content of the estuarine waters (Mandovi and Zuari) which was found to be of the order of 2.05 millimols /l during the months January to the middle of March, registered a sharp fall to half the concentration during the subsequent months till May. This sharp fall in the total carbon-dioxide content is attributed to increased temperature of the waters causing the decreased solubility of  $\text{CO}_2$ . This is evidenced by the corresponding fall in the partial pressure of carbon-dioxide ( $\text{PCO}_2$ ). pH of waters also showed slight increase during the months April-May. However, during the entire period the predominance of bicarbonate concentrations over that of carbonate is maintained. Salinity of the waters indicate the marine dominance of the environment during the period April-May for a considerable stretch upstream.

#### **6. Studies on Inorganic Nutrients, their Stoichiometry and Trace Metals of the Arabian Sea**

Under the joint Oceanographic Expedition of INS *Darshak* 1973-74 extensive chemical data were collected from the north-eastern and northern

Arabian Sea during the period December 1973 to May 1974.

The area covered during the programme was between 20°30' to 24° 00'N, 59°30' to 70°00'E Long, and 19°15' to 21°30'N Lat., 68°00' to 72°30' E Long. comprising of 5 cruises covering 210 stations. The following chemical parameters were studied during this programme: dissolved oxygen, inorganic phosphate, total phosphorus, ammonia, nitrite, nitrate, pH and alkalinity. Analysis for few transition elements at selected depths are in progress.

In the northern Arabian Sea, oxygen concentrations showed two minima. The first one was present at depths between 150 and 300 metres while the second one was almost always around 1000 metres. Below 1500 metres, however, the oxygen concentration showed an increase with lower temperature and salinities which is probably due to the presence of a water mass of different origin.

Phosphate concentrations did not show any abnormality and increased almost continuously with depth. A very interesting feature was observed about the nature of the inorganic nitrogen compounds in the Arabian Sea, particularly in the northern region. At depths where the oxygen concentrations were almost at the limit of detection by the analytical method, nitrate and nitrite were not present in unusual high amounts. Ammonia concentration was also low at these depths. This indicate that the nitrate, resulting from the oxidation of organic matter and during denitrification, was probably converted to gaseous nitrogen. This phenomenon

is quite similar to that observed at intermediate depths off the coast of California in the Pacific.

Concentrations of nutrients below 1500 metres generally showed a decrease with increasing oxygen contents of the water mass. pH in the water column showed a gradual decrease with depth except below 1500 metres where it showed an increase continuing deeper down. This may be the result of carbonate precipitation as is observed in the deep waters of all the oceans.

On the continental shelf region during February through April nitrate was almost absent at depths between 30 and 50 metres associated with slight increase in the dissolved oxygen. Phosphate was, however, almost always present. This, perhaps, supports the conclusion that in the Arabian Sea, as in almost all oceanic regions, nitrate has a stronger influence to regulate the photosynthetic production than phosphate.

Oxygen concentrations in the upper layers decreased from January to April which is, perhaps, due to the effect of surface warming. The Arabian Sea being an area of negative water balance loses oxygen from its surface waters with evaporation. This process does not seem to have any effect below 20 metres, for oxygen concentrations between 20 and 40 metres were higher than the surface concentrations.

One very interesting feature was observed during February. In the surface waters at stations north of the mouth of

the Gulf of Cambay, nutrient concentrations were higher than the region south of the Gulf mouth. Studies to find out the proper explanation for the area are in progress from a detailed analysis of the data. It may depend on, perhaps, (i) higher production of organic matter south of the mouth of the Gulf and/or (ii) the Gulf may exercise some sort of ecological barrier as has been postulated from marine biological observations.

## **7. Carbohydrate Concentration in the Waters of Goa Coast**

Analysis of surface waters north of Goa (off Terekhol) for dissolved and particulate carbohydrates showed variations between 2.1 and 4.5 mg glucose and 0.21 to 0.28 mg glucose/l respectively. While the particulate carbohydrate concentrations are of the same order as reported in the waters from the other parts of the world, the dissolved carbohydrates are found to be higher in these waters.

## **2.22 Marine Fouling and Pollution**

### **1. Marine Fouling**

Preliminary studies on the various physico-chemical factors responsible for the settlement and growth of marine foulers in space and time in the local estuarine system and waters around Mormugao harbour have been completed. Further to augment the results drawn a study on the efficiency of the commercial

antifouling coatings on test panels against control has been planned and initiated. In addition, a study on the effectiveness of cashewnut shell liquid as antifouling coating for the wooden country, crafts and its optimum period has been conducted. The preliminary studies, show that the effective period has been observed to be about 45 days with two coats of cashewnut shell liquid when applied on wooden panels. But if the initially settled foulers are mechanically removed after a month the effectiveness can be increased to a further period of another month.

### **2. Marine Pollution (Chemical)**

Three stations off Bombay were repeated every cruise of INS *Darshak* to study short term variations of the parameters and eventual effects of pollution from the city. Apart from dissolved oxygen and nutrients Biological Oxygen Demand (BOD) was also measured at all the depths at the station closest to Bombay. It was observed that the rate of oxidation of organic matter is the most intense between 5 and 15 metres below which the rate was naturally rather slow.

Difference between  $BOD_2$  and  $BOD_5$  was not significant which indicates a very fast rate of decomposition of most of the organic pollutants, minus that portion which sediments. As the region is well aerated no appreciable depletion of oxygen in the water column could be observed.

## 2.3

### geological oceanography

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|---|--|
| <b>2.31 Marine Geology Continental Shelf and Slope of India</b> | 1. Mineralogy and Petrology                |
| 1. Geological History   | <b>2.33 Studies of Estuaries and Lakes</b> |
| 2. Micropalaeontology   | Sedimentation and Bottom Sediments         |
| 3. Geochemistry   | 1. Sedimentation and Bottom Sediments      |
| <b>2.32 Studies of Coastal and Near-shore Areas</b>             | 2. Deep Sea Drilling Project               |
- 

Research activity in the Geological Oceanography Division centered around three principal projects, viz., (1) Marine Geology of the continental shelf and slope of India, (2) Studies of coastal and nearshore areas, (3) Studies of estuaries and lakes.

Field programmes of the Division were also considerably augmented through participation in the INS *Darshak* cruise to the northern Arabian Sea.

Under the project 'Marine Geology of the continental shelf and slope of India', the geological history of the western shelf was investigated by radiocarbon dates and studies of bottom topography. Micropalaeontological aspects dealt with the planktonic forms and nanno fossils. The study of trace elements have brought out significant differences in the geochemistry of the various types of sediments on the western shelf. Petrography, mineralogy of sediment sample from Deep Sea Drilling Project sites 219 and 220 is being studied. The results of these studies are expected to contribute to a better understanding of the origin and evolution of ocean basins in general and in particular the western continental margin of India. More important, the outcome of these studies will be highly relevant to offshore mineral exploration on the western continental margin of India.

Under 'Studies of coastal and nearshore areas', the petrology and mineralogy of the rocks found along the Goa coast have been undertaken. Concurrently mineralogical studies of the beaches and dunes in this area were also carried out to understand the nature of minerals contributed by the coastal rocks to these sediments.

'Studies of estuaries and lakes' comprises sedimentological and geochemical aspects in combination with hydrographic characteristics of two different estuarine systems—the Vembanad Lake and the Mandovi and Zuari estuaries. Data obtained from these studies provide a basis for evaluating the degree and impact of possible pollution that may affect these estuaries and also provide essential information for port development, navigational problems and allied aspects.



## 2.31 Marine Geology of Continental Shelf and Slope of India

### 1. Geological History

Lowering of sea-level due to glaciation during the Pleistocene subjected the rocks and sediments on the continental shelf to attacks by the surf. The ancient shorelines on the western shelf were investigated by echosounding and subsequently by radiocarbon dating of calcareous shells and rock. The investigations show the presence of a number of submarine terraces dating between 9000-11000 years B.P. Provisional Holocene sea-level variation curve, based upon C-14 dates on the dredged samples, for the northern half of the western continental shelf shows general similarities to global Holocene still stands despite the seismic activity reported in this area.

### 2. Micropalaeontology

Studies of planktonic foraminifera indicate that the outer western shelf is dominated by relict fauna and substantiate the earlier sedimentological findings. The percentage of planktonic foraminifera increases from the shore to the outer shelf and upper continental slope and the species increase progressively with depth. An interesting finding is the presence of the cold water *Globigerina pachyderma* (Ehrenberg) in the slope sediments off Bombay. Preliminary studies of nanno fossils in the sediment samples from the Arabian Sea have shown the presence of the following :

*Gephyrocapsa* sp., *Emiliani huxley*, *Braarudosphaera* sp., *Ceratolithus* sp., *Coccolithus* sp., *Helicopontosphaera* sp., *Pontosphaera* sp., *Umbilicosphaera* sp., *Syracosphaera* sp., *Scapholithus* sp., *Pontosphaera* sp., *Arkhangelskiella* sp., *Fasciculithus* sp., In a sample collected at 2240 metres on the western continental slope *Braarudosphaera* bigelow, a shallow water form, was noticed and this suggests possible transport of sediments from shallow to deeper depths by turbidity currents.

### 3. Geochemistry

Studies of the distribution of copper in the sediments of the western shelf show that the lithogenous and non-lithogenous contributions are greater in the inner shelf silts and clays as compared to the outer shelf calcareous sands. The copper in the sediments was derived from detrital minerals originating on land and in part by adsorption on clay minerals and on hydrated oxides of iron and manganese.

About 100 samples collected from different parts of Vembanad lake were analysed for manganese, titanium, nickel, cobalt and copper to understand the behaviour of the elements in the different environments of the lake and to compare their concentrations with those in the adjacent continental shelf.

## 2.32 Studies of Coastal and Nearshore Areas

### 1. Mineralogy and Petrology

Geological traverses along the Goa coast have shown the presence of un-

usual mega-porphyrite dolerites intruding country rock comprising quartzites. The quartzites are considered to have formed under conditions of green schist facies. Textural studies of beach rock of Goa coast suggest that the beach rocks originated in environments with differing energy inputs. Mineralogical studies of the dune and beach sediments indicate low to high grade metamorphic, acid and basic igneous source rocks.

## **2.33 Studies of Estuaries and Lakes**

### **1. Sedimentation and Bottom Sediments**

The study of sediments of Vembanad Lake, a complex estuarine system with a number of rivers flowing into it, shows that coarse sediments are confined to the western margin of the southern half of the lake and finer sediments are found in the northern half. Sediment transport and depositional process as interpreted from grain size parameters indicate that bed load transport is confined to rivers Muvattupuzha and Ittupuzha rivers, rolling and suspension populations occupy the southern end of the lake and suspended loads are restricted to the estuarine regions.

Size analysis of sediments from the Mandovi and Zuari estuaries\* shows that the sediments in lower reaches of the estuary are composed of silts and clays whereas the upper reaches are dominated by fine sand. Monthly variation in sand size in the Zuari estuary

has also been studied in relation to benthic productivity.

### **2. Deep Sea Drilling Project**

Samples from Deep Sea Drilling Project sites in the Indian Ocean, viz., 219, 220, 221 are being studied in the Division. Site 219 on the Laccadive ridge shows a sedimentary sequence ranging from Paleocene to Recent. Phosphorite concretions in the early Eocene sediments indicate that upwelling on the western continental margin continues from Early Eocene. Conditions for formation of phosphorite were favourable only when shelf edge conditions prevailed on the site. The subsidence at the site which led to the formation of Laccadive Sea and subsequent separation of the ridge from the Indian sub-continent was initiated in the Early to Middle Eocene. Organic carbon, iron, titanium, manganese, cobalt and copper have been analysed in 52 samples from site 219, 25 from site 220 and 10 from site 221. Iron and titanium in the samples analysed show a distinct trend in that they are enriched in stratigraphic unit 1 (Middle Miocene to Pleistocene). Copper and manganese show enrichment in unit 4 (Early to Middle Eocene). The enrichment of Cu and Mn may be indicative of concentration by biogenous agencies but confirmation from further analyses is required. Studies of volcanic glass indicate that the percentage of glass in the acid insoluble residue varies from 11-43% in Pleistocene and 34-41% in the Miocene. The R. I. indicate that the composition of source volcanic rocks remained almost uniform (acid to intermediate) in both the sections.

\* Work carried out jointly with the Biological Oceanography Division.

The Division participated in the Oceanographic Expedition (OCEANO-VEX) of 'INS *Darshak*' in the north-eastern Arabian Sea.

During the 1st, 2nd, 3rd and 4th cruises, 27 cores, 71 snapper, 20 dredge and 28 water samples were collected in the shelf region between Bombay and Rann of Kutch. The sediments will be studied in the laboratory for sedimentological, Geochemical, carbonate, geomorphology and micropalaeontology and the water samples for sus-

pending load estimations. The preliminary examination of the sediments indicate that the inner shelf is covered with clays, silty clays (upto about 40 m) followed by silty sands and sands in the outer shelf region. The sandy sediments in the outer shelf region are relict sediments and are mainly composed of oolites, shells and corals. The oolites vary widely in size and colour and at one location oolitic rock (cemented oolites) was also dredged. Rock (sandstone with ferruginous encrustation) was also dredged at another location.

# 2.4

## biological oceanography

### 2.41 Invertebrates

1. Rearing and Maintenance of Planktonic Organisms in Natural and Laboratory Conditions
2. Marine Aquaculture
3. Taxonomy, Biology and Life Histories of Marine Molluscs

### 2.42 Algae

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2. Culture of Diatoms

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3. Management of Clam Fishery in Kali Estuary
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5. Physiology and Dynamics of the Growth of Prawn

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## 2.47 Zooplankton (IIOE Collections)

1. Systematic Study of Various Sub-sorted Groups
2. Preparation of IIOE Plankton Atlases
3. Preparation of Handbooks of the International Zooplankton Collections
4. Preparation of Illustrated Manual on Zooplankton
5. Sorting of Plankton Samples of UNDP Pelagic Fisheries Project

6. Studies on Fixation and Preservation of Marine Zooplankton
7. Studies on the Plankton of Cochin Backwaters

## 2.48 Oceanography of the Waters around Lakshadweep

## 2.49 Apparatus and Methods

1. Establishment of New Methodology to Identify Marine Population using Karyological, Serological and Bio-chemical Methods

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The investigations in respect of Biological Oceanography are carried out at the Biological Oceanography Division of the Institute at Goa and the Regional Centres at Cochin and Bombay. While some of the projects operated during the previous year were continued, a few new projects were started during the year under review, such as studies on aquaculture, oceanography of the Laccadives and on the effect of the weed *Salvinia auriculata* on the Cochin backwaters. A new collaborative programme with the National Chemical Laboratory, Poona and the Central Drug Research Institute, Lucknow was also initiated during the year with a view to studying medicinal value of the marine plants and animals.

Under the Biology programme of participation in the INS *Darshak* Oceanographic Expedition, studies were made on the primary, secondary and benthic productivity of the Northern Arabian Sea.

Studies on the estuaries of Goa indicated that the Chapora estuary north of Goa has a high rate of organic production and chlorophyll-*a/c* ratios. It is an indication of a healthy plankton community. Majority of the phytoplankton pigments (upto 90%) in the Mandovi - Zuari estuarine system was found to be contributed by the nanoplankton.

Studies on the mangroves available along the estuaries of Goa have shown that they are normally absent in areas of high wave action. Faunistic and environmental investigations of the mangroves show that these environments are favourable for the culture of animals such as prawns, crabs, mullets and milk fish.

Trends in the quantitative distribution of benthos in the inner shelf of the central-west coast of India further supports that the demersal fishery is influenced by benthic productivity.

Detailed studies on the sub-sorted groups of IIOE collections were continued at the Indian Ocean Biological Centre and work on some species of copepoda and decapoda were completed. Studies on the distribution of the penaeid larvae have shown higher concentrations of them in the Bay of Bengal especially in the waters around Andaman and Nicobar islands and off

Madras. In the Arabian Sea, high concentrations were found along the Malabar Coast and off Somali coast. These areas are, evidently, the potential grounds for prawn fisheries. Some stages of the phyllosoma larvae of commercially important lobsters were also identified. Detailed ecological analysis of plankton data collected during IIOE Expedition was started which would be further augmented by similar studies on UNDP samples.

Pre-pollution and pollution studies were continued. Regular checks on the environment in and around Velsao is being made, where the Zuari Agro Chemicals discharge their effluents. Work on the effect of urea and heavy metals on marine organisms is also being carried out. Studies on the extent and effect of coal tar deposition along the Indian coast were continued.

Preliminary studies were initiated, on aquaculture using the green mussel, *Mytilus viridis* as the test animal. An average growth of 8 mm/month was noticed with good survival. Oceanographic studies in the Laccadive area were initiated with a view to explore the resources and to develop suitable methods for conservation of the valuable fauna and flora of the area.

## 2.41 Invertebrates

### 1. Rearing and Maintenance of Planktonic Organisms in Natural and Laboratory Conditions

In this period the rearing of four species, viz., *Euterpina acutifrons*, *Pseudodiaptomus aurivelli*, *P. merotoni* and *Tortanus forcipatus* was undertaken and complete larval stages were traced. *E. acutifrons* and *T. forcipatus* show 12 larval stages (6 naupliar and 6 copepodid) as in most of the free living copepod. But in case of *P. merotoni* and *P. aurivelli* there were found 11 stages only - the first naupliar stage is suppressed and they hatch out directly in second naupliar stage. The detailed results are being compiled.

### 2. Marine Aquaculture

This new aspect was initiated this year and the green mussel - *Mytilus viridis* was selected for the preliminary studies. The seeds were collected from intertidal rocks at Velsao bay, kept

in meshed nylon cloth jackets and transplanted on rope in the Dona Paula Bay. Regular weekly observations were made on the environmental factors including, temperature, salinity and suspended organic matter. The survival rate of transplanted mussel was found to be very high and an average growth of 8 mm per month was noticed in the last four months. This is being continued. The success of this project will enhance the culture prospects and will directly increase the marine food production.

### 3. Taxonomy, Biology and Life Histories of Marine Molluscs

Under grant-in-aid scheme on above subject, the work was continued this year. The main findings are: A new species of nudibranchiate gastropod from Goa waters has been described and named *Dendodoris goani* after the locality of its occurrence. The *D. goani* has a combination of characters separately met with in other species of the same genus. The detailed morphological characters of its different systems have been worked out and the

results are being published in JMBA Vol. 15. Under the same group of mollusc three more species of scientific interest have been studied. They are : (i) *Asteronotus caespitosus* (Van Hasselt), (ii) *Phyllidia* (*Phyllidia*) *varicosa* Larmarek and (iii) *Phyllidia* (*Phyllidiella*) *zeylanica* Kelaart, all from Lakshadweep islands. The first two have been reported for the first time from the Indian Ocean while third is extremely rare. Throughout Indo-Pacific region there appears to be only one species under the genus *Asteronotus* Ehrenberg, viz., *A. caespitosus*. It has been shown that other species described are synonymous with *A. caespitosus*. The family phyllidiadae has very few members, represented along Indian coasts and the taxonomic status of some of them is open to doubt. *Phyllidia* (*Phyllidia*) *varicosa* and *P.* (*Phyllidiella*; *zeylanica*) have been studied to show their distinctive taxonomic features. Some of their internal anatomical characters have also been studied and results are being published in JMBA, India.

The morphological characters of yet another species *Discodoris fragilis* have been sorted out for comparison with those of allied species. Its early development has been traced. The veliger larva is about 180  $\mu\text{m}$  in the long axis, having a broad spiral shell of pale pinkish line. Other work being continued are (1) Breeding and growth studies of economic molluscan species particularly *Mytilus viridis* and (2) general faunistic distribution of the species along central and north western coast of India.

## 2.42 Algae

### 1. Occurrence of Red Tide in Goa Waters

During the routine observations off Velsao, a bloom of dinoflagellate was observed in September. Regular samplings of these area showed a bloom conditions of a dinoflagellate *Noctiluca miliaris* causing "Red Tide". This is in vicinity of Zuari-Agro Chemicals, a fertilizer plant, where heavy fish mortality might have been partially due to this red tide. Plankton samples and cell counts were made along with the environmental features which indicated little upwelling in this area.

### 2. Culture of Diatoms

Several diatom cultures were maintained. Some of the important are *Skeletonema costatum*, *Tetraselmis* spp. *Chlorella ovalis*, *Asterionella japonica* and *Synechocystis*. Under similar laboratory conditions it was found that *Tetraselmis* spp. and *Synechocystis* showed better growth than others.

### 2.43 Chemistry of the Marine Organisms

An interlaboratory project to study the chemistry and pharmacology of extractives from marine flora and fauna has been started during 1973. The other laboratories collaborating in this project are CDRI, Lucknow and NCL, Poona. This Institute's work is restricted to collection and identification of marine flora and fauna and send them to CDRI and NCL for further analysis. Mangrove leaves have already been sent for chemical analysis and further samples of seaweeds, mangrove bark and Holothurians are being processed. These studies are aimed at the usage of marine organisms for medicinal use. The work has recently been started and would be continued.

## 2.44 Plankton and Productivity

### 1. Biological Productivity of Waters along the Central West Coast of India

(i) *Primary Production* : During this year, the studies were limited to two locations during few pre-monsoon months only. Two stations each off Aguada and Cabo were covered where depthwise studies on production, chlorophyll estimation and nutrient determination were made along with light penetration measurements. The attenuation Coefficient (K) off Aguada and Cabo in the month of April was 0.19 and 0.35 at 20 m depth zone and 0.10 and 0.15 at 40 m depth zone while the Chlorophyll *a* values were 30.6, 13.4, 18.8 and 26.1 mg/m<sup>2</sup> respectively.

In September 1973 a diurnal experiment was run 3 km off Bogmolo in the nearshore waters. Three hourly samples were taken for chlorophyll (whole and nanno), phytoplankton (whole and nanno) and productivity by C<sup>14</sup> assimilation. Simultaneously samples were taken for other parameters like temperature, salinity, oxygen, phosphate and nitrate. The total chlorophyll concentration was very less and ranged between 1.0 to 2.18 mg/m<sup>3</sup> and maximum was noticed at 1700 and 0500 hours. The chlorophyll was mostly

contributed by nannoplankton (< 64 µm) and chlorophyll *a* was dominant. The study indicated the influence of estuarine water in this area. Further studies are in progress.

(ii) *Primary Production Studies in the Arabian Sea*: In collaboration with various Research Institutes of India, Indian Navy planned a joint oceanographic cruise in Arabian Sea and drafted their vessel INS *Darshak* for this purpose. The first cruise was conducted in December 1973 and since then 3 cruises had been completed till March 1974. In all these cruises 46 stations have been worked out and samples were taken from 6 different depths covering the whole euphotic zone. The work included C<sup>14</sup> studies, plant pigment estimation and phytoplankton studies along with other hydrographic parameters. The C<sup>14</sup> incubation was done on the deck (simulated) while 8 experiments were done *in situ*. The analysis of samples is in progress.

(iii) *Zooplankton* : The zooplankton studies were continued as carried from previous year, but at only three transects, viz., Terekhol, Aguada and Cabo de Rama. Surface samples were collected from the 4 depth zones of 10, 20, 30 and 40 m. The average biomass values at these transects are shown in Table I.

TABLE I  
*Mean biomass (ml/m<sup>3</sup>) at different depth zone*

Transect	10 m	20 m	30 m	40 m
Terekhol	0.093	0.053	0.205	0.287
Aguada	0.058	0.152	0.086	0.040
Cabo de Rama	0.045	0.042	0.051	0.059



The average production for this area was found to be 0.159 ml/m<sup>3</sup>. As seen from the above data, the production is highest at Terekhol while the area between 20-30 m depth zone is the most productive at Aguada and Cabo de Rama while at Terekhol biomass values were higher at area of 30-40 m depth. In general, the secondary production is low at 10 m zone, increases at 20 m and again declines further. Detailed studies on faunistic composition are being made.

(iv) *Benthos* : In continuation of earlier investigations observations on ecology and distribution of benthic macrofauna along 0-40 m depth zone off Terekhol, Aguada and Cabo de Rama on Goa coast were made. On the basis of the earlier and this year's data a report on the quantitative distribution of benthic fauna in the inner shelf of central west coast has been prepared wherein the role of benthos in demersal fisheries of this region is also discussed.

(v) *Ecology and Production of Karwar and Vengurla Bay with reference to Fish Trawling Grounds* : Regular observations on environmental parameters in relation to benthic production and possible correlation with demersal fisheries are being continued at these two bays. It is observed that benthic production in Karwar bay is higher (0.869-217.552 gm/m<sup>2</sup>) than in Vengurla bay (0.052-64.00 gm/m<sup>2</sup>). The Karwar bay under estuarine conditions shows wide fluctuations in environmental factors and benthic production whereas Vengurla bay, having marine characteristics has less succession in benthic fauna. The Karwar bay with high organic matter in substratum provides ideal grounds for demersal fisheries. A comparative study on the growth of green mussel

(*Mytilus viridis*) indicates that in Vengurla bay the growth is much faster than in Karwar bay.

(vi) *Mangroves* : The work on mangroves along central west coast was started in September 1973 and the survey of the coastal region from Panaji to Mangalore towards South has been completed. It is proposed to survey the region upto Ratnagiri in North. From the observations made so far, it is observed that the mangroves are extensive along this part of the coast and develop in estuarine environment. All these mangrove swamps along central west coast are being mapped.

(vii) *Benthos of the Arabian Sea* : As mentioned above 'Darshak' cruises in Section 2.44 (iii), benthos samples were collected from north-eastern Arabian Sea, Persian Gulf, Gulf of Kutch and from continental shelf as well as from Deep Sea. Various stations have been covered in these areas and benthic samples from grab, core and dredge have been collected to study the qualitative and quantitative variations in benthic fauna. The sorting and analysis are underway.

## 2. Ecology of Estuaries

(i) *Primary Production (Mandovi, Zuari and Cumbarjua Canal Complex)*: These studies were continued at four stations near Aguada and Pilegaon in Mandovi and near Mormugoa harbour and Mercaim in Zuari estuary. Measurements were made of C<sup>14</sup> uptake, chlorophyll contents and nutrients along with environmental parameters. Light attenuation and chlorophyll *a* concentration are shown in Table II for April and May.

TABLE II

*Light attenuation K and chlorophyll-a concentration in Mandovi & Zuari Estuary*

Station	April			May		
	k	Chl.	a	k	Chl.	a
Aguada	1.3		10.9	1.7-2.3		6.9-26.6
Pilegaon	2.6		7.6	1.4		23.8
Harbour mouth	0.5-1.10		11.0-13.8	2.4		3.7
Mercaim	1.5-1.9		8.2-10.2	—		—

Analysis of chlorophyll samples of monsoon period have shown that in these two estuaries more than 90% of the chlorophyll is contributed by nanoplankton (less than 64  $\mu$ m).

Diurnal studies were also conducted in September/October 1973 at Verem in Mandovi estuary. This comprised of three hourly collection of environmental, nutrient,  $C^{14}$  uptake, chlorophyll and phytoplankton data from surface waters. The chlorophyll estimations indicated that most of it was contributed by nanoplankton. The total chlorophyll from whole phytopigments (micro and nanno) and nanoplankton varied from 0.67 - 13.72 and 1.62-12.74  $mg/m^3$  respectively and the maximum concentration was observed during afternoon and early morning.

*Chapora Estuary* : During this year study was extended in Chapora estuary - a small perennial estuary north of Panjim. It is shallow with an average depth of 5 to 6 m. Monthly sampling was done at a single station. Primary production was measured by oxygen method. Samples were also taken for chlorophyll concentration besides measuring hydrographic parameters and nutrients. So far nine observations have been made

from 3 different depths in the euphotic zone, *i. e.*, 100%, 60% and 1% light penetration zone. The result shows that the gross column production varied from 237.12-2480.72  $mgC/m^2/d$ —low in monsoon reaching its maximum in November to decrease again. These results are in conformity with chlorophyll concentration.

The maximum concentration of Chl. *a* was observed in October (27.65  $mg/m^3$ ) and again in February (23.02  $mg/m^2$ ). The range of Chl. *b* was 0.49 to 4.48  $mg/m^2$ . The monthly variation of Chl. *c* was similar to Chl. *a*. The *c/a* ratio indicated healthy phytoplankton crop.

(ii) *Zooplankton in Mandovi, Zuari and Cumbarjua Canal Estuarine Complex:*

The zooplankton studies were made from 12 stations particularly during monsoon when the environment is very unstable. It has confirmed the earlier views that Zuari is more saline than Mandovi where almost fresh water conditions are observed. And also Zuari estuary is more productive and the highest biomass value during monsoon period was recorded near Cortalim (152g/1000  $m^3$ ). The main groups of zooplankton were Copepoda, Decapoda, Chaetognatha, Lucifer and fish eggs

and larvae. The faunal groups and species distribution is more diverse in the Zuari than in the Mandovi estuary and Cumbarjua Canal.

Zooplankton distribution was studied with particular reference to salinity gradient. Fortnightly observations were made from 7 stations (upper, middle and lower reaches) in Mandovi and Zuari estuary between October 1973 and March 1974, covering postmonsoon and pre-monsoon period. The middle reaches were found to be most productive particularly in Zuari while upper reaches were least productive. The higher production at mid-reaches may be due to the stable environment. The faunal and species differences were discernible in both the estuaries and at the three different salinity regions.

Diurnal studies in zooplankton variations were made at Verem and off Bogmalo. Higher biomass was found at high tide during night at both the places. There was similarity in faunistic groups and their species indicating the estuarine influence off Bogmalo. Nocturnal abundance was noticed at both the stations. The important planktonic groups at Verem were Copepods, Decapods, Lucifer, Gastropoda, fish eggs and larva whereas at Bogmalo the dominant groups were Copepods, Chaetognaths, Oikopleura, Siphonophora and fish eggs and larvae. The analysis and processing has been completed and report is being prepared.

(iii) *Benthic Production (Macrobenthos)*: These studies were continued till June 1973 for seasonal changes in benthic resources and as a part of pre-pollution baseline studies. The data on ecology and standing crop of macro-

benthos upto the extent of salinity intrusion in these two rivers have been processed and are being published. Detailed investigations on the ecology, growth and standing crop of commercially important clam, *Meretrix casta*, Chemnitz and ribbed mussel, *Modiolus metacalfei* (Hanley) were completed.

(iv) *Ecology of the Cochin Backwater with special reference to African Payal (Salvinia auriculata)*: The African payal forms a thick mat over extensive area in the backwater during the major part of the year. The influence of the weed on the ecosystem and on the prawn population may be significant. Work has been initiated to study the part played by the African payal in the ecosystem and the fauna associated with them.

(v) *Ecology of Mangroves*: The earlier work on ecology of mangroves in Mandovi, Zuari and Cumbarjua Canal was continued and the results published in IJMS. According to this the mangroves are absent from high wave action area, *i.e.*, at mouth but in Cumbarjua Canal they grow fairly well. Succession of species was noticed in these mangroves.

Quantitative aspects of mangrove fauna were studied in the Mandovi, Zuari and Cumbarjua Canal system of Goa and continued till June 1973. The faunal distribution as assessed from biomass measurements and population count exhibit striking seasonal changes with maxima and minima in post-monsoon and monsoon respectively. Analysis of data on environmental parameters and qualitative and quantitative distribution of fauna indicate the possibility of initiating commercial cultures

of crabs, prawns, mullets and milk fish in the estuarine fringe mangroves of Goa.

Studies on mangroves are extended in region near Mashem about 75 km away from Panaji around Galjibag river. Monthly samples are collected for hydrographic and biological parameters including mangrove fauna from 5 stations. These studies are aimed at evaluation of mangroves and using these swamps for aquaculture.

## **2.45 Nekton (Fish and Fisheries, Molluscs)**

### **1. Fish and Fisheries**

During this year, the work on different fisheries of Goa water was initiated to assess the living resources of Goa and nearshore waters in relation to environmental features. The pelagic fishing grounds and trawling grounds are being regularly visited and biological and hydrographical parameters were collected. The fisheries of particular interest are those of mackerel, sardines, prawns and crabs. The mackerel fishery consisted of a single dominant size group of 210-220 mm. Catch composition is being found out and correlated with environmental features.

During the fishing season of 1973-74 (October-February) studies were also made on the occurrence, sp. composition, size frequency, length/weight relationship, their fishing areas and suitable craft and gear for Tuna and seer fisheries along Goa coast. The results are being compiled.

### **2. Electrophoretic Studies on Meckerel Eye Lens Nucleus Protein**

These investigations were started with, a view to find out whether the Indian mackerel occurring on West coast belong to a single genetic race or different races. The protein of eye lens nucleus is separated by electrophoresis. The results on the fishes from different places show 7 protein fractions behaving in two different types. In first, all move towards cathode while in other type, four of them acquire anodic mobility. The studies have been correlated with age and sex of the fish and it has been seen that the differences are not ontogenetic but purely genetic. It is inferred therefore that two different stocks of mackerel fishes frequent in the Goa coast.

### **3. Management of Clam Fishery in Kali Estuary**

This has recently been started from January, 1974. Clam fishery was found to be composed of *Meritrix casta* and *Paphia* sp. Monthly collections are being made and samples of clams are collected for further study along with ecological features. The studies are in progress. Preliminary study shows that both the species constitute in equal numbers and their flesh contribute about 40% of the total weight.

### **4. Theoretical Studies on Population Dynamics and Optimum Exploitation of Fish Populations**

Initial studies on the efficiency of the existing mathematical models in maximizing the long term average yield from

exploited marine fish populations were made. Under equilibrium conditions, *i.e.*, when recruitment growth, natural mortality, fishing effort, etc. are all constant maximum yield can be obtained with a particular fishing intensity and mesh size. In nature equilibrium conditions seldom exist. But as long as the population is subjected to random environmental effects the long term average yield obtained by adopting the optimum fishing conditions as determined for equilibrium conditions by steady state models will tend to be equal to the maximum yield determined by these models. But Ricker has made some preliminary studies using simple population models and has shown that the maximum average yield obtained by keeping the fishing intensity constant need not be the maximum but the yield can be made to increase further by judicious regulation of the fishing effort. The biggest hurdle here is that it is not easy to assess the exact amount of fishing effort to be expended in each year. Further studies along this line for multiple age class fishery for cases where recruitment is dependent and independent of stock sizes is proposed to be taken up. Under this programme due consideration will be given to the study of the change in the average yield when regulation is only partial, *i.e.*, when it is to some extent arbitrary. On the basis of a preliminary study in the above line the *concept of partial regulation of fishery* is proposed since the existing models for equilibrium conditions do not appear to be fully efficient in maximising the yield even though they may be the most practical of all available methods. The above study when undertaken will confirm the validity of this concept.

## **5. Physiology and Dynamics of the Growth of Prawn**

Data have been collected on oxygen consumption of *Penaeus indicus* and *Metapenaeus dobsoni*, for examining the physiological basis of Von Bertalanffy growth equation.

Preliminary experimental studies on the juveniles of *Penaeus indicus* collected from the Cochin backwater are also taken up for understanding the physiological basis responsible for the migration of this species back to the sea and other relevant factors useful for improving existing culture techniques.

## **6. Studies on Parasites of Marine Food Fishes and Prawns**

The marine fish *Carangoides malabaricus* was studied on parasitological grounds. Interspecific relations and spatial distribution of the more common gill parasites of the fish, seasonal variations of the parasitic fauna and dynamics of the parasites in relation to sex, growth and maturity of the hosts are being studied.

## **2.46 Marine Ecology and Pollution**

### **1. Ecology and Production of Sandy Beaches**

These studies were carried forward from last year and during this year work was done at Bogmalo, Sinquerim, Calangute, Benaolim and Dias beaches in Goa while Vengurla beach in Maharashtra and Karwar in Karnataka.

Monthly observations have been made at all these beaches at high, mid

and low tide mark. Biomass samples along with environmental data such as oxygen, salinity, temperature, water table are taken. Also the samples for organic carbon (sand and surf water) and chlorophyll (surf water) were taken to assess the food available in natural condition.

At Dias beach the highest biomass of 122.19 gm/m<sup>2</sup> was noticed in post-monsoon and was followed in pre-monsoon (108.84 gm/m<sup>2</sup>) and monsoon (68.61 gm/m<sup>2</sup>). Mid tide mark showed highest biomass. At this beach the salinity varied from 9.93 to 37.99 ‰, dissolved oxygen from 1.68 to 4.37 ml/l and temperature from 26.6 to 29.5°C. Similar gradation of biomass values were observed at Bogmalo beach. In post-monsoon the biomass was highest 567.61 gm/m<sup>2</sup> and lowest in monsoon 34.96 gm/m<sup>2</sup>. The range of salinity and temperature was like in Dias beach but values of dissolved oxygen were found as low as 0.5 ml/l.

Some of the salient features of intertidal study at Karwar and Vengurla are : Maximum biomass (104.41 gm/m<sup>2</sup>) was noticed at LT mark at one Karwar beach and minimum of 0.38 gm/m<sup>2</sup> was found in August at LT mark. The salinity ranged between 6.9 to 32.97‰, the range of oxygen was not much (4.54-4.59 ml/l). At Vengurla the maximum biomass at LTM was 50.095 gm/m<sup>3</sup> in October when the salinity was 34.83‰ and oxygen 4.48 ml/l while minimum was observed in May when the biomass was 7.34 gm/m<sup>2</sup>, salinity 37.83‰ and oxygen 4.14 ml/l.

The detailed data of these beaches are being processed and given final form.

## **2. Production Ecology and Energetics of Bivalve *Donax* Spp.**

Based on earlier preliminary data on energy budget and production of *Donax* spp. regular studies were started at four beaches of Goa. Apart from regular monthly samplings at 5 m interval from high to low water mark, beach condition was also noted. Chlorophyll and organic carbon of the surf water has been estimated to assess the amount of food available to the animals in natural conditions. The results are being analysed.

## **3. Ecology of Sand Dune Vegetation at Miramar Beach**

Ecological investigations of the sand dune vegetation were undertaken during 1973-74. Various aspects of different climatological and environmental parameters were studied. The role of temperature, sand grain size, humus and water table was given more stress. The problem of erosion on this beach has also been investigated with reference to sand dunes. Data are being processed.

## **4. Intertidal Ecology**

Ecological investigations of the marine and estuarine sandy beaches around Cochin are continued, to study the species succession and their correlation with environmental factors. The environmental parameters taken up for this study are beach profile, organic contents, chlorophyll, dissolved oxygen, sand grain size, salinity, temperature, etc. Ciliates were found to be the most dominant group at all tidal levels. The distribution and abundance of other groups of animals studied are nematodes, oligochaetes, Harpacticoids, gastrotrichs, Archiannelids, Polychaetes, forami-

ferans, isopods, tardigrades and nauplii. At the estuarine beach the fauna was more concentrated at mid tide level than at high or low tide levels.

### **5. Ecology and Production of Karwar and Vengurla Bay with Reference to Fish Trawling Grounds**

Monthly observations were made in Vengurla (North of Goa) and Karwar Bay (South of Goa). The parameters studied besides, temperature, salinity and oxygen are zooplankton by horizontal hauls, sediment samples for grain size and organic carbon and food and feeding of fishes available there. This is to study the productivity at different levels on these places, which are rich fishing grounds.

### **6. Studies on Foraminifera from Shore Sands of Velsao Beach with Special Reference to Coastal Monitoring**

During the months from December 1973 to April 1974 regular foraminiferal collections were made from Velsao beach which is found to be rich in foraminifera. Its composition revealed that *Streblus beccarri* group is most dominant followed by miliolids represented by the genera *Spiroloculina*, *Quinqueloculina* and *Triloculina*. Arenaceous foraminifera are represented by the single genus *Textularia*. Sixteen species were identified. It can be inferred that the environment is clean as regards foraminifera is concerned. Further studies are still in progress.

### **7. Bioassay Studies on Marine Organisms in Relation to Pollution Monitoring**

As a part of the programme of work on bioassay studies with heavy metals, pesticides, etc., investigations on toxicity of mercury have been carried out on the bay mussel *Mytilus viridis* and the estuarine fish *Ambassis* sp. The test animals have been exposed to different concentrations of mercury and the tolerance limits were calculated for different periods of exposure. The levels of mercury in the medium at which no lethal effects have been observed are as below :

<i>Test animal</i>	<i>Safe level of mercury in the medium</i>
<i>Mytilus viridis</i>	0.37 µgm/l
<i>Ambassis</i> sp.	0.0014 µgm/l

From these observations it can be said that mussels can withstand higher levels of mercury than fish.

### **8. Effect of Urea on Marine Organisms**

Studies have been started recently on the effect of different concentration of urea on different species of phytoplankton. The pure cultures of phytoplankton are exposed to different concentrations of urea and the growth rate of various phytoplankton spp. are being estimated. Chlorophyll *a* has been used as the index of growth. Studies are in progress.

### **9. Ecological Monitoring in Coastal Region with Reference to Pollution from Baga to Colva**

This programme is being operated from December, 1972 and studies were continued on hydrology, benthos, phytoplankton and zooplankton for a 50 km stretch of Goa coast which is affected by discharge of industrial effluents. A part of area under investigation suffered from

fish mortality immediately followed by 'red water' phenomenon in September, 1973. A detailed investigation revealed the presence of waters of high salinity, rich nutrient, low temperature and low oxygen. These conditions were accompanied by phytoplankton bloom, loss of benthic fauna and adverse effects on pelagic fishery.

#### **10. Effects of Effluents of ZAC on the Nearshore Organisms**

Zuari-Agro Chemicals — a fertilizer factory is discharging its effluents in sea at Velsao while its effluents from urea plant are discharged into Bisso reservoir. Studies were conducted and it was found out that there is not much harmful effect in the supralittoral flora since after regulation of effluents a tremendous growth of *Enteromorpha* was noticed. *Enteromorpha* is an indicator species for pollution. Situation is under constant vigil.

The Bisso reservoir was found completely devoid of any living organisms. This may be attributed to high concentration of ammonia and nutrients. On the basis of laboratory experiments it was found that the unicellular algal species of *Chlorella* can be grown in this water provided the ammonia concentration is reduced.

#### **11. Effect of Sewage and Domestic Wastes upon Estuarine Ecology**

In Mandovi estuary the domestic waste and sewage are discharged at a few points. This was studied at 12 points including two monitoring points. It was seen that at the discharge point important organisms like amphipods, glycerid and polynoid polychaetes are

completely absent while presence of capitellid polychaete and nematodes was observed.

#### **12. Coal Tar Pollution on Beaches along Indian Coast**

Studies on the incidence of pollution of Indian beaches by oil derivatives were continued. During May-July observations were carried out on a number of beaches between Porbunder (Gujarat) in the North and Cape Comorin (Tamil Nadu) in the South. The studies include observations on time, process and intensity of deposition, associations and its effects, if any, on intertidal organisms. 11 beaches in Karnataka were inspected and all were found polluted with coal tar, maximum was found in Mavanthe. All the beaches visited in Maharashtra and Goa were found to be polluted. In Kerala 17 out of 19 beaches were having coal tar deposition.

Investigations were conducted on the oil pollution caused by the wreck of an oil-tanker "*Cosmos Pioneer*" on the Saurashtra coast in July, 1973. In spite of release of thousands of tons of crude oil, the amount of damage to marine life was not very significant, mainly because of rapid disposal of oil by prevailing natural forces.

#### **13. Hydrographic Condition around Bombay**

As part of the environmental monitoring programme at Bombay, observations were made periodically in the harbour area and Thana Creek. Temperature, salinity, oxygen, nutrients and plankton values were recorded. The data reveals a poorer phosphate content at the surface at almost all the stations



but slightly higher values were observed at the bottom. The nitrate value on the west coast of the harbour varied from 3.00 to 3.75 µg-at/l on the west coast, whereas in Thana Creek, nitrate values were considerably high perhaps due to the release of nitrogenous materials from the industries around Thana. The maximum value was 18.5 µg-at/l. The zooplankton was represented largely by chaetognaths and copepods at almost all the stations, however, the medusae were predominant near the Trombay jetty.

The values compare well with the earlier observations made in 1970-72 at the request of Bombay Municipal Corporation.

## 2.47 Zooplankton ( I I O E Collections )

( Studies carried out at the Indian Ocean Biological Centre )

### 1. Systematic Study of Various Sub-sorted Groups

Investigations on the sub-sorted groups of different taxa allotted to specialists in IOBC were continued during the period. Some of the results are given below. Publications during the year are given separately.

(i) *Copepoda*: Systematic study of the family Scolecithricidae revealed the occurrence of a new species belonging to the genus *Macandrewella* in the Indian Ocean. This was named *M. cochinensis* and described.

Distribution patterns of species of Copepoda belonging to the family Corycaidae were studied based on the analysis of 200 samples. The 3 species,

namely, *Corycaeus (Urocorycaeus) furcifer*, *C. (U) longistyllis* and *C. (U) lautus* exhibited different patterns of distribution in the main regions of the Indian Ocean.

The copepod genus *Haloptilus* was analysed from 150 samples. 12 species were identified. Out of these, *Haloptilus longicornis* and *H. spiniceps* dominated in the samples. 3 species were recorded for the first time from the Indian Ocean. Hitherto unknown male of *H. acutifrons* was described.

Detailed study of the species belonging to the genus *Pleuromamma* gives evidence of a region of isolation of one species *P. indica* near the Gulf of Oman, all the other species of the genus being eliminated in this restricted area. At the same time *P. indica* appears to be the most widely distributed species in the Indian Ocean region, able to tolerate wide ranges of hydrographical conditions.

(ii) *Decapod Larvae* : Based on the study of the density of larvae of Penaeidae sorted out from the IIOE samples an attempt was made to correlate their occurrence and abundance with the penaeid prawn fishery of the various regions especially in the Arabian Sea and the Bay of Bengal. Out of 1518 standard samples from which decapod larvae have been obtained, 463 samples yielded penaeid larvae. 353 of these samples contained larvae of prawns of the sub-family Penaeinae. Larvae of several of the genera and species of penaeidae of commercial importance in the coastal area of the Indian Ocean have been identified from the collections in the work carried out so far. Developmental stages of 17 species belonging to 10

genera have been located in different areas. Few of the larval stages of the genus *Metapenaeopsis* hitherto undescribed have also been identified. Larvae of penaeid species are formed in larger numbers in the Bay of Bengal, more especially in the waters around the Andaman and Nicobar islands and off the Madras coast, in the West coast of India mainly in the Malabar coast and off the Somali coast, indicating the possibility of higher concentrations of the adults in those regions which are likely to prove highly potential grounds for future exploitation of prawn fisheries.

The larval collections of the sub-family Aristaeinae is found to contain mainly of mysis stages of *Aristeus semidentatus* and *Aristeus* sp. and zoeal stages of *Gennadas scutatus*. The Solenocerinae consists mainly of mysis stages of *Solenocera indica* and some other species.

Studies on the phyllosoma larvae of spiny lobsters and scyllarid lobsters have been completed. Some stages of development of most of the commercially important lobsters of the Indian coast have been identified and their descriptions are ready for publication.

The well-known Atlantic species of Pandalid, *Parapandalus richardi* has been obtained from the Indian Ocean for the first time.

(iii) *Fish Eggs and Larvae* : Studies on the fish eggs and larvae are being continued. Out of the 3 families Engraulida, Clupeidae and Scombridae, the study on the family Scombridae has been completed. Specific identification of the larvae of Heterosomata of IIOE also was completed. About 18 species

belonging to 9 genera and 3 families were obtained from this group. Most of the larval stages of these species are reported for the first time. Distribution pattern of the flat fish larvae of the Indian Ocean was studied. The physico-chemical parameters in relation to the flat fish larvae of the Indian Ocean are being studied.

(iv) *Other Groups* : Taxonomic and distribution studies on the Heteropoda are in progress. Identifications of all the species of Carinariidae and Pterotracheidae are completed. The most widely distributed species is *Firoloida desmaresti*. In abundance also it excels all the other species. *Pterotrachea hippocampus* is more abundant than *P. coronata*. This is in contradiction to previous observations. However, the latter species has a wider distribution than the former. *P. minuta* is sparsely distributed. *P. scutata* was found only in one station. The species of Carinariidae presents very interesting pattern of distribution. Among the species of this family, *Carinaria cithara* is the most common. *Pterosoma planum* is more common in the equatorial zone and appears to be absent from the Arabian Sea. There are several records from the Bay of Bengal. *Cardiapoda placenta* shows scattered distribution in the Arabian Sea and several records from the Bay of Bengal. *Cardiapoda richardi* is recorded only from one station. The distribution charts of most of the species are ready.

Distribution studies of 3 species belonging to the family Paraphronimidae (Amphipoda) have been completed.

The analysis of all the IIOE chaetognath samples available at the IOBC is completed.

Study of the systematics and distribution of pelagic Polychaetes of the Indian Ocean also has been completed. Result of a thesis submitted for Ph. D. degree of Kerala University on this topic is awaited.

Distribution charts of different species of Ostracoda in Arabian Sea have been drawn and those of Bay of Bengal are under preparation. Redescription of the systematics of *Cypridina* group is being carried out.

(v) *Statistical Studies of the IIOE Data* : Detailed ecological analysis of the data using statistical methods for studying the existence of ecological zonations and associations of species having similar biological environments is initiated in order to fully utilise the existing data on the Indian Ocean zooplankton. Similar studies with the UNDP samples when carried out is expected to reveal new information on the biological environment off the West Coast of India.

## 2. Preparation of IIOE Plankton Atlases

IIOE Plankton Atlas Volume IV, Fascicles 1 and 2 and Volume V, Fascicles 1 and 2 have been published in March and July, 1973 respectively. Volume IV has 21 maps showing the distribution of Platyhelminthes, Polychaeta, Trochophores, Sipunculida, Actinotrocha, Brachiopod larvae, Chaetognatha, Copelata, Pyrosoma, Salps, Doliolids and Amphioxus of the Indian Ocean. Volume V contains 16 maps on the distribution of Hydromedusae, Scyphozoa, Anthozoa, Foraminifera, Echinodermata, and Tornaria of the Indian Ocean.

## 3. Preparation of Handbooks to the International Zooplankton Collections

Handbook Volume IV containing 3 papers on IIOE Plankton samples was brought out in August, 1973. The papers are :

1. Mysidacea of the Indian Ocean — N. Krishna Pillai
2. On *Euchaeta* (Copepoda - Calanoida) of the Indian Ocean—Otohiko Tanaka.
3. A few comments on the zooplankton investigations of the IIOE —M. Sakthivel and T. S. S. Rao.

Handbook Volume V containing 14 papers was brought out in December 1973. The papers are :-

1. On the ecology of Indian Ocean Hydromedusae—M. Vannucci and D. Navas.
2. On the occurrence of *Dairella latisima* and *Dairella californica* (Dairellidae, Hyperideae, Amphipoda) in the Indian Ocean—K. K. C. Nair.
3. On a collection of planktonic Decapoda (Penaecidae) from the south west coast of India—M. J. George and V. T. Paulinose.
4. The location of Cephalopod nursery in the Indian Ocean — P. N. Aravindakshan and M. Sakthivel.
5. Latitudinal distribution of a few species of pelagic polychaetes in the upper 200 m water of the Indian Ocean—George Peter.
6. On the ecology of pelagic polychaetes newly recorded from Indian Ocean — George Peter.
7. Breeding and growth of Chaetognaths in the Cochin Backwaters — Vijayalakshmi R. Nair.

8. Developmental stages of *Penaeopsis rectacuta* Bate (Decapoda : Penaeidae) from the Indian Ocean—V. T. Paulinose.

9. Zooplankton investigation in Indian waters and the role of the Indian Ocean Biological Centre—N. K. Panikkar and T. S. S. Rao.

10. Distribution of Decapod larvae in the Indian Ocean—P. Gopala Menon.

11. Distribution of *Haloptilus acutifrons* (Copepoda - Calanoida) in the Indian Ocean with a description of hitherto unknown male—Rosamma Stephen and K. Satala Devi.

12. A new species of *Macandrewella* (Copepoda - Calanoida) from off Cochin, southwest coast of India—T. C. Gopala-krishnan.

13. The genus *Gaussia* (Copepoda; Calanoida) with a description of *G. sewelli* sp. nov. from the Indian Ocean — M. Saraswathy.

14. *Leptochela robusta* Stimpson (Decapoda, Caridea, Pasiphaeidae) from the southwest coast of India and its larval development — M. J. George and V. T. Paulinose.

#### **4. Preparation of Illustrated Manual on Zooplankton**

In connection with the publication of the illustrated manual on zooplankton most of the photographic work for the 50 plates to be prepared is completed. The rest of the work in getting the plates press ready and writing up of the material to go with each plate is in progress.

#### **5. Sorting of Plankton Samples of UNDP Pelagic Fisheries Project**

In continuation of the sorting of fish eggs and larvae from the plankton sam-

ples collected by the UNDP Project commenced last year, 900 plankton samples collected from the coastal waters between Quilon and Ratnagiri were processed during the period under report. Fish eggs and larvae were separated from the samples, other major planktonic groups estimated and the data in respect of these logged. Distribution charts of planktonic biomass, fish eggs, fish larvae and other groups are being prepared.

#### **6. Studies on Fixation and Preservation of Marine Zooplankton**

Under the SCOR/UNESCO/WG-23 work on fixation and preservation of marine zooplankton was continued. For mixed plankton in general formaldehyde was found to be the best fixative and preservative. 2% formaldehyde solution acts as a good fixative. 1% formaldehyde solution was proved to be a good preservative provided (a) sea water is used as a diluent, (b) 2% borax or excess calcium carbonate is added to concentrated formaldehyde as a neutralising agent and (c) 10% propylene glycol and 1% phenoxetol are added as additives. As a storage fluid the best ratio between formaldehyde and plankton was found to be 5:1.

Phenoxetol as a sorting medium-cum-preservative was found to give good results when 0.5% solution in distilled water buffered with 1% sodium tetraborate was used after adequate fixation in 2% formaldehyde.

For calcareous plankton, 2% formaldehyde in distilled water (stock formal-

dehyde of 40% is neutralised with excess sodium tetraborate) with 3 to 5% potassium oxalate was found to be the best preservative.

In the case of gelatinous plankton narcotisation is necessary before fixation to avoid shrinkage. M.S.S. 222 and Benzamine hydrochloride were equally good narcotising agents. Of the various fixatives and preservatives tried, 1-2% formaldehyde was found to be the best. For jelly plankters a fixative stronger than the storage fluid was found unnecessary.

## 7. Studies on the Plankton of Cochin Backwaters

Analysis of the zooplankton samples collected from 7 fixed stations in the backwaters from Cochin to Alleppey in every month of the year during 1972 was completed. The total samples which numbered 84 were studied for spatial and seasonal distribution of different groups and species in relation with hydrographic features. Statistical analysis of the data for testing the significance of variation in abundance of the different groups and species of importance was completed and a paper is under preparation. The analysis of the zooplankton samples collected from the Cochin bar-mouth, Aroor and Narakkal is also in progress.

## 2.48 Oceanography of the Waters around Lakshadweep

*Algal Farming* : Preliminary investigation shows that several algae of great

economic importance are seen growing in these lagoons. Some of them like *Gracilaria lichenoides*, *Geledium* sp., *Hypnea muciformis* etc. are widely used in the manufacture of agar-agar. This has its use in the preparation of cosmetics, medicines, food products and for bacteriological tests. Species of brown algae like *Sargassum*, *Padina*, *Turbinaria*, *Laminaria*, etc., which are used as fertilizer and fodder and for the extraction of algin and its other constituents, are also common in the lagoon. It appears to be possible to undertake large scale farming of such commercially important algae in these waters. Studies of the physico-chemical parameters also vouch this possibility. Attempts are being made to establish an experimental farm in the lagoon of one of these islands.

*Turtle Farming* : Lakshadweep has a vast potential in setting up a turtle farm primarily to conserve its natural stock and secondarily for controlled exploitation. A survey conducted shows that two of the most important marine turtles *Chelonia mydas* (green turtle) and *Chelonia imbricata* (Howk bill turtle) abound these waters.

It has also been found that many of the inhabited islands are the breeding grounds of the marine turtles. *Thalassia hemprichii* (Turtle grass) on which adult turtles graze are seen abundantly in the lagoons. Preparations are underway to establish a farm starting with hatcheries and nurseries.

Turtles have great commercial importance. The oil is used in the manufacture of cosmetics. The cartilaginous material

between shell bones is a delicacy for making turtle soup. The turtle skin is considered to be high quality leather. Turtle shell is used in the manufacture of various fancy items and turtle flesh is considered a delicacy.

*Coral Reef Studies* : No place is ideally suited than the islands of Lakshadweep to study the enigmatic ecological problems of coral reefs and the biology of individual corals. Such studies will not only reveal answers to many a problems of coral reef ecology, and community life but also provide information such as the extent of live coral beds in the Laccadive sea, their rate of growth and the extent to which destruction is caused to the corals by biological as well as physical means. Steps have already been taken to study the coral reef community and the biology of the individual corals in detail.

*Exploring the Marine Living Exploitable Resources* : As a result of the preliminary observations it has been found possible to develop in Lakshadweep a parallel fishery of squids, molluscs, rock lobsters, beach-de-mer, etc. in addition to the major fishery of tuna, sharks, seer, etc. Studies are being undertaken in these lines to explore the extent of natural stock available in these waters.

*Physical Oceanographic Studies* : The staff participating will be studying the physical parameters like temperature, salinity, transparency of the waters, currents, waves and tides. Also, it is decided to collect data on the extent of coastal erosion observed at the north

eastern area of Kavaratti island and to devise ways to prevent it.

*Chemical Oceanographic Studies*: This part of the programme will be taken up after adequate staff is provided. Under this study, regular fortnightly sampling at selected stations for dissolved oxygen, pH, redox potential, phosphate, silicate, nitrate, nitrite and ammonia will be done. In addition particulate organic carbon, chlorophyll and phaeophytin contents of the lagoon waters and the sea round islands through different seasons will be estimated.

*Marine Geological Studies* : It is decided to study the geology of the sea around Lakshadweep and also to estimate the mineral resources of the lagoons and shallow offshore area. The objective also include investigations to assess the reserves of calcareous sand and suggests their best possible utilisation in industry and to ascertain the likely effects of mining and dredging of coral sands from the lagoons of these islands and if possible suggests the safe limits for dredging and the optimum quantities to be dredged.

## **2.49 Apparatus and Methods**

### **1. Establishment of New Methodology to Identify Marine Population Using Karyological, Serological and Bio-chemical Methods**

The karyological studies were conducted during this year mostly on calanoid copepod—an intermediate link between phytoplankton and fish in the marine food chain. Eleven species of calanoid

copepods, previously unknown cytologically have been investigated—they are: *Labidocera pectinata*, *L. acuta*, *L. kroyeri*, *L. pavo*, *Tortanus forcipatus*, *T. gracilis*, *T. barbatus*, *Acartiella keralensis*, *A. gravelyi*, *Centropages furcatus* and *Temora turbinata*. For this purpose fortnightly collections were made from Mandovi and Zuari estuarine system during pre-monsoon period. These species show a diploid number of chromosomes numbering 20 for *Labidocera*, 12 for *Tortanus*, 10 for *Acartiella*, 11 for *Acartia* and 6 for *Centropages* and *Temora*. These details suggest that evolution has taken place at the genic level. All these species have a

sex mechanism of the  $xy\ xx$  type except for the genus *Acartia* where it is  $xo\ -xx$  type.

There is difference of opinion about the taxonomic position of genus *Acartia* Dana and *Acartiella* Sewelli. Some authors keep them separate while others keep the latter as sub-genus of the former, i.e., *Acartia*. The present karyological studies of the two genera show certain variations and favour to keep them under two separate genera.

Studies on other calanoid copepods and fishes are in progress.

## 2.5

### sponsored projects

**2.51 Bathymetric and Hydrographic Survey off Tarapur**

**2.52 Bathymetric and Hydrographic Survey of Mahisagar Estuary (Gujarat)**

**2.53 Studies on the Physical Parameters of the Sea at Loliem (Goa)**

**2.54 Studies on the Beach and Nearshore Environment at Sinquerim (Goa)**

**2.55 Studies on the Nearshore Waters off Velsao (Goa)**

During the year under review five sponsored projects were undertaken at the request of various government and private agencies. While the first two projects were carried over from the previous year, the other three were undertaken during the current year. The studies were mainly oriented towards the development of beach resorts and efficient disposal of industrial and other wastes.

#### **2.51 Bathymetric and Hydrographic Survey off Tarapur**

This project was operated at the request of the Tarapur Atomic Power Authority, Bombay. Collections made for biological, chemical and physical parameters in the preceeding period were further analysed and two more surveys of 10 days duration were carried out during the year. The salinity values remained more or less constant in this area. The values observed were 34.5 to 35 ‰ salinity. The temperature values showed some variations ranging from 24°C in December to 30°C in May. The waters were found to be well saturated with dissolved oxygen. Echo-soundings of the bottom were repeated in specified areas to find a smooth course for the pipeline from the plant to about 20 m depth.

The nearshore waters were found to be highly turbid. Secchi disc values were

as low as 35 cm in the region, temperature observations were made along the intake and discharge canals to observe if there was any rise in temperature as a result of the discharge of warm waters from the plant. However, it was noticed that even at a distance of 200 metres from the coast, the difference in seawater temperature was only about 0.5°C, which quickly came to normal. The observations on the distribution and quantity of zooplankton, in the intake and discharge canal regions did not show any significant effect of heat from the discharge water even at the nearest stations in the canal. The plankton was found to be very rich and was represented by various groups like chaetognaths, copepods, fish larvae, etc.

#### **2.52 Bathymetric and Hydrographic Survey of Mahisagar Estuary (Gujarat)**

Studies on the impact of large quantities of discharged effluents on the



hydrography of the Mahi estuary were continued. The hydrographic data was collected over the entire length of the Mahi river upto Jaspur on the riverside and extended upto Gangua on the seaward side. The project was undertaken at the request of the Government of Gujarat.

Observations ranging to a full tidal cycle were carried out. As already reported, the fresh water influx during the dry season is almost negligible and during the ebb the water level in the river goes down very low almost to few inches. During this period high salinity values were observed. However, it showed a decreasing trend with the increasing tidal height. Flood tides were preceded with a fast moving tidal bore, the height and velocity of which varied with the phase of tide. The velocity of the tidal bore was observed to be 3.47 knots at Kavi. During the flood tide the tidal heights increased very rapidly. An increase of 12 ft. in 45 minutes of the flood has been recorded at Shiv Mandir. Maximum current velocities upto 320cm/sec were observed during the high spring floods. Considering the region upstream of Kavi, it is estimated that 140 million m<sup>3</sup> of water is being flushed by each incoming tide on ordinary tides. During the spring tides this quantity is doubled. Because of the absence of fresh water throughout the length of the river upto Dabka, salinity remains comparatively very high. A value as high as 37.8‰ has been recorded in this region. The river patterns are also found to be constantly changing with the floods during the monsoon period. A small projection at the J-point, the proposed site of effluent release by the Government of Gujarat, was completely washed out by the floods

during the monsoon. Even the channel geometry in the region was completely changed. This fluctuating nature of the channel system indicates that, the river bed patterns are not stable.

The waters in this region are highly turbid and suspended sediment to about 7.5 gm/l were observed associated with high current speed. The water was well saturated with dissolved oxygen at all the stations in channel formations.

It was observed that there was a gradual increase in the quantities of zooplankton, fish eggs and larvae along the length of the river and the maximum production was observed beyond Kavi and Gangua. Zooplankton were mainly represented by copepods and medusae. Large quantities of prawns and flat fishes were collected in the estuarine region near Gangua which indicated the high productivity of the area. This area was quite rich in nutrients, phosphates and nitrates.

The fertilizer factory near Baroda, discharges about 17 tons NH<sub>3</sub>-N per day into the Mahi river at Jaspur and this is perhaps the major pollutant in the receiving water. Ammonia as high as 649 ppm was observed near Jaspur where the effluent is discharged. The NH<sub>3</sub> - N concentrations gradually decreased along the downstream region. Bioassay tests were conducted on mudskippers (*Periophthalmus* spp) which are found in Mahi estuary and the results have indicated that the ammonia was toxic even at 5 ppm level. It is, therefore, very strongly indicated that proper treatment of the effluent is absolutely essential before discharging it into the river.

### **2.53 Studies on the Physical Parameters of The Sea at Loliem (Goa)**

At the request of Goa Government, work was started in January 1974, in the sea off Loliem, Goa, in connection with the selection of a suitable site for the proposed Atomic Power Station in this territory. The studies include measurement of currents, temperature, salinity and sediment load, at different depths in, the water of the sea near Loliem, bathymetry of the area, beach changes, etc.

### **2.45 Studies on the Beach and Nearshore Environment at Sinquerim (Goa)**

This study which was taken up during the year as a sponsored project includes investigation on the nature of waves, nearshore currents and rip currents affecting the nearshore region of the sea off Sinquerim, and the stability of the adjoining beach, in connection with the development of this region for recreation and tourism. The field investigations are in progress.

### **2.55 Studies on the Nearshore Waters off Velsao (Goa)**

Field investigations on the waters off Velsao where a fertilizer factory which utilizes arsenic in their manufacturing process discharges its effluents were made during the year, under request

of the Government of Goa. The circulation pattern and mixing processes in the nearshore area, where the effluent is discharged are being studied. Biological aspects of the possible impact of these on the beach and nearshore waters are also being studied.

Special investigations were conducted in the nearshore waters of Velsao beach (near Panaji) where the effluent is discharged into the sea. In the month of April, before the factory was in operation, the arsenic concentrations were found to be slightly higher than the other regions along the coast; surface values ranged from 3 to 16  $\mu\text{g}/\text{l}$  and the bottom values from 7 to 43 $\mu\text{g}/\text{l}$ . These values are found to be more or less of the same order as those of estuarine waters and this feature is due to the proximity of the region to the mouth of the estuary. In September when the fertilizer factory was in operation, the arsenic levels in the nearshore waters in the vicinity of the effluent discharge location showed no significant variations. However, during the second fortnight the arsenic levels in the nearshore waters increased to as high as 58  $\mu\text{g}/\text{l}$  and were obviously due to the higher concentrations of arsenic in the effluent from the factory as evidenced by the analysis of the effluent water which contained about 4000  $\mu\text{g}/\text{l}$  (4 ppm). Subsequently, the arsenic levels returned to normal. Analysis of the sediments for the adsorbed arsenic indicated considerable amount of removal of arsenic by the sediments from the overlying waters.

# 2.6

## oceanographic instrumentation

Three main R & D programmes were taken up in the field of oceanographic instrumentation : (i) development of marine electronic system with special reference to oceanographic data acquisition through digital instrumentation and telemetry, (ii) development of maintenance, servicing and calibration facilities for the oceanographic instruments available in the Institute and (iii) development of workshop and allied facilities necessary for the R &D programmes of the division and the Institute.

Under the first programme, design and development of sensors/transducers and associated instruments for the measurement of ocean parameters like conductivity/salinity, temperature, pressure/depth, and turbidity as well as of a graphic digitiser and sub-carrier oscillators have been initiated. The work so

far completed includes the development of an oscillator and amplifier system for the inductive and non-inductive type salinometer and the design of the graphic digitiser. The brief specifications of these have been given in Table I.

The graphic digitiser development could not be completed due to want of I. C. chips for the counter portion and the display tubes. At present, work on the design of the inductive and non-inductive sensors for the conductivity/salinity is in progress.

Studies have also been conducted on the sensitivity and time response of the indigenously available thermistors. Suitable closed loop circuits incorporating these thermistors in the feed back path have been developed with a view to improve their response characteristics.

TABLE I

(i) Oscillator frequency	7500 Hz (nominal)
Output voltage	2 V. rms (maximum)
Output impedance	< 60 ohms
Power supply	12V, 5 mA
(ii) Amplifier gain	60 db (nominal)
Bandwidth	40 Hz to 40 KHz
Input impedance	> 20 K ohms
Output impedance	< 50 ohms
Power Supply	12V, 3mA
(iii) Graphic digitiser range	10 volts (maximum)
Input impedance	> 1 M ohms
Accuracy	better than 0.2%

The fabrication of the data logging system for the oceanographic research vessel, R. V. *Gaveshani* has been taken up under this programme. The design specifications for the system have been drafted and action has been taken to procure the necessary sub-units and components for the fabrication.

Preliminary work has been initiated to develop sub-carrier oscillators to IRIG Standards, to telemeter ocean parameters.

Under the second programme, many instruments like power supplies, current-meter, STD recorder and spectrophotometer have been serviced in the division. Repairs pertaining to many mechanical instruments like auto clave, vacuum pump, centrifuge, snapper, gravity corer, wind wane, etc., modification of the gamma-ray spectrophotometers lead shield, servicing of the airconditioners, supervision of the repair and over-

hauling of the boat *Tarini*, have been undertaken. In addition, some of the medical instruments of the Orthopaedic Department of the Goa Medical College and the Weather Radar of the Meteorological Department, Goa, have been set right.

The graphic art group coming under this programme has catered to the drawing needs of the scientific and technical staff of the Institute. These included preparation of drawings, taking ammonia prints, making charts, layouts of buildings, enlargement and reduction of drawings, etc.

Under the third programme, organisational work has been in progress. One Universal Milling machine has been obtained to improve the facility. This facility will ultimately cater fully to the needs of the Institute in fabricating devices for the R & D work.

## 2.7

### data, publications & information

#### 2.71 Progress Achieved in the Collection, Processing and Storage of Oceanographic Data

#### 2.72 Publications and Information

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#### 2.71 Progress Achieved in the Collection, Processing and Storage of Oceanographic Data

During the period under report, the Data Centre has started the work on the transferring of processed hydrographic data (Physical & Chemical) on to punch cards, which are stored in the listing form. So far data of about 600 stations collected by various organizations were transferred into card format and stored. An output format was also designed for obtaining the listings of these data on a tabulating machine.

Work on the writing up of computer programmes for processing oceanographic data on electronic computer is being continued. Programmes for computing  $\sigma_t$  and sound velocity have been completed on IBM 1620 computer with the help of the Computer Division of the Indian Institute of Tropical Meteorology, Poona. Further efforts are being made for the development of these programmes for computing other parameters at observed and standard depths.

*Services rendered to other Divisions:*  
The Data Centre is offering service facility for punching and verifying various marine data for the scientists of the Institute who will be processing their data on electronic computers. Bathythermography data collected on board the Indian research vessels during the 'MONEX-73' programme were put on to punch cards and sent to Naval Hydrographic Office and Indian Meteorological Department.

*Research input:* The data collected for the above study were analysed and processed. The study showed the presence of upwelled water in the Mandovi and Zuari estuaries from the last week of July upto the end of August. In the estuary, this water had a  $\sigma_t$  between 23.00 and 24.00 and in the nearshore region it was between 24.00 and 25.00. The oxygen value also was very low (0.5 ml/l). This shows that the upwelling starts from below 100 m. The cessation, however, takes place in the month of October.

The maximum tidal current velocity recorded at the surface on 27th July, 1972 was 110 cm/sec during ebb and the minimum was 26 cm/sec. On 9th

of August, 1972, a current velocity of 212 cm/sec was recorded at the surface during ebb and the minimum value from the same phase of the tide was 13 cm/sec.

## 2.72 Publications and Information

"*Mahasagar*", the quarterly bulletin of National Institute of Oceanography was continued to be published. The June 1973 issue was a special number devoted to 16 scientific articles presented by scientists at the colloquium organized by the Institute on 26th May, 1972 marking the completion of 'Ten Years of Integrated Ocean Research in India'.

September and December 1973 issues have been combined due to paper crisis and difficulties at the local presses. The first number of volume 7 for the year 1974 is to be published with a changed format. It will contain mostly original

scientific contributions and short notes. There will be a small section for book reviews and another for news and comments.

Annual Report 1972-73 was published. Both, *Mahasagar* and Annual Report were mailed to about 600 addresses on the mailing list of the Institute. The mailing list is being revised with a view to restrict mailing of NIO publications only to those who can make good use of them.

Information about the Institute was published in *Mahasagar* as well as in local newspapers. Articles highlighting activities of the Institute were issued for lay public. Radio talks on items of topical interest were organized. Queries from individuals and organizations and the visitors including student parties, scientists and officials were attended to and their visits to the Institute were organized.

# 3

## administrative set-up

### 3.1 Executive Committee

- |   |                 |
|---|-----------------|
| 1. Dr. S. Z. Qasim,<br>Director,<br>National Institute of Oceanography,<br>Panaji (Goa).  | <b>Chairman</b> |
| 2. Commodore F. L. Fraser,<br>AVSM, MIS,<br>Chief Hydrographer to the<br>Government of India,<br>Naval Hydrographic Office,<br>Dehra Dun. | <b>Member</b>   |
| 3. Prof. B. G. Deshpande,<br>Head of the Department of Geology,<br>Poona University,<br>Poona.  | "               |
| 4. Shri P. K. Eapen<br>Head, Fisheries Division,<br>Tata Oil Mills Co. Ltd.,<br>H & C Lane, Karuvelipady,<br>Cochin - 5.                  | "               |
| 5. Dr. V. V. R. Varadachari,<br>Head, Physical Oceanography<br>Division,<br>National Institute of Oceanography,<br>Panaji (Goa).          |                 |
| 6. Dr. T. S. S. Rao,<br>Officer-in-Charge,<br>Regional Centre of NIO,<br>Cochin - 18.   | "               |
| 7. Dr. S. N. Dwivedi<br>Head, Biological Oceanography<br>Division,<br>National Institute of Oceanography,<br>Panaji (Goa).                | "               |

8. Shri T. S. Bawa, Member  
Administrative Officer,  
National Institute of Oceanography,  
Panaji (Goa).
9. Accounts Officer  
National institute of Oceanography,  
Panaji (Goa).

### 3.2 Scientific Advisory Committee to the Executive Committee

1. Shri K. A. Varughese,  
Managing Director,  
Zuari-Agro Chemicals,  
Zuari Nagar (Goa).
2. Prof. D. B. Wagh,  
Director,  
Bombay University Post Graduate  
Centre,  
Panaji (Goa).
3. Shri R. P. Rai,  
Director of Industries & Mines,  
Government of Goa, Daman & Diu,  
Panaji (Goa).
4. Shri P. K. Eapen,  
Head, Fisheries Division,  
Tata Oil Mills Co. Ltd., Ernakulam,  
Cochin-5
5. Prof. B. N. Ghosh,  
Head, Department of Chemistry,  
Bombay University Post  
Graduate Centre,  
Panaji (Goa).
6. Prof. R. L. Mehrotra,  
Principal,  
Government College of Engineering,  
Farmagudi, Ponda (Goa.)

### 3.3 Budget

The budget of the Institute for the year 1973-74 is given below :

<i>Budget item</i>	<i>Sanctioned (Final grant Rs. in lakhs)</i>	<i>Actual (Rs. in lakhs)</i>
1. Recurring	31.880	31.936
2. Capital	<u>58.665</u>	<u>59.480</u>
Total	90.545	91.416

### 3.4 Scientific and Technical Staff

#### *Director*

Dr. N. K. Panikkar  
(till 17th August 1973)

Dr. S. Z. Qasim  
(from 7th January 1974)

### A. Divisions at the Headquarters

1. Physical Oceanography

#### *Head of the Division*

Dr. V. V. R. Varadachari

#### *Scientists*

Shri L. V. Gangadhara Rao  
Shri C. S. Murty  
Shri P. K. Das  
Shri M. J. Varkey  
Shri P. G. Kurup



*Senior Scientific Assistant*

Shri Thomas Cherian

*Junior Scientific Assistants*

Shri K. K. Varma

Shri G. Narayana Swamy

Shri V. Kesava Das

Shri P. S. Joseph

Shri V. Ramesh Babu

Shri A. Balachandran

*Senior Research Fellow*

Shri M. Veerayya

*Junior Research Fellows*

Shri N. Bahulayan

Shri K. Gurunadha Rao

### **Geophysics Unit**

*Scientist*

Shri T. C. S. Rao

*Senior Scientific Assistant*

Shri D. Gopala Rao

*Junior Scientific Assistant*

Shri G. C. Bhattacharya

## **2. Chemical Oceanography**

Shri C. V. Gangadhara Reddy

Dr. R. Sen Gupta

Shri S. P. Anand

Shri V. N. Sankaranarayanan

*Senior Scientific Assistants*

Shri S. Y. S. Singbal

Shri S. N. D'Souza

*Junior Research Fellows*

Shri S. B. Kamat

Shri S. Pai Fondekar

Miss S. Naik

## **3. Geological Oceanography**

*Head of the Division*

Shri H. N. Siddiquie

*Scientists*

Dr. M. G. Anantha Padmanabha  
Setty

Shri P. S. N. Murty

Shri R. R. Nair

Shri Madhusudana Rao Ch.

*Senior Scientific Assistants*

Dr. V. Narayanan

Shri B. G. Wagle

Shri G. Victor Rajamanickam

Shri M. V. S. N. Gupta

*Junior Scientific Assistants*

Shri R. M. Kidwai

Shri F. Almeida

## **4. Biological Oceanography**

*Head of the Division*

Dr. S. N. Dwivedi

*Scientists*

Dr. K. Radhakrishna

Dr. A. H. Parulekar

Dr. A. G. Untawale

Shri R. M. S. Bhargava

Shri V. P. Devassy

Shri R. M. Dhawan

Shri P. M. A. Bhattathiri

*Senior Scientific Assistants*

Shri S. A. H. Abidi

Shri R. Alfred Selvakumar

Shri S. C. Goswami

Shri K. Kameshwara Rao

Shri P. S. Gore

Shri S. Ayyappan Nair

*Junior Scientific Assistants*

Shri S. N. Harkantara  
Shri V. M. A. Hakim  
Shri C. T. Achuthankutty  
Shri N. B. Bhosle

*Pool Officers*

Dr. (Mrs) Usha Goswami  
Dr. (Miss) Aditi Pant

*Retired Scientist*

Shri K. Virabhadra Rao

*Research Fellows*

Mrs. K. Warriar  
Shri Verlekar  
Miss Lok Bharti

**5. Planning & Data**

*Scientists*

Dr. V. S. Bhatt (Officer-in-charge)  
Shri D. Panakala Rao

*Senior Scientific Assistant*

Shri M. K. Antony

*Junior Technical Assistants*

Shri P. Venugopal  
Shri S. P. Sharma (Proof Reader)

**6. Instrumentation**

*Scientist*

Shri.P. E. Sankaranarayanan  
(Officer-in-charge)

*Junior Scientific Assistant*

Smt. Vani B. Peshwe

*Junior Mechanical Assistant*

Shri K. K. Mohammed Rafique

*Senior Draughtsman*

Shri Md. Wahidullah

*Pool Officer*

Dr. E. Desa

*Junior Research Fellow*

Shri N. V. Karmali

**B. Regional Centre of NIO,  
Cochin**

**1. Indian Ocean Biological Centre**

*Officer-in-charge*

Dr. T. S. S. Rao  
(On extra-ordinary leave)  
Dr. M. Krishnan Kutty  
(Officiating)

*Scientists*

Dr. M. J. George  
Dr. R. V. Unnithan  
Shri H. Krishna Iyer  
Shri P. Gopala Menon  
Dr. M. Sakthivel  
Shri K. J. Peter

*Senior Scientific Assistants*

Dr. M. Saraswathy  
Dr. (Mrs.) Vijayalakshmi R. Nair  
Shri T. Balachandran  
Smt C. B. Lalithambika Devi  
Shri P. N. Aravindakshan  
Shri V. T. Paulinose  
Shri Jacob George  
Shri George Peter  
Shri Chandrasekharan Nair K. K.

*Junior Scientific Assistants*

Shri T. C. Gopalakrishnan  
Dr. V. Santhakumari  
Smt. P. P. Meenakshi Kunjamma  
Smt. Rosamma Stephen  
Shri P. Haridas  
Shri P. N. Nair

*Pool Officer*

Dr. Saramma Abraham

#### *Junior Research Fellows*

Shri M. Madhupratap  
Shri E. V. Radhakrishnan  
Shri Simon John  
Shri V. Baby  
Shri Prasad Thomas  
Shri M. Vijayan  
Miss K. N. Remani  
Miss Grace Mathew

## 2. **Physical Oceanography Unit**

#### *Scientists*

Shri V. S. Rama Raju  
  
Shri P. Udayavarma Thirupad

## 3. **Biological Oceanography Unit**

#### *Scientists*

Dr. M. Krishnankutty  
Shri B. M. Panikkar  
Shri U. K. Gopalan  
*Research Fellow*  
Shri S. R. Sreekumaran Nair

## C. **Field Unit of the NIO, Bombay**

#### *Scientists*

Dr. B. N. Desai (Officer-in-charge)  
Dr. A. B. Wagh

#### *Senior Scientific Assistant*

Shri V. Josanto

#### *Junior Scientific Assistants*

Shri M. M. Sabnis  
Miss Saramma U. Panampunnayil  
Shri M. D. George

#### *Junior Research Fellow*

Shri A. A. Shaikh

## 4. **Library**

The Library continues to grow and has now about 7711 items including books, back volumes of periodicals and Technical Reports on the various aspects of Marine Science. 400 books and 200 Technical Reports were added during the year under review.

The Library subscribes to 130 journals and receives 25 journals on gift or exchange basis. A start in the direction of providing microfilm and related facilities has also been made by obtaining microfilms of books and journals.

The Inter-Library loan facility was extensively utilised by NIO Staff and a number of books were loaned to other libraries and to Research Institutions.

## 5. **Awards, Honours, Memberships of Various Committees**

Dr. N. K. Pannikkar was awarded Chandra Kala Hora Medal for the period 1965-70 for his outstanding contribution in the research, development and promotion of fisheries in India.

Dr. S. Z. Qasim was awarded *Padmashri* by the President of India on 26th January, 1974 for his outstanding contribution in the development of Marine Sciences in India.

Dr. V. V. R. Varadachari was elected Fellow of the Indian Academy of Sciences effective from 1st January 1974.

— was nominated member, W.M.O. Technical Commission for Marine Meteorology.

— was nominated as member of Executive Committee of the N.I.O,

Dr. S. N. Dwivedi has been approved and appointed Examiner for the Ph. D. Thesis of Vikram and Bhopal Universities.

— was nominated as Member of Executive Committee of N. I. O.

Dr. T. S. S. Rao was nominated as Member of the Executive Committee of N.I.O.

Dr. B. N. Desai served as

— Member of NCST Committee on Oceanographic Instruments.

— Member of Indian Standards Institution's Committee CDC 26:3:1.

— Member on Advisory Panel for Government of Gujarat Planning Commission.

— Member of Advisory Committee on Science and Technology, Government of Maharashtra.

— Departmental Member on Deep Sea Fishing Advisory Committee.

Shri P. E. Sankaranarayanan was nominated as Member of the Sub-Committee on Process Control Instrument of the Co-ordination Council of the Earth Sciences Group of C. S. I. R. and was nominated as Member of the Group IV sub-committee on Marine Scientific Instruments for data acquisition of NCST Panel on Marine Resources.

Shri M. Sakthivel, Scientist was awarded Ph. D. degree by the Cochin University for the thesis submitted on "The Studies on the Thecosomata of the Indian Ocean."

Shri V. M. A. Hakim has been elected Member of Senate of Cochin University.

Shri A. F. Anto was awarded the M. Sc (Tech.) degree by the Andhra University.

## 6. Deputations

Dr. N. K. Pannikkar attended the Conference on Marine Parks, organised by the Mediterranean Association of Marine Biologists with cooperation of the Italian Government from 18th to 22nd, June 1973 at Naples.

— attended the IVth Convention on the *Pacem in Maribus* which was organised from 23rd to 26th June, 1973 under the auspices of International Ocean Research Institute at Malta.

Dr, T. S. S. Rao, Officer-in-charge, Regional Centre of NIO, Cochin is on extra-ordinary leave from 27.6.73 to 25.9.74 to participate as a Visiting Professor in the Multinational Project on Marine Sciences of the OAS Regional Scientific and Technological Development Programme at Cumana, Venezuela, South America.

Dr. S. N. Dwivedi participated in the SMBA meeting on International Biological Programme in November 1973 at the invitation of Royal Society, U. K. and SMBA, Scotland.

— participated in Symposium held in November 1973 by Zoological Society of London on the invitation of British India Forum.

Dr. B. N. Desai, Officer-in-charge, Regional Centre of NIO, Bombay was deputed to Sweden to attend IInd

FAO/SIDA Training Course in prevention of Marine Pollution and Preservation of Marine Environment in August 1973.

Dr. V. S. Bhatt attended the 15th Indian Standards Convention of the Indian Standards Institution (ISI) from 17th to 21st December 1973 at Coimbatore.

Shri L. V. Gangadhara Rao participated in the Indo-Soviet joint expedition 'MONEX-73' on board Russian Research Vessel 'Ocean' during May-June 1973.

— attended the sixth meeting of National Working Group for Global Atmospheric Research Programme (GARP) held at New Delhi on 28.8.73.

Shri M. J. Varkey and P. G. Kurup, scientists, participated in the Indo-Soviet joint expedition 'MONEX-73' on board vessels of Indian Navy.

The deputation of Shri S. A. H. Abidi SSA has been extended for another two years as Fisheries Officer to the Government of Tanzania. He is likely to return in February 1976.

Shri B. G. Wagle, SSA is on deputation to Indian Institute of Photo-interpretation, Dehra Dun for training in Air Photo Interpretation for Geomorphology.

Shri T. C. Gopalakrishnan, JSA is on deputation for 9 months from 9.10.73

to work at the Smithsonian Institution, Division of Crustacea, Washington D. C, U. S. A. under UNESCO Regular Programme Fellowship in Marine Sciences (Planktonology).

Shri A. F. Anto was deputed to attend the training programme of FAO/NORAD on "Acoustic methods for fish detection and abundance estimation" from 5th November to 23rd November 1973, held at Cochin.

Shri Md. Wahidulla, Senior Draftsman was deputed for training for a week on the fabrication of printed boards at the National Aeronautical Laboratory, Bangalore.

## 7. Meetings, Exhibitions, Seminars and Symposia

Shri H. N. Siddiquie attended the meeting of the *Darshak* cruise programme at Dehra Dun in September 1973.

— attended the meeting of the Working Group on Offshore Mineral Exploration at Calcutta in December, 1973.

Shri R. R. Nair attended the meeting of the 3rd Working Group on Offshore Mineral Exploration at Calcutta in April 1973.

Shri K. J. Peter attended the symposium on the Early Life History of Fishes held in May, 1973 at Oban, Scotland, U. K.

## 8. Colloquia and Special Lectures

### Colloquia (in Goa)

Speaker	Subject	Date
1. Shri S. R. Rao	Maritime activities of the Harappas	25.6.73



Shri S. K. Bannerjee	Lt. Governor of Goa, Daman & Diu
Shri D. B. Bandodkar	Chief Minister of Goa, Daman & Diu
Smt. Sumati Morarjee	Executive Director, Scindia Steam Navigation Co. Ltd., Bombay
Shri M. K. Roy Chowdhury	Director General, Geological Survey of India
Shri R. K. Bera	Scientist, NAL, Bangalore
Mr. R. P. Cuzondu Rest	NOAA/EDS/NODC Rockville.
Capt. V. A. Pomortsev	160, Malcha Marg, New Delhi-21
Dr. C. S. Mason	Bedford Institute of Oceanography Darmouth Nova Scotia, Canada
Col. D. Veitch	Canadian High Commission, New Delhi
Dr. B. P. Dash	Imperial College of Science & Technology, London, S. W. 7, England
Shri N. R. Mirdha	40 Canning Line, New Delhi
Dr. J. I. W. Anderson	Unilever Research, Aberdeen, U. K.
Shri Maurise H. Strong	United Nations Environment Programme Nairobi, Kenya
Dr. Ravi Prakash	Vice Chancellor, Bhopal University
Dr. Hari Narain	Director, N. G. R. I., Hyderabad
Dr. Gautam Mathur	Department of Econ., Osmania University
Capt. H. S. Punia	Commanding Officer, Indian Navy <i>INS Amba</i>
V. A. Skossyrev	B-9/21 Vasant Vihar, New Delhi
Dr. Nityanand	Deputy Director, Central Drug Research Institute, Lucknow
Dr. Suk Dev	Deputy Director & Head, Organic Chemistry Division, NCL, Poona
Dr. P. J. Deoras	Emeritus Scientist Haffkine Institute, Bombay - 12.
Shri Daniel Ohreny	U. S. Vice Counsel, Bombay
Col. K. K. Gupta	Senior Adviser in Medicine, Northern Command, Indian Army
Shri K. G. Krishnamurty	Council of Scientific & Industrial Research, New Delhi
Cdr. V. F. Rebello	Chief Staff Officer to NOIC Goa Navy Office, Vasco-da-Gama

Shri S. K. Sinha		Manager, Deck Machinery Garden Reach Workshop Ltd., A. G. O. I. Undertaking, Calcutta
Mr. V. P. Sondhi & Party		Iron Ore Board of India
Shri B. K. Rao		Chairman, Visakhapatnam Port Trust
Shri R. Shrinivasan		Deputy Chairman, Vishakhapatnam Port Trust
Shri T. V. Rajagopalan		Technical Manager, Mangalore Chemicals & Fisheries, Mangalore
Shri Steve Worley		Worley Engineering, INC, 9800 NW Freeway, Houston, Texas
Shri Albert Vaz Ztverdew	6118	Fordham, Houston, Texas, 77005 U.S.A.
Shri Reagan W. McDonald		(Worley Engr) 7506 Thurow St., Houston, Texas 77017, U. S. A.

#### **Visits to Regional Centre, Cochin**

Bernt J. Dybern		Fishery Board of Sweden, Gitebory, Sweden
Leif E. Andren		Fishery Resources Division, Dept. of Fisheries, FAO, Rome, Italy
Shri C. Achutha Menon		Chief Minister, Kerala State, Trivandrum
Shri C. Subramaniam		Vice-President of CSIR & Union Minister for Industrial Development, Science & Technology, New Delhi
Shri C. R. V. Raman		Director, Regional Meteorological Office, Colaba, Bombay - 5
Dr. M. Vannucci		CPOM Institute de Biologica, UNAM, C. U., A. P. 70-233, Mexico 20, D. F. Mexico
William B. Cox		Geographic Officer, American Embassy New Delhi
Dr. K. V. Natarajan		Associate Professor, Greater Hartford College, Hartford, U. S. A.
J. A. Bartle		National Museum of New Zealand, Wellington, New Zealand



# 11

## publications

### 11.1 publications of the Institute

1. Annual Report 1972-73.
2. Quarterly, Bulletin of the Institute, '*Mahasagar*' Vol. 6, Nos. 1-4.
3. International Indian Ocean Expedition Plankton Atlas, Vol. IV, *Fascicle 1* : Distribution of Platyhelminthes, Tomopteridae, other Pelagic Polychaeta, Trochophores and Sipunculida of the Indian Ocean. *Fascicle 2* : Distribution of Actinotrocha, Brachiopod Larvae, Chaetognatha, Copelata, Pyrosoma, Salps, Doliolids and Amphioxus of the Indian Ocean.
4. International Indian Ocean Expedition Plankton Atlas Vol. V, *Fascicle 1* : Distribution of Hydromedusae; Scyphozoa and Meroplanktonic Stages of Anthozoa of the Indian Ocean. *Fascicle 2* : Distribution of Foraminifera, Echinodermata and Tornaria of the Indian Ocean.
5. Handbook to the International Zooplankton Collections Vol. IV & V : Papers on the Zooplankton Collections of the IIOE.

### 11.2 Papers Published by Staff Members

- 227 **Achuthankutty, C. T.**, 1973. Sexual abnormalities in the genus *Acetes* (Sergestidae, Decapod)., *Curr. Sci.*, 42(23): 827-828.
- 228 **Achuthankutty, C. T., K. K. C. Nair and K. S. Purushan.** 1973. A shoal of sergestid *Acetes* in association with a swarm of gammarid amphipods in the southwest coast of India. *Curr. Sci.*, 42(23): 840.
- 229 **Achuthankutty, C. T. and M. J. George.** 1973. *Acetes sibogalis* sp. nov. (Crustacea: Decapoda, Sergestidae) from Cochin backwaters with a note on its impregnation. *Indian J. mar. Sci.*, 2(2): 139-144.
- 230 **Anand, S. P.** 1973. Effect of tidal currents and barge traffic on marine foulers in Mandovi estuary. *Indian J. mar. Sci.*, 2(2): 108-112.
- 231 **Aravindakshan, P. N.** 1973. Distribution and ecology of *Pterotrachea coronata* (Forsk.) In *The Biology of the Indian Ocean. Ecological Studies*, Bernt Zeitzschel (Ed), 3 : 399-400.
- 232 **Aravindakshan, P. N. and M. Sakthivel.** 1973. The location of Cephalopod nurseries in the Indian Ocean. *Handbook to the International Zooplankton Collections*, IOBC, Cochin, 5: 70-75.

- 233 **Balachandran, T.** 1973. Meroplanktonic stages of Anthozoa in the Indian Ocean. In *The Biology of the Indian Ocean, Ecological Studies*, Bernt Zeitzschel (Ed.), 3: 289-293.
- 234 **Balachandran, T.** 1973. Investigations on formaldehyde as a fixative and preservative for zooplankton. *Curr. Sci.*, 42(9) : 322-323.
- 235 **Bhargava, R. M. S.** 1973. Diurnal variation in phytoplankton pigments of Mandovi estuary, Goa. *Indian J. mar. Sci.*, 2(1): 27-31.
- 236 **Bhargava, R. M. S., R. A. Selvakumar and S. Y. S. Singbal.** 1973. Hydrobiology of surface waters along Panaji-Bombay coast. *Indian J. mar. Sci.*, 2(2) ; 103-107.
- 237 **Bhatt, V. S. and R. M. S. Bhargava.** 1973. Studies on eggs and larvae of the garfish, *Tylosurus crocodilus* (Le Sueur). *Indian J. mar. Sci.*, 2(2): 127-132.
- 238 **Chandrasekharan Nair, K. K.** 1973. On the occurrence of *Dairella latisimma* and *Daire California* (Amphipoda) in the Indian Ocean. *Handbook to the International Zooplankton Collections*, IOBC, Cochin, 5 : 55-59.
- 239 **Chandrasekharan Nair, K. K., P. G. Jacob and S. Kumaran.** 1973. Distribution and abundance of Planktonic Amphipods in the Indian Ocean. In *The Biology of the Indian Ocean. Ecological Studies*, Bernt Zeitzschel (Ed.), 3 : 349-356.
- 240 **Cherian, Thomas.** 1973. Studies on the size distribution and physical parameters of the sediments of Cochin Harbour. *Proc. Ind. Geophys. Union*, Vol. 10.
- 241 **Delia Croce, N. and P. Venugopal** 1973. *Penilia avirostris* Dana in the Indian Ocean (Cladocera). *Int. Revue ges. Hydrobiol* , 58(5): 713-721.
- 242 **Desai, B. N.** 1973. Benthic productivity in the Indian Ocean. *Mahasagar*, 6(2) : 128-132.
- 243 **Dwivedi, S. N.** 1973. Some biological problems of the west coast of India. *Mahasagar*, 6(2): 112-119.
- 244 **Dwivedi, S. N., S. V. A. Rahim, and S. Ayyappan Nair,** 1973. Ecology and production of intertidal sand fauna during SW monsoon along Mandovi estuary (Goa). In *Recent Researches in Estuarine Biology*. R. Natarajan (Ed.), Hindustan Publishing Corpn. (I) Ltd., New Delhi, India : 1-20.
- 245 **George, M. J.** 1973, Prawn larvae and assessment of prawn resources. *Mahasagar*, 6(2): 133-139.
- 246 **George, M. J.** 1973. An assessment of the fishery resources for the non-penaeid prawns in India. *Symp. on Living Resources of the Seas around India*, CMFRI (ICAR), 1968 : 557-562.
- 247 **George, M. J.** 1973. The influence of backwaters and estuaries on marine prawn resources. *Symp. on Living Resources of the Seas around India*, CMFRI (ICAR), 1968: 563-569.

- 248 **George, M. J.** 1973. The lobster fishery resources of India. *Symp. on Living Resources of the Seas around India*, CMFRI (ICAR), 1968. 570-580.
- 249 **George, M. J.** 1973. Deep Sea spiny lobster, *Puerulus sewelli* Ramadan. Lts. Commercial potentialities. *Symp. on Living Resources of the Seas around India*, CMFRI (ICAR): 1968: 634-640.
- 250 **George, M. J.** 1973. A brief review of the progress of prawn mariculture. *Proc. Seminar Mariculture and Mechanised Fishing*, Madras. 1972 : 77-83.
- 251 **George, M. J. and V. T. Paulinose.** 1973. On a collection of decapoda (Penaeidea) from the south-west coast of India. *Handbook to the International Zooplankton, Collections*, IOBC, Cochin, 5: 60-69.
- 252 **George, M. J. and V. T. Paulinose.** 1973. *Leptochela robusta* Stimpson (Decapoda, Caridea, Pasiphaeidae) from the south-west coast of India and its larval development. *Handbook to the International Zooplankton Collections*, IOBC, Cochin, 5: 196-210.
- 253 **George Peter.** 1973. Latitudinal distribution of a few species of pelagic polychaetes in the upper 200 m water of the Indian Ocean. *Handbook to the International Zooplankton Collections*, IOBC, Cochin, 5: 76-80.
- 254 **George Peter.** 1973. On the ecology of pelagic polychaetes newly recorded from Indian Ocean. *Handbook to the International Zooplankton Collections*, IOBC, Cochin, 5: 81-86.
- 255 **Gopalakrishnan, T. C.** 1973. A new species of *Macandrewella* (Copepoda : Calanoida) from off Cochin, south-west coast of India. *Handbook to the International Zooplankton Collections*, IOBC, Cochin, 5: 180-189.
- 256 **Gopala Menon, P. and V. T. Paulinose,** 1973. Distribution of Decapod larvae in the Indian Ocean. *Handbook to the International Zooplankton Collections*, IOBC, Cochin, 5: 161-171.
- 257 **Gore, P. S. and S. Y. S. Singbal.** 1973. Ecology and production in two sandy beaches of Goa. Part A—Distribution of bacteria in Colva and Siridao in relation to certain environmental parameters. *Fish. Technol.*, 10U): 55-60.
- 258 **Goswami, S. C.** 1973. Observations on some planktonic group of Kavaratti atoll (Laccadives). *Proc. Ind. Acad. Sci.*, 39 B(6): 676-686.
- 259 **Gupta, M. V. S. N.** 1973. A preliminary report of the foraminiferal assemblages from the lagoon sediment of Kavaratti atoll (Laccadives). *Curr. Sci.*, 42(22): 781-782.
- 260 **Gupta, M. V. S. N.** 1973. Planktonic foraminifera from the sediments off Cochin. *Indian J. mar. Sci.*, 2(2): 147-148.
- 261 **Haridas, P., Madhu Pratap M., and T. S. S. Rao.** 1973. Salinity, temperature, oxygen and zooplankton biomass of the backwaters from Cochin to Alleppey. *Indian J. mar. Sci.*, 2(2) : 94-102.

- 262 **Kasturirangan, L. R., M. Saraswathy and T. C. Gopalakrishnan.** 1973. Distribution of Copepoda in the Indian Ocean. In *The Biology of the Indian Ocean. Ecological Studies*, Bernt Zeitzschel (Ed.) 3 : 331-333.
- 263 **Krishnankutty, M.** 1973. New ideas on fish population dynamics. *Mahasagar* 6(2) : 120-127.
- 264 **Krishnankutty, M.** 1973. Maximum yield from fishery resources. a re-examination. *Fisheries Week Souvenir*. (Nov. 73). Dept. of Fisheries, Univ. of Calicut (India): 29-30.
- 265 **Krishnankutty, M., Kesavan Nair, A. K. and S. Z. Qasim.** 1973. An evaluation of the sampling design adopted by the Central Marine Fisheries Research Institute for estimating marine fish production of India. *Indian J. Fish.*, 20(1) : 16-34
- 266 **Murty, C. S., Das P. K., and V. V. R. Varadachari.** 1973. Circulation in the shallow waters of the shelf region using sea-bed drifters. *Proc. Indian Geophys. Union*, Vol. 10.
- 267 **Murty, P. S. N., Rao, Ch. M. and C. V. G. Reddy.** 1973. Partition patterns of Iron, Manganese, Nickel and Cobalt in the shelf sediments of west coast of India. *Indian J. mar. Sci.*, 2(1) : 6-12.
- 268 **Nair, K. K. C., Jacob George and T. S. S. Rao.** 1973. Distribution of certain planktonic crustaceans and insect Halobates in the Indian Ocean. *Indian J. mar. Sci.*, 2(2) : 116-121.
- 269 **Nair, R. R., Varma, P. U., Pylee, A. and V. V. R. Varadachari.** 1973. Studies on the sediment transport in Moplah Bay Harbour, Cannanore using fluorescent tracers. *Proc. Indian Geophys. Union*, Vol. 10.
- 270 **Panikkar, N. K., A. H. Parulekar and A. G. Untawale.** 1973. Continental shelf islands of the Konkan coast. *Proc. Ind. Geophys. Union*, 10: 112-115.
- 271 **Panikkar, N. K. and T. S. S. Rao.** 1973. Zooplankton investigation in Indian waters and the role of the Indian Ocean Biological Centre. *Handbook to the International Zooplankton Collections*, IOBC, Cochin, 5: 111-162.
- 272 **Parulekar, A. H.** 1973. Quantitative distribution of benthic fauna on the inner shelf of central west coast of India. *Indian J. mar. Sci.* 2(2) : 113-115.
- 273 **Parulekar, A. H. and S. N Dwivedi.** 1973. Ecology of benthic production during south west monsoon in an estuarine complex of Goa. In *Recent Researches in Estuarine Biology*. R. Natarajan (Ed.) Hindustan Publishing Corp. (I) Ltd., New Delhi, India.
- 274 **Singhal, S. Y. S.** 1973. Diurnal variations of some physico-chemical factors in the Zuari estuary of Goa. *Indian J. mar. Sci.*, 2(2) : 90-93.

- 275 **Paulinose, V. T.** 1973. Developmental stages of *Penaeopsis rectacuta* (Bate) (Decapoda : Penaeidae) from the Indian Ocean. *Handbook to the International Zooplankton Collections*, IOBC, Cochin, 5: 97-110.
- 276 **Peter, K. J.** 1973. Seasonal variation of Ichthyoplankton in the Arabian Sea in relation to monsoon. *FAO Fishery circular*, June 1973.
- 277 **Pillai, V. Narayana, Thomas Cherian, George M. D , and A. F. Anto.** 1973. The effect of tidal currents on the hydrography of the backwaters around Cochin bar mouth during post and premonsoon seasons. *Proc. Indian Geophys. Union*, Vol. 10.
- 278 **Qasim, S. Z., Bhattathiri, P. M. A. and V. P. Devassy.** 1973. Growth kinetics and nutrient requirements of two tropical marine phytoplankters. *Mar. Biol*, 21: 299-304.
- 279 **Rama Raju, V. S.** 1973. Indian Continental shelf in relation to the 100 fm. line. *Proc. Indian Geophys. Union*, Vol-10.
- 280 **Rao, Ch. Madhusudana, Murty, P. S. N. and C. V. G. Reddy.** 1974. Distribution of Titanium in shelf sediments along the west coast of India. *Proc. Indian natn. Sci. Acad.*, 38(384): 114-119.
- 281 **Rao, K. Kameshwara.** 1973. Quantitative distribution of planktonic foraminifera in the south west coast of India. *Indian J. mar. Sci.*, 2(1): 54-61.
- 282 **Rao, K. Virabhadra.** 1973. On dendronotacean nudibranch gastropods of the genera *Hancockia* and *Doto* from the Gulf of Mannar. *Spl. Publ. mar. biol. Ass. India* : 321-332.
- 283 **Rao, K. Virabhadra and L. Krishna Kumari.** 1973. Structure and early development of an Opisthobranch mollusc, *Caloria militaris* (Alder and Hancock). *Indian J. mar. Sci.*, 2(1): 32-37.
- 284 **Rao, T. S.S** 1973. Zooplankton studies in the Indian Ocean. In *The Biology of the Indian Ocean, Ecological Studies*, Bernt-Zeitzschel (Ed.), 3: 243-255.
- 285 **Rao, T. S. S., M. Sakhivel and S. V. M. Abdul Rahim.** 1973. Disjunct distribution of pyrosomids in the Indian Ocean. *Curr. Sci.*, 42(19) : 688-689.
- 286 **Rao, T. S. S. and Vijayalakshmi Nair.** 1973. Chaetognaths in the upwelling area of the Arabian Sea. *Spl. Publ. mar. biol. Ass. India*, 183-192.
- 287 **Reddy, C. V. G. and S. Y. S. Singbal.** 1973. Chemical characteristics of tar-like materials found on the beaches along the east and west coast of India in relation to their source of origin. *Curr. Sci.*, 42(20): 709-711.
- 288 **Reddy, M. P. M. and V. V. R. Varadachari.** 1973. Sediment movement in relation to wave refraction along west coast of India. *Proc. Indian Geophys. Union*, Vol. 10.

- 289 **Rosamma Stephen and K. Sarala Devi.** 1973. Distribution of *Haloptilus acutifrons* (Copepoda : Calanoida) in the Indian Ocean with a description of the hitherto unknown male. *Handbook to the International Zooplankton Collections*, IOBC, Cochin, 5: 172-179.
- 290 **Sakthivel. M.** 1973. Studies on *Limacina inflata* d'Orbigny (Thecosomata, Gastropoda) in the Indian Ocean. In *The Biology of the Indian Ocean, Ecological Studies*, Bernt Zeitzschel (Ed.), 3: 383-397.
- 291 **Sakthivel, M.** 1973. Biogeographical change in the latitudinal boundary of bisubtropical pteropod *Styliola subula* (Quoy et Gaimard) in the Indian Ocean. In *The Biology of the Indian Ocean, Ecological Studies*, Bernt Zeitzschel (Ed.), 3: 401-404.
- 292 **Sakthivel, M and T. S. S. Rao.** 1973. A few comments on the zooplankton investigations of the International Indian Ocean Expedition. *Handbook to the International Zooplankton Collections*, IOBC, Cochin, 4: 150-161.
- 293 **Sankaranarayanan, V. N.** 1973. Chemical characteristics of waters-around Kavarathi atoll (Laccadives). *Indian J. mar. Sci.*, 2(1): 23-26.
- 294 **Sankaranarayanan, V. N. and C. V. G. Reddy.** 1973. Copper content in the inshore and estuarine waters along the central west coast of India. *Curr. Sci.*, 42(7) : 223-224.
- 295 **Santhakumari, V. and N. Balakrishnan Nair.** 1973. Seasonal infestation of the commensalic ciliates of the shipworm, *Nausitora hedleyi* and *Teredo furcifera*. *J. mar. biol. Ass. India*, 14(2).
- 296 **Santhakumari, V. and N. Balakrishnan Nair.** 1973. The commensalic ciliates of *Nausitora hedleyi*: Survival in seawater in relation to infectivity, *J. mar. biol. Ass. India*, 14(2) : 872-874.
- 297 **Saraswathy, M.** 1973. The genus *Gaussia* (Copepoda) with a description of *Gaussia sewelli* sp. nov. from Indian Ocean. *Handbook to the International Zooplankton Collections*, IOBC, Cochin, 5: 90-95.
- 298 **Saraswathy, M.** 1973. The distribution of *Gaussia* in the upper 200 m in the Indian Ocean. In *The Biology of the Indian Ocean, Ecological Studies*, Bernt Zeitzschel (Ed.), 3: 335-338.
- 299 **Saraswathy, M.** 1973. The growth rates of a tropical estuarine shipworm *Nausitora hedleyi*. *Spl. Publ mar. biol. Ass., India*, 366-385.
- 300 **Saraswathy, M.** 1973. The breeding season of *Nausitora hedleyi* as determined by gonad index. *Hydrobiologia*, 43: 13-28.
- 301 **Setty, M. G. Anantha Padmanabha.** 1973. Foraminifera as climatic indicators in the sediments of western Indian continental shelf. *Mahasagar*, 6(2): 70-74.

- 302 **Setty, M. G. Anantha Padmanabha and B. G. Wagle.** 1972. Beach rock from Goa coast. *Proc. Indian natn Sci. Acad.*, 38A (1 & 2) : 9-20
- 303 **Setty, M. G. Anantha Padmanabha and M. V. S. N. Gupta.** 1972. Recent planktonic foraminifera from the sediment off Karwar and Mangalore. *Proc. Indian natn Sci. Acad.*, 33A (5 & 6): 148-160.
- 304 **Victor, G. Rajamanickam and M. G. Anantha Padmanabha Setty.** 1973. Distribution of phosphorus and organic carbon in the nearshore sediments of Goa. *Indian J. mar. Sci.*, 2(2): 84-89.
- 305 **Srivastava, P. S., M. K. Antony and V. C. John.** 1973. A study on the accuracy of the different wave forecasting techniques with reference to recorded waves off Cochin. *Proc. Ind. Geophys. Union*, Vol. **10**.
- 306 **Srivastava, P. S., P. U. Varma, A. Pylee and P. G. Kutup** 1973. Surface and sub-surface currents in Moplah Bay during the NE monsoon season. *Proc. Ind. Geophys. Union*, Vol. 10.
- 307 **Untawale, A. G., S. N. Dwivedi and S. Y. S. Singbal.** 1973. Ecology of mangroves in Mandovi and Zuari estuaries and interconnecting Combarjua canal of Goa. *Indian J. mar. Sci.*, 2(1): 47-53.
- 308 **Veerayya, M., C. S. Murty and V. V. R. Varadachari.** 1973. Effect of artificial dumped material on the configuration of Baina beach, Goa. *Indian J. mar. Sci.*, 2(2): 78-83.
- 309 **Vijayalakshmi, R. Nair.** 1973. Breeding and growth of chaetognath in the Cochin backwaters. *Handbook to the International Zooplankton Collections*, IOBC, Cochin, 5: 87-96
- 310 **Vijayalakshmi, R. Nair and T. S. S. Rao.** 1973. Distribution of chaetognaths in the Arabian Sea. In *The Biology of the Indian Ocean, Ecological Studies*, Bernt Zeitzschel (Ed.), 3: 293-317.
- 311 **Vijayalakshmi, R. Nair and T. S. S. Rao.** 1973. Chaetognaths from the Laccadives with the new record of *Spadella angulata* (Takoita, 1951). In *The Biology of the Indian Ocean, Ecological Studies*, Bernt Zeitzschel (Ed.), 3:319-327.

### 11.3 Popular Articles and Reviews

- 1 **Bhatt, V. S.** 1973. Sun's effect on ocean level. *Science Reporter*, 10(8) 380-381.
- 2 **Bhatt. V. S.** 1973. Progress of oceanic research in India. (Feature article accepted by Press Information Bureau of the Govt. of India for publication on All India basis in English and other languages); *Free India*, 25 Nov., 1973: 13-14; *Sumudrache Pot-Ek Gurh Samasya*, *Konkan Vaibhav* (In Marathi) 22 Dec, 1973; *Navprabha* (in Marathi) 1 Dec. 1973.

- 3 **Kurup, P. G.** 1973. Energy from the ocean tides (in Malayalam ). *Vijnana Kairali*. June 1973.
- 4 **Kurup, P. G.** 1973. The Arctic Ice (in Malayalam). *Sastra Keralem*, July 1973.
- 5 **Kurup, P. G.** 1973. The mud banks and the beach erosion (in Malayalam). *Vijnana Kairali*, October 1973.
- 6 **Panikkar N. K.** 1973. Integrated Ocean Research in India. *Mahasagar*, 6(2): 39-42.
- 7 **Rao, T. S. S.** 1973. Tropical Plankton. *Mahasagar*, 6(2): 109-111.

#### 11.4 Reports Prepared by the Staff Members

<i>Sl. No.</i>	<i>Contributors</i>	<i>Report</i>	<i>Year</i>	<i>Sponsored by</i>
1	A. H. Parulekar, A. G. Untawale, Surendara Kumar & S. N. Dwivedi	Report on feasibility studies on Anjdiv Island as a tourist resort	1973	Govt. of Goa, Daman & Diu