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(Council of Scientific & Industrial Research)

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INDIA

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general introduction

The National Institute of Oceanography is passing through an active organizational phase with new developments taking place in many fields. The scientific activities are being oriented to meet new needs and responsibilities. Several appointments have been made in the current year and new facilities have been provided for work. The construction of laboratory buildings, scientists' hostel, residential accommodation for senior staff members, roads in the Institute campus have all been proceeding actively.

Amongst the new scientific activities of the Institute a few aspects may be indicated here. The project undertaken at the request of Bombay Municipal Corporation to conduct an oceanographic survey of the waters around Bombay was completed this year. A report on the physical aspects of Hydrographic Survey off Bombay has already been issued. A similar report on the biological and pollution aspects is under preparation. The results will help the Corporation in planning their sewage pipeline system in the sea for disposal of the sewage.

The activities of the Chemical Oceanography Division, have taken a distinct shape with some new projects during the current year. An integrated project on the oceanography of Central/West Coast of India was started by the Biological Oceanography Division during this year to collect data on the oceanic productivity between Karwar and Ratnagiri. Parallel observations are taken on the physical parameters. Composite oceanographic studies on the Mandovi and Zuari estuarine systems are being made by all the divisions of the Institute. The survey of the fishery potential of waters off Goa in the 20 and 40 meter areas was completed and the report prepared. The work was done at the request of the State Government of Goa, Daman and Diu.

The Division of Instrumentation was started this year and it will form a central facility for the Institute in Instrumentation. The Division will also carry out R & D work relating to oceanographic instruments.

The Administration Division was strengthened with the filling up of the post of administrative officer.

With the growth of the activities of the Institute, the existing accommodation fell far short of requirements and two new buildings were hired during this year to accommodate new divisions and scientific staff.

For the expanded activities, a 60 foot vessel, *Arjun Prasad* was hired for the implementation of the Project on the Central-West Coast of India. A trawler *'Jalmaharudra'* for the Goa Fishery Project was also hired to make an overall assessment of demersal fishery potential of the waters around Goa. The Indian Ocean Biological Centre at Cochin participated in the 4th cruise on *Bluefin,* a vessel of the Central Institute of Fisheries Operatives. The project relates to the studies of zooplankton in the waters off Cochin, Alleppey and Quilon, and is being carried out in collaboration with the CIFO.

While all the divisions of the Institute are functioning in rented buildings at the moment, the construction relating to the first phase of laboratory buildings and the 46 staff quarters was started this year. The work is proceeding rapidly and it is expected to be completed during 1973. The construction of Director's bungalow was completed; the scientists' hostel and senior scientists' residences are in the finishing stages.

The Institute participated in the Seminar on the Scientific, Technological and Legal Aspects of the Indian Continental Shelf organised in Panaji under the auspices of Indian Geophysical Union. On this occasion the Institute had the honour of having Shri C. Subramaniam, Vice President of the CSIR, the late Dr. Vikram A. Sarabhai, Prof. Bhagavantam, Prof. Ramanathan and several other distinguished scientists amidst them. The Director, Dr. N. K. Panikkar, took an active part in the work of the National Commission on Agriculture as a part time member of the Commission. He also organised at the Institute a meeting of the fishery working group of NCA to discuss national problems of fisheries. Dr. Panikkar also served as a member of the governing body of the ICAR, besides several scientific bodies within the country. In July-August 1971, he participated in the Sea Bed Committee of the United Nations as a member of the Indian delegation.

Shri R. Jayaraman served as a member of Task Force on Marine Resources (both living and non-living) constituted by the Planning Commission, Govt. of India and NCST Planning Groups on Marine Chemicals under the Chemical Industry Panel and Data and Information Management under the Panel on Marine Resources.

The CSIR have converted many positions in the Institute into permanent ones during the year and against these posts, persons who have served the Institute for long periods in temporary capacity are being confirmed.

N. K. PANIKKAR
Director

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research activities

2..1

physical oceanography

2.10 Oceanic Properties

1. Oceanographic Studies at Mormugao and Cochin Harbours
2. Stability Studies

2.11 Physical Processes

1. Indian Continental Shelf Profiles
2. Beach Studies along the Goa and Kerala Coasts
3. Sediment Transport Studies at Moplah Bay
4. Physical Studies of the Estuaries of Goa and Kerala
5. Aguada Bar
6. Studies on Beach Sediments along the Goa Coast

2..12 Waves

1. Wave Studies off Goa Using Wave Recorders
2. Wave Refraction in Relation to Sediment Transport

2.13 General

1. Oceanographic Studies Oriented Towards Sewage Disposal off Greater Bombay
2. Hydrographic Survey off the Central West Coast of India

The research activities of the Physical Oceanography Division for the year under report are as follows:

(a) *Oceanographic Studies oriented towards Sewage Disposal off Bombay*—These studies which were started last year at the request of Bombay Municipal Corporation were completed during this year and a report was brought out incorporating the relevant data and main findings.

(b) *Coastal and Nearshore Oceanographic Studies along the Goa and Kerala Coasts*—The existing programmes dealing with the problem of erosion of some

of the beaches along the Goa and Kerala coasts, the problem of sedimentation in Moplah Bay, Cannanore, and the sand bar (Aguada Bar) formation at the mouth of Mandovi river in Goa, were continued.

The studies on wave refraction in relation to sediment transport along the West Coast of India undertaken during the previous year were completed during the period under report.

A comprehensive programme of studies on the physical aspects of Mandovi-Zuari estuarine system was taken up.

(c) *Hydrographic Survey off the Central West Coast of India*—A detailed hydrographic survey of the shelf waters between Vengurla and Karwar was taken up during the year and the monthly variations of the physical properties of the waters were studied for the Winter and Spring periods. Detailed spot current measurements using current-meters were also made.

Some preliminary studies on the stability of nearshore waters off the Goa coast were carried out.

(d) *Wave Studies Using a Wave Recorder*—A new programme for studying the characteristics of waves approaching the Goa coast was taken up during the year and records of waves were obtained for the different months of Winter and Spring using an OSPOS Wave Recorder.

2.10 Oceanic Properties

I. Oceanographic Studies at Mormugao and Cochin Harbours

Studies on the diurnal and seasonal variation of hydrographic and meteorological parameters at the Mormugao harbour are continued. The data is being analysed.

The studies conducted in the nearshore regions off Cochin Harbour during February indicated :

(i) Existence of highly turbid waters close to the coast with values of extinction coefficients as high as 2.8 and occurrence of comparatively clear waters at the 15 fathom contour with an extinction coefficient of 0.6.

(ii) The studies on currents indicated velocities varying between 0.30 m/sec. to 0.11 m/sec. Steep vertical temperature gradients of the order of 1°C per 10 meters were also observed.

(iii) The salinity of waters varied between 31.78‰ and 33.77‰ The less saline water occurred near the shore apparently under the influence of the outflow of the estuarine water through the harbour mouth.

(iv) The density of the water increased rapidly with depth and stable conditions prevailed with the least mixing of the water in the vertical.

2. Stability Studies

The studies on the stability in the nearshore areas (around 15 meter depth contour) off Goa revealed the following results:

(i) During the month of December the waters are more unstable, throughout the layer, compared to the succeeding months. The top layer (surface to 4 meters depth) is relatively more unstable, than the layer below.

(ii) In January the instability is less than in December. Stable conditions prevail during the noon hours. Instability predominates in the early morning hours. In the late evenings, the surface and bottom layers are stable while the intermediate layer is slightly unstable.

(iii) During February the conditions shift more towards a stable state in these nearshore waters.

2.11 Physical Processes

I. Indian Continental Shelf Profiles

Under this programme, twenty-one continental shelf profiles and two insular shelf profiles were drawn for the Indian Coast and for the Andaman and Laccadive Islands. The shelf characteristics were studied and the averages were compared with the world averages. It was found that there was no definite relation between the shelf width, the depth at which the main break in slope occurs and the average slope of the shelf. It was observed that the shelf off the east coast is narrower and steeper, while the shelf off the west coast is broader and flatter compared to the world averages. Further it was found that for both the eastern and western shelves, the distance of the 100 fathom line from the shore is close to the shelf width.

2. Beach Studies along the Goa and Kerala Coasts

Along the Goa Coast, a total of 164 beach profile observations were made during this period. The beaches experience severe erosion during May to July and to a lesser degree in August and February and a build up in the remaining months. The data so far collected is being analysed statistically to find out the trend in the behaviour of the beaches and their stability.

Some studies on littoral currents in the Surf Zone, were made along the Calangute and Colva beaches. The speeds of the currents observed are as follows:

Locality	*Calangute*	*Colva*
Jan. '72	0.30 to 1.74 km/hr	0.12 to 1.3 km/hr
Feb.'72	0.24 to 2.6 km/hr	—
Mar.'72	0.06 to 1.4 km/hr	0.6 to 1.5 km/hr

Wave refraction studies conducted for the Calangute region coupled with observed deep water wave-heights revealed the possibility of waves of maximum heights of 2.94 meters and 2.4 meters with periods 8 and 6 sec respectively approaching the region from SW and W. The presence of converging and diverging zones of wave energy along this strip and the possibility of rip currents with moderate intensity has also been revealed by this study.

Beach studies along the Kerala coast indicated that Thumboli beach was comparatively stable whereas the beaches at Purakkad and Punnappra were susceptible to erosion.

3. Sediment Transport Studies at Moplah Bay

As a continuation of the studies on the sediment transport at Moplah Bay, current measurements were made using c'rift buoys. These measurements showed that during the N. E. monsoon season the surface current speeds varied from

2.5 cm/sec to 9 cm/sec in the bay. Outside the breakwater the current in the surface layer was in the same direction as the wind.

4. Physical Studies of the Estuaries of Goa and Kerala

A systematic study on .the physical aspects of Mandovi-Zuari estuarine system with a view to understand the salinity and circulation patterns and mixing processes in these estuaries was started recently.

5. Aguada Bar

Some preliminary studies suggest that the formation and maintenance of the sand bar near the mouth of the river Mandovi (popularly known as Aguada Bar) may to a great extent be controlled by the narrow and differential channelization of flood and ebb currents produced by the constriction in the river channel half a mile upstream of the bar. The high sediment load ebbing out during the monsoon has a possibility of settling down, downstream of the constriction due to divergence in the current and a sudden fall in speed below the critical value required to keep sediments in suspension, while the deep and narrow channel adjacent to the bar remains flushed due to relatively high velocities maintained there.

Further investigations utilizing surface drifters to delineate ebb-flow trajectories are being continued.

6. Studies on Beach Sediments Along the Goa Coast

Physical — The studies on some of the geological aspects of the beach and dune sediments from the Calangute beach were completed. The results indicate that the beach and dune environments could be differentiated based on their textural characteristics. The student's 't' test results show that the environments of the dune and beach differ significantly from one another and the differences are highly significant in respect of all the textural parameters. Further it was possible to separate the beach environment into the backshore (region unaffected by wave action) and foreshore (region under the influence of active wave action).

Geochemical—The carbonate content of the beach sediments vary from 0.70% to 45% along Calangute, 0 to 8% along Miramar-Caranzalem area and 0.30% to 63% at Colva. In general, the carbonate content of these beaches is fairly high except along Miramar beach and the high value has been attributed to the presence of shells, shell fragments. The carbonate content of the dune sediment is much lower compared to the corresponding beach sediment.

2.12 Waves

1. Wave Studies off Goa Using Wave Recorders

An OSPOS Wave Recorder was used off Calangute, Goa at 16 meters depth contour to record the waves approaching the locality, during December '71, January, February and March '72. The records obtained were analysed following the Zero-crossing method. Based on the Zero-crossing periods and significant wave heights, it has been found that the region is characterised by waves of periods ranging from 6.3 sec to 8.3 sec with

significant wave heights ranging from 23 cm to 48 cm during the period of observations. The waves were found to be approaching from directions lying between WNW and NW.

2. Wave Refraction in Relation to Sediment Transport

Wave refraction diagrams were constructed for waves having periods 8, 10, 12 and 14 seconds approaching the coastline between Cape Comorin and Goa from WNW, SW and WSW directions. For waves approaching from WNW, the wave height is generally reduced as the waves approach the coast since the refraction function values are found to be less than the critical values for all the stations along the coast for all the wave periods studied. For the waves approaching from WSW, W and SW relatively higher wave energies and wave heights are noticed at most of the stations. The inshore sediment movement is in general directed towards the north for waves coming from SW and for waves coming from W and WNW, it is directed to the south. For waves approaching from WSW, the littoral transport is not in one direction and converging and diverging littoial currents are found at many localities along the coast. Along the coast of Kerala, the occurrence of these converging and diverging littoral currents seems to be an important factor associated with the formation of mudbanks along the coast. Sediment movement into the bays along the Coondapur-Goa coast is also revealed by the study.

2.13 General

1. Oceanographic Studies Oriented Towards Sewage Disposal off Greater Bombay

The hydrographic survey which was started last year in connection with the sewage disposal studies off Bombay was continued and the work was completed during this year. The survey covered the area of the sea between Manori in the north and Colaba in the south along the coast of Bombay, upto 10 km offshore. Bathymetric Survey was also carried out off Manori, Bandra, Worli and Malabar Hill to explore the suitability of these areas for laying sewage pipelines. The main findings are given in the following paragraphs:

(a) The surface temperature of the waters varied from a low value of 23.0°C in January to a high value of 31.5°C in April while the waters near the bottom attained the lowest temperature of 22.75°C in January and the umperature rose to 31.2°C in April.

(b) The salinity of the surface waters varied between 24.98‰ in June and 36.67‰ in November, while that of the bottom waters varied from 30.33‰ during June to 36.72‰ in November.

(c) The Sigma-*t* (density) values of the surface waters varied between 15.02 in June and 24.31 in January. The lowest density for the bottom waters was attained in June (Sigma-*t*= 19.11), while the highest density was observed in November (Sigma-*t* = 3).

(d) The temperature gradients of these waters were negative *(i.e.* temperature decreasing with depth) during the period September to May (practically isothermal during the period December to March), while positive gradients were noticed in June after the commencement of the monsoon. The gradients were

weak throughout the period except in the months of September and October when they were comparatively strong.

(e) Strong density gradients exist in June due to the presence of very dilute water of the rain-fall and runoff, at the surface due to the monsoon rains. During the non-monsoon months *(i e.* September to May) the density gradients are in general rather weak except in the months of September and October when they are relatively strong.

(f) The transparency of the waters is very low throughout the period of the survey. The lowest Secchi disc reading obtained was 15 cm in June off Versova and the highest reading was 190 cm in February off Malabar Hill.

(g) Observations on currents indicate that the currents maintain practically the same direction from surface to bottom, while the speed decreases with depth. Strongest currents were noticed during the monsoon with speeds of surface currents exceeding two knots and with very little decrease in speed up to a depth of 1 metre above the bottom. The currents tend to move northward during the rising tide and southward during the falling tide, indicating a strong influence of tide on the coastal circulation of this area.

(h) Observation on wind indicates that the wind speed is normally less than 10 knots during the period September to March while it exceeds 10 knots during April and May and 20 knots occasionally during the monsoon months.

(i) Float tests off Colaba indicate that the onshore and offshore components, during the rising and falling tides respectively, are much stronger than the longshore components and there is a danger of sewage material entering the harbour and polluting the area if a sewage pipeline is laid off Colaba as originally planned. The float tests at other places (Manori, Bandra, Worli and Malabar Hill) indicate that the waters in general move northward with rising tide and southward with falling tide and that the floats let off beyond six fathom contour have less onshore component during the tidal cycle than the ones let off within the six fathom contour.

(j) Studies on bottom drifters released within six kilometers from the coast, show that during the months of May and June the net bottom drift is southward and it is about 0.5 nautical mile per day. This shows that although the currents in the area are mostly influenced by the tide, there is a net movement southward under the influence of the seasonal coastal current which is directed southward along the coast during this season.

(k) The bathymetry off Manori indicates a smooth profile along the traverses 298° and 270°. The bottom profiles off Worli (Lovegrove) indicate a smoother profile along the traverse 300° than along 285° and 260°. The Echosounding results off Malabar Hill show that the bottom is more irregular up to about 4 kilometers along the traverses 300° and 285° than along the traverse 272°.

2. Hydrographic Survey off the Central West Coast of India

Hydrographic survey off the Central West Coast of India was started in Jan 1972 and the survey was carried out at

monthly intervals to obtain a detailed picture of the time variation of different parameters such as temperature, salinity, currents etc. with special reference to the process of upwelling. Details of scientific cruises carried out under this programme are given below :

Cruise No.	*Period*	*Area*
AP-6	24-25 Jan 1972	Shelf waters off the southern part of Goa coast
AP-7	29-30 Jan 1972	Shelf waters off the northern part of Goa coast
AP-13	22-23 Feb 1972	Shelf waters off the northern part of Goa coast
AP-18	7-8 Mar 1972	Shelf waters off the southern part of Goa coast
AP-23	20-21 Mar 1972	Shelf waters off the northern pait of Goa coast
AP-25	23-24 Mar 1972	Shelf waters off the southern part of Goa coast

2.2

chemical oceanography

2.21 Composition of Sea Water

1. Inorganic Phosphates in the Deep Waters
2. Phosphates in the Upper 1000 m
3. Chemical Characteristics of Laccadive Waters

2.22 Composition of Estuarine Waters

1. Upwelled Water in Mandovi and Zuari
2 Iron Concentrations in the Estuarine Waters of Goa

2.23 Organic Compounds in Sea Water

1. Estimation of Dissolved Organic Matter

2.24 Marine Pollution and Fouling

1. Fouling in Relation to Physico-Chemical Factors

2.25 Apparatus and Methods

1. Non-returnable Valve of Water Sampler
2. Fabrication of Floating Rafts

The chemical oceanographic studies were undertaken broadly under three catagories: (1) Distributional aspects of nutrients (organic and inorganic compounds) of sea water in the inshore, offshore and more open parts of the Arabian Sea and the Bay of Bengal, (2) Distribution of chemical constituents in the estuarine waters, and (3) Marine pollution and fouling.

Studies on the distribution of nutrients in the deep waters of the Arabian Sea and the Bay of Bengal are mainly based on the analysis of IIOE data. The work on the chemical characteristics of the waters around Laccadive Islands was undertaken as a part of general oceanographic studies of the region having special environmental disposition. Studies on the dissolved organic matter in sea water were undertaken in view of its importance as a potential source of energy available to the higher trophic levels through the complex food chain of the marine environment. The extremely low concentrations of dissolved organic matter offers cosiderable difficulties in its estimation. Therefore, as a substitute for the complicated and time consuming wet oxidation technique, the simple ultraviolet absorption spectrophotometric estimation of DOM is being standardised for routine analysis.

Work on the Chemical constituents (inorganic nutrients, organic matter, iron, dissolved oxygen etc.) of the Mandovi and Zuari estuaries of Goa, is in progress. This study, apart from acquiring information as to the distribu-

tion and variation of the important chemical parameters, enables us to understand the interaction of marine and river system, peculiar to the locality. Part of this study also provides the base line information for the future marine and estuarine pollution programmes.

Studies on the physico-chemical aspects of marine fouling are in progress with special reference to the intensity of fouling settlement in Mormugao waters. Studies were also undertaken to understand the effect of tidal currents (Flood and Ebb currents) on the growth of marine fouling organisms in relation to chemical conditions of these waters. During the course of these studies, improvements were made in the design of the shallow water sampler fabricated. Two floating rafts were also designed and fabricated with easily interchangeable components.

The salient features of the entire work carried out in the chemical oceanography division is presented below.

2.21 Composition of Sea Water

1. Inorganic Phosphates in the Deep Waters of North Western Indian Ocean

A detailed study of the inorganic phosphates in the deep waters of Northwestern Indian Ocean in relation to oxygen content is made based on IIOE data to understand their distributional patterns and nature of origin. The data was pooled into 1° square and the averages were taken as representative values for that square and contours were drawn for 1000, 2000 and 3000 m levels. The Apparent Oxygen Utilisation (AOU) was calculated as the difference between the oxygen concentration of water in equilibrium with normal atmosphere at *in situ* temperature and salinity and the oxygen concentration as measured.

The distribution of inorganic phosphates show a general increasing trend towards North from the equator. The concentrations were maximum in the region north of Lat. 10° N and the values range between 2.6 and 3.0 µg at/L. Depthwise distribution showed a decreasing trend below 1000 m. The AOU and inorganic phosphates showed direct relationship.

Phosphorus of Oxidative Origin (POX) was found to be much higher than what was observed in the Atlantic Ocean. The POX formed is more than 50% of the total inorganic phosphate, indicating that the major portion of the inorganic phosphate concentration in the deeper layers is predominantly of regenerative character.

2. Phosphates in the Upper 1000m of Eastern Bay of Bengal

Analysis of the phosphate distribution in the Bay of Bengal between Lat. 5° or 11°N and Long. 92° and 100°E (South of Andaman Islands), based on the data collected during the 19th and 20th cruises of INS *Kistna* in August and September, was completed.

A notable features is the high degree of variability in the horizontal and vertical distributions of phosphates in the region, probably influenced by the proximity of the land and the river discharges as also due to the exchange of waters from the Western Pacific through the straits of Malacca. Over the entire region under investigation, the sufrace values varied between 0.22 and 1.0 µg at/L. Higher values were encountered

in the northern and eastern parts of the region. Strong concentration gradients occur below 75-100 m coinciding with the thermocline and the oxygen discontinuity layers.

In the deeper waters high phosphate concentrations are associated with very low oxygen levels. The depth of phosphate maximum varies between 800 and 1000 m and the maximum ranged between 2.5 and 4.4 µg at/L, the highest value being observed around Lat. 10°N and Long. 90°E. The variability of the deep maxima may perhaps be attributable to the degree of decomposition of the planktonic detritus depending on the regenerative character of the waters at different locations.

Another feature of interest is the considerable amount of movement of the deep waters as indicated by the vertical profiles. A strong subsurface divergence is indicated around Long. 95° E and Lat. 8° N at about 100 m and the phosphate concentrations are between 2 and 3µg at/L. Along Long. 95°E, between Lat. 9° and 10°N a core of high phosphate waters is present at the surface, oriented in southerly direction. Another strong subsurface divergence occurred at Lat. 6°N between Long. 96° and 95 E (off Sumatra). In this region the phosphate rich waters (1.5 µg at /L) reach up as far as 20-40 m.

3. Chemical Characteristics of the Waters Around Laccadives

These studies were undertaken as a part of the general oceanography of the waters around Laccadives having special environmental disposition, surrounding a group of coral islands. Analysis of various chemical parameters, *viz.* salinity pH, total alkalinity, dissolved oxygen, norganic phosphate, total phosphorus, chlorophyll and paniculate organic carbon of the lagoon waters of Kavaratti atoll was done during the pre-monsoon period.

All the chemical parameters with the exception of salinity, pH and alkalinity were highly variable with location in the lagoon. Inorganic phosphate of the waters is very low (0.1 to 0.4 *µg* at/L). Much of the phosphorus is bound organically (70 to 90 % of total phosphorus) and the range of variation is considerable. Organic phosphorus is invariably high in the vicinity of the coral reef suggesting the influence of metabolic activity of the reef community. This factor is consistant with the high organic carbon values. Dissolved oxygen showed a very high degree of variability (4 to 9.2 ml/L) and an inverse trend of distribution with organic phosphorus. The high oxygen levels and variations are associated with the photosynthetic activity of algal mats extensively distributed at random within the lagoon.

Diurnal studies on the chemical factors show that the dissolved oxygen is subjected to wide variations (1.8 to 8.8 ml/L) while the fluctuations in inorganic phosphate are not significant. pH varied between 7.9 to 8.1.

Comparison of the inorganic phosphate concentration between inside and outside waters of the lagoon indicate that the concentrations are lower in the lagoon water than in the oceanic waters. The reason may be the active uptake by the benthic macrophytes present in the lagoon. It may be mentioned here that the consumption of phosphate by phytoplankton population is negligible in the lagoon waters as evidenced by very low chlorophyll content. Analysis of a few lagoon sediments for total phosphorus (0.09 to 0.11% as P_2O_5) indicate

low retention of phosphorus by the sediments.

2.22 Composition of Estuarine Waters

1. Upwelled Water in Mandovi and Zuari

In the course of investigations on the hydrological conditions, of Mandovi and Zuari estuaries cold water with low oxygen and high inorganic phosphate content has been encountered in the estu aries extending to a distance of about 5 km. This phenomenon was observed with varying degrees from the month of August extending upto September and October. This feature was very well marked during the month of September and October. During this period the phenomenon of upwelling is fairly wide spread along the West Coast of India and this upwelled water is characterised by low temperature, high salinity, low oxygen and high nutrients content.

2. Iron Concentrations in Mandovi, Zuari and Inshore Waters of Goa

Iron is an important growth promoting trace element for the marine organisms and plays a significant role in the geological processes controlling and concentrations of other elements of biogeochemical importance. The proximity of iron ore deposits influences the estuarine and the coastal waters to a considerable extent in space and time, having an impact on the biological and geochemical conditions of the water. The present survey of total iron content in the estuary and inshore waters, is one where a continuous system was undertaken as a first step to a detailed study of iron cycle in the waters.

Total iron content in the estuaries (Mandovi & Zuari) and inshore warers of Goa are generally higher (0.08-1.0 mg/L) than normal levels. Iron ore deposits in this region appear to be influencing the concentrations to a great extent. Maximum concentrations and variations with location and time are observed in the estuaries whereas the conditions in the coastal waters are more or less stable. The estuarine values during the monsoon months are significantly higher than post-monsoon period, attributed to the influences of land drainage. The data indicate that the excess iron entering the coastal waters through the estuaries is buffered by interaction with sea water.

2.23 Organic Compounds, in Sea Water

1. Estimation of Dissolved Organic Matter in the Sea

Work on the analytical aspects of Dissolved Organic Matter (DOM) in sea water by ultraviolet absorption spectrophotometry around 250-260 mμ. was continued as a substitute for the complicated technique by wet oxidation. Standard DOM solution is prepared from fresh plankton. Calibration tests with DOM in all glass redistilled water show good linearity with optical density at 260 mμ. The same tests using aged sea water free of DOM showed deviations. The high redox potential (+400 mv) of sea water is considered to be the main factor responsible for the deviation. The DOM is slowly getting oxidised in the sea water by dropping the redox potential to an optimum level without affecting U-V absorption characteristic of the DOM.

2.24 Marine Pollution and Fouling

1. Fouling in Relation to Physico-Chemical Factor

The growth of common assemblages of micro-plants and animals on artificial structures other than on natural objects, called fouling, is mainly controlled by the physical and chemical characteristics of the waters. In view of the economic importance of this aspect, a scheme was initiated in Dec. 1972 to study the factors responsible for the marine fouling in time and space.

Preliminary observations show that the intensities of fouling in harbour waters and in the waters opposite to the harbour near Dona Paula, are in the ratio of 1:44.

In the estuarine waters of the river Zuari, the strong ebb flow at the rate of 2.16 to 3.6 km per hour prevailing for 3 to 7 hours duration as compared to the flow of 2.1 km per hour for about one hour during the high tide appear to be nonconducive to the growth of marine fouling organisms. This was indicated on test panel installed in the waters near the Borim bridge, which shows an apparent growth of marine fouling organisms on the shadow side even though the characteristics of the water remain the same. The ratio of biomass (wet weight basis) on the front side and shadow side was observed to be of the following order:

Period of exposure	2 months
Biomass front-side	7.32 g
Biamass shadow side	22.42 g

3.25 Apparatus and Methods

1. Fabrication of Non-returnable Valve for Water Sampler

The prototype shallow water sampler designed in this Institute has been thoroughly tested for any operational defects. It was found that a portion of the water collected flows out when the sampler is hauled up from deeper depths due to reduction of pressure. In order to check this a non-returnable valve made of glass capable of withstanding pressure upto 25 kg/cm^2 is designed and fabricated. Its function is tried successfully and the same is incorporated as an integral part of the new shallow water sampler.

Data on the reproducibility and efficiency of the new sampler as compared to the other sampler in use, are being collected and processed.

2. Fabrication of Floating Rafts

In connection with the study of the intensity of fouling in relation to physico-chemical factors in the Mormugao Harbour, two floating rafts of different design with easily interchangeable parts were designed and fabricated and finally installed in December 1972 at two different sites in harbour waters.

2.3

geological oceanography

2.31 Sedimentation (Stratigraphy and Sedimentology)

1. Sediment of the Beaches in Northern Goa
2. Beach Conglomerates Along Goa

2.32 Bathymetry and Topography

1. Echosounding Studies off Goa, Ratnagiri and Bombay Transects

2.33 Bottom Sediments

1. Heavy Minerals Suite in the Sediments of Continental Shelf of Madras Coast

2.34 Micropaleontology

1. Holocene Planktonic Foraminifera from the Shelf Sediments of Kerala Coast
2. *Globigerina pachyderma* (Ehrenberg) in the Shelf Slope Sediments of Northern Indian Ocean

2.35 Mineralogy and Geochemistry

1. Phosphorus, Carbonate and Organic Matter in the Arabian Sea Sediment Cores
2. Phosphorus in the Sediments of Vembanad Lake, Kerala
3. Partition studies of Manganese and Iron in the Shelf Sediments

2.36 General

1. Marine Geology of the Continental Shelf off the Goa Coast
2. Basic Intrusives along the Northern Goa Coast
3. Petrology and Mineralogy of the Coastal Rocks of Goa
4. Clastic Dike from Baga, Goa

The year under review was devoted to a study of (1) the coastal rock formation along the Goa coast, (2) the sediments of the beaches of the northern Goa coast, (3) mineralogical, micropaleontological and geochemical aspects of the bottom sediments of western and eastern shelf of India, and (4) the sediments of Vembanad Lake, Kerala State.

With a view to study the sediment distribution, its mineral potential, and the source of the sediment, a project entitled, "Geology of the Continental

Shelf off the Goa Coast" was undertaken. The study of the coastal rock formations of Goa coast is very closely linked with this. This study relates to the preparation of the geological map of the entire coastal region of Goa on 1 inch : 1 mile basis, collection of various rock types encountered in the area and their study in thin section. Out of 250 rock samples collected from northern Goa coast 43 are of basic igneous dibasic and doleritic dikes, which appear to be related to the Deccan Traps; 5 of them to clastic dike found near Baga and the rest to quartzites, phyllites, shale and metasediments. The bottom sediments collected from the inner shelf (upto 50 meter depth) off Goa coast indicated distinct areas of sand, silt and clay distribution.

Interlinked with these two aspects, was the study of the beach deposits of this region. Monthly collection of samples and profile studies revealed accretion and removal of sediment from the beaches on a seasonal basis and a regular pattern in grain size, sphericity, roundness, etc., of the sediment. The associated and partly exposed beach rock and beach conglomerates in the study area are also being studied for their role, their past history and environment.

Along a few transects of Goa, Ratnagiri and Bombay, in the offshore region, carbonate pinnacles of algal origin dating back to 10,000 years B.C. were noticed. However, a very rich heavy mineral suite off Madras was noticed delineated by dominant mineral groups of stable and unstable constituents indicating mixing and overlapping and three different source areas. The contained micro-fauna of the bottom sediments off Kerala coast revealed 22 planktonic foraminifera, two of which *(Globogerina hexagona* and *Globoquadrina conglomerata)* that were reported to have disappeared nearly one million years ago are found to be living in this region even today. *Globigerina pachyderma* (Ehrenberg), a cooler water bipolar species, whose value as a paleoclimatic indicator being significant, occurs in the northern Indian Ocean.

The geochemical aspects of the marine sediments related to : (1) the distribution pattern of phosphate, carbonate and organic matter in the cores of the Arabian sea. It was found that all the three constituents are genetically related to each other and the high values of phosphate suggests this being one of the modern phosphate depositional regions of the world. (2) The partition of manganese and iron in the shelf slope sediments between Bombay and Quilon wherein a range of Mn (25-332 ppm) and iron (0.11-1.2%) is noticed besides a decreasing trend in their concentration further southwards is also indicated. Similarly, the distribution pattern of phosphorus in relation to the sediments and the hydrographical features of the waters of Vembanad Lake was also studied.

2.31 Sedimentation (Stratigraphy and Sedimentology)

1. Sediment of the Beaches in Northern Goa

Monthly collections of sands and profile studies of Morjim-Arambol beach along northern Goa are completed. Over 250 samples are collected during 12 monthly cycle. Size analysis for half the samples are drawn. Detailed studies on mineralogy, other size parameters like roundness, sphericity and heavy mineral assemblage are in progress.

The size analysis done so far, has revealed that the sands are well sorted,

medium to fine grained, relatively skewed and leptokirtic whereas the dune sands in the area are fine grained, better sorted and slightly positively skewed than the beach sands. Both beach and dune sands contain 30-35% of heavy minerals like Hornblende, Augite, Spinel, Tremolite-Actinolite, Tourmaline, Rutile, Staurolite and Opaques.

2. Beach Conglomerates Along Goa

Thin beds of conglomerates are found exposed along Goa coast in a discontinuous sequence, some along the beach and some others at a little elevated region. These conglomerates are hardened and appear to be beds of beach conglomerates; however the composition, orientation, roundness and such other parameters are being studied. Most of the pebbles vary in size from 150-4 mm; and the majority of them are of quartz and quartzite, but are associated with laterite, gneissic granite and granite pebbles also. This variety is indicative of the source area.

2.32 Bathymetry and Topography

I. Echo Sounding Studies off Goa, Ratnagiri & Bombay Transects

The principle aim of this study undertaken aboard INS *Darshak* was a detailed investigation of the reported carbonate pinnacles and sampling by dredge and grabs in the region of the outer shelf. As a result, it was noticed that these pinnacles and troughs are prominently developed and present throughout in the area. These pinnacles are algal in nature and very recent (10,000 years B.P.) in origin. The sediment is composed chiefly of oolites and shell debris. Some of the shells and oolites are found to be blackened.

2.33 Bottom Sediments

1. Heavy Mineral Suite in the Sediments of Continental Shelf of Madras Coast

The heavy mineral suite of the shelf sediments of this area is characterised by a dominant group of minerals such as Hornblende, Augite, Hypersthene, Garnet and Opaques; common by Apidote, Zircon, Mica and Rutile; and rare by Staurolite, Monazite and Olivine. These appear to be derived from the Charnockitic province of Madras, and also another metamorphic and igneous source nearby. The abundance of unstable minerals at depth and low clays suggests a rise and fall of sea level during Pleistocene and a possible relict structure being present there. Augite is present abundantly at 131-183 m in the southern region but it extends through the middle shelf at 50 m in the north, which suggests two types of sediments mixing and overlapping in this region, thus giving rise to augite rich and augite poor zones. Further, authegenic growths in Zircon and Tourmaline are noticed.

2.34 Micropaleontology

I. Holocene Planktonic Foraminifera from the Shelf Sediments of Kerala Coast

22 Planktonic foraminifera were identified from a few samples collected aboard INS *Kistna* from the outer shelf off Kerala coast. Some of the species have a geological range from Miocene to late Pleistocene and recent also. *Globogerina hexagona* Natland and *Globoquadrina conglomerata* (Schwager) which disappeared from the Atlantic earlier (50,000 to one million years ago) are seen to be living today in the Indian Ocean.

2. *Globigerina pachyderma* (Ehrenberg) in the Shelf-slope Sediments of Northern Indian Ocean

Globigerina pachyderma (Ehrenberg) is a bipolar, cooler water species whose value as a paleoclimatic indicator is greatest and its occurrence in a sediment assumes greater importance, more so of areas which are known today as tropical regions of the world. Its occurrence in outer shelf-slope sediments off Kerala, Mangalore and Karwar beyond the equator in the northern Indian Ocean is of great importance and interest and involves change in coiling direction, tolerance, temperature variation, lowering of earth's temperature, polar wandering and also movement of subpolar intermediate current and also possibly the Antarctic Bottom Drift.

2.35 Mineralogy and Geochemistry

1. Phosphorus, Carbonate and Organic Matter in the Arabian Sea Sediment Cores

Phosphate, organic matter and calcium carbonate in the five sediment cores from the Arabian Sea revealed that the distribution pattern has a close genetic relationship to each other. It is found that the total phosphorus value is high (1.04-0.84% P_2O_5 on carbonate free basis) in the upper layers of the slope, but low (0.025-0.22% P_2O_5, on carbonate free basis) in similar sediment on the shelf. The organic carbon closely fluctuates with increase and decrease of the phosphate content and ranges from 4.655-0.385%, Calcium carbonate percentage is uniform in the sediments from the slope and basin region but varies considerably in the cores from the shelf. Calcareous oolites are present throughout the cores. Further, it is proved that wherever phosphate is high, organic matter is also high which is directly related to upwelling, organic productivity, a non-depositional environment and abundant carbonate being present in the sediment, which is indicative of one of the modern phosphate depositional regions of the world.

2. Phosphorus in the Sediments of Vembanad Lake, Kerala

In the sediments of the lake between Cochin and Alleppey the phosphorus content varies 0.037-0.167% with an average of 0.041%. It is higher in silty clays and clayey silts than sands and silty sands. Further, the estuarine sediment seems to be richer in phosphorus than elsewhere. Fractionation and statistical studies reveal that it is higher with silts and strongly oriented with organic matter than with iron. Comparatively, it is noticed that the marine silts are richer in phosphorus than estuarine or lake silts.

3. Partition Studies of Manganese and Iron in the Shelf Sediments

A range in manganese (25-332 ppm) and iron (0.11-1.2%) is noticed in the acid soluble fractions. Oolites and shell fragment constituents contain only Mn (50 ppm) and Fe (0.5%). The decreasing trend in concentration of these elements southward confirms the earlier observation.

2.36 General

1. Marine Geology of the Continental Shelf off the Goa Goast

Under this programme, bottom sediment sampling (using Phlegar corer and Peterson grab) was done on a grid pattern along eight transects (Terekol

river, Baga, Aguada fort, Mandovi-Zuari estuaries, Baina, Colva, Sol river and Cabo de Rama) aboard F/T *Arjun Prasad* during premonsoon and postmonsoon periods upto 50 m at every 5 m depth interval. 20 cores and 80 grab samples were collected. It is noticed that at 0-5 m depth subsurface is blanketed by fine, well sorted sand; between 5-40 m it is chiefly clayey, and at 40-50 it is suddenly silty. Further work beyond 50 m to the edge of the shelf will be taken up very soon. Presently, the geochemical and micropaleontological aspects of these samples collected are being studied.

The main objectives of this project are : (1) to get a clear understanding of sedimentary processes along the Goa coast, (2) to delimit the role played by the rivers in the adjacent region which have different geological history and form the source area of sediment to the shelf and (3) to trace the possible workable mineral potential in the inner shelf of the region.

2. Basic Intrusives Along the Northern Goa Coast

Forty-three basic igneous (diabasic and doleritic) dikes along Morjim-Arambol, Chapora, Baga, Aguada and Mormugao headlands were traced. All of their landward extensions are traced to the extent possible since a thick laterite cover overlaps them. Undoubtedly they have a seaward extension also. These dikes intrude into the quartzites of Cuddapah (Precambrian) age. The possible relationship of these dikes to the nearby Deccan traps is being investigated.

3. Petrology and Mineralogy of the Coastal Rocks of Goa

Nearly 250 rock samples have been collected from the northern coastal region of Goa. The rock types include diabases, dolerites, beach rock, phyllites, quartzites, shale and metasediments. 150 thin sections of these rocks are being analysed for their mineral constituents, optical properties, alterations, etc. Besides, geological maps of the area are prepared on 1 inch : 1 mile basis for the coastal region. Further mapping and collection of samples for the southern region is underway.

4. Clastic Dike from Baga, Goa

Clastic dikes and related sills are tabular intrusive rock bodies analogous to igneous dikes in appearance and field relationships. These are injections of mobilised sediment into fracture zones and bedding planes of sedimentary sequences ranging in age from Precambrian to Quaternary.

A dike of this type is encountered as a vertical, wall like mass being 0.5 m wide, 4 m high, trending east-west, composed of argillaceous sandstone, cutting across earlier formed current bedded sandstone and shale sequence, but not the overlying laterite. It is exposed along the slope of a hill outcropping to about 15-20 m but its inward extension into the hill is not traceable. The dike rock, sedimentalogically, is light brown, moderately indurated and iron stained—sometimes plates of iron oxide stand out prominently (being resistant to weathering). Several smaller dikelets are noticed in the vicinity. The dike is composed of very fine grained, angular, fractured quartz, felspar and biotite with traces of heavy minerals. It is considered that this dike is the resultant of a thick low viscosity slurry of unconsolidated argillaceous sandy material injected downward under great pressure into sets of joints present in the country rock. The age of this clastic dike intrusive is either Neogene or Quaternary.

2.4

biological oceanography

2.41 Productivity

1. Productivity Studies Along the Central West Coast of India
2. Productivity and Environmental Characteristics of Coastal Waters between Goa and Bombay—Zooplankton Studies

2.42 Phytoplankton (Including Algae)

1. Blooms of Marine Blue Green Algae and Diatoms with reference to Antibacterial Toxic Substances and Mass Mortalities in the Ocean
2. Laboratory Culturing of Marine Blue Green Alga *Trichodesmium erythraeum*
3. Experimental Studies on Phytoplankton Cultures

2.43 Zooplankton (IIOE Collections)

1. Systematic Study of Various Subsorted Groups
2. Preparation of Plankton Atlases
3. Preparation of Handbooks to the International Zooplankton Collections

2.44 Ecology

1. Studies on Recent Foraminifera of Indian Seas
2. Study of Shrimps and Prawns with Reference to Identification of Stock and Species by Methods not used in Conventional Taxonomy
3. Studies on the Life Cycle of Prawns
4. Intertidal Ecology of Cochin, Sheratallai Beach
5. Ecology and Production of Macrofauna in the Intertidal Region
6. Ecology of Mandovi, Zuari and Cumbarjua Canal Complex
7. Distribution and Production of Benthic Organisms in Relation to Salinity Intrusion in Mandovi and Zuari Estuaries
8. Studies on Variability and Ecology of Zooplankton in the Brackish Waters

2.45 Microbiology

1. Bacteriological Studies in Coastal Areas

2.46 Fisheries and Resources

1. Studies on Population Models and Optimum Exploitation of Fish populations
2. Assessment of Living Resources with Particular Reference to Marine Fisheries off the Goa Coast

2.47 Pollution

1. Marine Pollution Studies off Greater Bombay

2.48 General

1. Feeding Metabolism
2. Participation in UNDP Arabian Sea Pelagic Fisheries Survey

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The Biological Oceanographic Investigations are conducted from Headquarters at Panaji and the two centres at Cochin and Bombay. The major projects in biological oceanography have an applied objective of the estimation of total potential of living resources of the Indian Ocean, the adjoining Arabian Sea and Bay of Bengal, location of newer resources, and the ecology of the marine environment including the foodchain and energy cycles. The major projects in progress are:

(i) Biological Productivity of waters along the Central West Coast of India
(ii) Study of some aspects of marine food chains under field and laboratory conditions
(iii) Zooplankton studies at IOBC, Cochin
(iv) Recent techniques for study of marine population
(v) Ecology of Estuaries : Ecology of Mandovi, Zuari and Cumbarjua Canal Complex with special reference to living resources.

Besides these, few sponsored projects were also undertaken and under an agreement with UNDP (United Nations Development Programme) studies on sorting of Zooplankton were started for Arabian Sea Pelagic Fisheries.

Some of the highlights are summarised below :

Investigations on the production at different trophic levels, hydrography, benthic and intertidal studies along the Central West Coast of India were started during this year. Similarly detailed ecological studies in Mandovi, Zuari and Cumbarjua Canal Complex were started. This is supplemented by ecology of intertidal region on different beaches of Goa. Similar intertidal studies are being carried at some beaches in Cochin. The benthic studies in Mandovi and Zuari estuaries have revealed that euryhaline zone was more productive than the fresh water zone. As regards gross primary production on central west coast, it was more at Karwar than at Vengurla. The prawn fishery of *Parapenaeopsis stylifera* in Zuari estuary has been reported and started for the first time.

A sponsored project on the marine pollution studies off greater Bombay was undertaken at the instance of Bombay Municipal Corporation. The effect of sewage and industrial effluent was studied on the living organisms around Bombay.

Another project on the "Assessment of Living Resources with particular reference to Marine Fisheries off Goa Coast" was undertaken at the request of Goa Government. Studies were restricted to 20 and 40 meter region and a 10 months' study indicate that 20 meter region particularly of Central Zone (Baga to Banaulim) is richer in fishery than the deeper area.

In addition to the above, the Institute participated in United Nations Development Programme (UNDP) Arabian Sea Pelagic Fisheries Survey. Under this programme 228 zooplankton samples have been sorted and as per agreement the total biomass and the sorted samples of fish eggs and larvae would be handed over to them.

Progress of the varions investigations undertaken during the year are given in the following pages.

2.41 Productivity

1. Productivity Studies Along the Central West Coast of India

(i) *Primary Production*— The work on Central West Coast of India was initiated with a view to assess and characterise the coastal waters for their production potential.

Studies were started in September 1971 at 3 stations *viz.* Karwar, Goa and Vengurla and monthly observations are being taken at these stations. The primary productivity is studied by light and dark bottles and C^{14} methods. Data on rate of photosynthesis, respiratory coefficient, primary productivity in surface waters and at 5 m depth are collected. Simultaneous recording of water temperature, Secchi disc reading, salinity and dissolved oxygen are made to understand their relationship with the primary production. Besides, samples are collected for phytoplankton, chlorophyll and nutrients also.

The preliminary analyses of data indicate that the gross production at surface is higher at Karwar in November (1.8 gc/m^3 /day), at Vengurla it is 1.2 gc/m^3 /day in September, 1971, while at depth it is higher at Karwar in months from September to December. The corresponding values at depth are comparatively lower with the exception at Vengurla where it reaches to 1.2 gc/m^3/ day in September 1971.

The observations are being continued and the data are under processing.

(ii) *Distribution of Zooplankton in Relation to Environmental Factors*— This study was started in December 1971 in order to assess the production at secondary level along the coast. The observations are taken off Vengurla, Goa, Karwar, Malpe, Tadri and Mangalore across the coast upto a depth of 30 meter. Collections have been made upto March, 1972 at 5, 10, 15, 20 and 30 meter depth. 10 transects have been made and the data is under processing.

(iii) *Benthic Studies* — The benthic programme in the project is conducted as a part of food chain as well as with reference to its special role in influencing demersal fisheries of the region concerned. The observations are being made along six transects, extending from Vengurla in the north to Malpe in the south. Each transect is worked out monthly.

The transect runs perpendicular to the coast and extends from 0 to 40 m depth. The variations in environmental parameters in relation to benthic biomass are investigated. Preliminary results indicate that the benthic biomass is higher in inshore areas than in the offshore region.

2. Productivity and Environmental Characteristics of Coastal Waters Between Goa and Bombay-Zooplankton Studies

Studies on the seasonal variation and distributional pattern of Zooplankton in relation to oceanographic parameters along the Konkan coast was initiated in November 1969, and monthly cruises were undertaken except during 3 monsoon months (June-August) and completed in May 1971. In all, 16 cruises were undertaken and 220 plankton samples were collected. Displacement volume for all the samples was taken. The overall picture shows that the production was slightly lower during the year 1971 than in 1970. The pooled mean values of biomass (Table 1) indicate that Janjira, Sriwardhan, Ratnagiri, Harnai and Vengurla are productive in that order and the remaining five stations Malvan, Deogad, Vijaydurg, Musakazi and Jaigad are less productive.

Mean volume of Zooplankton of monthly samples collected during 1969-1971.

Station	*Volume in ml.*
Vengurla	3.62
Malvan	2.03
Deogad	2.77
Vijaydurg	4.52*
Musakazi	2.68
Ratnagiri	4.65
Jaigad	2.40
Harnai	3.92
Sriwardhan	5.27
Janjira	7.94

*lot of detritus matter

Two peaks of plankton biomass were observed one after the south-west monsoon during October - November and another before monsoon during March-April. The magnitude of plankton biomass varied at different stations and the difference between minimum and maximum was about 2 to 6 times. Detailed qualitative studies on these samples are in progress.

2.42 Phytoplankton (Including Algae)

1. Blooms of Marine Blue Green Algae and Diatoms with reference to Antibacterial Toxic Substances and Mortalities in the Ocean

Investigations on the occurrence of blooms of blue green algae and diatoms were undertaken during the year under report. The present study is concerned with the recent bloom of *Trichodesmium* in the waters off the coast of Goa with particular reference to associated environmental conditions and the metabolic products and their toxicity or otherwise to the other organisms including fish in these waters.

(i) *Occurrence, Duration and Characteristics—Trichodesmium* bloom in the waters off the Central West Coast of India were observed in the 2nd week of March 1971 and found to occur for 14 to 17 days. Four stations were selected to study these blooms which occupied a width of 5 to 7 meters and extended to several nautical miles in the form of threads. In some areas they also occurred

as patches. The bloom varied between 0.5 to 1.0 meter in thickness and maximum growth was at the surface. The colour of the bloom in day-light was mostly grey with some pink to light vermilion patches.

Samples taken were found to contain almost exclusively the filamentous blue green alga *Trichodesmium erythraeum.* The filaments were clustered together and formed characteristic rafts. 25 to 35 filaments clustered together as clumps. Though there is an aggregation in the form of clumps, there is no organic connection between the filaments. The cell counts during the red tide ranged from 10^5 to 100^5 per 0.1 ml of sea water. It was also observed that the bloom of *Trichodesmium* succeeded the mixed bloom of centric and pennate diatoms at all the four stations. The mixed diatom bloom consisted of *Asterionella, Thalassiothrix, Coscinodiscus, Melosira* and *Stephanopyxis* and the cell counts ranged from 20^4 to 40^4 per 1.0 ml.

(ii) Environmental Parameters — The studies have shown that the bloom has not resulted in any toxic conditions in the environment. No large-scale mortality of other organisms and fish has been observed during the period of bloom. There had not been any marked changes in the physical and chemical conditions of these waters. The salinity remained constant and there was no evidence of the dilution of sea water due to rainfall during and before the outbreak of red tide. The bloom of *Trichodesmium* occurred only during the hot weather seasons. The higher temperature was also associated with other conditions like absence of strong wind and calmness of the sea when compared to other seasons.

2. Laboratory Culturing of Marine Blue Green Alga *Trichodesmium erythraeum*

Trichodesmium erythraeum is one of the causative organisms for the red tide outbreak in Indian coasts.

For the first time laboratory culture of *Trichodesmium erythraeum* has been maintained in axenic conditions in this Institute. This species was originally isolated from Bay of Bengal in 1965 at the Centre of Advance Studies in Marine Biology, Annamalai University.

Further experimental work in relation to nitrogen fixing capacity, antialgal properties, purification of antibacterial substance with gel and predictions of red tide outbreak in laboratory are now in progress.

3. Experimental Studies on Phytoplankton Cultures

Experiments using unialgal phytoplankton cultures were conducted to study the rate of primary production in relation to nutrient concentration. It was found that the phosphorus requirements of *Biddulphia sinensis* was lower than that of the dinoflagellate, *Ceratium furca.* It was also found that at higher concentration of nutrients there was a decrease in the rate of Photosynthesis.

Studies on the amount of organic carbon excreted by the organisms during photosynthesis were continued. The data suggest that salinity has no influence on the excretion loss.

2.43 Zooplankton (IIOE Collections)

(These studies are beinq carried out at the Indian Ocean Biological Centre, Cochin}

1. Systematic Study of Various Subsorted Groups

Studies on the subsorted groups of different taxa were continued during the period under report and some of the results are given below :

Based on ecological theory, an attempt was made to analyse the relationship between number of Hydromedusae (carnivores), Chaetognatha (carnivores), Copelata (nannoplankton feeders) and total zooplankton volume and number of animals. According to theory, a young ecosystem has an association of species with proportionally larger number and volume of producers than a mature ecosystem As the association becomes gradually older, the number of animals at higher levels in the food web grows while the number of producers and herbivores placed at a lower level in the food web, proportionally decreases. There are reasons to believe that similar relationships are valid also for plankton associations. No single water mass was followed and studied methodically as a unit during the standard zooplankton sampling done for the International Indian Ocean Expedition, but the great number of samples sorted at the Indian Ocean Biological Centre has made it possible to study specifically some areas from the point of view of the relative abundance of animals at a different trophic level in ecosystems of a different degree of aging. Although the results are not sharp, there is an indication that the theory holds true for the plankton also.

Plankton samples taken by *R. V. Africana* with the Indian Ocean Standard Net at a grid of stations on the Agulhas Bank between 20° E and 22°E long, were studied and compared with the hydrographical data collected at the same time. The average monthly distribution over the Bank and the time/space distribution at the fixed stations were studied for the following aspects: total biomass, Copelata, Chaetognatha, Copepoda, fish eggs and fish larvae. It is revealed from these studies that the Agulhas Bank region has a very high plankton productivity with a comparative less degree of fluctuations in abundance. Marked seasonal variations have been observed in the case of fish eggs and larvae.

Study of the copepod genus Gaussia collected from different depths during the IIOE has shown that the genus which had been considered monospecific comprises of two distinct species, *G. scotti* (Giesbrecht) a species found in all oceans and *G. sewelli* n. sp. isolated in distribution to the northern areas of the Indian Ocean. A definition of the genus and also distinctive characters of the two species have been described in a paper under publication.

Larvae and adults of the genus *Thalassocaris* (Caridae : Decapoda) were studied in detail. Three species of this genus : *T. lucida* (Dana), *T. crinita* (Dana) and *T. obscura* sp. n. were present in the collections. In each species there are 10-13 zoeal stages. In this zoea the cephalothorax is very broad and shallow, the maxilla has only one coxal endite and exopods present on legs 1 to 4. The larval characters do not support the inclusion of *Thalassocaris* in the family Pandalidae. Recognition of the family Thalassoceridídae is advocated. Subsorting of copepods into different groups on the basis of one sample for every 5° square is completed.

The list of international specialists to whom sorted material has been despatched, is given below:

Group	*Specialist & Address*	*Date of Despatch*
1. Fish larvae	Prof. T. S. Rass, Institute of Oceanology, Academy of Sciences, 1, Sadovaya, Lublino, Moscow, J. 387, USSR.	12.5.1971
2. Brachyura Larvae	Dr. C. Sankarankutty, Fisheries Officer, Marine Fisheries, Research & Training, Institute, Kunduchi, P. B. No. 23126, Da r-es-Salaam, Tanzania.	12.5.1971
3. Lucicutidae	Dr. T. Minoda, Hokkaido Regional Fisheries Research Laboratory, Yoichi-Hokkaido, Japan.	26.5.1971 (2nd batch)
4. Heterorhabbidae	Dr. T. S. Park, Weeds Hole Oceanographic Institution, Woods Hole, Massachusetts, USA.	26.5.1972 (2nd batch)
5. Centropagidae Pontellina Labidocera	Dr. A. Fleminger, Scripps Institution of Oceanography, La Jolla, California, USA.	26.5.1971 (2nd batch) 27.3.1972 (3rd batch)
6. Candaciidae	Dr. George Grice, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA.	31.7.1971 (3rd batch)
7. Pontella Pontellopsis	Mr. P. Parameswaran Pillai, Central Marine Fisheries Research Institute, Gopala Prabhu Road, Cochin-11.	2.3.1971 (2nd batch)
8. Hyperiidae	Dr. T. E. Bowman, Supervisor & Curator, Division of Crustacea, Smithsonian Institution, United States National Museum, Washington D. C, USA.	17.9.1971

	Group	*Specialist & Address*	*Date of Despatch*
9.	Aeitideidae Phaennidae	Dr. W. Vervoort, Ryjke Museum Van-Naturlijke, Historie Leiden, Ramsteog-2, Amsterdam, Netherlands.	29.11.1971
10.	Triglidae Scorpionidae	Dr. K. V. Rama Rao, Zoological Survey of India, 8, Lindsay Street, 9th Road, Calcutta-16.	29.2.1971

2. Preparation of Plankton Atlas

Plankton Atlas volume III fascicle 2 showing the distribution of planktonic mollusca of the Indian Ocean has been published. This fascicle contained 20 maps showing the distribution of the following groups and families: Thecosomata; Cavolinidae; Limacinidae; Peraclidae and Cymbulidae Heteropoda; Carinariidae and Pterotracheidae. Also in addition the distribution of Cephalopoda, bivalve larvae, Gymnosomata and Nudibranchia were also depicted in these maps.

The preparation and contouring of 21 maps to form the next fascicle on the distribution of Crustacea (Cladocera, Ostracoda, Cirripedia, Mysidacea, Cumacea, Isopoda, Amphipoda, Euphausiacea, Stomatopoda) and Insecta (Halobatidae) of the Indian Ocean has been completed and is in press.

3. Preparation of Handbooks to the International Zooplankton Collections

The volume II of the Handbook showing environmental data for the IOSN stations was published as per the recommendation of the Consultative Committee for IOBC at its 5th meeting held in 1967 at Cochin. The committee recommended that a second volume of the Handbook be prepared containing environmental data pertaining to the International Collections. It was decided to summarize the environmental data between 0 to 200 meter, particularly temperature, salinity, phosphates, nitrates and oxygen for each station from which zooplankton samples were collected. The World Data Centre A, Washington D.C. co-operated by sending computer readings of hydrographic data for all the cruises conducted during the International Indian Ocean Expedition and this forms the basis for the present volume. The manuscript and format of this volume were approved by the 8th meeting of the Consultative Committee held at Cochin in March, 1970. The data are arranged in fifteen columns. Columns 1-4 (Identification) indicate the stations where the samples were taken. Columns 5 and 6 contain maximum values of temperature in °C. Columns 7 and 8 contain maximum and minimum values of salinity ‰. Column 9 gives the thickness of the surface layer in meters. This layer is synonymous with the isothermal or mixed layer in the sea. The lower limit of the surface layer is distinguished where the temperature decreases by 0.1°C for every meter continuously for a minimum of 15-20 meter depth. Columns 10 and 11 give maximum and minimum phosphate values in microgram atoms per litre (µg at/1). Columns 12 and 13 show maximum and minimum nitrate values in µg at/1. Columns 14 and 15 give maximum and minimum oxygen values in ml/1.

Volume III of the Handbook, which has also been published incorporates the the proceedings of the Workshop on Plankton Methods, held in February 1969 at the IOBC. The Workshop was organised as per the recommendations of the Sixth UNESCO Consultative Committee meeting in 1963 with a view to enable the members of the Consultative Committee, the representatives of other marine science institutions in India and abroad to attend and participate in the Workshop. The information contained in the Handbook would enable specialists working on the IIOE material and other fellow scientists to understand the role of the Indian Ocean Biological Centre in handling the International Plankton Collections, particularly in the Zooplankton research.

2.44 Ecology

1. Studies on Recent Foraminifera of Indian Seal

Foraminifera were studied from plankton as well as sediment samples at three areas perpendicular to the coast off Cochin, Alleppey and Quilon. In all 23 species of planktonic foraminifera were recorded and a high concentration was found off Alleppey. A significant finding of this study is that few species like *Pulleniatina obliquiloculata, Globigerinoides sacculifer, G. conglobatus* and *Sphaeroidinella dehiscens* which are characteristic forms of low-latitude were encountered in the Kerala coast. More snapper samples have been collected from the same areas and a study of the distribution pattern of the foraminifera is in progress.

2. Study of Shrimps and Prawns with reference to Identification of Stocks and Species by Methods not used in Conventional Taxonomy

In many cases the conventional taxonomic methods for the identification of prawn stocks do not account for some genetic variations. Biochemical methods are therefore employed. Such studies have been initiated and some experiments on serum protein differences in prawns were carried out. The preliminary results are positive and the differentiation is visible.

Ecological features on the prawn fishing grounds off Calangute were studied. The occurrence of the prawn *Parapenaeopsis stylifera* in the estuarine waters of Goa during monsoon (1971) prompted to observe its salinity tolerance and it was found out that this species can tolerate salinity as low as 8.5‰. The species is commercially important in marine fishery of Goa waters. Its fishery from the estuarine waters of Zuari estuary has been reported for the first time.

3. Studies on the Life Cycle of Prawns

The closed system of circulation of sea water has been set up for rearing of marine organisms, especially commercially important penaeid prawns. Experimental trawling was conducted off Cochin and live prawns with maturing gonads were transported to the laboratory and put in the rearing tanks of the circulating system. Further work is in progress.

4. lntertidal Ecology of Cochin, Sheratallai Beach

Studies on the distribution and abundance of meio and micro-fauna in the Cochin and Sheratallai beach were continued. Differential distribution of the organisms at different depths was quite conspicuous; as for instance the ciliates were more abundant at the mid and low tide levels while at the high tide level

they were abundant only near the water table.

The vertical distribution of the interstitial fauna at the Cochin beach with a steep slope was more or less the same as that of the Sheratallai beach which has a gentle slope. The ciliates were the dominant group here, although other organisms such as nematodes, turbellarians, etc., are also common.

Studies on the ecology of interstitial fauna were extended this year to include estuarine beaches as well. Here also, the ciliates were quite abundant. Their maximum distribution was at 0-5 cm depth at the mid-tide level although they occur from surface to subsoil water level at all the tidal regions. Next to ciliates the nematodes were the most abundant group and were also found in greater density at the mid tide level in the 0-5 cm depth range. Archiannelids, Oligochaetes, Polychaetes and Harpacticoids were also recorded from this region.

5. Ecology and Production of Macro fauna in the lntertidal Region

(i) *Studies along the Mandovi Estuary*- Study on the ecology and production of macrobenthos in the intertidal region was undertaken at Miramar beach from June 1971. The beach situated along the left bank of Mandovi estuary at a point opposite to its confluence with the Arabian Sea, has physical continuity from Miramar light house to Caranzalem, but it has three sectors represented by Miramar light house, Miramar and Caranzalem.

Fortnightly observations are being made on these sectors along the transects at 5 m intervals between high and low tide mark. The various environmental changes such as beach profile, temperature, pH, salinity, dissolved oxygen and qualitative and quantitative changes in the intertidal fauna are being studied.

The intertidal expanse at all the three transects was variable during monsoon. The most stable beach was Miramar with an intertidal region of 37.8 +or- 8.5 m.

The sand grain size and beach profile underwent significant changes. During monsoon, beach erosion at Caranzalem accompanied by building up processes at Miramar was observed. This information will add to the understanding of erosion of Caranzalem beach and help in the measures that are being taken by building a wall to check the erosion; It appears that these processes also influences the Aguada bar formation, a problem which is being studied in detail by the Physical Oceanography Division.

Ecological differences also influenced the biomass production at three transects. The average values of biomass for the period June to September was 4-7 g/m^2 at Miramar, 4.1 g/m^2 at Miramar Light House and the lowest of 2.8 g/m^2 at Caranzalem.

The rate of production of macrofauna varied at different tide levels. The mid tide level was most productive amongst the three and at this level, highest rate of production of 7.1 gm/m^2 was recorded at Miramar light house.

(ii) *Studies along an Estuarine Beach in Zuari at Siridao and Open Sea Beach at Colva*—Siridao and Colva beaches were studied for their ecology and production of macrofauna in the intertidal region. Significant changes in the beach

profile and the beach expanse were found to occur during monsoon months. The beach expanse at Siridao was between 30-70 m and at Colva 65-130 m. The estuarine beach at Siridao and marine beach at Colva have almost marine conditions during premonsoon period. During monsoon the salinity at Colva and Siridao comes down significantly. Low salinity occurred in August at both the beaches. The lowest salinity recorded at Siridao was 12.8°/$_{00}$ and at Colva 19.0°/$_{00}$. The highest salinity recorded during the second fortnight of September was 34.2°/$_{00}$ at Colva and 31.2°/$_{00}$ at Siridao. The change in salinity was found to mcdify the environment and also the quantity as well as quality of the biomass at the two beaches. The standing crop of biomass during July to October was between 1.2 to 10.5 g/m^2 at Siridao and 10.8 to 62.5 g/m^2 at Colva. The Faunal composition at Siridao was tubiculous polychaetes, amphipods, megalopae of brachyuran crabs, hermit crabs and egg cases of molluscs. At Colva bivalves *(Donax incarnatus, D. apperitus)* polychaetes, amphipods, mysids, dotillid and ocypodid crabs and egg cases of molluscs were found.

Colva beach is richer in the production of the molluscs; higher values of the biomass at Colva were due to the abundance of Donax spp. The possibilities for the development of molluscan fisheries are imminent at Colva beach.

6. Ecology of Mandovi, Zuari and Cumbarjua Canal Complex

(i) *Chlorophyll*—This was started in 1971 in order to assess the living resources and potentialities of the estuarine system of the Mandovi and Zuari rivers and their connecting Cumbarjua Canal. Fortnightly observations are taken at 14 stations spread all over the estuarine complex and collection of surface plankton and chlorophyll along with other parameters, were made. The chlorophyll values during monsoon are towards lower side particularly in Mandovi estuary where the water are quite turbid. Inspite of the absence of positive correlation of the phytoplankton with the zooplankton in estuarine environment, there appears to be a definite pattern of succession of certain species.

(ii) *Zooplankton*—28 samples were collected every month upto the year ending in March 1972, and in all 280 plankton samples were colleted. Fortnightly mean biomass values for each sector is given below for monsoon months.

(Plankton Biomass ml/100^3 m)

	June		*July*		*August*		*September*	
	I	II	I	II	I	II	I	II
Mandovi Sector	7.46	1.7	12.4	1.1	1.5	10.1	17.8	27.1
Canal Sector	9.2	2.0	53.4	5.0	2.0	13.8	29.9	77.8
Zuari Sector	1.7	5.0	23.9	3.3	9.2	35.4	53.3	40.9

An increase in plankton production is seen by the end of August. In canal and Zuari sector the biomass is comparatively more than Mandovi sector. The higher values observed during August-September is due to the swarm of clado-

cerans and ctenophores. The project is being continued and analysis is underway.

(iii) *Production and Ecology of Benthic Organisms*— Studies on the distribution and production of benthos was started during the current year. Analysis of data on the ecology of benthic production during southwest monsoon period (June-September) brought out the following features: (a) of the physical environmental factors that affect the distribution and production of benthic fauna, the most significant seem to be salinity and nature of substratum; (b) sediment animal population relationship clearly indicates that a particular animal assemblage flourishes only in certain kind of substratum where favourable conditions prevail. In this estuarine complex it is the sandy substratum that supports high production with a recorded overall mean value of 50.9 g/m^2; (c) the wide fluctuations in the evironmental factors, especially in the salinity values (0.12-32.90‰) clearly indicate that inspite of the freshwater drainage, it is the strong tidal influence that balances the environment; (d) when compared with Mandovi or Zuari, the Cumbarjua Canal appears to be a more stable ecosystem, as evidenced by lesser degree of fluctuations in the environmental parameter and high rate of production. (e) Mandovi and Zuari undergo a similar trend of fluctuations, both seasonal and diurnal, but it is the availability of favourable substratum and secondly the predominance of euryhaline faunal assemblages, that account for a comparatively high rate of benthic production in Mandovi. (f) The river mouths coincide with the zone of low benthic production. It is in this sector that mixing of sea and fresh water is at its maximum and the ecosystem is unstable, (g) It is concluded that the estuarine complex though formed of physically interconnected watermasses, is not, homogenous ecologically. There exist three different ecosystems which are to a greater extent, independent of each other.

Investigations for postmonsoon and premonsoon period are in progress.

(iv) *Studies on Diurnal Variation*— The studies are conducted at 4 selected stations—two are in Mandovi estuary, one is in Cumbarjua Canal and one is in Zuari Estuary. Surface samples are taken at every three hours for chlorophyll, phytoplankton and zooplankton alongwith other hydrographical parameters. Observations for two seasons have been completed and the analysis and processing is under way.

(v) *Foraminifera of Mandovi and Zuari Estuaries and Cumbarjua Canal*— 15 species have so far been identified. The other findings of the preliminary studies are: (1) In comparison to Mandovi estuary, high concentration of 'dead' foraminifera were found in Zuari estuary. (2) Living population was poor in both the estuaries but was found rich in Cumbarjua canal which is dominated by arenaceous foraminifera. (3) Some shallow water calcareous foraminifera belonging to *Streblus beccarii, Miliolids* and *Elphidium* groups are abundant near the mouths of both the estuaries indicating their drift by bottom transport from the Arabian Sea. :

7. Distribution and Production of Benthic Organisms in Relation to Salinity Intrusion in Mandovi and Zuari Estuaries

The research work was undertaken as a short term project to understand the distribution and production of benthos in the estuaries with particular reference to the salinity intrusion. In all 144 obser-

vation points along 40 cross-sections were worked out for both the estuaries. Data on environmental parameters, *viz.* Temperature, pH, salinity, dissolved oxygen, organic carbon and total phosphates in the substratum, has also been collected. The analysis of data indicate that (a) both the estuaries are of coastal plain type (Pritchard 1965) wherein the rate of mixing of sea and freshwater always exceed the rate of evaporation; (b) the salinity restricts the distribution, abundance and production of benthic organisms. In the estuaries under study based on salinity intrusion, the environment is divided into 4 distinct ecological niches: (c) the ecological niches, along with their salinity features, have been recognized as

(i)	Marine zone	salinity values above 28‰
(ii)	Euryhaline zone	salinity values between 12 - 28 ‰
{iii)	Oligohaline zone	salinity values between 2-12‰.
(iv)	Fresh water zone	below 2‰.

(d) the euryhaline zone was observed to be most productive and the fresh water zone was least productive.

8. Studies on Variability and Ecology of Zooplankton in the Brackish Waters

(i) *Ecological Succession of Plankton :* Monthly collections are made at the barmouth using Clark Bumpus plankton sampler and HT Net for a full tidal cycle of a day and night. These studies are important for identifying the incursion of marine plankton and the outflow of brackish water population through the harbour mouth. Similar day and night samplings are being made at Aroor and Narakkal so as to get a full picture of the stability of the ecosystem. Aroor and Narakkal are places almost equidistant (8 km) from the barmouth on its southern and northern side respectively. Further, the analysis of the samples is expected to give better estimates of the ecological succession of species in space and time. In all these places sampling is made at different depths depending on the stratification of salinity and temperature. The amount of dissolved oxygen is also estimated at these depths. So far five sets of collections were made on the following dates: 4th November 1971, 3rd December 1971, 19th January 1972, 4th February 1972, and 7th March 1972.

(ii) *Variability studies at Aroor—* This is in continuation of the samples collected at Aroor in 1970 and 1971. In 1972, twenty collections were made on alternate days starting from February 1972 to March 1972. These collections are meant for the studies in population dynamics. Sampling is done with a HT Net hauled horizontally along four stations and the depth, temperature, salinity and dissolved oxygen are measured every time. Such an intensive sampling over the same area over a specific period is expected to give a picture of the biology and ecological successions of plankton populations and the stability of the environment.

With the aim to examine the effect of salinity on the distribution of plankton organisms and their tolerance, monthly sampling is undertaken upto Alleppey about 40 miles south of Cochin, where salinity is almost that of fresh water, with seven stations on the way. Cruises were undertaken on the following dates: 24 Jan. 1972, 28 Feb. 1972 and 28 March 1972.

The sampling is done by an HT Net hauled obliquely. Oxygen, Salinity and Temperature are also measured at all stations.

A study was made of copepods of the family Acartiidae which form the dominant component of the plankton in the Cochin Backwater. At least nine species in habit the backwater at one time or another. Reasons were sought for this diversity. The surface plankton was sampled from the head of the estuary to the mouth and from one season to another. There were large seasonal changes in salinity 0 to 35%**o**, due to monsoonal flooding and associated changes in species composition were noticed. Species diversity was highest during the dry season and lowest in the wet. It is suggested that this annual catastrophic flooding leads, in the long run to high species diversity by imposing a regular check on interspecific competition. A new species of Calanoid copepod, *Acartia bilobata* was described from Cochin harbour and adjacent areas.

2.45 Microbiology

1. Bacteriological Studies in Coastal Areas

Bacteria are known to be the chief agents for inter-conversion of salts and degradation of organic matter into simpler substances and regenerate the nutrients. In order to understand the role and significance of marine bacteria, work was initiated in November 1971 at two stations in the nearshore waters off Karwar and Vengurla. The study included basic survey of different groups of bacteria occurring in the inshore environment, their abundance and possible variation in relation to other factors like salinity, temperature, dissolved oxygen and phytoplankton. The quantitative observations are given in table-1.

TABLE 1

(The Bacterial Counts per ml in the Inshore Waters and per gram in the mud off Venguria and Karwar)

Month	*Place*	*Surface Water (per ml)*	*Bottom Water (per ml)*	*Mud Wet basis (per gram)*
Nov. '71	Karwar	320	120	Over I lakh
	Venguria	300	202	Over 1 lakh
Dec. '71	Karwar	240	180	90,000
	Venguria	212	168	88,000
Jan. '72	Karwar	340	192	Over 1 lakh
Feb. '72	Karwar	310	180	80,000
	Venguria	220	190	Over 1 lakh
Mar. '72	Karwar	290	220	Over 1 lakh
	Venguria	274	300	Over 1 lakh

The physiological groups encountered in these areas were: (1) Nitrifying bacteria, (2) Denitrifiers, (3) Nitrate reducers, (4) Sulphate reducers, (5) Pigment producing bacteria and (6) Nitrogen fixers.

The mud samples and seawater from bottom contains mostly denitrifiers while pigment producers, nitrifying bacteria and nitrate reducers were abundant in surface seawater.

A few strains of nitrogen fixers were noticed in mud samples and these are being isolated and recultured.

2.46 Fisheries and Resources

1. Studies on Population Models and Optimum Exploitation of Fish Populations

Theoretical studies on the optimum exploitation of fish population using the Bevetton-Holt model were continued. The important results that arose from this study can be summarised as follows. Exact methods of determining the optimum conditions of exploitation under both isometric and allometric growth conditions are developed. This include (a) the description of the eumetric fishing curve by an equation; (b) estimation of the field by approximate integration so that the population parameters need not be constant; (c) estimation of potential yield and the corresponding age of optimum exploitation by different methods; (d) estimation of the conditions of optimum exploitation using Holt's version of the Beverton-Holt model since it is more useful for tropical fish populations; (e) the application of numerical analysis in studies on optimum exploitation and (f) the examination of the defects of the allometric growth formula in yield studies and the advantages of the cubic equation.

Further work on the theoretical studies are being continued with emphasis on examining the effect of fishing on the major fish populations and in determining the optimum levels of exploitation. This work will be conducted partly in collaboration with the Central Marine Fisheries Research Institute and partly by using published data.

2. Assessment of Living Resources with Particular Reference to Marine Fisheries off Goa Coast

Investigations were started in May 1971. In view of the limitation of the vessel facilities the sampling region could not be extended beyond 40 metre depth. Studies were undertaken at two stations off Calangute in the 20 and 40 meter regions and later extended to Chapora and Terecol in the north and Betul and Polem in the south. In all 22 scientific cruises were made between May 1971 and March 1972.

During each cruise experimental fishing was conducted in the 20 and 40 meter regions using a standard trawl net. In addition to this, data on various environmental factors viz. temperature, salinity, oxygen content of water, nutrient composition, nature of bottom, etc., were also recorded. Plankton samples were collected from the area of experimental fishing.

In analysing the data pertaining to the fishery resources, the Goa coast between Terecol and Polem has been demarcated into three zones namely northern, central and southern, the first one extending from Terecol to Mandrem, the second from Baga to Banaulium and the third from Betul to Polem.

In the northern zone the catch per hour in the 20 meter depth varied between

40 and 75 kg and in the 40 meter depth between 20 and 500 kg. In the central zone the catch per hour varied from 12 to 500 kg in the 20 meter region whereas in the 40 meter region the range was between 8 and 300 kg. In the southern zone, the catch per hour both in the 20 and 40 meter regions varied between 20 and 100 kg.

The most distinguishing feature of the northern zone is the dominance of *Opisthopterus tardoor, Trichiurus* sp., *Leiognathus* sp., *Neptunes pelagicus* and prawns. It may be stated here that prawns and crabs were observed only in the 20 meter region. In the 40 meter region the important species noticed were *Lactarius lactarius, Chirocentrus dorab, Arius* sp., *Leiognathus* sp. and *Johnius* sp. In the central zone while the percentage of prawns was relatively much higher the 20 meter region appeared to be richer than 40 meter region as the percentage of prawns was as high as 63% compared to 39% in the 40 meter region. The central zone appears to support a better pomfret fishery, percentage of which ranged from 1 to 13. Another feature was the occurrence of perches (*Epinephelus* sp. 68%), catfishes (*Arius* sp. 79%), butter-fish (*Lactarius* 23%) and soles (*Cynoglossus* sp. 23%). In the southern zone the composition of the catches appeared to be of a miscellaneous nature. A notable feature was the absence of prawns. The dominant species observed were *Lactarius lactarius* (40%), *Leiognathus* sp. (91%), *Trichiurus* sp. (40%), *Opisthopterus tardoor* (51%), *Pampus* sp. (26%), and *Arius* sp. (26%).

Taking into consideration the entire Goa coast, the central zone appears to have better fishing potential. Within this region the 20 meter area seems to be richer than the deeper area.

This may perhaps explain the concentration of commercial fishing fleet around the 20 meter region. These studies are of a preliminary nature and hence there is need for carrying out intensive and extensive exploratory survey beyond the 40 meter region along the Goa coast.

2.47 Pollution

1. Marine Pollution Studies off Greater Bombay

This sponsored project was operated by the NIO's laboratories at Bombay. The studies on disposal of sewage and industrial effluent from the Bombay city was continued during the year. Collection of data from five predetermined transects on the western coast of Bombay and 7 stations in Thana Creek was undertaken every month. Various hydrographic and biological parameters were measured and the preliminary report was submitted to the Bombay Municipal Corporation in August, 1971. The detailed analysis of data collected is continued. However, the results indicate that the effect of release of the domestic waste of the west coast of Bombay is felt more in the intertidal regions at Worli and Mahim Bay. The dissolved oxygen content of the water was between 2.3 to 3.0 ml/1, which is below the normal level for coastal waters. Turbidity was very high but no temperature gradient was observed. The benthic fauna was very poor and represented by only few polychaete worms. The plankton was dominated by medusae, sagitta and hydromedusae which are more tolerent to oxygen deficiency. A rich plankton was found representing true coastal forms in the other transects. In Thana Creek on the other hand, dissolved oxygen was very low ranging from 1.5 to 2.3 ml/1. In some collections turbidity was very high and bottom fauna was extremely

poor. Plankton was represented mainly by medusae which can stand upto low oxygen tension. Temperature was slightly higher in Thana Creek due to the circulation of warmer water from the atomic reactor and other industries.

Assistance was also accorded to the Bombay Municipal Corporation to study the bottom profile of the transects on the west coast of Bombay. Continuous echographs were charted for all the five transects and station fixes were provided in collaboration with the scientists from Physical Oceanography Division.

It is proposed to continue this work to keep a constant watch on the state of pollution and protection of living resources around the Bombay region.

2.48 General

1. Feeding Metabolism

Feeding experiments on penaeid prawn were continued using different food items. Earlier observation that *Metapenaeus dobsoni* is essentially a predator with maximum selectivity to live on animal food was confirmed. The formula suggested by Ivlev was utilized for the quantitative assessment of the degree of selectivity. It has also been observed that the selectivity values depend on the proportion of the various items in the food complex. A conversion rate of 17.3% was obtained with live polychaetes worms while it was less than 1% when Lyngbya (alga) was given as food. The rate of conversion with detritus depends on the quantity of organic matter of animal origin it contains.

2. Participation in UNDP Arabian Sea Pelagic Fisheries Survey

It has been agreed that the regular plankton samples taken by UNDP by using a Bongo net will be turned over to IOBC where total biomass will be measured as displacement volume and the fish eggs and larvae sorted out. The total biomass data along with the sorted fish eggs and larvae will be handed over to the UNDP for their studies. The rest of the plankton will be retained in IOBC and used for detailed studies on different taxa by the different personnel concerned. Since the commencement of this project in January 1972, 228 samples have been sorted. Investigations on the different taxa are in progress.

2.5

data, publication & information

2.51 Data Exchange, Preparation of Catalogues

2.52 Publication and Information

The work related to oceanographic data of the Indian Ocean is handled by the Indian National Oceanographic Data Centre, the Planning and Data Division of the Institute. The Publicity and Public Relations activities are channelled through the Publication & Information Section.

2.51 Data Exchange, Preparation of Catalogues

During the period the Planning and Data Division was active in the acquisition of new ocean data for the Indian Ocean region collected by different countries through World Data Centre 'A' and U. S. National Oceanographic Data Centre, Washington, D.C. A total number of 902 station data pertaining to physical and chemical aspects collected during various expeditions including the IIOE period have been acquired in the form of computer listings and punch cards. The total number of station data with these additions in the form of listings have come to about 5000, besides the data reports and publications received regularly from the Australian Oceanographic Data Centre, CSIRO and CSK data from Japanese Oceanographic Data Centre. Efforts are being made to acquire some more data with the help of the ocean data catalogues prepared and issued by the World Data Centre 'A'— Oceanography, Washington, D.C.

The work on the classification of the so far acquired data monthwise is being continued. About 5000 station data have been grouped into one degree squares for each month and the information is being transferred on to the catalogue cards to give an idea of the density of the station data in each one degree square for each month, as well as the different parameters collected in these regions. These catalogue cards are also useful for the retrieval of the information relating to the availability of ocean data for a particular region for a specific period.

Besides the classification of these data into one degree square and preparing catalogues, work is being carried out on the preparation of station location maps for the Indian Ocean region to give a pictorial view of the areas that have been explored so far. These charts were prepared for each month.

Preparations are under way for switching over to the machine processing of the oceanographic data. Initially, the work on the coded systems for transfer-

ring the Hydro data (Physical and Chemical) Bathythermograph data on to the punch cards has been taken up. The designing of the various types of punch cards suitable for these data transformation, compilation and retrieval, the input and output formats for entering the unprocessed data, the cruise master information sheets and the instructions for coding the data have been taken up on the priority basis. The keypunching of the back logs of the existing data will be taken up as soon as the peripheral equipment for data processing are received.

List of the Data Received During the Period

Country	*Name of the Ship*	*No. of Stations*
USA	Atlantis II	147
USA	Anton Bruun	74
USA	Davis, C.H.	22
USA	Horizon	30
USA	Rhoboth	30
USA	Stranger	187
USA	Eastwind	59
USA	Conrod	58
USA	Requisite	55
USA	Serrano	35
Thailand	Bangrachan	57
W.Germany	Meteor	148

A total number of 902 station data were acquired.

2.52 Publication and Information

The Publication and Information Section is charged with the responsibility of informing the public about the oceanographic activities of the Institute through *Mahasagar*, the quarterly bulletin of the Institute and also by way of issuing press releases to the newspapers. Besides, the Section also issues popular articles. Other mass media such as Radio were also used to broadcast talks on popular oceanographic subjects.

3

administrative set-up

3.1 Executive Council

1.	Mrs. Sumati Morarjee, Chairman, Scindia Steam Navigation Company, Scindia House, Narottam Morarjee Marg, Ballard Estate, Bombay-1	**Chairman**
2.	Dr. P. Koteswaram, Director-General of Observatories, India Meteorological Department, Lodi Road, New Delhi-3	**Member**
3.	Dr. A. N. Bose, Head of the Department of Food, Technology & Biochemical Engineering, Jadavpur University Jadavpur, Calcutta-32	,,
4.	Cdre. K. R. Ram Nath, I. N., Director, Naval Science & Technology, R & D Organization, Ministry of Defence, New Delhi	,,
5.	Prof. S. P. Chatterjee, Director, National Atlas Organization, 1, Acharya Jagadish Bose Road, Calcutta-20	,,
6.	Shri C. V. Gole, Director, Central Water & Power Research Station, Govt. of India, 20, Bombay Poona Road, Poona-3	,,

7. Prof. R. Ramanadham, Professor of Meteorology & Oceanography, Andhra University, Waltair (A. P.) — Member

8. Shri S. K. Ranganathan, Deputy Director, Naval Science & Technology, R & D Organization, Ministry of Defence, New Delhi — ,,

9. Director-General, Scientific & Industrial Research, Rafi Marg, New Delhi — Ex-Officio Member

10. F. A. to C. S. I. R. — ,,

11. Director, National Institute of Oceanography, Panaji-Goa. — ,,

3.2 Sub-committees of the Executive Council

1. Scientific Sub-committee

A. Physical and Chemical

1. Prof. A. N. Bose
2. Prof. R. Ramanadham
3. Shri C. V. Gole
4. Dr. P. Koteswaram
5. Prof. D. Lal
6. Dr. A. K. Ganguly
7. Director, Naval Physical and Oceanographic Laboratory, Cochin
8. Prof. D. B. Wagh
9. Director, NIO — Convener

B. Biological

1. Dr. C. V. Kulkarni
2. Dr. R. Raghu Prasad
3. Shri G. N. Mitra
4. Prof. S. Krishnaswami
5. Director, Naval Chemical & Metallurgical Laboratory, Bombay
6. Director, NIO — Convener

C. Geological

1. Shri K. K. Dar (Atomic Minerals Division)
2. Representative from Geological Survey of India
3. Prof. A. G. Jhingran, Delhi University
4. Director, Naval Science & Technology
5. Director, NIO — Convener

11. Building and Finance Sub-committee

1. Chairman, Executive Council, NIO
2. Secretary, CSIR
3. FA to CSIR

4. Principal Engineer, PWD, Govt. of Goa, Daman & Diu
5. Director, NIO — Convener

III. Ship Facilities Sub-committee

1. Chief Hydrographer to the Govt. of India
2. Commodore I. K. Puri, I. N. (Retd.)
3. Shri M. C. Perumal, Director, Central Inst. of Fisheries Operatives, Cochin
4. Shri M. Devidas Menon, Director, Indo-Norwegian Project, Cochin
5. Director, NIO — Convener

3.3 Budget

The Budget of the Institute for the year 1971-72 is given below :

Budget item	*Sanctioned* (Final grant Rs. in lakhs)	*Actual* (Rs. in lakhs)
1. Recurring	16.719	16.783
2. Capital	18.000	16X93
Total	34.719	32.876

3.4 Scientific and Technical Staff

Director

Dr. N. K. Panikkar

A. DIVISIONS AT THE HEADQUARTERS

I. Physical Oceanography

Scientist-in-Charge

Dr. V. V. R. Varadachari

Scientists

Shri L. V. Gangadhara Rao
Shri C. S. Murty

Senior Scientific Assistants

Shri P. K. Das
Shri M. J. Varkay
Shri Thomas Cherian
Shri Gopala Rao

Junior Scientific Assistant

Shri K. Kerala Varma

2. Chemical Oceanography

Scientists

Shri C. V. Gangadhara Reddy
Shri S. P. Anand
Shri V. N. Sankaranarayanan

Senior Scientific Assistant

Shri S. Y. S. Singbal

Junior Research Fellows

Shri S. B. Kamat
Miss M. Gaundalkar

3. Geological Oceanography

Scientists

Dr. M. G. Anantha Padmanabha Setty
Shri P. S. N. Murty
Shri R. R. Nair

Junior Scientific Assistants

Shri R. M. Kidwai
Shri F. Almeida

Senior Research Fellow

Shri Victor Rajamanickam

Junior Research Fellows

Shri Shankaranarayana Gupta
Shri B. G. Wagle

4. Biological Oceanography

Scientist-in-Charge

Dr. S. N. Dwivedi

Scientists

Dr. M. S. Prabhu
Shri R. M. Dhawan
Shri R. M. S. Bhargava

Senior Scientific Assistants

Shri R.A. Selvakumar
Shri S. C. Goswami
Shri Promod Kumar S. Gore

Junior Scientific Assistants

Shri K. Kameshwara Rao
Shri S. V. M. Abdul Rahim

Senior Research Fellow

Dr. V. D. Ramamurthy

Junior Research Fellow

Shri Ayyapan Nair

5. Planning & Data

Scientist-in-Charge

Shri R. Jayaraman

Scientist

Dr. V. S. Bhatt

Senior Scientific Assistants

Shri D. Panakala Rao
Shri M. K. Antony

Junior Technical Assistants

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

6. Instrumentation

Scientist

Shri P. E. Sankaranarayanan

Mechanical Assistant

Shri Mohammed Rafique

B. REGIONAL CENTRE, COCHIN

1. Indian Ocean Biological Centre

Scientist-in-Charge

Dr. T. S. S. Rao

Scientists

Dr. M. J. George
Dr. R. V. Unnithan
Shri P. Gopala Menon
Shri K. J. Peter

Senior Scientific Assistants

Shri M. Sakthivel
Dr. M. Saraswathy

Junior Scientific Assistants

Shri P. N. Aravindakshan
Shri Jacob George
Shri George Peter
Shri V. T. Paulinose
Mrs. Vijayalaxmi R. Nair
Shri T. Balchandran
Smt. C. B. Lalithambika Devi
Shri T. C. Gopalakrishnan
Shri K. K. Chandrasekharan Nair
Smt. V. Santhakumari

Junior Research Fellows

Miss Saramma U. Panampunnayil
Shri P. Haridas
Shri M. Madhu Pratap
Shri C. T. Achuthankutty

2. Physical Oceanography

Scientist

Shri V. S. Rama Raju

Senior Scientific Assistants

Shri P. Udayavarma Thirupad
Shri P. Gopalakrishna Kurup
Shri Ch. Madhusudana Rao

3. Biological Oceanography

Scientists

Dr. M. Krishnankutty

Shri B. M. Panikkar
Shri U. K. Gopalan

Senior Scientific Assistants

Shri P. M. A. Bhattathiri
Shri V. P. Devassy

C. FIELD UNIT OF THE NIO, BOMBAY

Scientists

Dr. B. N. Desai
Dr. A. B. Wagh

4. Library

The Library facilities are available at the Headquarters and the Regional Centres. Total collection of books including back volumes of periodicals on various disciplines of Marine Sciences is 6000. Collection is being classified according to Colon Classification (6th Revised Edition). An up-to-date catalogue satisfying all the approaches is also being prepared. Library is subscribing to 125 journals of which 15 are being received on exchange. The Library receives and issues book and periodicals on Inter-library loan basis with the libraries of various institutions in the country. The copies of the Acquisition List, consisting of latest additions of book and periodicals, are periodically distributed among Scientific Staff to keep them informed of the new books received at the Library.

5. Awards, Honours, Memberships of Various Committees

Shri R. Jayaraman has been nominated as the National Coordinator for International Oceanographic Data Exchange.

Dr. M. G. Anantha Padmanabha Setty was elected as a member of the Executive Council of Indian Society of Earth Scientists, Poona.

Dr. V. S. Bhatt was awarded a certificate of Intensive Training in Communication for Science and Technology by the Indian Institute of Mass Communication (Government of India), New Delhi.

Shri D. Panakala Rao was awarded a certificate of Merit by US National Oceanographic Data Centre, NOAA in recognition of his training in ocean data processing.

Shri P. Udayavarma Tirupad was awarded the M. Sc. degree by research in oceanography of the University of Kerala.

6. Deputations

Dr. N. K. Panikkar attended *international Conference on Environmental Future* at Helsinki and Jyvaskyla, Finland from 27 June to 3 July 1971. The conference was sponsored by the Govt. of Finland, the Finnish National Commission for UNESCO and Jyvaskyla Arts Festival.

...attended the second *Pacem in Maribus* Convocation which was held at the request of Govt. of Malta by Continuing Group for Policy Research from 29 June to 5 July at Malta.

...attended the United Nations Seabed Committee Meeting held in August 1971 at Geneva (Switerland) as a member of the Indian Delegation.

...attended meeting held in Mexico from 14 to 20 Febrary 1972 under the

auspices of the UNESCO to discuss problems pertaining to the Marine Biological Centres in different parts of the World, particularly those working with the International Cooperation.

Shri R. Jayaraman was deputed to attend the seventh session, of Intergovernmental Oceanographic Commission held at Paris from 6th Oct. to 5th Nov. 1971 and also attended the extraordinary session of the Commission under the new statutes on 6th Nov. 1972.

Dr. V. S. Bhatt was deputed to participate in the three month In-service Professional Course in Mass Communication and intensive training in Communication for Science & Technology. The course was organised by the Indian Institute of Mass Communication (Govt. of India), New Delhi during August-October 1971.

Shri D. Panakala Rao was deputed to attend the training course in acquisition, processing and utilisation of ocean data held at Woods Hole Oceanographic Institution, Woods Hole and US National Oceanographic Data Centre, NOAA, Washington DC organized by UNESCO from 6th June to 5lh Dec. 1971.

Shri M. Sakthivel, S.S.A. went on deputation from June 1970 to September 1971 to West Germany under Exchange Programme.

The following members of the IOBC were deputed to attend the Kiel Symposium on "The Biology of the Indian Ocean" during March-April, 1971 and presented 10 papers.

1. Dr. T. S. S. Rao, Officer-in-Charge.
2. Dr. Marta Vannucci, UNESCO Expert.
3. Dr. M. Saraswathy, S. S. A. After the Symposium, Dr. Saraswathy went to Smithsonian Institution, USA for training for 6 months under UNESCO travel grant.
4. Mrs. Vijayalaxmi R. Nair, J.S.A.
5. Shri P. N. Aravindakshan, J.S.A.
6. Shri T. Balachandran, J.S.A.
7. Shri K. K. Chandrasekharan Nair, J.S.A.

7. Meetings, Exhibitions, Seminars and Symposia

The Scientists of the NIO took active part in the Seminar on the Scientific, Technological and Legal Aspects of the Indian Continental Shelf organised by the Indian Geophysical Union, at Panaji from l1th to 13th November 1971.

The Regional Centre of NIO, Cochin participated in the "Open House" exhibition of the Indo-Norwegian Project at Cochin held on 17th to 19th October, 1971. Among other things the live plankton projected on a screen was of great interest to the public who visited the exhibition.

Dr. M. J. George attended the workshop on All India Coordinated Research Project on studies on marine prawn biology and resources conducted by ICAR at C.M.F.R. Institute, Cochin on 23rd and 24th March 1972.

Seminars held at IOBC

	Speaker	*Date*	*Subject*
1	P. N. Aravindakshan	29-5-71	Vertical distribution of Zooplankton
2	L. R. Kasturirangan	21-7-71	On Science Writing
3	Dr. M. J. George	28-7-71	Overfishing problem in prawn fisheries of Cochin
4	Mrs. Vijayalakshimi R. Nair	4-8-71	Papers of J. H. Fraser
5	Jacob George	11-8-71	Plankton adaptations of Copepods
6	V. Santhakumari	25-8-71	Parasites and associates of marine woodboring organisms
7	C. B. Lalithambika Devi	8-9-71	Synopsis of biological data on eel *Anguilla anguilla* (Linnaeus)
8	Dr. T. S. S. Rao & Dr. M. Vannucci	15-9-71	IOBC Working Paper
9	M. Sakthivel	13-10-71	The working system in the Institute fur Meercshunde, Kiel, W. Germany
10	Dr. M. Saraswathy	20-10-71	On a recent visit to Smithsonion Institution, Washington
11	P. Udayavarma Thirupad	27-10-71	On the surface circulation in Indian Ocean
12	Dr. T. S S. Rao	17-11-71	The recent syposium on "Science, Technological & Legal Aspects of Indian Continental Shelf" held at Goa
13	V. S. Rama Raju	15-12-71	Indian Continental Shelf
14	B. M. Panikkar	5- 1 -72	Intertidal Ecology
15	Dr. T. S. S. Rao	16-2-72	Production of zooplankton in the Sea
16	M. Madhu Pratap	23- 2 -72	Calanus distribution
17	C. T. Achuthankutty	1-3-72	The life history of a marine copepod

8. Colloquia and Special Lectures

Colloquia (in Goa)

	Speaker	*Subject*	*Date*
1	Dr. S. N. Dwivedi	Education and Scientific Research in Laos, Vietnam and Cambodia	April 7, 1971
2	Shri R. Jayaraman	Recent trends in Chemical Oceanography	May 20, 1971
3	Dr. V. D. Rama Murthy	Laboratory culturing of Marine Blue Green Algae	Dec 14, 1971
4	Shri C. S. Murty	Some Aspects of the Tidal Flow Characteristics of the Mandovi Estuary and the Cumbarjua Canal	Dec 14, 1971

	Speaker	*Subject*	*Date*
5	Shri D. Gopala Rao	A Review of 'Geological and Geophysical Studies in Western part of Bengal Basin, India' by S. Sengupta	Jan 5, 1972
6	Shri R. M. S. Bhargava	Organic Production in the Mandovi and Zuari Estuaries	Jan 5, 1972
7	Dr. H. G. Kewalaramani	Some Aspects of Fisheries Research in Maharashtra	Jan 21, 1972
8	Dr B. L. K. Somayjulu	Oceanographic Programmes at the Geophysics Section of Tata Institute of Fundamental Research	Jan 31, 1972
9	Shri V. N. Shankaranarayana	Some of the Environmental Characteristics of the Waters Around Kavaratti (Laccadives)	Feb 4, 1972
10	Shri R. R. Nair	A Review of 'The Structure of the Indian Ocean' by A. S. Laughton et al.	Feb 25, 1972
11	Shri Victor Rajamanickam	Heavy Minerals in the Shelf Sediments off Madras Coast	Mar 17, 1972
12	Dr. V. S. Bhatt	An Introduction to the Antarctic Oceanography	Mar 24, 1972

Special Lectures at Cochin

	Speaker	*Date*	*Subject*
1	Dr. A. Eleftheriou	22-4-71	Benthic Studies at Aberdeen
2	K. Gapalakrishnan	15-5-71	Biological Programme at Scripps Institution of Oceanography
3	Dr. N. M. Dowidar	14-7-71	The Present Situation of Plankton Immigration through Suez Canal
4	Prof, R. Ramanadham	25-9-71	Air, Water and Land rollution
5	Dr. O. J. Qstvedt	8-12-71	Plankton Research in Relation to Fisheries
6	Dr. T. Wyatt	29-12-71	Population Dynamics of Oikopleura

9. Radio Talks

	Speaker	*Date*	*Subject*
1	Dr. N. K, Panikkar	25-7-71	*Future of the Environment* Talk in English
2	Dr. N. K. Panikkar	2-9-71	*Research and Results:* Discussion (English)
3	Dr. N. K. Panikkar	9-1-71	*Homage to Dr. Vikram Sarabhai*: Talk in English
4	Dr. N. K. Panikkar	20-2-72	*Mass Mortality in the Sea :* Talk in English

10. Distinguised Visitors

Mr. Wadayan & Mr. G. G. Heiemath	MPPTC & Fisheries College, Mangalore
Dr. H. G. Kewalramani	Fisheries Dept, Taraporewala Aquarium, Bombay-2
Prof. P. N. Ganapati	Andhra University, Waltair
Prof. C. V. Kurian	Kerala University Oceanographic Laboratory, Cochin-16
Mr. P. M. Gokulapala Menon	Joint Director, Kerala State Fisheries, Trivandrum
Mr. T. R. Thankapaan Achari	State Planning Board, Trivandrum
Dr. N. M. Dowidar	Director, National Marine Biol. Centre, Alexandria, Cairo
Dr. Vagu Hansen	Phuket Marine Biological Centre, Phuket Thailand
Dr. M. Appaswamy Rao	Professor of Zoology, Karnatak University, Dharwar
Prof. R. Ramanadham	Department of Meteorology & Oceanography, Andhra University, Waltair
Dr. K. V. Sekharan	Prof. of fisheries, University of Calicut, Calicut
Prof. S. Krishnaswamy	Dept. of Zoology, Madurai University Madurai
Dr. K. Nagaraja Rao	The Fort Foundation, Prog. Officer, Science & Technology (Latin America), New York
Mr. Ben. Fukuzaki	Van Camp Sea Food Company, Terminal Is., California
Dr. O. J. Ostvedt	Fisheries Institute, Bergen, Norway
Mr. T. Wyatt	Fisheries Laboratory, Lowestoft, U. K.
LCDR C. S. Dandekar and Group	Officer-in-Charge, Hydrographical School, Naval Base, Cochin-4
Dr.M. R. Ranade	Marine Biological Research Station, Taraporewala Aquarium, Bombay-2
Dr. K. K. Tiwari	Zoological Survey of India, Calcutta-18
Dr. H. G. Kewalramani	Specialist Fisheries, National Commission on Agriculture, New Delhi

Mr. D. Macdougall	Scripps Institute of Oceanography, La Jolla, California 92037
Dr. P. S. Gill	C.S.I.O. Chandigarh
Dr. I. J. Billington	Dilworth Seacord Meagher & Assoc 4195 Dunes St. W. Toronto, Canada
Dr. K. Jacob	Member, Indian National Committee for Cooperation with UNESCO
Shri M. Mukundan Unni	Managing Director, Kerala Fisheries Corporation, Cochin
Shri S. Thyagerigan	Project Officer, Tamil Nadu, Agro Industries Corporation, Madras
Donald W. Pritchard	Director, Chesapeake Bay Institute, The Johns Hopkins University, USA
Com. Don Walsh	Office of the Assistant Secretary of the Navy (Research & Development) Navy Dept. Washington, D. C. 20350
Shri C. Subramaniam	Union Minister for Planning, Science & Technology, New Delhi
Dr. K. R. Ramanathan	Director, Physical Research Laboratory, Ahmedabad-9
Prof. S. Bhagavantam	525, Rajmahal Extensions, Bangalore-6
Shri A. Parthasarthi	Special Science Assistant to Prime Minister, P. M. Secretariat, New Delhi
Dr. K. V. Subrahmaniam	Madras
Dr. Vikram A. Sarabhai	Physical Research Laboratory, Ahmedabad
Shri U. P. Kahr	C/o UNESCO, New Delhi
Shri S. P. Herskouich	C/o UNESCO, New Delhi

11

publications

11.1 Publications of the Institute

1. Annual Report 1970-71.
2. Bulletin of the Institute, *"Mahasagar"* : Vol. 4, Nos. 1-4.
3. International Indian Ocean Expedition Plankton Atlas Vol. III, Fascicle 1: Distribution of Crustacea and Insecta of the Indian Ocean.
4. International Indian Ocean Expedition Plankton Atlas. Vol. III Fascicle 2: Distribution of Planktonic Mollusca of the Indian Ocean.
5. Brochure of Indian Ocean Biological Centre.
6. Brochure of National Institute of Oceanography.
7. Handbook to the International Zooplankton Collection Vol. II and Vol. **III.**

11.2 Papers Published by Staff Members

126 **Anand, S. P. and S. Y. S. Singbal.** 1970. Shallow Water Sampler. *Mahasagar,* 3 (3) : 35-36.

127 **Balakrishnan, K. P. and Devi, C. B. Lalithambika.** 1970. Preliminary observations on circulatory system *in* eggs and early larvae of some Teleostean fishes. *Mar. Biol.,* 6(3): 256-261.

128 **Chandrasekharan Nair, K. K.** 1971. A note on an amphipod swarm along the south-west coast of India. *Curr. Sci.,* 41(5**):** 185-186.

129 **Desai, B. N.** 1971. Mollusca in the benthic fauna of Cochin. *J. Bombay nat. Hist. Soc.,* 68(2): 355-362.

130 **Devi, C. B. Lalithambika.** 1971. Fixation and preservation of plankton samples. *IOBC Handbook,* 3: 24-32.

131 **Devi, C. B. Lalithambika.** 1971. Rearing fish egg in the laboratory. *IOBC Handbook,* 3 : 53-56.

132 **George, M. J.** 1970. Synopsis of biological data on the Penaeid prawn, *Metapenaeus dobsoni* (Mier, 1878). *FAO Fish. Rep.,* (57)4: 1335-1358.

133 **George, M. J.** 1970. Synopsis of biological data on the *Metapenaeus affinis* (H.Milne Edwards, 1837). *FAO Fish. Rep.,* (57)4: 1359-1376.

134 **George, M. J.** 1970. Synopsis of biological data on the Penaeid prawn, *Metapenaeus monoceros* (Fabricius, 1798). *FAO Fish. Rep.,* (57)4 : 1539-1558.

135 **George, M. J.** 1970. Synopsis of biological data on the Penaeid prawn, *Metapenaeus brevicornis* (H. Milne Edwards, 1837) *FAO Fish. Rep.,* (57) 4 : 1559-1574.

136 **George, M. J. and A. Noble.** 1970. Occurrence of Pea Crabs *Pinnotheres gracilis Burger* and *Pinnotheres modiolicolus* Burger in the Indian Coast. *J. Mar. biol. Ass. India,* 10(2): 392-394 (1968).

137 **George, M. J. and M. S. Muthu.** 1970. *Solenocera waltairensis,* a new species of Prawn (Decapoda Penaeidae) from Indian waters. *J. Mar. biol. Ass. India,* 10(2) : 292-297 (1968).

138 **George, M. J. and M. S. Muthu.** 1970. On the occurrence of *Metapenaeosis barbata* (De Haan) (Decapoda: Penaeidae) in Indian waters with taxonomic notes on the genus. J. *Mar. biol. Ass. India,* 10(2): 286-291 (1968).

139 **George, M. J. and Rao, P. V.** 1970. Observations on the development of the external genitalia in some Indian Penaeid prawns. *J. Mar. biol. Ass. India,* 10(1) : 52-70 (1968).

140 **Gopalakrishnan, T. C.** 1971. Folsom Splitter Accuracy. *IOBC Handbook,* 3:35.

141 **Gopalan, U. K.** 1971. Soles, flounders and halibuts in India. *Seafood Export Journal,* 3(1): 155-159.

142 **Gopala Menon, P. and Williamson, D. I.** 1971. Decapod Crustacea from the International Indian Ocean Expedition - The species of *Thalassocaris* (Caridea) and their larvae. *J. Zool. Lond.,* 165: 27-51.

143 **Gore, P. S.** 1971. Some bacteria isolated from marine plankton and mud. *Fish. Technol,* 9(1) : 48-63.

144 **Gore, P.** S. 1971. Some observations on the bacterial flora of the beth sand and beach seawater. *Environmental Health,* 13(2): 115-119.

145 **Gore, P.** S. 1971. A note on the successive egglaying without mating of some Indian crabs. *Curr. Sci.,* 40(2): 48.

146 **Gore, P. S. and Ranade, M. R.** 1971. Record of cestode parasites from Penaeid prawns of Ratnagiri. *Fish. Technol.,* 8(2) : 227.

147 **Goswami, S.C.** 1971. Comparison of plankton catch by pump and net. *IOBC Handbook,* 3: 20-24.

148 **Goswami, Usha and Goswami,** S. C. 1972. Karyological studies on three species of Copepods. *Curr. Sci* , 41(4)**:** 154-155.

149 **Jacob George.** 1971. On the occurrence of *Bathyconchoecia deeveyae* Kornicker (Ostracoda) in the Indian Ocean. Symposium on the Biology of the Indian Ocean, IIOE, Kiel 1971 *(Abstract)* and *Crustaceana,* 21(2): 141-144.

150 **Kameswara Rao, K.** 1970. Foraminifera of the Gulf of Cambay. J. *Bombay nat. Hist. Soc,* 1970, 67(2): 259-293; 1971, 68(1**):** 9-19.

151 **Murty, P. S. N. and Rao, C. H. M. & Reddy, C.** V. G**.** 1970. Geological studies on the shelf sediments off the west coast of India (summary). *Proc. of Joint Oceanographic Assembly, Tokyo.* 1970 : 504-506.

152 **Nair, N. Balakrishnan and M. Saraswathy.** 1971. The bioiogy of woodboring Teredinid Molluscs. *Adv. mar. Biol,* 9 *:* 335-509.

153 **Nair, R. R.** 1971. Favourable environments for minerals exploration on the western continental shelf of India. *Mahasagar,* 4(2) : 65-70.

154 **Nair, R. R., Murali, R. S. and R. M. Kiidwai.** 1971. Ca/Mg ratios in the sediments on the continental shelf off Bombay. *Proc. Indian Acad. Sci.,* 73 (1 B): 29-36

155 **P. Chandramohan and Rao, T. S. Satyanarayana.** 1971. Tidal cycle studies in relation to Zooplankton distribution in the Godavari estuary. *Proc. Indian Acad. Sci.,* 75 B (1) : 23-31.

156 **Panikkar, N. K.** 1972. (Ed.) Distribution of Crustacea (Cladocera, Ostracoda, Cirripedia, Mysidacea, Cumacea, Isopoda, Amphipoda, Euphausiacea, Stomatopoda) and Insecta (Halobatidae) of the Indian Ocean. IIOE *Plankton Atlas,* 3(1).

157 **Panikkar,** N. **K.** 1971. (Ed.) Distribution of Planktonic Mollusca of the Indian Ocean. IIOE *Plankton Atlas,* 3(2).

158 **Panikkar, N. K. and T. M. Srinivasan.** 1971. The concept of tides in Ancient India. *Indian J. Hist. Sciences,* 6(1): 36-50.

159 **Parulekar, A. H** 1971. A new sea ancmone, *Cribrinopsis rebertii* (Endomyaria : Actiniidae) from Maharashtra and Goa coast. *J. Bombay nat. Hist. Soc,* 68(1): 291-295.

160 **Parulekar, A. H.** 1971. Polychaetes from Maharashtra and Goa. *J. Bombay nat. Hist. Soc.,* 68 (3): 726-749

161 **Peter, K. J.** 1971. A newly designed Neuston Sampler, Proceedings of Plankton Workshop, Cochin, 1969. *IOBC Handbook.* 3 : 17-20.

162 **Qasim, S. Z. and Bhattathiri, P. M. A.** 1971. Primary production of a seagrass bed on Kavaratti atoll (Laccadives). *Hydrobiologia,* 38(1): 29-38.

163 **Qasim, S. Z., Bhattathhri, P. M. A. and Devassy, V. P.** 1971. The influence of salinity on the rate of photosynthesis and abundance of some tropical phytoplankton. *Mar. Biol.,* 12 (3): 200-206.

164 **Rao, T. S. Satyanarayana, Rao, K. Kameshwara, Wagh, A. B. and B. N. Desai.** 1971. Studies on hydrobiological features of the Gulf of Cambay Part I — Preliminary Account. *Mahasagar,* 4 (3 & 4): 101-107.

165 **Sakthivel, M.** 1971. Simple underway Sampler and its performance. *IOBC Handbook,* **3** : 8-17.

166 **Sankaranarayanan, V. N. and R. Jayaraman,** 1971. Intrusion of upwelled water in the Mandovi and Zuari estuaries. *Curr. Sci.,* 41 (6): 204-206.

167 **Santhakumari, V. and N. B. Nair.** 1970. *Nucleocorbula adherans* gen. and sp. nov. (Ciliata, Thigmotrichida) from . shipworms *Ophelia,* 7(2): 139-144.

168 **Saramma Abraham.** 1970. A new species of *Acartia* (copepoda, calanoida) from Cochin Harbour, India and adjacent areas. *Crustaceana,* 18 (1): 49-54.

169 **Saraswathy, M.** 1971. Distribution of bivalve larvae in the Indian Ocean. IOBC *Handbook,* 3: 43-53.

170 **Saraswathy, M. and N. Balakrishnan Nair.** 1971. Observations on the structure of the shipworms, *Nausitora Ledlevi Teredo furcifera* and *Teredora primcesae* (Bivalvia: Teredimidae). *Trans Roy. Soc. Edin.,* 68 (14): 507-566.

171 **Selvakumar, R.** A. 1971. Notes on the biometric features of *Nemipterus japonicus* (Bloch). *J. Bombay nat. Hist. Soc.,* 68 (2) : 467-473.

172 **Setty, M. G. Anantha Padmanabha.** 1972. Holocene planktonic foraminifera from the shelf sediments off Kerala coast. *J. Geol. Soc. India.,* 13(2): 131-138.

173 **Stephen R. and K. Sarala Devi.** 1971. Relationship between numbers, displacement volume and wet weight. *IOBC Handbook,* 3 : 37-43.

174 **Tranter, D. J., Devi, C. B. Lalithambika and K. P. Balakrishnan.** 1971. Heron Tranter Net. *IOBC Handbook,* 3 : 6-8.

175 **Tranter, D. J. and Saramma Abraham.** 1971. Coexistence of species of Acaitiidae (copepoda) in the Cochin backwaters: a monsoonal estuarine lagoon. *Mar. Biol.,* 11 (3): 222-241.

176 **Unnithan, R. V.** 1971. On the functional morphology of a new fauna of Monogenoidea on fishes from Trivandrum and environs. Part IV. Microcotylidae sense stricto and its repatri ation into subsidiary taxa. *Amer. Midl. Nat.* 85 (2) : 366-398.

177 Vannucci, M. and V. Santhakumari. 1971. New records of hydromedusae from the shelf area off the Kerala coast. *J. Mar. Biol. Ass. India,* 11 : 40-43 (1969).

178 **Vannucci, M., V. Santhakumari and E. P. Dos Santos.** 1970. On the ecology of hydromedusae from the Cochin area. *Mar. Biol,* 7(1): 49-58.

179 **Wagh, A. B.** 1971. Biometrical comparison between *Balanus tintinnabulum* L. and *Balanus amaryllis* D. *J. Bombay nat. Hist. Soc,* 68 (1) : 282-286.

180 **Wagh, A. B.** 1972. On the southern limits of *Tetraclita squamosa* rufotincta (Pilsbry) (Cirripedia, Balanidae) along the west coast of India. *Curr. Sci.,* 41 (1) : 38.

11.3 Popular Articles and Reviews

1 **Bhatt, V. S.** 1971. Tarkibcn Samudra Ka Kharapan Door Karne Ki (in Hindi). *Dharmayug,* June 20, 24-26.

2 **Bhatt, V. S.** 1971. Methods for the Study of Marine Benthos by N. A. Holme and A. D. Mclntyre (Book Review). *Maliasagar,* **4(2)** : 71-72.

3 **Bhatt, V. S. and S. K. Kumar.** 1971. Discussions on the Indian Ocean and its Adjacent Seas. *Mahasagar,* 4(3 & 4): 118-131.

4 **Bhatt, V. S.** 1971. Seminar on the Scientific, Technological and Legal Aspects of Indian Continental Shelf. *Mahasagar,* 5(1): 36-41.

5 **Bhatt, V. S.** 1971. Plankton in the Sea. *Science Reporter,* 8(10): 461-465.

6 **Bhatt, V. S.** 1972. Lal Chatri Programme of the NIO. *Navhind Times* (Sunday Magazine), March 12, Page 3.

7 **George, M**. J. 1971. Lobster fisheries of the Indian Ocean region. *Vijnana-kairali* (Special number on Indian Ocean), 2(8): 56-57 (In Malayalam).

8 **Kurup, P. G.** 1971. Silting in Cochin Harbour. *Seafood Export Journal* (Annual Number), January.

9 **Kurup, P. G**. 1971. A river in the Ocean (in Malayalam). *Sastra Keralam*, 24, May.

10 **Kurup, P. G.** 1971. Beneath the Ocean Waters (in Malayalam). *Sastra Keralam*, 24, May.

11 **Kurup, P. G.** 1971. Nodules (in Malayalam). *Eureka*, 2(1), June.

12 **Kurup, P. G.** 1971. "Chakara-the False Land (in Malayalam), *Sastra Keralam*, 29, October.

13 **Panikkar, N. K.** 1971. C. V. Raman—The Unique Mentor. *Curr. Sci.*, 40: 215-217.

14 **Panikkar, N. K.** 1971. Development of Marine Fisheries in India (in Russian). *Research & industry* (USSR), 1968 : 92-101.

11.4 Reports Prepared by the Staff Members

Sl. No.	*Contributors*	*Collaborators*	*Report*	*Year*	*Sponsored by*
1.	Panikkar, N. K., Jayaraman, R. and V. V. R. Varadachari	IUGG Association of Physical Oceanography	National Report for India on Physical Oceanography (1967-70)	1971	—
2.		National Institute of Oceanography and Central Public Health Engineering Research Institute	Report on the Physical Aspects of Hydrographic Survey off Bombay. (Sept. 1970 to July 1971)	1971	Bombay Municipal Corporation

national institute of oceanography

its divisions and units

The various divisions and units of the National Institute of Oceanography have been re-organised during the year under report as given below :

	Telephone Number	*Telegraphic Address*
A. Headquarters, Panaji, Goa		
1. Physical Oceanography Division, NIO, Miramar, Panaji, Goa	3253 2923 (Extn. 8)	OCEANOLOGY PANJIM
2. Chemical Oceanography Division, NIO, Miramar, Panaji, Goa	3085	—do—
3. Geological Oceanography Division, NIO, Miramar, Panaji, Goa	2923 (Extn. 9)	—do—
4. Biological Oceanography Division, NIO, Miramar, Panaji, Goa	2923 (Extn. 6)	—do—
5. Indian National Oceanographic Data Centre (Planning & Data Division), NIO, Miramar, Panaji, Goa	3255 2923 (Extn. 5)	—do—
6. Instrumentation Division, NIO, Miramar, Panaji, Goa	3085	—do—
B. Regional Centre of the NIO, Cochin		
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2. Physical Oceanography Unit	—do—	—do—
3. Biological Oceanography Unit	—do—	—do—
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