

national institute of oceanography, india

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ANNUAL REPORT

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NATIONAL INSTITUTE OF OCEANOGRAPHY

(Council of Scientific & Industrial Research)

PANAJI, GOA

INDIA

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general introduction

This year has been important to the Institute in many ways. On 26th May, 1972, we completed 'Ten Years of Integrated Ocean Research in India'. The occasion was celebrated at the Institute and a colloquium on Ocean Research in India was organized. Leading Indian Marine Scientists attended the colloquium, the proceedings of which will be published in June 1973 issue of *Mahasagar*, the quarterly bulletin of the Institute.

The Institute acquired a 68-m Hopper Vessel from the Calcutta Port Commissioners at a cost of Rs. 61.6 lakhs and handed it over to Garden Reach Workshop, Calcutta, for modifications, conversions and refittings at an additional cost of Rs. 65 lakhs. The vessel is named *R. V. Gaveshani*.

The Scientists' Hostel and the Senior Officers' Residential accommodation were completed and occupied during the year. The construction of the first phase of Laboratory Buildings of the Institute and 46 Staff Quarters of the NIO Residential Colony has been in progress. A 1.48 acre plot was acquired at Cochin for the construction of buildings of the Regional Centre of the Institute. It is expected that the buildings would be completed within the next two years.

The scientific activities of the Institute have been varied. The Institute took up

Bathymetric and Hydrographic Surveys off Tarapur at the request of Atomic Power Authority, Bombay. The findings will help the authority to design a submarine pipe-line for safe discharge of the effluents from the Atomic Power Station and Fuel Processing Plant. Another project involving Bathymetric and Hydrographic Survey of Mahisagar Estuary was undertaken at the request of the Government of Gujarat with a view to locating a suitable point for the discharge of industrial wastes of Baroda city. Several private and Government agencies have shown interest in the development of beach resorts in Goa and have requested the Institute to make surveys and give advice on the suitability of some of these beaches as resorts. The work has been in progress.

The copper concentrations in the Inshore and Estuarine Waters along the Coast of Goa have been found to be unusually high. Other studies in Chemical Oceanography are on the Iron cycle, distribution of Phosphorus and Carbon-dioxide system in the estuarine, inshore and offshore waters of Goa. Studies on marine pollution and fouling are also being pursued.

The sedimentological, micropalaeontological, mineralogical and geochemical work relating to the sediments of beaches of Goa and some selected regions of the

continental shelf of the West Coast was continued during the year.

The biological studies were mainly devoted to two major aspects, first being the characterization of the different areas of the Central West Coast of India, Mandovi and Zuari Estuarine Systems, Mangrove Swamps and the sandy beaches of Goa, Bombay and Cochin. The second major aspect relates to the studies of the IIOE Zooplankton collection. Besides, some studies on fish, fisheries and resources were also undertaken. A report on the 'Assessment of Marine Fishery Resources of Goa' was presented to Shri D. B. Bhandodkar, Chief Minister of Goa and the 'International Indian Ocean Expedition Atlas' Vol. 3, Fascicle 1, on the Distribution of Crustacea and Insecta of the Indian Ocean was released by Shri S. K. Banerjee, Lt. Governor of Goa, Daman & Diu.

Efforts were made towards developing modern methods of acquisition, processing, storage and retrieval of Indian Ocean Data at the Data Centre of this Institute. The activities of the Institute were highlighted through *Mahasagar*, the quarterly

bulletin, and by issuing news releases to the press.

On the Instrumentation side, efforts were made to create the requisite facilities for R & D work. A service group is also being organised towards maintenance and repairs of mechanical and electrical instruments and minor workshop services.

Marine Geophysical studies were started during the year with a view to develop a better understanding of the geophysical problems of the sea.

On 26th January, Dr. N. K. Panikkar, Director of the Institute, who is also the Chairman of the Indian National Committee on Oceanographic Research, was awarded '*Padmashri*' by the President of India for his outstanding work on Research and Development in the field of Marine Sciences in India.

On 16th March, 1973 the Institute suffered a grievous loss in the death of Shri R. Jayaraman, Head of the Planning and Data Division of the Institute, a distinguished chemical oceanographer who worked hard for the growth of Indian Oceanography.

— DIRECTOR

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research activities

2..1

physical oceanography

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| 2.10 Oceanic Properties | 6. Studies on Aguada Bar |
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The Physical Oceanography Division has undertaken two new programmes during the year under report, namely, Bathymetric and Hydrographic Survey off Tarapore at the request of the Atomic Power Authority, Bombay, and Bathymetric and Hydrographic Survey of Mahisagar Estuary at the request of the Gujarat State Government. These have been reported under sponsored projects. Other highlights of the year are the starting of studies on sea-level variations at Mormugao Harbour, the completion of sedimentological studies of the Mormugao Bay and the beginning of studies on some marine geophysical problems.

The existing programmes of coastal and nearshore environment, namely, studies on circulation of Moplah Bay and circulation in the shelf waters off Goa coast, studies on beach erosion and beach sediments along the Goa and Kerala coasts, studies on the physical aspects (salinity pattern, circulation, siltation, etc.) of the estuaries of Goa and studies on the formation of mud banks along the Kerala coast and the Aguada Bar at the mouth

of Mandovi river in Goa, were continued. Monthly cruises in the shelf region of the Central West Coast of India started in the previous year were continued during this year in order to cover the summer season also for studying the spatial and short term variations in the hydrographical features and circulation pattern prevailing in the shelf waters.

2.10 OCEANIC PROPERTIES

1. Oceanographic Studies at Mormugao Harbour

Studies on the seasonal and spatial variations in the hydrographic conditions, transparency and suspended sediment load of the waters of the Mormugao Bay were continued. Preliminary results of a comparative study of the hydrographical features and suspended sediment load of the waters in the sea adjoining Mormugao Harbour with those of the waters in the Mormugao Bay, carried out during March 1972 are given in the following paragraph.

During March, the waters in the Mormugao Bay are warmer (about 30°C) than the waters in the adjoining sea, where the temperatures are generally below 28.5°C. The salinity of the waters in the Bay is mainly controlled by the tidal action and generally varies between 34.8 ‰ and 34.0 ‰, from the bay mouth to the tail end of the bay, while in the adjoining sea, the salinity values are generally above 34.4‰. The suspended sediment load in the adjoining sea waters is generally less than 16 mg l in the bay waters the range of variation during falling tide being significantly high compared to that during rising tide.

Studies on sea level variations at Mormugao Harbour have been started during the year under report. A preliminary analysis of the recorded data on tides for the period 1965-1970, has shown that the sea level at the harbour varies considerably from season to season and has a maximum value in December and a minimum value in September. The factors responsible for these variations are being studied.

2.11 PHYSICAL PROCESSES

1. Beach Studies along the Goa and Kerala Coasts

Along the Goa coast, studies on the Calangute and Colva beaches started earlier, were continued. In addition, investigations on the Baina beach were taken up during the year under review. A total of 270 beach profiles were made so far. At one of the three stations chosen for observations on the Baina beach, considerable accretion was noticed due to the disposal of dredged material from the Mormugao Harbour during July-August 1972. This feature was significant apart from the seasonal and cyclic erosional tendencies and erosion due to high waves of short period during the monsoon period were noticed along the other beaches. This part of the beach, in effect, showed marked variations by way of increase in beach width and surplus foreign sediment dumped artificially.

Studies on the littoral currents off Calangute beach using fluorescent dye indicated that the littoral currents are directed northward most of the time and have speeds upto 2.65 km hr. Presence of strong rips was observed at certain regions of this beach during the monsoon season.

Along the Kerala coast, studies on the stability of the beaches at Thottapally, Punnappra, Thumboli, Manasserry, Saudi, Elankunnapuzha and Narakhal were continued. The profile measurements indicated that the beaches at Thottapally, Punnappra, Manasserry and Saudi are un-

stable, while the beach at Thumboli, north of Alleppy Pier shows some natural stability. The stability of beaches at Thottapally and Punnappa was found to be determined mainly by the offshore relief formation such as mud banks, offshore bar, etc.

2. Studies on the Littoral Transport and Rip Currents

Theoretical studies on the littoral transport and rip currents with the help of wave refraction diagrams have been undertaken and refraction diagrams for 10 and 12 sec. periods for southwest, west, west-northwest and west-southwest directions of wave approach along the Calangute beach of Goa, have been constructed.

The rip currents generally coincided with the areas of long wave energy, which is in full agreement with the theoretical studies made elsewhere. A rip current was found to occur near Baga for all the periods and for most of the directions of wave approach. The southern part of the beach near Aguada and in front of Tourist Resort, commonly used by swimmers, was found to be free of strong rip current.

3. Studies on Mud Banks along the Kerala Coast

Studies on the phenomenon of formation of mud banks along the Kerala coast have indicated a good build up of beaches in the area of mud banks and erosion of beaches at the peripheries of these mud banks. With the slow southward movement of mud banks, the areas of erosion and accretion along the beaches were also found to shift correspondingly. Rip currents and converging nearshore currents due to wave refraction were found to favour the formation of mud banks.

The seasonal variations of hydrographic parameters in the mud bank region were found to be similar to those outside the mud bank region. In the littoral zone north of mud bank region the surface currents were found to be directed towards south while south of the mud bank region they were found to be directed towards north. The velocity of the littoral flow was found to vary between 0.5 and 2 knots on either side of the mud bank region. The textural analysis of the bottom samples from the mud bank region indicated that the bottom sediment in this region is mostly clayey in nature and contains more water than that in the adjacent regions.

4. Studies on Circulation of Moplah Bay

To achieve a better understanding of the sediment transport in Moplah Bay, investigations on the pattern of surface and subsurface currents in the Bay started earlier, were continued. Observations on currents were carried out at monthly intervals using floats and direct reading currentmeter. Studies carried out so far indicated that the net transport of water in the Bay, under the influence of local wind and tide, is in an anti-clockwise direction and the artificial breakwater was, to a large extent, responsible for creating a calm zone in the Bay resulting in the accumulation of sediment right at the beat landing jetty.

5. Studies on the Estuaries of Goa

For studying the salinity and circulation patterns, water transparency and sediment load in the Mandovi and Zuari estuaries, 26 stations covering the entire estuarine system including Cumbarjua Canal were chosen for observations and cruises were carried out occupying these stations twice (during falling tide and rising tide) a month. Hourly observations on currents and other physical parameters

over 12 hours tidal cycles were conducted at a few important stations located in the mouth, middle and upstream portions of the estuaries during April, September and January. The data collected so far are being processed for evaluating the results. Some preliminary findings of these studies are given in the following paragraphs:

In the Mandovi-Zuari estuarine system the limit of water with measurable salt content extends gradually towards the upstream from September onwards, reaching a maximum distance of about 22 miles upstream in the Mandovi river from the mouth of Aguada Bay, and about 28 miles upstream in the Zuari from the mouth of Mormugao Bay by summer (March-May) and with the outburst of monsoon rains, recedes quickly towards the sea (being located at about 2 miles and 6 miles upstream from the mouths of Aguada Bay and Mormugao Bay respectively in July). Even though the run off resulting from heavy rains significantly reduces the influence of tidal action during the monsoon season the circulation in these estuaries during the rest of the period is controlled primarily by tidal currents which often reach values higher than 2 knots in certain regions.

In the Chapora estuary, hourly observations on currents and other physical parameters were carried out at a station near Colvale in November 1972 during the period of spring tides. These observations were conducted at the request of Public Works Department, Government of Goa, Daman and Diu for obtaining information on maximum speeds of tidal currents at the site proposed for the construction of a bridge. Currents with speeds upto 1.5 knots were encountered at the said station during the period of these observations.

6. Studies on Aguada Bay

Studies on the formation and maintenance of Aguada Bay near the mouth of the river Mandovi, started earlier, were continued. In order to obtain the flow pattern of surface waters during the ebb and flood stages, a number of floats were released in the region of the bar and their movements were tracked by means of sextants. These observations showed considerable reduction in the flow rate in the neighbourhood of the bar, suggesting possible chances for deposition of the suspended sediments in the bar region and revealed differential channelization of ebb and flood currents near the constriction, east of the bar confirming the information obtained earlier through measurements of currents with current meters.

7. Studies on the Circulation in the Shelf Waters off the Goa Coast

Seabed drifters were released at monthly intervals along four sections situated two miles apart off the Goa coast between Terekhol and Colva during the premonsoon period. Information on the site of recovery of these drifters suggests that the bottom currents in this region have southerly components during March and April.

8. Studies on Beach Sediments along the Goa Coast

As a part of the investigations on the distribution, composition and origin of the beach and dune sediments of the Goa coast, nearly 275 sediment samples were collected between Consolum-Colva-Cavelossim on the southern part of the Goa Coast and studied. Analysis of these samples for particle size distribution indicate that the sediments of the foreshore have their mean grain in medium to very

fine sand range, well to very well sorted and are negatively skewed, while dune sediments are in fine to very fine sand range, very well sorted and fall in symmetrical to positively skewed class. Coarse fraction analysis of the samples revealed that the beach samples are composed of quartz, felspar, pyroxenes, amphiboles, zircon, tourmaline, sphere and opaque minerals apart from shells and shell fragments i.e. foraminifera, ostracods, bivalves.

Sediment samples are being collected at monthly intervals from the beach off Baina since April 1972 onwards. The laboratory analysis of these sediments is in progress.

2.12 MARINE GEOPHYSICS

1. Magnetic Studies

Aeromagnetic data along four profiles over the continental margins of the east coast of India and Ceylon were selected for the analysis and interpretation of the total field anomalies in relation to the major structures beneath the ocean bottom. The length of the profiles vary between 300 and 450 km. These data obtained from U.S. Coast and Geodetic survey were collected under the auspices of 'Project Magnet'. The data were digitized for each four kilometer and the total field anomalies were computed by subtracting the regional field from the observed field. Analysis and interpretation of these anomalies by curve fitting method is in progress. Literature studies are being made to standardize the methods by the spectral and statistical analysis of the total field anomalies.

Performance characteristics of various Marine Geophysical equipment with special reference to continuous seismic profilers and marine proton magnetometers were

studied to select suitable equipment that would be required to undertake the Marine Geophysical studies at NIO.

2. Sedimentological Studies

Bottom sediments were collected in the Mormugao Bay at 39 stations along 8 sections. Percentage composition of each sample for sand, silt and clay has been determined from seive and pipette analysis using Wentworth classification. Statistical parameters of the size distribution were also determined and studied in relation to the mode of transport and deposition. Results in general indicate the presence of sand proportion all along the northern portion of the Bay and in the central portion at the Bay mouth. The silt and clay proportions predominate in the central portion and suggest the silting in this area.

2.13 GENERAL

1. Hydrographic Survey off the Central West Coast of India

In continuation of the six cruises carried out under this programme during Jan-Mar. 1972, the following two cruises were undertaken during April 1972.

<i>Cruise No.</i>	<i>Period</i>	<i>Area</i>
AP-33	25-26 April '72	Shelf waters off the northern part of Goa Coast.
AP-34	28-29 April 72	Shelf waters off the southern part of Goa Coast.

In the above cruises, four sections (off Vengurla, Aguada, Cape Ramas and Karwar) each comprising of four stations situated at distance of 1, 3, 8 and 15 miles from the coast were covered each month.

A preliminary study of the hydrographic data collected under this programme has shown that in January, the waters of the coast between Vengurla and Karwar arc well mixed and homogeneous, and the water temperature slightly increased seaward from around 27°C in the nearshore regions to around 27.5°C in the offshore region. During April, the water temperature is generally above 30°C in the near-

shore waters and in the upper 5 meters of the offshore waters, where it decreases gradually towards greater depths. However, off Vengurla upwelling of relatively cool, more saline and dense subsurface waters towards the surface is indicated in the region between 5 miles and 10 miles seaward from the coast during this month. There is indication of some upwelling off Aguada also, at more or less the same distance from the coast during this month. Further investigations are necessary to confirm the existence of upwelling indicated by these studies and to make a quantitative assessment of the same.

2.2

chemical oceanography

2.21 Composition of Marine Waters

1. Iron Cycle in the Mandovi and Zuari Estuaries and in the Near-shore Waters of Goa
2. Copper Concentrations in the In-shore and Estuarine Waters along the Central West Coast of India
3. Intrusion of Upwelled Water in the Mandovi and Zuari Estuaries
4. Distribution of Phosphorus in In-shore Regions of the Central West Coast of India
5. Carbon-dioxide System in the Estuarine, Inshore and Offshore Waters of Goa

2.22 Organic Compounds

1. Chlorophyll and Phaeophytin Concentrations in the Estuarine Waters
2. Dissolved Organic Carbon in the Sea Water

2.23 Marine Pollution and Fouling

1. Marine Pollution Studies
2. Marine Fouling

2.24 Apparatus and Methods

1. Instrument for Measuring Light Penetration in Shallow Water

Studies during the period under report relate to (1) distributional aspects of the organic and inorganic constituents of the waters in the estuarine, inshore and offshore regions of the Central West Coast of India with special reference to Goa region and (2) Marine pollution and fouling.

Studies on the distribution of nutrient salts and trace elements (iron and copper) were undertaken in the waters along the Central West Coast of India and also in the estuarine waters of Goa. Studies on the Bio-geochemical Cycles of phosphorus and nitrogen compounds and carbon dioxide system in the inshore and estuarine waters are in progress. Investigations on the chlorophyll *a* and phaeophytin (dead chlorophyll) contents in the inshore and estuarine waters are being carried out to understand the various proportions of the two existing together with place and time and to find out the possible influence of phaeopigment on the routine chlorophyll *a* estimation. Further studies on the ultra-violet spectrophotometric technique on the estimation of dissolved organic matter using natural plankton extract as standard are being continued and the results are encouraging. Studies on the carbohydrate content of the waters have been commenced and the work is in progress.

In view of the growing population and industrialisation of Goa region, and possible discharge of toxic effluents into the estuarine and marine environment, studies on the distribution of certain chemical parameters serving as indices of chemical pollution are initiated at suitable locations. Distribution of arsenic, which is one of the constituents of the effluent of the local fertilizer factory, is also being studied in detail in the inshore and estuarine regions.

Investigations on the physico-chemical aspects of marine fouling are continued with special reference to the intensity of fouling settlement on the artificial structures in the Mormugao harbour waters. Organic matter in the waters is found to be one of the influencing factors in promoting the growth of sessile organisms.

2.21 COMPOSITION OF MARINE WATERS

1. Iron Cycle in the Mandovi and Zuari Estuaries and in the Near-shore Waters of Goa

Analysis of the particulate iron in the estuarine and inshore region showed high values with considerable annual fluctuations. The values varied from 4 to 70 mg/l. The high values of particulate iron are encountered during the monsoon months (June-August) when the fresh water discharge is at maximum. During the pre-monsoon and post-monsoon seasons the values were comparatively low (4-20 mg/l). Particulate iron values at the bottom were always higher than the surface values. The iron values of the inshore waters were lower (0.7-16 mg/l) than the estuarine waters.

Total iron (all forms of iron excepting that of mineral origin) showed a good amount of annual variation in the concentration, both in the estuaries and in the inshore region. As in the case of particulate form the total iron values were also high during the monsoon months indicating that major contribution of iron in the inorganic and organic forms is through rivers.

Estimation of total iron by the conventional bromine oxidation technique as applied to this environment does not include the particulate mineral form. Since a large part of the iron in these waters is of mineral nature, other oxidation techniques are also being tried.

2. Copper Concentrations in the Inshore and Estuarine Waters along the Central West Coast of India

The copper concentrations in the inshore as well as in the rivers are much higher

than those reported so far from anywhere else. Surface concentrations in the inshore waters range between 4-45 $\mu\text{g/l}$, and the bottom values between 15 and 75 $\mu\text{g/l}$. In general, high concentrations (720 $\mu\text{g/l}$) are encountered all along the coast excepting the section off Cape Ramas. The copper levels in the two rivers Mandovi and Zuari are also found to be high (6-66 $\mu\text{g/l}$).

The high concentrations observed in the inshore waters appear to be contributed by the rivers flowing through the ore bearing (Iron and Manganese) terrain, picking up the element in significant amounts.

3. Intrusion of Upwelled Water in the Mandovi and Zuari Estuaries

Intrusion of upwelled water in the Mandovi and Zuari estuaries has been reported during last year (1971-72). Further detailed observations made during July-October '72, when the phenomenon of upwelling is prevalent along the west coast of India confirm the earlier findings.

The upwelled water is characterised by low temperature, low oxygen, high salinity and rich nutrients. This year also cold and low oxygenated water was observed in the estuaries in the last week of July. It persisted till the end of September. Towards the upper reaches of the river, the characteristics of the upwelled water gradually showed sign of losing identity. Oxygen values as low as 0.4 ml/l, were recorded at the bottom of the estuaries during this period.

Studies on various physico-chemical factors in relation to tide indicated the flow of upwelled water into the estuary during the high tide when the subsurface waters of the estuary clearly reflected the characteristics of the upwelled water. However, during receding tide the water loses its

identity due to mixing with the predominantly flowing fresh water from the river.

During July-September the physico-chemical parameters showed wide variations with reference to tide. The maximum variations were observed in August. The temperature of the surface and bottom varied between 25.8 - 28.5°C and 24.4 - 27.8°C respectively. The salinity varied from 6.4-32 ‰ at the surface and 15.8 to 34.2‰ at the bottom. Oxygen content of the surface water ranged between 2.15 and 4.5 ml/l and of the bottom water between 0.75 and 3.70 ml/l. Phosphate concentration varied from 0.70 to 1.0 µg at/l at the surface and 0.80 to 1.90 µg at/l at the bottom.

The hydrographical conditions observed in the inshore region during September-October showed the existence of intensive upwelling. The temperature of the surface and the bottom waters were 26.6 and 22.5°C respectively. Dissolved oxygen content at 20 m during this period was at the lowest undetectable amounts.

In the month of October the upwelled water was found to be present below 10 m in the offshore region about 7 miles from the coast. In the upper ten meters the water was homogeneous due to mixing. During this period, the upwelled water does not seem to intrude into the estuary with the tide. The intrusion into the estuaries takes place when the upwelled water in the inshore region reaches only the surface layers (10 m).

4. Distribution of Phosphorus in the Inshore Regions of the Central West Coast of India

Eight sections consisting of 4 stations each along the Central West Coast of India between Karwar and Vengurla were selected to study the distribution of in-

organic and organic phosphorus in relation to other hydrographical factors during the premonsoon period (January-April).

The studies on the hydrographical parameters clearly indicate the homogeneous condition of the waters. During January-February the inorganic phosphate concentration was high. The values of inorganic phosphate varied between 0.3 - 0.8 µg/l and the organic phosphate ranged between 0.2 and 1.3 µg at/l. During later months most of the phosphorus present was bound organically. The inorganic phosphorus values were 0.1 - 0.6 µg at/l. The organic phosphorus values varied from 1.0-3.2 µg at/l.

The low inorganic phosphorus values observed may be due to its active utilization by the blue green algal bloom observed during this period. At the same time there is an increase of organic phosphorus concentration of the waters also.

5. Carbon-dioxide System in the Estuarine, Inshore and Offshore Waters of Goa

The total alkalinity of the Mandovi and Zuari estuarine systems and the inshore waters of Goa are predominantly contributed by bicarbonate component of the CO₂ system especially during monsoon months. During the post-monsoon months, while the bicarbonate still remains to be a dominant component, there is a slight change in the equilibrium showing the probable influence of borate ions.

The distribution of partial pressure of CO₂ (*p*CO₂) in the waters was erratic but the values are very high as compared with that of normal sea water (maximum of 10 fold increase). This feature could be attributed to the high degree of turbulence of the waters characteristic of the shallow estuarine systems permitting the dissolution

of atmospheric carbon-dioxide which is also more soluble in low saline waters. Moreover, the carbon-dioxide formed due to the oxidation of organic matter near the bottom at mud water interface as evidenced by higher bottom $p\text{CO}_2$ values and low pH conditions may also be contributing to the general high levels of $p\text{CO}_2$ in the waters due to mixing.

2.22 ORGANIC COMPOUNDS

1. Chlorophyll and Phaeophytin Concentrations in the Estuarine Waters

The proportions of chlorophyll *a* and phaeophytin are found to be highly variable with location and time during the period of observations commencing from the month of July. Chlorophyll α is higher than phaeophytin in July to early August at all locations in the estuaries and the channel. From the second week of August to February the concentration of phaeophytin generally exceeds chlorophyll *a*. The high concentrations of phaeophytin during the postmonsoon and premonsoon months indicate the presence of considerable amount of dead chlorophyll of terrigenous plant origin. The possibility that some of the high chlorophyll *a* values, especially in the estuarine waters, might also be partly of terrigenous origin cannot be ruled out. Existence of both chlorophyll *a* and phaeophytin in high concentrations in the waters, therefore, may suggest that due consideration should be given to the pigments of terrigenous origin in assessing the general productivity of the waters.

2. Dissolved Organic Carbon in the Sea Water

Experimental studies on the ultraviolet absorption spectrophotometric method of estimating of DOC using plankton extract as standard are continued. Experiments

indicate that redox potential of sea water should be below 300 m.v. to obtain a fairly good relation between optical density and DOC concentration. It appears that concentrations greater than 100 $\mu\text{g/l}$ could be detected by this method. Further studies are in progress in standardizing the method in terms of increasing the sensitivity, concentration techniques of DOC in seawater to detectable levels and reducing the redox potential of seawater to optimum levels suitable for the method.

2.23 MARINE POLLUTION AND FOULING

1. Marine Pollution Studies

Observations on certain chemical indices of pollution such as B.O.D, pH, Eh, alkalinity and electrical conductivity of the waters in the local estuaries and the inshore waters of Goa region, do not indicate the effects of pollution so far. The fluctuations remain within the normal expected fluctuation values. Studies on the distribution of arsenic which is one of the constituents of the effluent from local fertilizer factory, is being studied in detail in the inshore and estuarine environments. The prevailing concentrations (3-40 $\mu\text{g/l}$) are far below the toxic levels.

2. Marine Fouling

During the course of investigations on the various factors responsible for the growth of fouling organisms, a survey was undertaken in the waters around Mormugao harbour and the local estuarine systems. The observations reveal that in certain regions, especially in shallow waters of the estuary, considerable enrichment of organic matter occurs during the flood period promoting the growth of sedentary marine foulers like Oysters. Barge traffic in this region is also one of the major

influencing factors in increasing the concentration of the organic matter of the waters. The currents and turbulence created by the barge traffic releases considerable amount of organic detritus from the sediments.

2.24 APPARATUS AND METHODS

1. Instrument for Measuring Light Penetration in Shallow Water

Measurement of light penetration in the natural waters is important from the productivity point of view. The methods available are based on (1) finding the limit of visibility of an object and (2) mea-

suring the light intensity of photometric-devices.

In the first method which is inexpensive and suitable for shallow waters, the common device used was Secchi disc. In the estuaries and inshore waters when the velocity of the currents increases to more than 40 cm/second, the disc is subjected to circulatory movements and drifts. Further the disc is also subjected to considerable hydrostatic pressure during the hauling operation, leading to the chipping of paint on the surface of the disc. To solve these problems, a modified instrument has been developed. The new device is ensured of vertical stability in the waters and reduces the effect of hydrostatic pressure during hauling. Field trials of the new prototype are being conducted.

2.3

geological oceanography

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| 2.31 Sedimentation (Stratigraphy and Sedimentology) | 2.33 Mineralogy |
| 1. Sediment of the Beaches from Northern Goa | 1. Mineralogy of Morjim-Arambol Beach Sediments |
| 2. Sedimentological Studies of Morjim-Arambol Beach Rock | 2.34 Geochemistry |
| 2.32 Micropalaeontology | 1. Distribution of Organic Matter in the Sediments of the Continental Shelf and Slope off Bombay |
| 1. Some Aberrant Foraminifera from the Shelf Sediments of Central East Coast of India | 2. Studies of the Sediments off the West Coast of India |
| 2. Agglutinated Foraminifera from the Shelf of East Coast of India | 3. Studies on the Sediments of Vembanad Lake |
| | 2.35 General |
| | 1. Marine Geology of the Continental Shelf off the Goa Coast |
| | 2. Petrology and Mineralogy of the Coastal Rocks of Goa |
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The programmes and projects of the previous year have been continued this year with emphasis on the detailed analysis in the laboratory.

The beach sediment and beach rock samples collected earlier are analysed for their mineralogy and sedimentological aspects. The mineral content indicates a low to high metamorphic and igneous provenance. Further it is observed that the sedimentological characteristics of dune and beach deposits are dissimilar.

The aberrations found in *Uvigerina* sp. (having two terminal apertures and also twinning), *Siphonoperta* sp. (having two end chambers as last chamber) and *Nodosaria* sp. (having a bend due to recalcification) are reported. Eighteen agglutinated foraminiferal species are found to have highest population in the region of fine sands than nearshore, however their presence at depths suggests submarine slumping.

The inner shelf and slope region off Bombay is found to have a very high organic content while the outer shelf carbonate facies is low which is controlled by factors of environment.

Some samples collected during IIOE are being studied. The partition studies and the distribution pattern of iron, manganese, cobalt and nickel of these sediments

show that higher concentration prevails in the silty clay or clayey silts fractions and a marked variation in their concentration from the north to the south.

The environmental conditions of deposition and the trace elemental pattern differ in an inland lake (Vembanad Lake in Kerala) though connected with the sea from that of the open sea. Hence, a study of the grain size distribution and the geochemical study which was undertaken earlier is being continued.

A study of the sediment blanket of the inner shelf off Goa coast has been made and the characteristic zones have been worked out. The Geochemical environment evaluated by the presence of phosphorus and organic matter in the sediment divides the region into two distinct zones, and the characteristics have been indicated.

2.31 SEDIMENTATION (STRATIGRAPHY AND SEDIMENTOLOGY)

1. Sediment of the Beaches from Northern Goa

Beach samples from the Morjim-Arambol beach in northern Goa were collected and studied for their grain size data, mineral content and the percentage concentration of calcium carbonate content. It is noticed that the major heavy mineral content is composed of Garnets, amphiboles, pyroxenes, tourmaline, epidote, staurolite, zircon, rutile, tremolite-actinolite and opaques. Quartz is the principal mineral in the light fraction. The mineral assemblage indicates a low to high grade metamorphic and igneous provenance.

The sediment is fine to very fine, moderately to well-sorted, mesokurtic to slightly leptokurtic. When compared with the dune sediment in the area it is noticed that roundness varies from sub-angular to sub-rounded between the two. The carbonate content varies from 2—12%.

2. Sedimentological Studies of Morjim-Arambol Beach Rock

Beach rock found at two elevations were studied for mineralogy, roundness and grain size. They are garnets, amphiboles, pyro-

xenes, staurolite, epidote, tourmaline and quartz which are medium to coarse grained, not well sorted and having low skewness kurtosis values. Texturally, they differ from the modern sediments in the area.

2.32 MICROPALAEONTOLOGY

1. Some Aberrant Foraminifera from the Shelf Sediments of Central East Coast of India

Some aberrant forms of *Uvigerina* sp., *Siphonoperta* sp. and *Nodosaria* sp. were encountered in the shelf sediments of the central east coast of India. The aberration is (1) in the development of two terminal apertures with parallel necks and phialine lips, and a twinned case in *Uvigerina* sp., (2) development of two end chambers as last chamber in *Siphonoperta* sp. and (3) *Nodosaria* sp. showing a 'bend' at an angle after being straight to some extent. These aberrations are considered to be cases of phylogerontism showing over-specialisation in *Uvigerina* sp. and *Siphonoperta* sp., accidental coalascence in *Uvigerina* sp. and recalcification and further growth after damage in *Nodosaria* sp.

2. Agglutinated Foraminifera from the Shelf of East Coast of India

Eighteen species of agglutinated foraminifera belonging to six families in a depth

zone of 35-222 m were identified. The highest concentration of these were found in the quiet region of the shelf and least in the deltaic region. The population is highest in the region of fine sands at a depth of 55-74 m and rare in the nearshore. Their occurrence in deeper waters is suggestive of submarine slumping.

2.33 MINERALOGY

1. Mineralogy of Morjim-Arambol Beach Sediments

The dominant heavy minerals found in these sediments are Amphiboles, Pyroxenes, Garnets, Tourmaline, Staurolite, Epidote, Rutile and Zircon, however, the chief constituent being quartz. The heavy mineral analysis is in progress.

2.34 GEOCHEMISTRY

1. Distribution of Organic Matter in the Sediments of the Continental Shelf and Slope off Bombay

The laboratory studies indicate that the inner shelf and the slope sediments have a very high organic matter content whereas the outershelf carbonate facies has a low concentration. This is attributed to the texture of the sediment, physico-chemical conditions of the overlying water mass and the nature of the organic matter itself.

2. Studies of the Sediments off the West Coast of India

The overall distribution pattern of iron, manganese, nickel and cobalt and their partition pattern among the different components of the sediment was studied. Higher concentrations are found in silty clays or clayey silts with low carbonates in the inner shelf than the silty or clayey sands of the outer-shelf slope areas. The partition studies of these elements further supports the above view. A marked variation in their concentration from north to

south is also noticed which may be due to the nature of the source material and also to the varying environment and the lithogenous material. The higher concentrations appear to be due to flocculation of colloids of iron and manganese hydroxides along with their adsorbed trace elements in the inner shelf.

3. Studies on the Sediments of Vembanad Lake

It was proposed to understand the various depositional processes in the different parts of the lake and the distribution pattern of the various trace elements present in the sediment. Grain size distribution maps are being prepared and the estimation of the different elements is in progress.

2.35 GENERAL

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

Sediment sampling of the inner shelf using gravity corer and grab at 5 m interval, along 6 transects, was completed. Logging, storing and preliminary investigation of the material collected was also completed. As reported earlier, a general survey indicated the nature of the sediment blanket in the study area, i.e., 0-5 m it is fine, well sorted sand; at 5-40 m it is chiefly clayey and at 40-50 m it is abruptly silty.

The geochemical environment prevailing at the present is being evaluated through the presence of certain major and minor elements and organic matter present in the sediment. Thus, it is found that the distribution of phosphorus and organic matter in the sediment is in direct relationship with the nature of the sediment such as colour, texture and Hthology.

The high and low values observed, indicate that the region can be distinguished into two northern high and southern low zones along Mormugao Head region.

Further work regarding the distribution pattern and concentration of iron and manganese in these sediments besides size distribution parameters of the deposit is in progress.

2. Petrology and Mineralogy of the Coastal Rocks of Goa

Now the detailed field mapping of the northern sector from Mormugao Head region is completed, the field work on the southern region is being started. A preliminary investigation of the field report reveals that this region is very much different from the northern portion in having rock types like granitic gneisses, chlorite schists, pegmatites, and also a few dikes.

2.4

biological oceanography

2.41 Integrated Projects

1. Biological Productivity of Waters along the Central West Coast of India
2. Ecology of Mandovi and Zuari Estuarine System
3. Ecology of Mangroves around Goa
4. Coastal Zone Management and Resource Evaluation

2.42 Fish, Fisheries and Resources

1. Theoretical Studies on Population Dynamics and Optimum Exploitation of Fish Populations
2. Stock Assessment Studies on Sardine and Mackerel Population of India
3. Dynamics of the Growth of Prawn
4. Fishery Possibilities of the Blue Crab, *Neptunus pelagicus* in Zuari Estuary

5. Marine Living Resources off Goa Coast
6. Fish Parasites

2.43 Zooplankton (IIOE Collections)

1. Systematic Study of various Subsorted Groups
2. Preparation of Plankton Atlas
3. Preparation of Handbooks to the International Zooplankton Collections
4. UNDP Arabian Sea Pelagic Fishery Survey Samples
5. Studies on Preservation Techniques

2.44 Miscellaneous Projects

1. Karyological Studies of Copepods and Commercially Important Fishes
2. Investigations on Marine Molluscs

Studies on biological oceanography are being carried out at the Headquarters at Panaji and Regional Centres at Cochin and Bombay. Various projects undertaken during the year have been broadly grouped into four heads.

'*Integrated Projects*' include work on 4 different areas where effort is being made to characterize them in regard to productivity, phytoplankton, zooplankton, benthos in relation to the environmental parameters including important nutrients. The areas distinct to each project are, the Central West Coast of India between Malpe and Ratnagiri, Mandovi and Zuari Estuarine Complex, Mangrove Swamps and the sandy beaches of Goa, Cochin and Bombay.

Group '*Fish, Fisheries and Resources*' includes studies on population dynamics, optimum exploitation and stock assessment of some fish population and growth pattern

of some commercially important species of prawns of Kerala waters. In Goa new areas have been located in Zuari estuary where the fishery possibilities of the blue crab, *Neptunus pelagicus* in certain months of the year are encouraging. The project on Marine Living Resources off Goa was completed during the year and fishery resources of this region have been reported.

Group '*Zooplankton*' relates to the work of Indian Ocean Biological Centre which is devoted to the study of international Collections of Zooplankton of the International Indian Ocean Expedition. Some allied work taken during the year has also been reported.

Under '*Miscellaneous Projects*' are included two projects. The project on 'Karyological Studies of Copepods and Commercially Important Fishes with Reference to Biochemical Taxonomy' is being operated by Dr. (Mrs.) Usha Goswami, Pool Officer under 'CSIR Scientists' Pool' Scheme. The other project 'Investigations on Marine Molluscs' under CSIR Grant-in-aid Scheme is headed by Shri K. Virabhadra Rao assisted by a Junior Research Fellow.

2.41 INTEGRATED PROJECTS

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

The investigations on this project were started in Sept. 1971, and were continued during the year from Malpe in the south to Vengurla in the north. Monthly observations were made on Primary Production, Secondary Production, Benthos and Bacteria from January to May 1972 in relation to environmental parameters.

(i) *Primary Production*: Findings on primary production in the waters off Karwar, Goa and Vengurla have been reported earlier (Annual Report 1971-72). During this year detailed investigations were made in the waters of Goa region at three new transects: (i) off Cabo-de-Rama (ii) off Aguada and (iii) off Terekhol. Monthly experiments on C^{14} assimilation were conducted at 20 m and 40 m zones at four depths having light penetration of 100, 60, 30 and 1 per cent. Estimations of phytoplankton, pigments and nutrients were also made at these depths. Analysis of samples for C^{14} assimilation, phyto-

plankton and pigments are yet to be completed. The alternation co-efficient for visible range at both the zones off Cabo-de-Rama was 0.5, but off Aguada and off Terekhol it varied between 0.24-4 and 0.5-0.7 respectively.

(ii) *Secondary Production*: The studies were made on zooplankton distribution, their abundance and seasonal fluctuations at six transects off Vengurla, Terekhol, Aguada, Cabo-de-Rama, Karwar, Tadri and Malpe. Samples were collected at 5, 10, 20, 30 and 40 m depth zones from surface water and environmental parameters were recorded from surface, mid depth and bottom.

The environmental parameters varied from month to month. The temperature varied from 26.3°C in January to 30.2° C in May. The salinity varied from 32.20 to 35.97‰. The values of PO_4^-P and NO_3^-N were high at 5-20 m depth. The highest values recorded were 1.78 μg at/1 for PO_4^-P and 3.4 μg at/1 for NO_3^-N . The waters off Vengurla, Karwar and Malpe were found rich in nutrients.

The zooplankton biomass was high at Vengurla and Karwar, the highest values

being 2.40 and 2.12 ml/m³ respectively. The areas were also found rich in fishery.

The biomass at Terekhol varied from 1.0 to 1.5 ml/m³, being most productive at 10 m depth zone.

The values at Aguada were comparatively lower and ranged between 0.25 - 0.75 ml/m³, highest values were found at 20 m depth zone. Similar picture was found in the waters off Cabo-de-Rama with biomass ranging between 0.15 to 0.90 ml/m³.

(iii) *Benthos* (Macrofauna): The studies were undertaken on ecology, quantitative distribution and standing crop of benthos on the inner shelf of area under investigation. An analysis of 198 samples indicated that the concentration of macrobenthos on an average is higher near the coast than at greater depths. The population density also decreases with the increasing depth. The benthic organisms were unevenly distributed at various depths and the individual faunal assemblages exhibited a positive sub-stratum selectivity. Among the ten faunal sub-groups encountered in the benthic population, the annelids were most dominant. These were closely followed by molluscs, crustaceans and echinoderms. Infauna was many times richer than epifauna and, among trophic groups, detritophages outnumber sestonophages. Demersal fish catches were found to be closely related with the benthic biomass of the region.

From December 1972 detailed investigations on the ecology and production of benthos in the bays of Vengurla and Karwar were also undertaken. These bays are fish trawling grounds and studies on benthos will help delineating its relationship with demersal fishery of these areas.

2. Ecology of Mandovi and Zuari Estuarine System

Studies on the ecology of Mandovi and Zuari estuaries was started in 1971 and was pursued during the year under report. In all 14 stations were selected for a fortnightly study throughout the year. Studies were conducted on primary production, pigments, zooplankton and benthos in relation to environmental parameters.

1. *Phytoplankton*: Phytoplankton samples were collected from 4 depths, i.e. 100, 60, 40 and 1 per cent light penetration limits at 5 stations during monsoon and later at 4 stations, two each in Mandovi and Zuari estuaries.

In Mandovi estuary, the phytoplankton counts in early June were high, reaching 686,000 cells/l at the river mouth (Verem) and 585,000 cells/l at the mid reaches (Ribander). At Verem the most abundant forms were *Skeletonema* spp. (330,000 cells/l) followed by *Coscinodiscus* spp. (85,000 cells/l) and *Asterionella* spp. (45,000 cells/l); other forms included *Chlorella* spp. and dinoflagellates.

At Ribander the most abundant forms were *Coscinodiscus* spp. (305,000 cells/l) *Nitzschia* spp. (65,000 cells/l) and *Navicula* spp. (60,000 cells/l).

In later part of June the number of phytoplanktons declined considerably. The total density at Verem and Ribander were 185,000 and 285,000 cells/l respectively. In July the counts further declined but showed improvement in August and September. The counts were 30,300 at Verem and 36,400 cells/l at Ribander in August while in September the counts were 43,600 and 268,000 cells/l at the two stations respectively.

The stations in Zuari showed comparatively lower densities of phytoplankton.

During monsoon the respective counts in Combarjua canal, mid and lower reaches at Zuari estuary were 769,000 cells/l, 615,000 cells/l and 265,000 cells/l.

The studies on primary production by C^{14} technique were also carried out at these stations and the data is being processed.

Plant Pigments: Studies were conducted at all the 14 stations in Mandovi, Zuari and Combarjua canal estuarine system. The salient features are given below:

Chlorophyll *a* varied from 0 to 16.28 mg/m^3 in different months of year. Its concentration was less in Mandovi than in Zuari estuary. High values were recorded in Combarjua canal during monsoon and premonsoon months, the highest value

(16.28 mg/m^3) was recorded at Mercaim in Combarjua canal in later half of June 1972.

The values of chlorophyll *b* were low at most of the stations, the highest value (3.43 mg/m^3) was recorded at Mercaim.

High values (11.03 mg/m^3) of chlorophyll *c* were found in Combarjua canal in February and lowest values reaching zero were recorded during monsoon. The values of chlorophyll *c* were always less than that of chlorophyll *a* which is a prerequisite for healthy crop.

These observations were supplemented by diurnal studies at four stations — 2 in Mandovi, 1 in Zuari and 1 in Combarjua canal. The mean total chlorophyll at these stations in different seasons is tabulated below:

Mean Total Values of Chlorophyll in mg/m^3

Season	Mandovi		Combarjua Canal	Zuari
	Station 1	Station 2	Station 3	Station 4
	(Verem)	(Ribander)	(Mercaim)	{River Mouth}
Monsoon ...	3.79	—	1.36	1.07
Post-Monsoon...	2.79	4.32	10.15	5.02
Pre-Monsoon ...	4.53	7.02	9.57	9.78

The diurnal studies also indicated that in Mandovi estuary the chlorophyll concentration was more during low tide while in Zuari estuary the concentration was higher in high tide and therefore, tide has a major role in regulating the chlorophyll distribution in two estuaries.

Zooplankton: Studies were conducted on zooplankton biomass and faunistic composition. The highest values of biomass recorded were 82.0 $ml/100 m^3$ in Zuari and 19.0 $ml/100 m^3$ in Mandovi. The biomass values depended upon salinity and were different at the upper, middle

and lower reaches of the two estuaries. The highest values recorded are given below :

<i>Region</i>	<i>Mandovi</i>	<i>Zuari</i>
	(in ml 100m ³)	
Upper Reaches	40.0	19.0
Middle Reaches	18.0	38.0
Lower Reaches	10.0	11.0

The major faunistic groups were copepods, decapods, chaetognaths, lucifers, cladocera, pleurobranchia, polychaeta and fish eggs and larvae. No single group was dominant throughout the year. In general, copepods was most dominant. Pleurobranchia and lucifers were major constituents before the onset of monsoon when the salinity was high. After the rainy season cladocerans occupied predominant position which forecasts the onset of mackerel season.

The systematic studies of planktonic copepods indicated that the dominant species belong to genera *Acartia*, *Pseudodiaptomus*, *Labidocera*, *Tortanus*, *Acrocalanus*, *Oithona*, etc. *Acartia centrura* Giesbrecht and *Pseudodiaptomus aurivillii* Cleve were the most common species present in these waters.

Benthos: Studies were carried out on the ecology and production of macrobenthos. 362 samples were analysed and the areas of important benthic food resources such as clams, mussels, oysters, crabs and prawns were mapped.

An investigation on the ecology of standing crop of backwater clam *Meretrix* (Chemnitz) from the clam beds of Ribander (Mandovi) and Banastarim (Combarjua

canal) was completed. The observations showed the influence of environmental factors on the life-cycle of the clam, thereby resulting in behavioural changes. The salinity with widest fluctuations of 0.12 to 37.78‰ acts as a limiting factor in the breeding and growth of *M. casta*. High temperature was found to be conducive for the growth. The organic matter ranged between 0.7 to 4.3 ‰ and had a pronounced effect on the stability of clam bed. Maximum size attained by *M. casta* in the estuarine system was 55 mm. The clams of average marketable size (22 mm) were found abundantly throughout the year. Studies on dimensional relationship showed the existence of two different stocks of *M. casta* at Ribander and Banastarim. Seasonal variations in the standing crop were found directly related to changes in the environmental factors, especially temperature and salinity. An overall appraisal of the results reveal the possibilities of culture of clams in the estuaries of Goa.

A survey of benthic standing crop of Mandovi and Zuari estuaries, in relation to salinity intrusion, was completed. Based on bottom salinity characteristics, it was observed that salt water intrudes upto 35.4 km and 36.7 km in Mandovi and Zuari, respectively. The longitudinal bottom salinity gradient was observed to be quite steep in Mandovi. A decrease of 31.7‰ in salinity was observed within a distance of 35.4 km. The lateral variations in bottom salinity distribution were insignificant in Mandovi and there is no

pronounced "Coriolis effect". With an uneven pattern of distribution the salinity values also revealed different salinity regimes comparable with the salinity zones under 'Venice system'. The characteristics of zones are tabulated below:

Zone	Range of salinity (‰)	Extent (km)	Temp. range (°C)	Diss. Oxygen range (ml/l)	Benthic biomass range	Standing crop (g/m ²)
Fuhaline ...	30-40	4	24-26.6	3.1-3.7	0.07-301	18.5
Polyhaline ...	18-30	9	24.8-25.7	2.7-4.1	0.10-160	198
Mesohaline ...	5-18	15	25.2-26.7	3.8-4.9	0.30-132	16.9
Oligohaline ...	0.5-5	7.4	24.5-25.7	4.2-4.8	0.2 -77	17.6

It was also observed that salinity distribution determines the quantitative composition of benthic fauna. Accordingly, the annalids are prominent in the euhaline and polyhaline zones whereas in lower salinity zones, namely, meso and oligohaline, the molluscs were dominant. Detailed floor geomorphology maps were prepared for both the estuaries and definite animal-sediment relationship was established.

A detailed study of benthic Foraminifera present in the sediment samples showed that the living population is poorly represented in the lower reaches of the two estuaries. However, relatively higher concentrations of total foraminifera (Live & Dead) and high species diversity are noticed in the Zuari estuary. Diversity of the species at different stations of the two estuaries ranged from 1 to 19.7. The ratio of live to total population in per cent is higher in the upper reaches of Mandovi and Zuari rivers suggesting relatively rapid rate of sedimentation in these areas. In the areas such as I B, Opposite Verem and 2 B, Mandovi Bridge where organic carbon content is high due to certain types of pollution, species diversity is low and *Strebleu beccarii* groups and arenaceous foraminifera are dominant. It is possible that these forms have got tolerance not only for high levels of organic carbon content but also for other types of organic pollution.

3. Ecology of Mangroves around Goa

The mangroves are special ecological niches which are known for their high biological activity. In Goa, there is dense mangrove vegetation, bordering the estuaries. The productivity potential of these mangrove flats is at present inadequately known. A detailed research programme was, therefore, started in June 1972.

Observations were carried out on sediment load and qualitative and quantitative distribution of epi and infauna in relation to environmental parameters. The results indicate that the processes of erosion and accretion are tide-controlled and are more or less balanced, except during monsoon (June-September), when erosion exceeds the accretion. In spite of high organic matter content (average 2.75%) in the substratum, the benthic production is rather poor (0.3 — 10.09 g/m²). Another interesting feature observed was the complete depletion of mangrove infauna with the onset of monsoon and repopulation in the post-monsoon period.

Foraminiferal studies of mangrove swamps of Goa indicated the dominance of species belonging to genera *Miliammina* and *Trochammina*.

Studies of the bacterial flora were undertaken at 5 stations in estuarine mangroves.

Bacteria of the mud were enumerated using the serial dilution and pourplating method in appropriate media. Numerical abundance of bacteria ranged from 50,000 to over 4 lakhs per gram of wet mud at room temperature. Majority of the strains were gram negative motile rods. The following flora were present in most of the samples: *Pseudomonas vibrio*, *Achromobacter*, *Aeromonas* and *Flavobacterium*. Gram positive rods were represented by at least 3 types of *Bacillus* sp. A large number of nitrogen fixing bacteria, sulphate reducers and photosynthetic purple sulphur bacteria of the genus *Chromatium* were also isolated and are being sub-cultured for further studies.

4. Coastal Zone Management and Resource Evaluation

This project was started with a view to acquiring full knowledge of the coastal zone, particularly sandy beaches around Goa, Cochin and Bombay. The main studies are directed to understand the ecology, productivity and pollution problem of the beaches.

(i) *Ecology of sandy beaches of Goa:* Investigation on the ecology of the sandy beaches along Goa were continued and observations completed for one full year at the estuarine beaches (i) Miramar, (ii) Miramar light house, (iii) Caranzalem and (iv) Siridao. Work on the open sea sandy beaches at Colva and Calangute is in progress.

The first three beaches situated on the north-south plane of Mandovi estuary were sampled at fortnightly intervals during favourable low tides. Detailed ecological observations including changes in beach profiles, gradients, textural characteristics of beach sand, dissolved oxygen of interstitial waters, salinity and organic carbon

of the beach sediments were analysed. The beaches varied considerably in their physical and environmental conditions, which influenced the distribution of macrofauna. Lower salinities in the estuarine beaches acted as a favourable condition for the breeding and early development and growth of the two common bivalve species *Donax incarnatus* and *D. apperitus*. The beaches were stable in the pre- and post-monsoon months. In pre-monsoon months the biomass values were generally good and the species were more diverse. Detailed work on the biology in relation to ecology of individual species is in progress.

The bacteriological studies at Colva and Siridao showed that the aerobic counts per gm of sand varied at different tide levels. Coliforms were also present at Siridao beach indicating that it is slightly polluted. Similar studies were started at Sinquerim and Bogmalo beaches in December, 1972.

(ii) *Programme on Production in Tropical Sandy Beaches (IBP):* Under International Biological Programme, since 1968 Scientists from U.K. have been working in collaboration with the scientists of this Institute on the production of tropical sandy beaches with a view to compare them with the temperate sandy beaches. This year the fifth and last batch of scientists represented by Dr. Donald S. McLusky and Miss Ann Stirling worked on the Calangute and Colva beaches of Goa from January—March 1973. Shri R. M. S. Bhargava and Shri V. P. Devassy of this Institute collaborated in the programme. Monthly observations were made at these two beaches during low tide with particular emphasis on wedge shell, *Donax* spp. Besides the field investigations, laboratory experiments were conducted to determine the feeding and growth rate. Availability of food was determined in the form of

chlorophyll and organic carbon from surf samples. According to the findings *Donax* spp. were available in enormous quantity at both these beaches. An amount of 80,000 kg of *Donax* was estimated at Calangute beach. The beaches of Goa were found to have a higher rate of biological production as compared to the sandy beaches of Scotland. This was perhaps due to higher temperature and greater abundance of available food. The processing of data is under way. The results of the work done during the last 5 years under this programme will also be used to produce an energy budget for tropical *Donax* spp. which will be compared with the energy budget of comparable temperate species.

(iii) *Ecology of Beaches at Cochin and Aroor*: Studies on the intertidal ecology with special reference to interstitial fauna were continued. The distribution and abundance of the fauna at high, mid and low tide levels were examined. The environmental factors studied were organic contents of sediment, dissolved oxygen, sand particle size, salinity and temperature. Regular sand samples were obtained from the three different tidal levels from the marine sandy beach at Cochin and from the estuarine beach at Aroor.

At all the tidal levels in the Cochin beach ciliates were the most abundant group although the mid tide level was the richest area faunistically. Nematodes were the dominant group of metazoan and their concentration is greatest at the mid tide level. The distribution of Polychaetes, Oligochaetes, Harpacticoids, Gastrotrichs, Archi-annelids, Tardigrades, etc. were also studied.

The estuarine beach at Aroor is rich in organic matter and detritus due to heavy deposition and decay of aquatic weeds. The fauna in this region is concentrated in the upper few centimeters.

(iv) *Studies on Versova and Juhu Beaches of Bombay*: To study the depositional and erosional characters of the beaches around Bombay, the beach profile studies at the two important beaches were commenced and observed periodically. The Juhu beach appears to be a protected type of beach with very little profile changes. Versova beach, on the other hand, is an exposed one where the wind and wave action is predominant. Slight erosion of Versova beach has been noticed during March, 1973. The work will be continued for a period of 2 years so as to find out ways and means to protect the two important holiday resorts of Bombay.

(v) *Oil Pollution of Beaches along Indian Coast*: In recent years during monsoon months the beaches of Goa were found to be affected by coal tar deposition. Later an extensive programme was undertaken in order to investigate the origin and intensity of coal tar deposition and its probable effects on beach environment on the other beaches of Indian coastline. A survey of more than 48 beaches on West and East coast of India was conducted between July and September 1972. At each beach, coal tar deposition at different tidal levels in relation to space and environmental features was recorded. Thirty-nine beaches, found to have deposits of coal tar. In Goa, Calangute beach contained as much as 230 g/m² of coal tar at certain spots. Probable chances of its origin are sludge discharge from oil tankers plying along the coast. With the general reversal of currents during monsoon, the deposition is observed to be intense in the months of June-September on the west coast. The work is in progress.

(vi) *Environmental conditions around Bombay*: As a part of the environmental monitoring programme at Bombay, the

hydrographic conditions were periodically checked and data were recorded to indicate any variations from the observations made earlier for the Bombay Municipal Corporation during the period 1970-72. No significant change in temperature, salinity and dissolved oxygen were noted at 4 stations on the western side of the harbour and three stations at the Thana creek. The values correspond with the values observed during 1970-72.

The nutrients which were not recorded in the earlier studies were estimated. The data reveals a poorer phosphate content at the surface in almost all the stations but slightly higher values were observed at the bottom. The nitrate values on the west coast of the harbour varied from 3.00 to 3.75 μg at/l on the west coast, whereas in Thana creek the values obtained were considerably high (18.5 μg at/l) indicating the presence of nitrogenous materials released by the industries around Thana. The zooplankton was represented largely by copepods and chaetognaths at almost all the stations. Near the Trombay jetty, however, the medusae were predominant.

2.42 FISH, FISHERIES AND RESOURCES

1. Theoretical Studies on Population Dynamics and Optimum Exploitation of Fish Populations

The length-weight relation of fishes is generally studied by the allometric formula. Beverton and Holt have pointed out that the two constants c and n , in the equation, $W=cL^n$ are very sensitive to small changes in the data and hence can introduce large errors in yield estimation if the length-weight data are not adequate. The extent to which these constants will vary when the data are restricted to certain size range or divided into seasons and

their effects on the yield were, therefore, examined using the length-weight data of buttersole, *Isopsetta isolepis* collected by the author in 1961 off the west coast of Canada. The advantages of the isometric equations to describe the length-weight data were also examined. It is found that the length-weight exponent obtained from the allometric formula need be used only if it is significantly different from three; otherwise the cubic equation may be preferred. The importance of the need for extensive data for fitting the allometric formula is also pointed out.

2. Stock Assessment Studies on Sardine and Mackerel Population of India

This project is being undertaken in collaboration with the Central Marine Fisheries Research Institute, India.

The sampling system for the collection of catch-statistics was examined as there is a need to improve the existing sampling design and also enlarge the sampling fraction. Accurate sampling is necessary since stock-assessment studies depend heavily on catch effort data.

At present equal weightage is given for sampling the different zones inspite of the significant regional differences in fish landings. The sampling problem was therefore examined from the point of 'optimum allocation.' It was pointed out that annual fluctuations in abundance and availability of fish populations should be considered in designing a sampling system which is not required in many other sampling surveys. Hence many years' data are to be used for obtaining reliable estimates of population variances required for optimum allocation. Since there are wide seasonal differences in landings, distribution of sampling personnel

based on optimum allocation has many practical difficulties. Hence an approximation to optimum allocation based on mean annual landings is suggested which will also considerably improve the efficiency of the existing sampling system. It is also recommended that the sampling fraction should at least be nearly doubled.

3. Dynamics of the Growth of Prawn

The growth pattern of the commercially important species of prawn is being studied with reference to the von Bertalanffy growth equation. It is proposed to undertake the different aspects of their growth since this study is expected to be useful in the large scale culture of prawns.

Optimum aquarium conditions and food requirements are being studied at present for two species of prawns, *Metapenaeus dobsoni* and *Penaeus indicus*. Suitable aquarium for the experimental work has been worked out and attempts are being made to construct the aquarium.

4. Fishery Possibilities of the Blue crab, *Neptunus pelagicus* in Zuari Estuary

During investigations on the ecology of Mandovi and Zuari estuarine system, a high concentration of the blue crab, *Neptunus pelagicus* was noticed in the lower reaches of Zuari estuary. As a result, a short term programme was taken up in December 1972 to study the ecology and seasonal variation of the crabs with a view to explore possibilities of their fishery. Twenty four trawling operations, each of half an hour duration, were made from Dec. 1972 — March 1973 and about 4,000 specimens were caught. Environmental parameters such as temperature, oxygen,

salinity etc., of the trawling ground were also recorded.

Detailed studies of the crabs indicated that the males are larger in size, heavier in weight and are more abundant than the females, the ratio of males to the females was 2.1 : 1.

The substratum of the area where the crabs were found in large quantity, was lamy and sandy loam. The water above showed strong marine influence. Majority of the crabs caught during the period under investigation, were of marketable size. It is proposed that the Zuari Estuary from Siridao to Mormugao harbour (7x2 km area) can be exploited for seasonal fishery of blue-crab from December to April.

5. Marine Living Resources off Goa Coast

During the year under review, work on the assessment of marine living resources with particular reference to marine fisheries off Goa coast was completed and results compiled in the form of a report which was submitted to the Government of Goa, Daman and Din.

For analysing the data pertaining to the fishery resources, the Goa coast between Terekhol in the north and Polem in the south was demarcated into 3 zones, namely, Northern, Central and Southern, the first one extending from Terekhol to Mandrem, the second from Baga to Banaulim and the third from Betul to Polem. The average catch in kg/hr in 20 and 40 metre depths in all the 3 different zones is shown in table below:

Depth	Northern Zone		Central Zone		Southern Zone	
	Min.	Max.	Min.	Max.	Min.	Max.
20 m.	40	58	65.5	182.8	65	182.8
40 m.	60	300	32.0	128.4	32	128.4

Northern Zone: In this zone the 40m depth region is more productive than 20 m depth. The most distinguishing feature of the northern zone in the former depth region is the dominance of *Ophisrhopterus tardoore* (37.6%) and *Trichiurus* sp. (24.1%). The percentage of other groups were: cat fishes (9.4%), sciaenids (7.6%) and prawns (4.0%). However, prawns and crabs were restricted to 20 metre depths only.

Central Zone: In this zone prawn catches were considerably higher (25.6%) in the 20 m depth than in 40 m depth (8.4%). The other dominant groups with major contribution in commercial catches were found mainly in the 20 m region. These were cat fishes (15.6%), squids (3.4%) and pomfrets (3.3%). This zone appears to support demersal fishery of a much higher magnitude.

Southern Zone: The different constituents in commercial catches in order of abundance in 20 m depth region were *Opisthopterus tardoore* (37.53%), *Lactarius lactarius* (12.65%), *Trichiurus* sp. (13.35%), sciaenids (4.4%), *Leiognathus* (6.15%), pomfrets (5.57%), whereas in the 40 m depth region the most abundant species were *Leiognathus* sp. (49.49%), *Lactarius lactariits* (28.45%), clupeids (3.74%) and perches (1.97%).

Based on the results obtained from different stations along Goa coast the expected yield of a 46-foot boat in the 20 and 40 metre depth region is estimated as follows:

Estimated yield/boat/day (in kg)*

Stations	20 metres		40 metres	
	Min.	Max.	Min.	Max.
Terekhol	...	187.5	...	1,500
Chapora	...	197.5	...	300
Calangute	...	914.0	...	642
Betul	...	350.0	...	150
Polem	...	327.5	...	275

* Day = 8 hours operation.

From the above table it can be observed that the catches tend to decrease from north to south in the 40 m region, whereas in the 20 m region an entirely different pattern indicating better returns in the central zone has been noticed. The central zone was observed to be most productive.

6. Fish Parasites

As part of the programme of research investigation in marine parasitology, studies on the micro-associates especially ectoparasites of the marine fish *Opisthopterus tardoore* (Cuv.) of Kerala coast has been completed. With the joining of a new research fellow to assist in this line of work, a faunistic survey on the parasites of the marine fishes *Rastrelliger kanagurta*, (Cuv.), *Sardinella longiceps* (Val.), *Lactarius lactarius* (Schn.), *Careingoides malaboricus* (Bloch) and some of the commercially important prawns of Kerala coast has been undertaken since January 1973. Pos-

sibility of some of the parasites to be used as biological tags in routine fishery biological studies is being explored.

2.43 ZOOPLANKTON (IIOE COLLECTIONS)

(These studies were carried out at 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. Some relevant observations are given below. Publications are listed separately.

The first phase of Copepod subsorting is completed and sorted taxa have been despatched to specialists along with a complete list of stations. Distribution maps prepared, based on numerical abundance of copepods, showed the areas of greatest density to be those of high plankton biomass. Studies on the genus *Gaussia* based on IIOE samples and also samples from Smithsonian Institution of Washington, have led to the recognition of a species endemic in the northern areas of the Indian Ocean. From data available, this genus is seen to inhabit greater depths in the southern parts of the Indian Ocean and the population surfaces towards the northern areas.

Studies on Chaetognaths have been attempted and completed along 3 lines *viz.*, distribution of chaetognaths in the Arabian Sea, chaetognaths of the Laccadive Islands, and ecology of the chaetognaths in the Cochin backwaters. The species composition of chaetognaths studied from the Arabian Sea (north of 10 S) is an evidence of the homogeneity of the Indo-Pacific fauna. Two categories of

species, those preferring northern latitudes and those preferring southern latitudes were distinguishable. 19 species of chaetognaths were obtained from the IIOE samples.

Studies on taxonomy and distribution of Euthecosomata and Pelagic Polychaeta of the Indian Ocean are completed. A total of ten patterns of distributions for Euthecosomata were elucidated in the Indian Ocean including the Red Sea, Persian Gulf and the Antarctic zone. Studies on Pelagic Polychaetes indicate that most of the species are euryhaline and eurythermal. The penetration of some of the cold water species into warm equatorial waters was observed. Of the 33 species obtained from the IIOE samples, 3 are new to science and 12 are new records.

Distribution pattern of the major larval decapods were studied. The larvae of most families were found very abundant around the southern extremity of the Indian Peninsula and off Somali coast. The larval stages from 1st protozoa to the juvenile of *Penaeopsis rectacuta* Bate have been identified for the first time based on a collection of 165 larval specimens obtained from 109 samples from both IIOE material as well as collections of 'Blue Fin' cruises. This is one of the penaeid species which has been collected in large quantities in the recent exploratory shrimp fishery in the 100-150 fathom region off the south-west coast of India. It is observed that the larvae are mostly found in coastal waters. Although this species has not been recorded from Australian and South African regions, few larvae were obtained from 30-280 m depth regions on the northwestern side of Australia and south of Africa in the Indian Ocean. The larval species *Atlantocaris gigas* Ortmann is found to be conspecific with

Heterocarpus ensifer A Milne Edwards, while *Procleptes biangulatus* Bate is the larva of *Heterocarpus levicarina* (Bate). Each species passes through 13-15 zoeal stages and 3-4 megalopal stages and these have been described. The later zoeal stages are large, have long toothed rostrum, a carinated carapace and dorsal abdominal spines. The carinae on the carapace are retained in the adult; the rostrum becomes shortened and the abdominal spines modified at metamorphosis. The larval characters support the retention of *Heterocarpus* in the Pandalidae. A study of the distribution shows new information on both species.

The distribution and seasonal variation of the larvae of Clupeidae, Engraulidae, Synodontidae, Exocoetidae, Bregmacerotidae, Carangidae, Stromateidae, Coryphaenidae, Trichiuridae, Gempylidae, Scombidae, Scomberomoridae, and Thunnidae in the Arabian Sea, have been studied in detail, based on the 694 collections of the IIOE. Though 92% of the samples contained fish larvae, the above groups in total are represented only in about 13% of the collections. Three peak periods of abundance have been noticed, one in

July, next in November and a third in April. The southwest and northeast monsoons seem to play an important role in the distribution of larvae of these groups. The larvae of some of the coastal fishes especially Engraulids are found in the offshore waters too. Bregmacerotidae, Carangidae and Stromateidae though found in large numbers in the offshore waters, are also found in the oceanic and coastal waters. Scombroids, Thunnidae and Scomberomoridae are mainly collected from offshore and oceanic regions, their concentrations being along the equatorial zone. The oceanic region has large resources of Thunnidae, Scomberomoridae, Trichiuridae and Gempylidae. In the offshore waters, in addition to Bregmacerotidae, Serranidae, Carangidae, Labridae, Gobiidae, there are large resources of Engraulidae. Sub-sorting of copepods, which are the major constituents of most of the samples, was continued. Samples are specifically chosen so as to enable representative coverage of different geographic areas.

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

<i>Group</i>	<i>Specialist & Address</i>	<i>Date of despatch</i>
1. Candaciidac	Dr. George Grice, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, U.S.A.	14.7.1972 (4th batch)
2. Temoridae, Calanopia	Dr. S. M. Haq, Reader in Zoology, Department of Zoology, University of Karachi. University Road, Karachi, Pakistan.	26.6.1972 (3rd batch)

3. Lucicutidae	Dr. T. Minoda, Faculty of Fisheries, Hokkaido University, Minato Machi, Hakodate, Hokkaido, Japan.	30.5.1972 (3rd batch).
4. Heterorhabdidae	Dr. T. S. Park, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA.	23.7.1972 (3rd batch)
5. Euchaeta	Dr. O. Tanaka, Ocean Research Institute, University of Tokyo, Nakano, Tokyo, Japan.	8.9.1972 (2nd batch)
6. Centropagidae, Pontellina, Labidocera	Dr. A. Fleminger, Scripps Institution of Oceanography, La Jolla, California, USA.	23.3.1973 (4th batch)
7. Undiruilla Augaptilus	Dr. J. B. L. Mathews, Biological Station, Espegrand, Blomsterdalen, Norway.	4.7.1972 (2nd batch)
8. Aettideidae Phaennidae	Dr. W. Vervoort, Rijks museum van, Natuurlijke Historie, Leiden, Netherlands.	4.7.1972 (3rd batch)
9. Pareuchaeta, Calanoides	Mr. D. J. Tranter, Principal Research Scientist, CSIRO, Division of Fisheries & Oceanography, P. B. No. 21, Cronulla NSW 2230, Australia.	14.7.1972
10. Pseudodiaptomus Tortanus	Dr. J. R. Grindley, Port Elizabeth Museum, Port Elizabeth, Humewood, S. Africa.	7.8.1972

2. Preparation of Plankton Atlas

Plankton Atlas Volume III Fascicle 1 with 21 maps, showing the distribution of Crustacea (Cladocera, Ostracoda, Cirripedia, Mysidacea, Cumacea, Isopoda, Amphipoda, Euphausiacea, Stomatopoda) and

Insecta (Halobatidae) of the Indian Ocean has been published. The preparation and contouring of maps forming Volume IV Fascicle 1, on the distribution of Platyhelminthes, Temoplerydidae, other Pelagic Polychaeta, Trochophores and Sipunc-

ulida and Fascicle 2 on the distribution of Actinotrocha, Brachiopod larvae, Chaetognatha, Copelata, Pyrosoma, Salps and Doliolids and Amphioxus of the Indian Ocean have been completed and the material is in press.

3. Preparation of Handbooks to the International Zooplankton Collections

Volume IV and V of the Handbooks, containing contributions mainly on IIOE material and some based on work done on fresh plankton collections from the areas round Cochin is completed and is in press.

4. UNDP Arabian Sea Pelagic Fishery Survey Samples

Plankton samples collected during regular cruises undertaken for the above project are sorted out at the IOBC and fish eggs and larvae were handed over along with total biomass values to the co-ordinators of the Arabian Sea Fishery Survey, a part of the Indian Ocean Fishery Survey and Development Programme, supported by the United Nations Development Programme. A total of 841 samples collected from the coastal waters of Ratnagiri, Karwar, Kasargod, Calicut, Cochin and Quilon have been received till March, 1973. Out of these, analysis of 767 samples has been completed, the eggs and larvae separated and the data are logged in duplicate.

5. Studies on Preservation Techniques

Experiments on fixation and preservation techniques conducted using fresh plankton collections are due to last till 1979. The results obtained so far indicate that 2% formaldehyde as a fixative and 1% formaldehyde as a preservative can do well

as a fixative-cum-preservative for mixed zooplankton provided that (a) Sea water is used as diluent, (b) 2% Sodium Glycero-phosphate is added to concentrated formaldehyde as a neutralising agent and (c) 10% propylene glycol to 1% propylene phenoxetol are added as additives. With regard to preservation of calcareous plankton 2% formaldehyde with 3 to 5% potassium oxalate is found to be the best preservative provided stock 40% formaldehyde is neutralised with 3% sodium tetraborate.

2.44 MISCELLANEOUS PROJECTS

1. Karyological Studies of Copepods and Commercially Important Fishes with Reference to Biochemical Taxonomy

The routine methods of taxonomy by morphological characters do not present a clear picture in many instances especially at the level of races and populations. The identification of the same in fisheries is extremely significant for understanding the food resources of our waters. The present studies on taxonomy using Karyological, serological and various biochemical techniques were undertaken during the year under report.

The karyological investigations have been carried out on some species of copepods and economically important fishes. Copepods form the dominant group of the zooplankton in the Mandovi-Zuari estuarine complex. The species investigated are *Acartia spinicauda*, *Acartia negligens*, *Acartia plumosa*, *Acartia centrura*, *Acartiella keralensis*, *Acartiella graveleyi*, *Temora tubinata*, *Pseudodiaptomus serricaudatus* and *Pseudodiaptomus aurivilli*. Their chromosomes have a diploid number ranging from 6 to 22, 6 in *T. tubinata* and 22 in *P. aurivilli*. The range of chromosome number in the species of the same

suborder Calanoida suggests that there are many divergent evolutionary offshoots from the main branch and hence their classification under the different family headings is quite justified. All the species of genus *Acartia* and one species of *Pseudodiaptomus* (*P. serricaudatus*) show 11 and 12 diploid number of chromosomes in the males and females respectively. The constancy of 11(2n) chromosome number in different species of genus *Acartia* suggests 11(2n) to be the modal number for this family and also confirms their taxonomically described close relationship. The evolution of the various species in this genus probably has taken place by some sort of chromosomal rearrangements on the genic level. In genus *Pseudodiaptomus* with 11 and 22, 2n number of chromosome, the trend of evolution is towards the polyploidy.

Amongst fishes the karyological investigations on Sciaenidae has been initiated as it is difficult to identify them by morphological characters even on the specific level. *Otolithus ruber* (Sciaenidae) shows a diploid number of 24 chromosomes, out of which 2 are metacentrics, 4 acrocentrics and remaining 18 telocentrics varying in their size. The detailed account of chromosome behaviour during mitosis have also been followed.

The studies of haemoglobin of these fishes by electrophoresis and separation of aminoacids by thin layer chromatography are being started.

2. CSIR Grant-in-aid Scheme on investigations on Marine Molluscs

The Council of Scientific and Industrial Research approved a grant-in-aid scheme on "Investigations on Systematics, Biology and Life-histories of Marine Molluscs" which came into operation at the Institute

since March 1972. Work was initiated under three major heads, viz., (1) Taxonomy and life-history of some nudibranch molluscs, (2) Observations on the breeding periodicities in clams and mussels and (3) General faunistic studies of marine molluscs along the central and north-western coasts of India.

(i) *Taxonomy and Life-history of Some Nudibranch Molluscs:* The group has a large number of species, which are widely distributed along the Indian coasts, but our knowledge is confined only to a small number of them from a few isolated localities. In the earlier works of various authors most species have been incompletely described and their life-histories are still little known. Some interesting forms obtained have been studied in detail.

The external and internal morphology, the spawn and early development of *Caloria militaris* (Alder & Hancock) (Synonymous with *Hervia militaris*, Farran) obtained from the vicinities of Goa have been described. It is a widely distributed species occurring along many coasts of the Indian and the Pacific Oceans. Its systematic position was under much confusion till 1970 when it was placed under the family Facilinidae of the suborder Eolidacea. The facilinid characters are elongate oral tentacles, smooth rhinophores, drawn out anterior angles of the foot and cerata arranged in clusters with varying number of oblique rows. It is small measuring about 4 cm in length and its alimentary system is characterised by the presence of oral and salivary glands, paired jaw plates with cutting edges, uniseriate radula with teeth having a prominent pointed median cusp and 7 lateral cusps on each side and a cleioproctic anus opening at about the middle of the second cluster of cerata on the right side. It feeds on certain hydroids found in the environ-

ment. The nervous, circulatory and renal systems are typically eolidacean in character. The paired statocysts have each numerous statoliths. A convoluted gonoduct enlarged into a seminal ampulla, a distinctly separate lobed prostate gland proximally connected to the vas deferens and an unarmed conical penis are prominent among the reproductive organs. The mucoalbuminous gland, the vaginal duct and the spermatheca are normal in character as in most nudibranch molluscs. The spawn string is a flat spiral with two rather irregular linear series of eggs and its attachment to the substratum leaves gaps where the string forms loops remaining free. The veliger larva when hatched is without the eyes, and its shell is smooth on the surface, spirally ovate and bears an operculum. The above work has been completed and the results are incorporated in a scientific paper entitled "Structure and early development of an Opisthobranch mollusc, *Caloria militaris* (Alder & Hancock)".

Work on two dendrenotacean nudibranch molluscs of the genera *Hancockia* and *Doto* has also been completed during the period under report. *Hancockia* is the only genus under the family Hancockiidae and the sole representative occurring along the Indian coast is *H. papillata* (O'Donoghue). The structure of the form has been previously reported, based upon examination of preserved material only, which failed to show many of the distinctive features. The species has now been re-described, with living material obtained from the Gulf of Mannar along the Indian Coast. As compared with other species under the genus occurring elsewhere, *H. papillata* is devoid of jaws. The presence of tubercles and branched papillary processes over the surface of the rhinophores and the dorsum is very characteristic of the

species. The larger of the two specimens examined was 19 mm long. The body is limaciform. The oral veil which overhangs the mouth is bilobed and its free edge bears finger-like processes. The rhinophores are longitudinally lamellate in their proximal regions and distally narrow each terminating in a knob-like swelling. They are retractile into funnel shaped rhinophore sheaths. The general colouration of the dorsal surface is greenish brown. The cerata are palm-shaped and arranged laterally in six pairs followed by a small unpaired one on the right side. The radula is triseriate as in other members under the genus. The spawn and the early developmental states have been examined for the first time. The veliger larva is characterised by a narrow much elongated spiral shell, with two denticulations one on each side at the base of the aperture.

A dotonid species under the group obtained from the Gulf of Mannar has also been studied. It is a minute form not exceeding 3 mm in length characterised by the presence of an abbreviated oral veil, slender very much elongated rhinophores, rhinophore sheath with a spoon shaped extension of the anterior margin and 7 pairs of nonbranchiate cerata with tubercles in 3 to 4 circlets. The dorsum and the sides are without any papillary processes. The present form appears to be distinctly separate from other known species under the genus *Doto*. Its larval shell is a short spire. When hatched the veliger is without the pigmented eye spots and the excretory organ is colourless.

(ii) *Breeding Periodicities in Clams and Mussels*: A large number of molluscan species which are of economic importance occur in Goa. Oysters, clams comprising several species, mussels and razor shells

are regularly fished for food and are sold in the local markets. Initially a study of the breeding periodicities in the clam species, i.e., *Meretrix casta*, *Paphia malabarica* and *Donax incarnatus* and in the mussel, *Mytilus viridis* has been taken up. Regular periodical samples of the species are being examined for gonadic condition. For detailed observations on the histology of the gonads, microtome sections are being taken and permanent stained preparations made adopting the usual techniques. From the occurrence of small juvenile stages in several months under observation, it appears that most of these species spawn for a prolonged period during the year. Microscopic preparations of the material of the clams and the mussels reveal that there is a spawning period which commences in the late summer months and extends into the monsoon period. Most members, especially the clams, spawn out completely by late monsoon period and pass into indeterminate state of the gonadic condition. In the post-monsoon months there is a recovery of the gonads with proliferation of gametes from the follicular walls. The work is being continued and is expected to furnish results which would throw light

on how often and in what definite periods the different molluscan species breed annually. The above information will help undertaking transplantation and culture of the economic species to augment their production.

(iii) *General Faunistic Studies*: Numerous bivalves and gastropods occurring in different localities along the central and the north-western coast of India and particularly those around Goa, have been identified and their regional distribution recorded. These molluscs belong to over 80 families including more than 250 species. It is proposed to give a detailed account of the collections. Among these are some of taxonomic interest, like *Geloina* sp. from Ratnagiri and *Maetra* sp. from several sandy beaches in Goa, both of which support fisheries of some magnitude.

Work Under Progress: Nudibranch molluscs of the Laccadive Sea and a few other regions including the vicinities of Goa are being studied. General faunistic studies on molluscs and the investigations on the breeding periodicities of the bivalve species are being continued. Growth and other biological studies on *Mytilus viridis* have been commenced.

2.5

sponsored projects

- 2.51 Bathymetric and Hydrographic Survey off Tarapur
- 2.52 Bathymetric and Hydrographic Survey of Mahisagar Estuary (Gujarat)
- 2.53 Preliminary Survey of Siridao Beach for Development of Beach Resort
- 2.54 Ecological Monitoring in Coastal Region with Reference to Pollution from Baga and Colva

These projects have been undertaken by the Institute at the request of different private and Government agencies. The first two of the following projects are co-ordinated by Dr. V. V. R. Varadachari, Head of Physical Oceanography Division with Dr. B. N. Desai, Scientist as project leader for Chemical and Biological studies and Shri C. S. Murty, Scientist, project leader for Physical studies.

The other two projects are operated by Dr. S. N. Dwivedi, Head of Biological Oceanography Division and other members of staff of the Division.

2.51 BATHYMETRIC AND HYDROGRAPHIC SURVEY OFF TARAPUR

On request of Atomic Power Authority, Bombay, Hydrographic Survey off Tarapur Atomic Power Station was initiated during November, 1972. This was to enable the authority to design a submarine pipe-line for a safe discharge of the effluents from the Atomic Power Station and fuel re-processing plant. A detailed hydrographic survey is being carried out since then and the data were collected monthly on physical, chemical and biological parameters.

Physical Parameters: Temperature and salinity measurements were recorded over three transects off the power station. The temperature and salinity do not show any appreciable difference excepting the seasonal change from winter to summer con-

ditions; being around 24°C in December and January to 30°C in May and June. Salinity was almost constant between 34.5 to 35‰. Vertical variations in temperature and salinity upto the 10 fm line were observed.

The bottom topography was marked out by the use of echo-sounder. Number of runs with the echo-sounder in the east-west and north-south directions off Tarapur Power Station were made and it was observed that the bottom was rocky upto about 7 fm., i.e., about 1.5 miles from the shore, beyond which a flat and muddy bottom was encountered.

The Drift Trajectory Studies: The drift trajectory studies were undertaken to understand the nature of the currents and the tidal movements as these will be very important to define the place where the waste water will have to be released. The

floats were tracked over a tidal period and the positions were fixed at half hourly intervals. Several floats were used at different distances as 1/2 km, 1 1/2 km, 2 km and 2 1/2 km.

The tide was observed to be a mixed semi-diurnal type with a tidal range of 5 to 6 m during the spring tides. During the flood tide the flow was oriented towards the north and reverses during the ebb. Maximum tidal displacement occurred during the 3rd and 4th hours of both the tides. Broadly speaking the flow remains parallel to the coast. Not much difference was observed with the surface and subsurface flow patterns. The flow upto a distance of 2 km from the shore showed a significant onshore component. Beyond that point a clear offshore component was exhibited upto 2 1/2 km. It was also observed that the particles released would be carried by the tidal currents to a distance of 18 to 20 km if released at a sufficient distance where the onshore component was minimised, thereby allowing enough dilution of the waste.

Chemical Parameters: The dissolved oxygen in the area under observation varied between 2.5 ml/l in December to 4.52 ml/l in February. An average of over 3 ml/l was recorded in other months. Oxygen was slightly less at the bottom layers than at the surface. No significant variation was observed in the dissolved oxygen.

Nutrients (phosphates and nitrates) were analysed periodically. Phosphate values varied from 0.58 µg at/l in April to 1.9 µg at/l in May with peaks in March and May. The Nitrate values showed inverse proportion to the phosphate values with peak in February and in April 5 µg at/l and 8.75 µg at/l respectively. The bottom layers were richer in nitrate than the surface layers.

The phosphate values showed an increase from surface to bottom which indicated a

fluvial influence. The maximum value of phosphate was recorded about the 7 fm line.

Biological Aspects: Abundance and variation of Zooplankton were recorded to understand the biological productivity of the water and the effect of effluent if any. The surface samples were collected from 9 stations in the areas of 3, 6, 9 fm depth. The volume of Zooplankton varied from 0.5 ml to 50 ml. High standing crop of Zooplankton occurred in November and March whereas in other months the volume was very poor.

The dominant groups were chaetognaths, copepods, decapods and their larvae. These were found to be present throughout the period of investigation. Siphonophores, mysids and fish-larvae were also observed. The poorly represented forms were medusae, ctenophores, polychaetes, amphipods, lucifers, ostracods molluscs and echinoderm larvae.

The most dominant single group in zooplankton was copepods. Its percent composition varied from 4.20% to 83.9% at different stations and in different months. Their peak period was March, April and May, whereas the low values were encountered in December. Chaetognatha was the other dominant group which varied from 1.6% to 26.5% in different seasons.

No harmful effects of thermal pollution on zooplankton is noticed. The seasonal variations and composition of planktonic forms are being worked out.

2.52 BATHYMETRIC AND HYDROGRAPHIC SURVEY OF MAHISAGAR ESTUARY (GUJARAT)

Baroda city and the area surrounding it, are becoming very heavily industrialised and the diverse nature of the industries

have posed a serious problem to release the effluents without polluting the surrounding region. Since Baroda is not on the shore, or near a big perennial river the problem of discharging the effluent, have become much more complicated.

With a view to design an adequate discharge system, the Government of Gujarat requested the NIO to undertake the hydrographic survey in the Mahisagar Estuary near the Gulf of Cambay, some 50 km from the city.

The survey is a complicated problem due to the tidal conditions in the river Mahi which contains very little quantity of fresh water. The range of tide here varies from 7 to 8 m during spring tide to 1 1/2 to 3 m during neap tide. The tidal effect during spring tide is felt upto Dabka which is about 25 km upstream. The flood lasts for less than 3 hours and the ebb is predominant. During this period about 80% of the area covered by the flood water is exposed. The water flow during this period is confined to the narrow channels of 20 m in width and less than half meter in depth. No slack period is particularly observed. However, a no flow period of approximately 1/2 a minute is noticed after which the reversal of the tide takes place.

Movements of water recorded was purely longitudinal, the velocity of the flow varied from 4 to 6 knots during neap tides to about 10 knots during spring tides. The tidal effects gradually decreased upstream and at Dabka the tidal range was only one meter. The surface floats indicated only unidirectional movement according to the state of the tide.

The temperature varied between 29°C to 32°C. The salinity values recorded in the region were fairly on the higher side being about 35‰ near Kavi Bunder.

At Shiv Mandir, 8 km upstream, salinity values of 37.1‰ were observed during the channel flow. The higher salinity values upstream are due to poor fresh-water flushing in the region and evaporation due to high temperature.

The confluence area at Kavi Bunder is rich in zooplankton and Benthos and appears to be good spawning ground for prawns and fish. The zooplankton show a gradual decrease from Kavi Bunder area to upstream stations. The values of plankton volume recorded at Kavi were 58 ml and 2.5 ml at Dabka, 25 km upstream. The copepoda constituted the most dominant group of zooplankton in this estuary. Chaetognaths and medusae showed much lower representation.

The preliminary findings indicate definite effects of pollution due to the release of effluent through Mini river joining Mahi in the upstream area. Therefore a properly designed effluent discharge system with treatment is highly commendable. Detailed studies are in progress.

2.53 PRELIMINARY SURVEY OF SIRIDAO BEACH FOR DEVELOPMENT OF BEACH RESORT

Some private agencies proposed to make investments to develop tourist resorts at Siridao beach of Goa. At the instance of Dempo Industries Pvt. Ltd., Panaji, preliminary survey of the beach was started with a view to find out suitability of the beach for undertaking proposed developmental work. The work included study of the intertidal region and parts of estuaries between Siridao head and the point opposite to Goa Shipyard. The work was started in July 1971 and one year observations were completed. Studies on the intertidal area regarding the environmental parameters, beach gradient, sand grain

size and production of biomass were undertaken fortnightly. In the estuarine environment, temperature, transparency, salinity, light penetration and the fauna specially undesirable marine fauna and sport fishery were undertaken. An account of preliminary information is given below:

(i) The beach at Siridao is divided into two parts. The first part extending upto rocky promontary has black medium size sand and in some areas fine sand is also present. The second part has coarse sand.

(ii) Entire length of the beach has steep gradient in the intertidal area but the gradient of the following region is very gradual.

(iii) The intertidal fauna in the beach is evenly distributed. However, the crabs and window-pan oysters are prominent.

(iv) The bacterial count on the beach is of the order of 5000-75,000 per gram of sand. It was also found to contain coliform bacteria which is due to organic discharge from human beings.

(v) The tidal range in this area is of the order of 1.8 meters. Due to specific location the beach has only mild surf action.

(vi) The water in the estuary is nearly marine and same character is maintained throughout the year except during monsoon months. The salinity range during the year under observation varied from 1.23% to 26.61% .

(vii) Due to the tidal action, the waters have high suspended load and low transparency. In view of this, the location does not appear very attractive for sea-bathing.

(viii) During monsoon months, the harmful animals such as Porpita, Physalia which have irritant effect on skin are washed ashore.

(ix) Siridao beach, when considered along with the other beaches such as Calangute, Colva etc., does not appear to be very

favourable site for development of a beach resort. In case it is decided to develop beach resort in this area, management will be necessary to modify the human interference and control the socio-economic conditions and waste disposals along the beach.

2.54 ECOLOGICAL MONITORING IN COASTAL REGION WITH REFERENCE TO POLLUTION FROM BAGA TO COLVA

Some agencies requested the Institute to advise them in regard to the suitability of certain spots on the following beaches for the proposed construction of Luxury Hotels:-

<i>Beaches</i>	<i>Agencies</i>
1. Sinquerim	Director of Information and Tourism Govt. of Goa, Daman & Diu, Goa.
	M/s. Sita Travels Pvt. Ltd., New Delhi-1.
2. Aguada	M/S Indian Hotels Pvt. Ltd., Bombay.
3. Colva	M/s. Sita Travels Pvt. Ltd., New Delhi-1.
4. Bogmalo	M/s. Trade Wings Pvt. Ltd., Bombay.

At the instance of these requests the work was taken up in December 1972 along the 35 km coastal zone of Goa from Baga to Colva. The beaches and nearshore area are being investigated on monthly basis for the sediment characteristics, environmental parameters, flora and fauna (including harmful animals and sport fishes). The work is in progress.

2.6

data, publications & information

2.61 Data Acquisition, Listing and Storage

2.62 Publications and Information

During the year under report efforts were made towards developing the modern methods of acquisition, processing, storage and retrieval of oceanographic data pertaining to the Indian Ocean at the Data Centre of the Institute. The Publications and Information Section continued to highlight the activities of the Institute, through quarterly bulletin, *Mahasagar* and by issuing News Releases as and when necessary.

2.61 DATA ACQUISITION, LISTING AND STORAGE

The work on the processing of hydrographic (Physical and chemical) data has been taken up initially. The work on the designing of input and output formats, various types of punch card systems and the coding instructions has been completed.

The following data processing peripheral equipment were acquired for key punching, sorting, merging of different types of data cards and preparing listings of the processed data.

1. IBM 029 card punch
2. IBM 056 card verifier
3. IBM 082 card sorter
4. IBM S21 Accounting Machine

These equipments were installed for the regular data processing work. The necessary control panel for producing the listings of the data on IBM 402 accounting machine

was also prepared to suit our card and printing formats.

Since all our holdings of station data, acquired from various sources are stored in the form of listings and hard copies, it was intended to transfer all these data on to punch cards on a priority basis, besides, our regular work. Transferring of these data on to punch cards and preparing listings of the data has been started and the work is being carried out regularly.

Cataloguing work of the new acquisitions of data has been taken up, for updating the station location maps for the Indian Ocean Region. The centre also continued to receive regular reports and publications pertaining to oceanographic data from World Data Centres A and B; US National Oceanographic Data Centre; Canadian Oceanographic Data Centre, CSIRO, Australia, Japanese Oceanographic Data Centre, etc.

2.62 PUBLICATIONS AND INFORMATION

Mahasagar, the quarterly bulletin of the Institute, was published according to the planned schedule. Thus the information on research activities of the Institute and the extent of their progress were communicated through this medium. Besides, other significant information from elsewhere in the field of marine science, specifically relating to the Indian Ocean in the form of abstracts, notes, articles and reviews, were also published in the bulletin.

Annual-Report 1971-72 was published. A bibliography comprising of publications of the Institute and staff incorporating IIOE period also, from 1962 to 1972, was published. All these publications were despatched to about 700 persons on the mailing list of the Institute, both in India and abroad.

The Institute celebrated 10 Years of Integrated Ocean Research in India and arranged a colloquium on 26th May 1972. The publication of a 6-page supplement of the local newspaper '*Navhind Times*' was arranged on this occasion. The supplement incorporated several articles dealing with different aspects of marine research

which were edited for the benefit of the public. Subsequently, the detailed version of these articles was published in the *Mahasagar* June 1972. The scientific papers presented at the colloquium are to be published in *Mahasagar* June 1973.

The duties connected with informing the public about the scientific activities of the Institute were carried out throughout the year. This was achieved by issuing News Releases to all the press agencies for publication in local papers as well as national papers. Similar information were also sent for publication in the 'CSIR News'. A total number of 20 news releases were issued during the course of the year under report.

On the occasion of 25th Anniversary of Independence of India, the Institute, like other National Laboratories of the CSIR, observed "Open-House" on 15th and 16th August, 1972. Activities of the Institute in various disciplines were explained to the visiting public. The demonstration of various sampling operations was made on R. V. *Tarini* of the Institute.

Several queries from public, private and Government Institutions, relating to the activities of the Institute were attended to.

3

administrative set-up

3.1 EXECUTIVE COUNCIL

1. Mrs. Sumati Morarjee Chairman
Chairman,
Scindia Steam Navigation Company,
Scindia House,
Narottam Morarjee Marg,
Ballard Estate,
Bombay-1.
2. Dr. P. Koteswaram Member
Director-General of Observatories,
India Meteorological Department,
Lodi Road, New Delhi-3.
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,
Chairman, Advisory Committee,
National Atlas Organization,
50-A, Gariahat Road,
Calcutta-19.
6. Shri C. V. Gole, "
Director,
Central Water & Power Research Station,
Government of India,
20, Bombay- Poona Road,
Poona-3.

- | | | |
|-----|---|-------------------|
| 7. | Prof. R. Ramanadham,
Professor of Meteorology & Oceanography,
Andhra University,
Waltair(A.R) | Member |
| 8. | Shri S. K. Ranganathan,
CITB Model House 23,
Seventh Cross Road,
Tenth Main Road,
Saraswathipuram,
Mysore. | |
| 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

I. 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. Prof. B. G. Deshpande
6. Director, NIO — Convener

II. Building and Finance Sub-committee

1. Chairman, Executive Council, NIO
2. Secretary, CSIR
3. FA to CSIR
4. Principal Engineer, P.W.D. 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 Institute 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 1972-73 is given below.

<i>Budget item</i>	<i>Sanctioned (Final grant Rs. in lakhs)</i>	<i>Actual (Rs. in lakhs)</i>
1. Recurring	28.977	28.886
2. Capital	85.780	84.616
Total	114.757	113.502

3.4 SCIENTIFIC AND TECHNICAL STAFF

Director

Dr. N. K. Panikkar

A. DIVISIONS AT THE HEAD-QUARTERS

1. Physical Oceanography

Scientist-in-charge

Dr. V. V. R. Varadachari

Scientists

Shri L. V. G. Rao

Shri C. S. Murty

Senior Scientific Assistants

Shri P. K. Das

Shri Thomas Cherian

Shri M. J. Varkey

Junior Scientific Assistant

Shri K. K. Varma

Senior Research Fellow

Shri M. Veerayya

Junior Research Fellows

Shri A. Balachandran

Shri V. Kesava Das

Shri G. Narayanaswamy

Shri M. Baba

Geophysics Unit

Scientist

Shri T. C. S. Rao

Senior Scientific Assistant

Shri D. Gopala Rao

2. Chemical Oceanography

Scientists

Shri C. V. Gangadhara Reddy

Shri S. P. Anand

Shri V. N. Sankaranarayanan

Senior Scientific Assistants

Shri S. Y. S. Singbal
Shri S. N. D'Souza

Junior Research Fellows

Shri S. B. Kamat
Shri Pai Fondekar S.

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 Fellows

Shri Victor Rajamanickam
Shri B. G. Wagle

4. Biological Oceanography

Scientist-in-Charge

Dr. S. N. Dwivedi

Scientists

Dr. A. H. Parulekar
Shri P. M. A. Bhattathiri
Shri R. M. S. Bhargava
Shri R. M. Dhawan

Senior Scientific Assistants

Shri V. P. Devassy
Shri S. A. H. Abidi (On de-
putation)
Shri R. Alfred Selvakumar
Shri S. C. Goswami
Shri K. Kameswara Rao
Shri P. S. Gore

Pool Officer

Dr. (Mrs) Usha Goswami

Junior Research Fellows

Shri S. Ayyappan Nair
Mrs. K. Warriar

5. Planning & Data

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

Junior Mechanical Assistant

Shri K. K. Mohammed Rafique

Junior Scientific Assistant

Smt. Vani B. Peshwa

**B. REGIONAL CENTRE OF NIO,
COCHIN**

**1. Indian Ocean Biological Centre
(IOBC)**

Scientist-in-Charge

Dr. T. S. S. Rao

Scientists

Dr. M. J. George
Dr. R. V. Unnithan

Shri P. Gopala Menon
Shri M. Sakthivel
Shri K. J. Peter

Junior Research Fellow

Shri S. R. Sreekumar

Senior Scientific Assistants

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

Junior Scientific Assistants

Shri T. C. Gopalakrishnan
Shri K. K. Chandrasekharan Nair
Dr. V. Santhakumari

Junior Research Fellows

Shri P. Haridas
Shri M. Madhu Pratap
Shri C. T. Achuthankutty
Shri E. V. Radhakrishnan
Shri P. Jayarajan

Physical Oceanography

Scientist

Shri V. S. Rama Raju

Senior Scientific Assistants

Shri P. Udaya Varma
Shri P. G. Kurup
Shri Ch. Madhusudana Rao

3. Biological Oceanography

Scientists

Dr. M. Krishnan Kutty
Shri B. M. Panikkar
Shri U. K. Gopalan

C. FIELD UNIT OF THE NIO, BOMBAY

Scientists

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

Junior Scientific Assistants

Shri M. M. Sabnis
Shri V. Josanto
Miss Saramma U. P.

4. Library

The Library facilities are available at the Headquarters and the Regional Centres. Total collection of books including back volumes of periodicals and Technical Reports on various disciplines of Marine Sciences is 7100. In all 1100 books were added during 1972-73. The collection is being classified according to colon classification 6th Rev. ed. An up-to-date catalogue satisfying all the approaches is under preparation.

The Library receives 152 journals of which 128 are subscribed and 24 are received on gift exchange.

The Library has arrangements for receiving and issuing books and periodicals on Inter-Library Loan with the Libraries of various other Institutions in the country. During the year 1972-73, twenty-eight books were loaned to other Libraries and twenty books were borrowed for reference.

The copies of Acquisition List consisting of latest addition of books and journals are periodically distributed among the staff to keep them informed.

5. Awards, Honours, Memberships of Various Committees

Dr. N. K. Panikkar was awarded *Padmashri* by the President of India on 26th January 1973 for his contributions in the field of Marine Sciences in India.

Dr. N. K. Panikkar served as

- Member of Governing Body of Indian Council of Agricultural Research from August 1972.
- Member of Standing Committee for Animal Science (ICAR) from July 1972.
- Member of Steering Group for the Assessment of National Resources of Planning Commission.
- Member of National Commission on Agriculture.
- Chairman, Achievement Audit Committee of Central Marine Fisheries Research Institute and Central Inland Fisheries Research Institute.
- Chairman of the Indian National Committee on Oceanic Research.
- Chairman of NCST Planning Group for Fish & Fisheries.
- Member of Joint Working Group for India on GARP.

Shri Jayaraman served as

- Member, Economic, Scientific & Technological Sub-committee of the Inter-Ministerial Committee on the Sea and Sea-bed.
- Member, Panel for Marine Disposal Industrial effluents of the ISI.
- Member, Planning Group on Marine Chemicals of the NCST Panel on Marine Resources.
- Member, Planning Group on Equipment of the NCST Panel on Marine Resources.
- Member, Planning Group on Sea Water of the NCST Panel on Marine Resources.

- Member, Planning Group on Research and Education of the Panel on Marine Resources.
- Member, Planning Group on Information Management and Data Collection of the NCST Panel on Marine Resources.
- Non-Member Secretary for the Executive Council of the NIO.

Dr. V. V. R. Varadachari served as

- Member of the Board of Studies and Faculty of Marine Sciences, University of Cochin.
- Member of the NCST Planning Group on Marine Resources, Survey Instruments.
- Member of NCST Planning Group on Environment.
- Member of NCST Planning Group for Research and Development Plans in Tropical Meteorology.
- Member of W.M.O. (World Meteorological Organization) Technical Commission for Marine Meteorology, and as alternate.
- Alternate Member of Joint Working Group for India on GARP (Global Atmospheric Research Programme).

Dr. M. G. Anantha Padmanabha Setty (a) re-elected as member of the Executive Council (1973-75), Indian Society of Earth Scientists, (b) elected as a member of Study Group No. 2 of Working Group No. 10 of the International Geodynamics Project (1972-1978) and (c) selected Liaison Scientist for India for Working Group No. 4 of Inter-Union Commission on Geodynamics (ICG) for 1972-78.

Shri P. E. Sankaranarayanan has been nominated as (a) Member, sub-committee of the Physical & Earth Sciences Group of CSIR on Process Control Instruments, (b) Member, Group IV Sub-committee on

Marine Scientific Instruments for data acquisition for minerals, oils and gas including sea-bed surveys, of the NCST panel on Marine Resources.

Shri P. S. N. Murty, nominated member NCST Sub-group on Marine Environmental Studies for Minerals.

Shri R. R. Nair, nominated member NCST Sub-group on Modern Environmental Studies for Oil and Natural Gas.

Mrs. Vijayalakshmi R. Nair, S. S. A. and Mrs. V. Santhakumari, J. S. A. were awarded Ph.D. degree by the Kerala University for the theses on 'The Chaetognaths of the Arabian Sea' and 'Studies on the Parasites and associates of Marine Wood Boring Organisms' respectively.

6. Deputations

Dr. N. K. Panikkar attended III *Pacem in Maribus* Convocation at Malta from 27th June to 3rd July 1972 as a member of the delegation from the Government of India, Ministry of External Affairs.

... attended the meetings of the Executive Council of Inter-Governmental Oceanographic Commission at Hamburg, West Germany, from 3rd July to 8th July.

... visited the Marine Institutes of Poland under the exchange agreement between the Polish Academy of Sciences and the CSIR.

... participated in the United Nations Seabed Committee Meetings held from 17th July to 18th August at Geneva as a member of Indian delegation.

... attended the meetings of the Planning Council of International Ocean Institute and *Pacem in Maribus* from 5th to 7th February 1973 in Canada.

... participated in FAO Technical Conference on Fishery Management and Development from 13th to 23rd February, 1973 in Vancouver.

Shri R. Jayaraman, Scientist and Head of the Planning and Data Division was deputed to USA under CSIR-NSF exchange programme for 6 weeks from 22nd August to 6th October 1972. During this period he visited World Data Centre A — Oceanography, US National Oceanographic Data Centre and other leading organisations engaged in ocean research and had discussions on the organisations of oceanographic data centres and data management with a view to understand the latest techniques of ocean data processing, quality control, storage and dissemination.

Dr. T. S. S. Rao, Officer-in-Charge, Regional Centre of NIO, Cochin, went on deputation to Tunis in May 1972 to attend the International meeting of the Sorting Centre Directors.

Shri U. K. Gopalan went on deputation to United States in May, 1972 for 9 months under UNESCO Fellowship to carry out studies in the field of biological oceanography.

The period of deputation of Shri S. A. H. Abidi, Senior Scientific Assistant, Biological Oceanography Division, has been extended for another two years upto June 1975 as Fisheries Officer to the Government of Tanzania. He was deputed in June 1970.

Shri T. Balachandran, Senior Scientific Assistant, Regional Centre of NIO, Cochin, went on deputation to Bath, England during July 1972 to attend the Symposium on "Fixation and Preservation of Marine Zooplankton."

7. Meetings, Exhibitions, Seminars and Symposia

Physical Oceanography Unit of the Regional Centre of NIO at Cochin took part in the Open House conducted by the Integrated Fisheries Project, Ernakulam.

Shri P. G. Kurup, SSA, participated in the 'Conference on Science in Indian Languages' held at Bangalore from 30th September to 2nd October 1972.

Dr. T. S. S. Rao, Officer-in-Charge Regional Centre of NIO, Cochin attended the international meeting of the Sorting Centre Directors held at Tunis in May 1972.

Shri T. Balachandran, SSA, Regional Centre of NIO, Cochin, participated in the Symposium on "Fixation and Preservation of Marine Zooplankton" held at Bath,

England from 13-18 July under the auspices of UNESCO / SCOR.

Scientific staff of the Regional Centre of NIO, Cochin, participated in the Symposium on "The Pelagic Fisheries Resources of the Seas Around India" conducted by the CMFRI, Cochin, in December, 1972. Dr. M. Krishnan Kutty presented a paper entitled, "Exploitation and Management of Pelagic Resources."

The Regional Centre of NIO, Cochin, participated in the "Open House & Fisheries Fair" exhibition of the Integrated Fisheries Project (Formerly Indo-Norwegian Project), Cochin from 25.1.1973 to 28.1.1973.

Dr. M. J. George, Scientist, Regional Centre of NIO, Cochin, attended the 2nd Workshop on All India Coordinated Project on Prawn Biology and Resources conducted at Madras by the Central Marine Fisheries Research Institute (ICAR) on March 5th and 6th, 1973.

Seminars held at IOBC

<i>Speaker</i>	<i>Date</i>	<i>Subject</i>
1. Shri T. Balachandran	2.8.72	Recent visit to Bath for attending the symposium on Fixation & Preservation of Marine Zooplankton.
2. Shri M. Sakthivel	9.8.72	Biohydrography of the Indian Ocean.
3. Shri Ch. Madhusudana Rao	30.8.72	The Origin of Earth.

8. Colloquia and Special Lectures

A special colloquium was organized by the Institute at its headquarters, Panaji, on 26th May, 1972 on the occasion of 10th Anniversary of Integrated Ocean Research in India and was participated by a large number of active scientists of India. The

papers presented by some of them related to various topics on the oceanology of the Indian Ocean and will be published in June 1973 issue of *Mahasagar*, the quarterly bulletin of the Institute.

Following is the list of papers presented at the colloquium.

<i>Speaker</i>	<i>Subject</i>
1. Dr. N.K.Panikkar	Oceanographic Research in India
2. Shri R. Jayaraman	Oceanographic Data Processing & Retrieval
3. Dr. K.R.Saha	Tropical Cyclones and Oceanography
4. Dr. V. Y. R. Varadachari	Coastal Oceanography & Coastal Management
5. Dr. A. K.Ganguly	New Fields in Chemical Oceanography
6. Prof. D. Lal	Trace Elements: Sea Water to Sediments
7. Dr. B. G. Deshpande	Basic Materials and Processes in the Formation of Natural Oil and Gas
8. Dr. M.G.A.P. Setty	Foraminifera as Climatic Indicators in the Sediments of Western Indian Continental Shelf
9. Shri S. Krishnaswami	GEOSECS Programme
10. Prof. T. V. Desikachary	Perspectives in Marine Phycology in India
11. Prof. P. N. Ganapati	Biological Oceanography of the Bay of Bengal
12. Dr. S. Z. Qasim	Productivity of Specialized Environments
13. Dr. N. Balakrishnan Nair	The Problems of Marine Timber Destroying Organisms along the Indian Coasts
14. Dr. T. S. S.. Rao	Tropical Plankton
15. Dr. S. N. Dwivedi	Biological Oceanography of the Arabian Sea
16. Dr. M. Krishnan Kutty	New Ideas on Fish Population Dynamics
17. Dr. B. N. Desai	Benthic Productivity in the Indian Ocean
18. Dr. M. J. George	Prawn Larvae and Assessment of Prawn Resources

Colloquia (in Goa)

<i>Speaker</i>	<i>Subject</i>	<i>Date</i>
1. Shri S. P. Anand	A New Shallow Water Sampler	7.4.1972
2. Mr. Alan Mackay	New Dimensions in Science	13.4.1972

3.	Prof. R. Bielawski	The Organisation and the Zoological Problems handled at the institute of Zoology of the Polish Academy of Sciences, Warsaw (Poland)	8.2.1973
4.	Dr. N. K. Srivastava	Diagenetic Changes in Recent Molluscan Shells	8.3.1973
5.	Miss Ann Sterling	The Effects of Copper on an Experimental Food-Chain	14.3.1973
6.	Dr. Donald S. McLusky	Ecology and Pollution of Estuaries in Britain	21.3.1973

Colloquia (in Cochin)

	<i>Speaker</i>	<i>Subject</i>	<i>Date</i>
1.	Dr. Janet M. Bradford	Oceanographic Studies in New Zealand	30.7.1972
2.	Dr. Donald S. McLusky	Physiological Aspects of Marine Invertebrates	13.2.1973
3.	Miss Ann Stirling	Effects of Heavy Metals on Marine Food Chain	13.2.1973
4.	Dr. P. Nemeč	Research & Teaching in Czechoslovakia	9.3.1973
5.	Dr. Ing. Josef Balan	—do—	9.3.1973
6.	Prof. P. Kochukutta Menon	ATP in Life	22.3.1973

9. Radio Talks

	<i>Speaker</i>	<i>Date</i>	<i>Subject</i>
1.	Dr. A. G. Untawale	15.5.72	Revolution in Botany
2.	Dr. V. S. Bhatt	9.7.72	A Decade of Ocean Research in India
3.	Dr. N.K.Panikkar	18.7.72	Exploring the Indian Ocean's Protein and Mineral Resources
4.	Dr. N.K.Panikkar	24.8.72	The Amazing Dolphin

10. Distinguished Visitors

Visits to Headquarters, Panaji

Shri A.S.Bowdale	Design Manager, Garden Reach Workshop Ltd., Calcutta-24
Shri M. A. Ganapathy	ONGC, Tel Bhavan, Dehra Dun

Shri D. N. Avathi.	Jt. Director (Geophys) Institute of Petroleum Exploration (ONGC), Dehra Dun
Dr. Inderjit Singh	Jt. Director (Reservoir & Prod. Engineering) I. P. E., Dehra Dun
Shri S. S. Paintal	Superintending Engineer (M) Offshore, Tel Bhavan, Dehra Dun
Dr. Richard Bainbridge	Zoological Laboratory, Downing Street, Cambridge (U.K.)
Dr. R. K. Andjus	Institute for Biological Research 29, Novembra 142, Belgrade, Yugoslavia
Mr. Jon B. Jolly	4832 1/2 Calif. Ave. S. W., Seattle, Wash-ton 98166
Mr. Allan J. Wise	Garden Reach Workshop, Calcutta-24
Shri K. G. Krishnaan	Superintending Epigraphist for Dravidian Inscription, Mysore-5
Kmdt. B. Forguson	Indian Norwegian Project, Ernakulam
Mr. Ole I. Oshrebb	Institute Uranic Research, Burgen, Norway
Mr. Peter Gurtner	FAO, Rome
Dr. Y. Nayudamma	Director General, CSIR, New Delhi
Mr. Victor T. Niel	NSF, Washington, D.C. (USA)
Shri D. B. Bhandodkar	Chief Minister, Goa, Daman & Diu
Shri Naraina S. Fugro	Speaker, Legislative Assembly, Goa, Daman & Diu
Shri B. S. Murthy	Member of Parliament, 5, Ashoka Road New Delhi
Mrs. Mukul Banerjee M.P.	6. Feroz Shah Road, New Delhi
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Dr. G. S. Sidhu	Director, RRL, Hyderabad
Shri K. R. Narayanan	Ambassador Designate to Turkey
Shri R. Dhingra & party	LBS, Academy of Administration, Mussoorie
Shri C. Karunakaran	Dy. Director-General, G. S. L, Hyderabad
Dr. John B. Herbich	UNDP Coastal Engg. Project, C/o CWPRS, Khadakwasla P.O., Poona
Dr. P. P. Vaidyaraman	Chief Research Officer, CWPRS, Poona-24
S. K. Banerjee	Lt. Governor, Goa Daman & Diu

Visits to Regional Centre, Cochin

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Dr. S. Dutt	Professor & Head of the Dept. of Zoology, Andhra University Post-graduate Centre, Guntur-5
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Dr. Janet Bradford	Smithsonian Institution of NH, Washing- ton, USA
Mr. G. Bhaskaran	Zocon Corporation, Palo Alto, Calif., USA
Mr. G. N. Prabhu	Director, Central Coir Research Institute, Kalavoor
Dr. Baldev Singh	Scientist-in-Charge, RCIL, CSIR, New Delhi
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Mr. P. A. Ramakrishnan	Shipping Corporation of India, Calcutta
Dr. M. S. Swaminathan	Director-General, ICAR, New Delhi
Dr. K. P. Singh	Secretary, ICAR, New Delhi
Dr. R. Viswanathan	BARC, Bombay-85
Dr. K. Chandrasekharan	Monsanto, Madras-1
Dr. W. Macnae	Associate Professor of Zoology, University WW Rond, Johannesburg, FAO Consultant on Mangrove potential.
Mr. K. G. Krishnamurthy	Secretary, CSIR, New Delhi-1
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Prof. Dr. Pael Nemeč	Slovak Polytechnical University, Bratislava, Czechoslovakia
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Prof. K. Kochukutta Menon	Retired Professor of Zoology, Presidency College, Madras
Dr. C. V. Kulkarni	Retired Director of Fisheries, Maharashtra State, Bombay.

11

publications

11.1 PUBLICATIONS OF THE INSTITUTE

1. Annual Report 1971-72
2. Quarterly Bulletin of the Institute, '*Mahasagar*' Vol. 5, Nos. 1-4

11.2 PAPERS PUBLISHED BY STAFF MEMBERS

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- 2 Bhatt, V. S. 1972. Zuari and Mandovi Estuaries. *Mahasagar*, 5(2): 95-99 and *The Navhind Times* — NIO Supplement 26th May.
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11.4 REPORTS PREPARED BY THE STAFF MEMBERS

<i>Sl. No.</i>	<i>Contributors</i>	<i>Report</i>	<i>Year</i>	<i>Sponsored by</i>
1	Prabhu, M. S. & R. M. Dhawan.	Report on the Assessment of Marine Fishery Resources of Goa.	1971-72	Govt. of Goa, Daman & Diu.

national institute of oceanography

its divisions, units and regional centres

The various divisions, units and regional centres of the National Institute of Oceanography are given below :

	<i>Telephone Number</i>	<i>Telegraphic Address</i>
A. Headquarters		
National Institute of Oceanography Dona Paula, Post Caranzalem Goa (403301)		
1. Physical Oceanography Division	2923	OCEANOLOGY PANJIM
2. Chemical Oceanography Division	2923	—do—
3. Geological Oceanography Division	2923	—do—
4. Biological Oceanography Division	2923	—do—
5. Data and Documentation Division	2 9 2 3	—do—
6. Instrumentation Division	2923	—do—
 B Regional Centre of the NIO, Cochin		
1. Indian Ocean Biological Centre, P. B. No. 1913, Pullepady Cross Road, Ernakulam, Cochin-682018.	33306/ 31814	OCEANOLOGY COCHIN
2. Physical Oceanography Unit		
3. Biological Oceanography Unit	—do—	—do—
 C. Regional Centre of the NIO, Bombay		
1st Floor, Sea-Shell Building, Seven Bungalows, Varsova, Bombay-400061.	573773	OCEANOLOGY BOMBAY