ANNUAL REPORT

1974

NATIONAL INSTITUTE OF OCEANOGRAPHY GOA-INDIA

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NATIONAL INSTITUTE OF OCEANOGRAPHY
(Council of Scientific & Industrial Research)
DONA PAULA, GOA
INDIA

c o n t e n t s

I

general introduction

The National Institute of Oceanography is engaged in the studies of the seas around India (Indian Ocean) with a view to making proper and judicious use of its resources. The multidisciplinary studies are organized by six Divisions at the Headquarters of the Institute in Goa and at its Regional Centres at Cochin and Bombay. In all, 54 projects were under investigation and 4 sponsored projects were completed during the course of the year.

From December 1973 to May 1974, the Institute made full use of the INS *Darshak* Expedition of northern Arabian Sea, organized by the Naval Hydrographic Office, Dehra Dun. During the cruises, an integrated study of physical, chemical, biological and geological features of the north-western Indian Ocean, upto the Persian Gulf, was made.

The Institute also participated in the Indo - Soviet Monsoon Experiments MONEX-I of 1973 for carrying out oceanographic studies relevant to the south-west monsoon. The data are being processed.

At the request of Goa Government, surveys were made and reports submitted on 'Seaweed resources of Goa', 'Feasibility of Anjadiv Island as a tourist resort' and 'Feasibility of Siridao beach for tourist resort'. Surveys were conducted to find out the areas suitable for swimming, surfing, boating, etc., at the Sinquerim beach (Goa) at the request of M/s India Resort Hotels Ltd., Bombay. The hydrographic survey of the nearshore region of the sea near Loliem (Goa) is being undertaken at the request of Goa Government. Similar studies are being conducted off Velsao for the location of a suitable point in the sea for the discharge of effluents from the Zuari-Agro Chemicals.

Intensive efforts are being made to develop sensors/transducers and electronic instruments for measuring oceanographic parameters. The R & D work in this direction has been accelerated and all efforts are being made to develop a full-fledged workshop for the maintenance and calibration of oceanographic instruments.

Further efforts have been made to develop an efficient system for the processing and dissemination of oceanographic data and information. Physical and chemical data for about 1500 stations were transferred to punch cards and processing of biological oceanographic data has been initiated. Queries from users of oceanographic data and information were attended to and special articles were published with a view to communicating oceanographic knowledge to its users.

The research vessel, *"Gaveshani"* of the Institute is likely to be ready for trial runs in August, 1975. Once the ship is commissioned the activities of Institute will multiply several folds.

The first phase of laboratory buildings is nearing completion and the building has been occupied part by part and all rented buildings have been released. Similarly, the residential colony has also been fully occupied by the staff.

All efforts are being made to look into the oceanographic problems of applied nature. Priorities have been set and projects have been drawn according to national needs to make the best use of the resources devoted to the Institute.

—Director

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research activities

2.1

physical oceanography

2.11 Land sea interaction and coastal zone management

1. Beach studies along the Kerala coast
2. Siltatipn in Cochin Harbour
3. Hydrography and circulation in the Velsao Bay (Goa)
4. Littoral and rip currents
5. Aguada sand bar
6. Beach sediment along the Goa coast
7. Stability of the beaches of Bombay

2.12 Waves

1. Wave characteristics along the Goa coast
2. Swell Atlas for the Arabian Sea
3. Fabrication of Energy Oscillator

2.13 General

1. Physical oceanographic studies in the northern Indian Ocean
2. Oceanographic studies under 'MONEX'
3. Oceanographic studies around Lakshadwecp

During the year under report, a sponsored project for studies on the shore-line and the adjoining sea at Loliem, Goa, was taken up at the request of the Government of Goa. Daman and Diu, to examine the environmental feasibility of setting up an Atomic Power Plant at Loliem. The hydrographic survey of Mahi Sagar estuary, taken up at the request of the Gujarat Government has been completed and final report is being prepared. Studies on the hydrography and circulation in the Velsao Bay, taken up at the request of the Government of Goa, Daman and Diu, and studies on beach and nearshore environment at Sinquerim, Goa, sponsored by Indian Resort Hotels Limited, Bombay, have been continued.

Scientists of the Division participated in the oceanographic cruises on board INS *Darshak* in the northern Arabian Sea during December 1973-May 1974 and carried out investigations on temperature and salinity structures using a salinity-tempcrature-depth profiling system and light transmission properties of the sea using a submarine photometer.

This Division has been chosen by the National Working Group for Global Atmospheric Research Programme (GARP) as the centre for analysis of the oceanographic data collected during the Indo-Soviet Monsoon Experiment (MONEX-I). Several organizations in the country dealing with oceanography sent their scientists to NIO to participate in the analysis of MONEX data.

Physical oceanographic studies in the waters around the Lakshadweep group of islands have been started in September 1974 in order to understand the oceanographic factors responsible for the problem of erosion on some of these islands.

The new programmes started during the year under report are (i) shore protection through wave energy utilization, (ii) preparation of a wave and swell atlas for the Arabian Sea, (iii) physical oceanographic studies of the Arabian Sea and Bay of Bengal using the data collected during previous years, and (iv) development of Ocean Data Telemetering System.

Setting the STD recorder before lowering into the sea

2.11 Land sea interaction and coastal zone management

I. Beach studies along the Kerala coast

The studies on the stability of different beaches along the Kerala coast were continued during the year. Beach profile measurements were made at Purakkad, Punnapra, Thumboli, Soudi and Narakkal beaches, once in each season. A study of the beach profiles showed that a general trend of stable conditions prevailed along all these beaches during 1974. At Purakkad, the width of the beach varied between 70 m and 115 m. The foreshore slope of the beach was quite stable for a long time. At Punnapra, the width of the beach increased from 40 m in '73 to '60 m in '74. However, due to severe wave action, the foreshore slope remained very steep. The beach at Thumboli, which was slightly eroded during the South-West monsoon period of 1973, did not show much recovery during the year 1974, probably due to weak littoral transport. The Narakkal beach profiles showed signs of slight accretion during the post-monsoon period. The Soudi beach was eroded very much at the beginning of the year and the width of the beach was reduced from 85 m to 45 m. However, during and after the south-west monsoon season, the beach showed some signs of accretion.

To study the pattern of long shore sediment transport between Thumboli and Thottappilly, the second sampling of the beach material at half mile interval was done during the South-West monsoon period. Preliminary studies on the grain-size distribution indicated a gradual decrease in the grain size of the beach sand from Thumboli to Thottappilly, suggesting sediment transport from north to south along this coastline.

2. Siltation in Cochin harbour

Siltation in the outer channel of the Cochin harbour area was studied using

the bathymetric data collected before and after dredging the outer channel, over a period of six years. These studies indicated a maximum amount of silt deposition in the region between 8000 and 19000 ft from the harbour mouth and the minimum deposition in the region between 1000 and 5000 ft from the harbour mouth. Statistical analysis of the data showed that there was no significant difference either in the annual variation of the silt amount near the entrance channel and the adjoining sea or in the siltation of the northern and southern regions of the channel.

The studies indicated that the present practice of dumping the dredged material to the north of the channel about 8 km off the coast is fairly reasonable as the dumped material is not likely to find its way back to the channel.

Operating submarine photometer

3. Hydrography and circulation in the Velsao Bay (Goa)

This project was undertaken at the request of the Government of Goa, Daman and Diu and aims at studying the hydrography and circulation pattern in the Velsao Bay, to locate a suitable region in the sea off Velsao for the discharge of effluents from the Zuari Agro Chemicals fertilizer plant located at Velsao. Observations carried out at 4 stations located at distances of 0 5 km, 1 km, 2 km and 3 km from the shore showed that the circulation in the region upto a distance of about 2 km from the shore is highly influenced by the tides.

4. Littoral and rip currents

Studies on the littoral and rip currents, which are dangerous to swimmers, along the Calangute beach, Goa, using fluorescent material (Rhodamine 'B' dye) have revealed a predominant northward flow along the beach during the fair weather season and a persistent zone of rip currents about 2 km south of Baga (opposite the Calangute Tourist Hotel). During the pre-monsoon and monsoon months, littoral currents were found to be directed northward in some places and southward in other places along the beach leading to numerous converging currents near the beach. The general pattern of these currents and the changes in their regimes, which have a bearing on the pattern of sediment distribution and sediment transport in the area, were also examined.

5. Aguada sand bar

The data collected so far on the surface drift during the different stages of the tide using surface floats and the sediment distribution pattern in and

around the Aguada bar have been processed and studied. These studies have indicated that a higher wave activity and the large amount of sediment-laden river discharge during the southwest monsoon season lead to a general shallowing up of the area adjoining the bar resulting in obstruction to navigation. The circulation pattern during the fair weather season suggested a gradual building up of the bar through yortices in the water movement in the bay near the mouth of the river.

6. Beach sediments along the Goa coast

Studies on the grain size parameters and environmental conditions of deposition of the beach and the dune sediments along the Calangute beach revealed significant differences in the grain size parameters of the sediments from the different environments. The grain size parameters were found to be useful not only in differentiating beach and dune sediments but also in delineating the beach into backshore and foreshore.

The areal distribution of mean grain size of the sediments from the Colva beach revealed the occurrence of distinct groups of sediments along this beach. At the extreme ends, sediments having mean grain size in coarser end of fine sand class were encountered. This zone is about 0.25 km on either side of the beach (which is about 30 km long). These sediments gradually grade into medium sand class and the extent of this zone is about 1.5 km on the southern side and 3 km on the northern side. This is followed by sediments with mean grain size in the coarser end of fine sand class and the extent of this zone is about 3 km in the north and 5 km in the south. Then the sediments with mean grain size values falling in the finer end of fine sand class occupy the remaining portion of the beach foreshcre. The mean grain sizes of the sediments of the berm are in medium to fine sand class while those of the dune sediments are in fine sand class.

7. Stability of the beaches of Bombay

During the course of the year, periodic observations were made at several beaches on the west coast of Bombay and these indicate that Juhu and Versova beaches have a tendency to get eroded whereas Madh and Manori beaches are fairly stable. Further studies on the stability of Bombay beaches are in progress

2.12 Waves

1. Wave characteristics along the Goa coast

Wave records obtained off Calangute, with an OSPOS wave recorder from November 1973 to May 1974, were analysed for basic wave parameters. During the period of observation, significant wave heights were found to vary between 10 and 75 cm. For about 90% of the time, the zero-crossing· periods ranged between 5 and 8 seconds. Waves of periods upto 14 seconds were also recorded. The energy spectrum obtained was rather narrow and it was concentrated between 0.12 Hz and 0.20 Hz. The direction of these waves, as determined from visual observations, was found to be WNW during the period November to March and SW during the month of May.

2. Swell Atlas for the Arabian Sea

A swell atlas for the Arabian Sea is being prepared using all the available data on the sea conditions for the period 1968 to 1973. The entire regions has been divided into 21 five degree squares and the percentage occurrence of waves in a particular direction, their period and height were presented in the form of rose diagrams for each month and for each square. It is hoped that the work for the entire Arabian Sea and Bay of Bengal will be completed soon.

3. Fabrication of Energy Oscillator

An instrument which dissipates the wave energy and at the same time works like an oscillator is being fabricated as a part of the project on shore protection through energy utilization from the sea.

2.13 General

1. Physical oceanographic studies in the northern Indian Ocean

Preliminary investigations on the physical oceanographic data collected on board INS *Darshak* in the Arabian Sea during December 1973 to May 1974 showed that the thermocline slopes up southwards. The salinity structure revealed the presence of Persian Gulf water at a depth of about 300 m in the northern Arabian Sea. Investigations on the light transmission properties in the sea indicated that the depth of 1% light energy varied between 10 m in the nearshore regions to about 50 m in the offshore regions. Particulate matter, both living and inert, was found to influence the extinction coefficient of the waters. Off Oman and Okha, regions of relatively high attenuation were noted and the concentration of suspended organic matter appeared to be mainly responsible for the high attenuation. In the Gulf of Cambay and nearby areas, transparency seemed to be greatly influenced by the bottom material which is stirred up by strong currents.

2. Oceanographic studies under 'MONEX'

Preliminary studies on the physical oceanographic data collected on board the U. S. S. R. and Indian ships during the Indo-Soviet Monsoon Experiment (MONEX-I) indicated a considerable mixing of various water masses in. the Arabian Sea. The Red Sea water could be traced only at a few stations at depths ranging between 500 m and 700 m. The Indian Ocean Equatorial Water was found to be the major water mass below the depth of 150 m in the southern region. The influence of upwelling near the Somali coast could be inferred even at 400-500 km off the coast. The thermal structure showed deepening of the thermocline from about 25 m in May to about 45 m in July along the 67° E meridian and also a downslope southward in July.

3. Oceanographic studies around Lakshadweep

Coastal erosion is a serious problem on Kavaratti Island (Lakshadweep). It is reported that the removal of the coral material from the protective coral reef has interfered with the balance of forces and resulted in severe erosion of some parts of the island. With a view to

Scene of erosion at Kavaratti Island, Lakshadweep showing the stumps of the fallen coconut palms

study the extent of erosion taking place and assess the causes, preliminary work was initiated by measuring the beach profiles and sampling of beach material. A detailed study with observations on currents, waves, wind, rainfall, etc., is being undertaken.

2.2

chemical oceanography

2.21 Composition of marine and estuarine waters

1. Chemical characteristics of the northern Arabian Sea
2. Carbohydrates in the coastal and estuarine waters around Goa
3. Urea concentrations in the coastal waters of Goa
4. Zinc and manganese in the sea water and marine organisms of the Goa coast
5. Seasonal variations in the physico - chemical characteristics in Zuari estuary
6. Calcium phosphate saturation in sea water
7. Calcium and magnesium in sea water around Goa coast
8. Calcium carbonate precipitation from the sea and estuarine waters

2.22 Marine Pollution

1. Off Bombay
2. Off Velsao (Goa)

2.23 Marine Fouling

1. Fouler settlement in relation to flood and ebb tides

2.24 Desalination

1. Use of different forms of carbon to promote the rate of evaporation by solar radiation

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During ihe year 1974, research programmes in Chemical Oceanography were mainly concerned with the (1) distribution and interrelationship of inorganic and organic components of the inshore and estuarine waters around Goa and the coastal, offshore and deep sea regions of the northern Arabian Sea and (ii) chemical aspects of marine pollution and fouling.

During this year two new programmes (i) chemistry of pharmacologically active extractives from marine flora and fauna and (ii) desalination process of sea water were initiated. The progress of this Division can be summarized as follows :

2.21 Composition of marine and estuarine water

1. Chemical characteristics of the northern Arabian Sea

The Division participated in the oceanographic expedition of INS *Darshak* in the northern Arabian Sea. The areas covered were north of 20°N latitude as well as north-eastern pans off Pakistan and Indian coasts, down to approximately 17°15'N. In all, 200 stations were covered during the five cruises. Along the Indian coast, stations were occupied near the coast extending up to the continental slope to a maximum depth of 3000 m.

The chemical parameters studied were 1) dissolved oxygen, 2) pH, 3) alkalinity, 4) inorganic phosphate, 5) total phosphorus, 6) ammonia, 7) nitrite-nitrogen, 8) nitrate-nitrogen, and 9) trace metals. Estimations for all parameters except for total phosphorus and trace

metals were carried out on board the ship itself, immediately after the collection of the samples.

The surface oxyen values varied between 10% super saturation to 10% under saturation. The oxygen concentration decreased from January to April.

The oxygen discontinuity layer was found to begin from 75-100 m and was associated with the thermal discontinuity layer. There were two oxygen minima (0.5 ml/l) present in certain parts of the Arabian Sea. The first minimum was observed around 100 m extending down to a depth of about 400 m. The second minimum was found between 800 and 1500 m depth.

At a few stations the oxygen concentration in this layer was very low almost approaching the limit of the accuracy of the analytical method used (0.05 ml/l). From this it is apparent that there exists a layer in the Arabian Sea with little or no oxygen in it.

The first oxygen minimum layer is perhaps due to the decomposition of unconsumed organic matter, because organic productivity in this part of the Arabian Sea is very high. The deeper oxygen and minimum probably appears to be due to the effect of water masses. The phosphate concentrations varied between 0.20-4.6 µg at/1. The phosphate maximum was found between 800 and 1200 m. The relationship between the apparent oxygen utilization (a. o. u.) and the inorganic phosphate in the upper 0-150 m layer showed a ratio of oxygen consumption to phosphate regeneration to 286 : 1 by atoms. The relationship in deeper layer (200-3000 m) was 306 : 1 by atoms.

In the upper 0-150 m layer, the organic phosphorus fraction varied from 40 to 70% of the total phosphorus. In the deeper layers, the organic fraction was very low and varied between 7 and 25% of the total phosphorus concentration.

Concentration of nitrate in this part of the Arabian Sea was lower (0.22µg at/1) than in the other regions. The nitrate concentrations in the surface layers were also low. There was no clear indication of a nitrate maximum layer. The relationship between nitrate and phosphate, calculated for the layer 0-150 m, give an atomic ratio of 6.4: 1. For deeper waters the N : P ratio was 17 : 1 by atoms.

The distribution of nitrite in the northern Arabian Sea showed the presence of nitrite in the upper 75 m except at a few stations. The variation being 0-3.2 µg at/1; the nitrite level always showed a maxima, invariably associated with the oxygen minimum. A secondary nitrite maximum has also been observed at some places between 200 and 500 m depth. This is more pronounced along the Indian coast between 17° and 22°N latitude.

The second nitrite maximum was associated with very low oxygen levels (0.5 ml/l); the first nitrite maximum observed was probably due to the process of denitrification, i.e., reducing nitrate to nitrite. The second nitrite maximum which was found associated with low oxygen concentrations has been attributed also to the process of nitrification.

The low oxygen concentration present here does not seem to be responsible for the nitrite maximum, but it is probably due to nitrification.

Ammonia occurred in low concentrations. High ammonia values were observed only at the surface layers. The values varied between 0-8 µg at/1. In the first oxygen minimum layer, the ammonia was found to be low and it was combined with low concentrations of nitrate, while nitrite was absent. Lower down at the second minimum level, nitrate hai a maximum while ammonia was very low.

The chemical data from MONEX (1973) and *Meteor* (1964-65) cruises during the monsoon period were also processed and analysed similar to INS *Darshak* data.

2. Carbohydrates in the coastal and estuarine waters around Goa

Carbohydrates are highly reactive and unstable components of organic matter in sea water and they are of great importance for several biological and biochemical reactions occurring in the aquatic system. The studies on carbohydrates were undertaken to understand its temporal and regional changes in dissolved and particulate fractions in coastal and estuarine waters and their relation with biological productivity.

The concentrations of particulate carbohydrate in the estuarine region (Zuari) varied between 0.14 to 0.8 mg glucose/1 in the surface waters and 0.14 to 1.1 mg glucose/1 in bottom waters. Dissolved carbohydrates were much higher than paniculate fractions. Surface values ranged between 1.62 and 8.0 mg glucose/1 and the bottom values ranged between 1.7 and 5.6 mg glucose/1. The bottom values of both forms of carbohydrates were higher during the monsoon whereas surface values were higher during postmonsoon period. In the coastal waters of Goa, the dissolved carbohydrates were very high at the surface during the post monsoon period (13.82 to 29.4 mg glucose/l) as compared to those of estuarine waters. The paniculate carbohydrates ranged between 0.28 to 0.46 mg glucose/1. In general, the surface concentrations were higher than those of bottom waters. The high concentrations of dissolved carbohydrate observed in the post-monsoon period seem to be related to a greater phytoplankton growth.

3. Urea concentrations in coastal waters of Goa

Urea concentrations were determined at some locations in the nearshore waters along the coast. The levels showed wide variations (0.12 to 3µg at urea - N/l). It was also observed that higher values were closely related to terrestrial discharges at particular locations.

4. Zinc and manganese in the sea water and in marine organisms of Goa coast

Estimations of the biologically active trace metals, zinc and manganese in sea water and marine organisms were undertaken to determine their distribution in place and time. The concentrations of zinc in the offshore waters showed some variations with location. The values ranged between 36 to 45 µg/1. In the nearshore waters, the variations were even greater between 18 to 68 µg/1. The manganese content in coastal waters was very high than those of the natural levels and ranged from 95 to 165 µg/1. These features were attributed to the effect of ore bearing nature of the coastal

terrain. Concentrations of both zinc and manganese progressively increased near the shore.

Analysis of some seaweeds and bivalves for zinc and manganese showed their varying capacities to concentrate these elements. In the seaweeds, the concentration of zinc was from 180 to 400 μg/g and manganese from 120 to 200μg/g. Bivalves concentrated the two elements to a great extent than marine plants. Zinc concentration ranged from 2000 to 3000 μg/g level while manganese from 265 to 850 μg/g in the bivalves.

5. Seasonal variation of physico-chemical characteristics in Zuari estuary

The study of physico-chemical characteristics in the Zuari estuary showed marked changes during the period June 1974 to January 1975. Both the physical parameters studied, viz., temperature and salinity registered a gradual fall from June to August and attained minimum values of 25.4°C and 13‰ respectively. Thereafter the two parameters followed different patterns.

Temperature was maximum in October-November (27°C) followed by a rapid decrease leading to a second minimum (23°C) in January. Salinity on the other hand first increased rapidly to 31.2‰ in September and thereafter recorded a gradual increase upto January reaching a value of 34‰.

Nutrients showed interesting variations in their concentrations for the same period. In general, nitrite, nitrate, ammonia and inorganic phosphate showed high concentrations at the onset of monsoon followed by a rapid decrease from July to November. Nitrate showed high values in July (8.0 μg at N/l) followed by a steep fall reaching its minimum (0.2 μg at N/l) in November and then a slight increase thereafter. Nitrite on the other hand showed a decrease from 1.7 μg at N/l in June to a minimum 0.1 μg at N/l in November. Ammonia showed two distinct maxima, its concentration rose from 2.3 μg at N/l in June to 3.4 μg at N/l in July followed by a steep fall in August, when it reached a minimum (0.6 μg at N/l) thereafter it increased slowly to 1.2 μg at N/l in October followed by a gradual fall leading to a second minimum (0.5 μg at N/l) in January. Most of the inorganic nitrogen occurred in the form of nitrate. Inorganic phosphate showed little changes. It decreased gradually from 2.1 μg at P/l in June to a minimum of 0.4 μg at P/l in October and thereafter it increased to 0.8 μg at P/l in November and remained more or less constant upto January.

The observed variations in the nutrient concentrations are attributed to land discharge during the onset of the monsoon and subsequent utilization by the phytoplankton and regeneration during rest of the period.

6. Calcium phosphate saturation in sea water

The study involved the estimation of pH, salinity, temperature, redox potential, alkalinity, calcium, phosphate, etc. To determine the degree of saturation of sea water with calcium phosphate, it becomes necessary to know the solubility product, i.e., the concentration and the activity coefficients of calcium and phosphateions in sea water.

The solubility product is generally influenced by biological activities, hydrogen ion concentration (pH), tempe-

rature, salinity, alkalinity, etc. The hydrogen ion concentration is the major factor affecting the solubility. Samples from Sinquerim and Calangute areas when analysed were found to be under saturated with respect to calcium phosphate. The solubility product was 2.272×10^{-20}. The under saturation was related to low phosphate and low pH. The samples collected at greater depths from Aguada and Verem were found to be super saturated. The solubility product being 7.931×10^{-19}. The greater degree of saturation observed here was related to high phosphate and high pH. The high pH causes a large fraction of inorganic phosphate to be present in the form of PO_4.

7. Calcium and magnesium contents of seawater around Goa coast

During the post monsoon period no significant differences in the concentration of both the metals were recorded. The concentration of calcium varied from 0.9×10^{-2} to 0.1×10^{-2} moles/1 and that of magnesium from 5.4 to 5.6×10^{-2} moles/1.

8. Calcium carbonate precipitation from the sea and estuarine waters

Samples collected from the Zuari estuary during high tides were analysed for calcium carbonate. The degree of saturation was determined from pH, alkalinity and saturometric measurements. The estuarine water was found to be supersaturated with calcium carbonate. The degree of saturation ranged between 250 and 300%. A few samples were also collected from Velsao, Calangute, Baga and Vagator beaches. The degree of saturation in these samples was about 300%. Calcium showed little variation and its values were nearer to 1.06×10^{-2} gm at/l. The degree of saturation varied with temperature and salinity.

2.22 Marine Pollution

1. Off Bombay

Observations at three locations off Bombay were repeated during each cruise of INS *Darshak* to determine the short term changes in some parameters as indices of pollution from the city. Apart from dissolved oxygen and nutrients, Biological Oxygen Demand (BOD) was also measured at several depths, from stations close to Bombay. The rate of organic matter decomposition was most intense between 5 and 15 metres below which the rate became somewhat slow. As the region is well aerated, no appreciable depletion of oxygen in the water column could be observed. The differences between BOD_5 and BOD_2 were not significant indicating a very fast rate of decomposition of organic pollutants. The quantity of phosphates in the inshore waters off Bombay has increased over a period of years, but due to the effect of tides and exchange of water, the situation has not yet become alarming.

2. Off Velsao (Goa)

Regular monitoring of chemical constituents was undertaken in the nearshore waters of Velsao beach (near Panaji) where a fertilizer factory uses arsenic in its manufacturing process and discharges effluents into the sea. Observations were made on temperature, salinity, pH, redox potential, dissolved oxygen, alkalinity, phosphates, nitrates, nitrites, ammonia

and inorganic arsenic. A considerable increase in the phosphorus and nitrogen compounds of seawater was recorded in the vicinity of the fertilizer factory. The variation in phosphate-P was from 3 to 9 µg at/1, nitrite-N from 4 to 32 µg at/1, nitrate-N from 6 to 900 µg at/1 and ammonia-N from 3 to 184 µg at/1. Inorganic arsenic concentrations ranged from 3 to 150 µg/1. All the values were far greater than those occurring normally in coastal waters. High concentrations of nitrite and nitrate are believed to be the oxidation products of ammonia which is the major constituent of the effluents.

2.23 Marine Fouling

1. Fouler settlement in relation to flood and ebb tides

In view of the great economic importance of antifouling measures, a project was planned to understand the physico-chemical factors responsible for settlement and growth of marine foulers. As a part of the project investigations were conducted in the estuarine waters of river Zuari on the effect of current strength on settlement and growth of foulers.

It was observed that the intensity of fouler settlement on surfaces facing flood tide (velocity - 2.1 km/hr) was four times greater than on the surfaces facing the ebb tide flow (velocity 2.2-3.6 km/hr). Accordingly, separate test panels with four coats of a commercial antifouling paint on their surfaces facing the flood tide and with two coats on the opposite surface facing the ebb tide, were exposed, for a period of six months (January 74 to July 74). No growth was observed on either side of the test panels whereas the control panel with two coats on either side showed substantial growth on the surface exposed to flood tide.

The results of the above observations suggest that substantial economy of paints can be effected on structures subjected to strong water flow.

2. Effect of Cashewnut shell liquid as antifouling surface coating for wooden crafts

Cashewnut shell liquid is a cheap and locally available byproduct from cashew industry. The liquid is widely used as surface coating on the wooden fishing boats. A field study was conducted to know its effective period as an antifouler. The results showed that the liquid is effective for 1.5 months only. Afterwards, the surface needs drying and applying more coats of the liquid at regular intervals to keep it fit.

2.24 Desalination

1. Use of different forms of carbon to promote the rate of evaporation by solar radiation

The use of solar still for the conversion of seawater and brackish water into fresh water is a well known technique. Black surfaces of the water trays used inside the stills are reported to give a better yield of freshwater. To improve its heat absorption further, a study on the use of different forms of carbon (lamp black, carbon and graphite) to promote the evaporation rate, was conducted. Preliminary results showed that carbon and lamp black improve the rate of evaporation when used in suspension than when used as lined coating.

2.3

geological oceanography

During the year the Geological Oceanography Division was engaged in the study of the echo-sounding data, geochemical, sedimentological and palaeontological aspects of the sediment and rock samples collected during the oceanographic expedition of INS *Darshak* on the north-eastern Arabian Sea. In addition to the expedition samples, progress was also made in the investigations on mineralogy and geochemistry of the samples of the Deep Sea Drilling Project obtained from the various sites of the Arabian Sea.

Noteworthy accomplishment of these investigations are (a) delineation of the depth of the shelf-break (range 120-183 metres) of the north-western continental shelf, (b) characterisation of the shelf into smooth, uneven and rugged topography, (c) determination of placer deposits off Ratnagiri containing as much as 18-19 kg/ton of ilmenite, (d) occurrence of iron rich sediments in the inner shelf as compared to the outer shelf, (e) chronological similarities between the sea-level fluctuations during Holocene and the global Holocene sea-level changes, (f) size distribution and grain attributes of skeletal and non-skeletal carbonate components which indicate that the inner shelf, outer-shelf and upper continental slope have distinctive sediment facies, (g) occurrence of reworked upper-Cretaceous coccoliths in the slope sediments and (h) determination of the suspended sediment load in the western shelf waters which seems to be largely governed by the river discharge and in parts due to high organic productivity.

The analyses of the Deep Sea Drilling Project from sites 219 and 220 samples resulted in the palaeo-environmental reconstruction of the stratigraphic history of the basin of deposition.

2.31 Regional geology petroleum and mineral prospects of the western continental margin of India

The study of echograms from the north-western continental shelf indicated that the shelf break occurs at 120-183 m and the slope extends to a depths of 2500-3000 m. The shelf is characterized by smooth, uneven and rugged topography which, owe their nature to the influence of the Indus and

Cambay rivers and due to the relict sediments respectively.

The onshore placers of Ratnagiri, Morgim and Chapora (Goa) were investigated for their mineralogy and it was found that the Ratnagiri placers on the beach and the adjacent shallow waters (10 m depth) contain 18 kg/ton to 90 kg/ton of ilmenite. The Chapora and Morgim beach-sands also show a high ilmenite content.

Investigations of DSDP site 219 led to the identification of volcanic sediments possibly related to the last phase of Deccan Trap volcanic activity. The occurrence of phosphoritic concretions indicated that though upwelling existed in the area from Paleocene onwards, the conditions for the formation of phosphorite were only favourable when the site was at shelf edge. Studies on heavy mineralogy as well as of clay mineral constituents have also been completed.

The geochemical analysis of samples from sites 219, 220 and 222 indicates that from site 219, iron, manganese, titanium show the maximum value in stratigraphic unit 5, lowest in stratigraphic units 2, 3 and 4 and intermediate values in unit 1. The iron and manganese are detrital, with very little contribution from the carbonate phase.

2.32 Elemental Geochemistry of the sediments of the western continental margin of India

The study of partition patterns of iron in the sediments from the north western continental shelf indicates that iron in the total sample analysis occurs in highest concentrations in the inner shelf due to its association with the non-lithogenous fractions. The inferences derived from the studies of partition patterns of iron are (i) that the bulk of the iron is of detrital origin, (ii) that the soluble iron supplied from land is removed from the waters and fixed in the sediments through flocculation of iron oxide, (iii) that the non-lithogenous carbonate phase does not contain appreciable iron.

2.33 Sediments of the western continental margin of India

The conclusions regarding the origin of the algal and oolitic rocks found on the outer continental shelf off Bombay and southwards have been arrived at on the basis of echo-sounding, petrography of the dredge samples, radiocarbon dating and from the study of the associated carbonate sediments. These are parts of the ridge system formed during the Holocene transgression.

Further studies on the size distribution, grain attributes (shape, size, colour, degree of fragmentation, and their relative proportions) of the skeletal and non-skeletal components have shown that the inner shelf, outer shelf and the upper continental slope have distinctive sediment facies.

Scanning electron microscopic study of calcareous nanno fossils taken from the cores of the western continental slope has shown the presence of some upper-cretaceous re-worked coccoliths and also the presence of Neogene discoasters in Holocene sediments.

Sixty five water samples of 7 litres each collected at 37 stations from the

surface and bottom were anlysed for suspended matter. The results indicate that the north-western continental shelf can be divided into three zones (i) Gulf of Cambay zone including a narrow belt along the coast from Daman to Ratnagiri which gave the highest values, (ii) a zone north of the Indus and (iii) a zone along the Kutch-Kathiawar coast.

Higher concentration of suspended matter in the north-west shelf waters have been attributed to the influence of river-borne matter whereas the high value in the outer shelf is probably due to higher productivity.

2.34 Foraminiferal distribution and their ecology along central west coast of India

Over 200 samples were collected from the beach and intertidal regions from Karwar to Ratnagiri along the central west coast of India. A detailed investigation of all the samples is underway. However, a preliminary study indicated that the distribution of foraminifera is controlled by the nature of the substrate, grain size and mineralogy of the sediment. It was observed that the foraminifera decreased in numbers when the substrate is very fine and clayey while in medium sized sandy sediment which is exposed more to the sea, their numbers increase. Miliolids, Rotalids, Nonions were found to be abundant, while a few planktonic species like *G. ruber, G. sacculifer* and *Globorotalia menardii* also occurred.

2.35 Seismic and magnetic studies

Continuous seismic profile and total magnetic field data were collected along a profile, 500 km long, off Quilon, covering the continental shelf, slope and the deep sea. The data were recorded on board R/V *Chain* - the oceanogrphic vessel of the Woods Hole Oceanographic Institution, at the request of the Institute. The significant features identified from these data include a terrace immediately after the shelf edge and two basement Highs in the deep sea. A detailed study of these data has led to the conclusion that the ancient Indian shield extends further west into the Arabian Sea and has undergone major faulting and subsidence.

Aeromagnetic data recorded by 'Project Magnet' were obtained along four profiles across the Bay of Bengal covering the area between 5ºN and 20ºN The data were digitized for each kilometre and the total magnetic field anomalies were computed. The anomalies indicate that the Indira and Indirani fracture zones, identified to the south of equator, continue northward upto 5ºN. Computation of depth to the basement show that the magnetic basement is more than 10 km deep. Over the Godavari graben area, the depth is more than 20 km. In the central Bay of Bengal, the basement layer shows several anticlinal features.

A method to classify the thickness and temperature gradients of the layers in the potential layer of the bathyther-

mogram was developed to simplify the plotting of sound ray paths. By this method it has become possible to minimize the layers in the potential layer to three or less, irrespective of the number of layers that are originally present in the bathythermogram. The method has been applied to several bathythermograms, and the horizontal range thus obtained at the bottom of the potential layer is mostly in agreement with the horizontal range obtained by drawing the ray paths for the original structure of the bathythermogram.

2.4

biological oceanography

2.41 Marine ecology and productivity

1. Ecology of Mandovi and Zuari estuarine systems
2. Ecology of mangroves
3. Ecology and production of Karwar and Vengurla Bays with reference to fish trawling grounds
4. Ecology and productivity of sandy beaches
5. Ecology, systematics and zoogeography of zooplankton
6. Ecological studies on the environmental preference, species-association, abundance and diversity
7. Experimental studies on secondary production

2.42 Bioenergetics and marine aquaculture

1. Environmental physiology in relation to culture
2. Bioenergetics, systems analysis and biodegradation
3. Coastal aquaculture

2.43 General

1. Biochemical taxonomy
2. Investigations on board INS *Darshak*
3. Pollution Studies

The results of the investigations of the Biological Oceanography Division of NIO at Dona Paula, Goa and its regional centres at Cochin and Bombay are reported here. The Institute proposes to carry out investigations in the field of coastal aquaculture on a large scale. The results of preliminary steps taken in this direction are given here. Studies on pollution and the protection of marine environment is another aspect which is receiving special attention of the Institute.

2.31 Marine ecology and productivity

1. Ecology of Mandovi and Zuari estuarine systems

Primary production: Investigations were undertaken in the estuarine complex of Goa at the primary level of the food chain in relation to environmental conditions. Detailed data for the monsoon months are available now. These show that the rate of primary production was highest in the Cumbarjua canal, followed by Zuari and minimum was in the Mandovi estuary, while chlorophyll and cell counts were high in the Zuari estuary. This indicates that the algal crop in Cumbarjua largely consists of nannoplankton and ultraplankton.

Orda mangrove of Goa - mangroves are potential areas for aquaculture

Secondary production : Studies were made at Seven stations in the Mandovi Estuary, at three stations in the Cumbarjua canal, and at four stations in the Zuari estuary. The highest zooplankton biomass (wet weight) of 108 g 1000 m^3 was found in Zuari followed by 67 g in Cumbarjua and 55 g in Mandovi. The biomass was maximum in the monsoon (June-September) l04g/ 1000 m^3, followed by premonsoon (February-May) 66 g and post monsoon (October-January) 48 g.

2, Ecology of mangroves

Detailed investigations from Ratnagiri to Mangalore showed that mangrove swamps are more productive than fringed mangroves. Strong wave action, rapid currents and rocky and sandy bottoms are probably unfavourable for the growth of mangroves.

Preliminary studies on primary production suggest that nannoplankton are responsible for 90% of the production in the mangrove as measured by ^{14}C fixation. Productivity in mangroves is almost twice that of the coastal waters. Species diversity in the mangrove fauna is also much greater as compared to inshore waters. At Galgibag estuary in Goa, a bloom of *Navicula* sp. occurred during February 1974. Seasonal changes were more pronounced in the fringed mangroves than in swamps.

3. Ecology and production of Karwar and Vengurla Bays with reference to fish trawling grounds

Studies were started in 1973 and completed in 1974. These revealed that (i) Karwar Bay has more estuarine influence than the Vengurla Bay and accordingly, the latter is more productive than the former. Results on the food and feeding habits of demersal fishes in relation to benthic standing revealed the dominance of carnivores in

Vengurla Bay and of detritus-feeders in Karwar Bay.

4. Ecology and productivity of sandy beaches

Four beaches namely Sinquerim, Bogmalo, Velsao and Dias were studied. The first three were marine beaches and the last one was an estuarine beach. Ecological parameters such as soil temperature, water table fluctuations, water temperature, salinity, oxygen, sand grain size, organic carbon and beach profiles were studied. Qualitative and quantitative analyses of macrofauna inhabiting the intertidal zone were also carried out. In both the estuarine and marine beaches, the production of macrofauna was at its highest during the premonsoon period, when the ecological conditions at these beaches were most stable, followed by the post monsoon and monsoon seasons, when the production of the estuarine beach was comparatively lower than that of the marine beach due to the fluctuations of the ecological factors. Spawning and larval recruitment of the major groups of animals took place during the premonsoon period.

5. Ecology, systematics and zoogeography of zooplankton

This is the main project of the Indian Ocean Biological Centre. The zooplankton material for this study consists of nearly 2000 samples collected from all over the Indian Ocean during the International Indian Ocean Expedition (1960-65) and 3000 samples collected by the Pelagic Fishery Project of UNDP and the IOBC in the coastal waters off the west coast of India and the backwaters since 1969. Analysis of these samples have been in progress for the last few years and results are being reported every year. This year also extremely valuable information on the various zooplanktonic groups in the Indian Ocean were obtained.

Studies revealed that Hydromedusae in the Indian Ocean are particularly concentrated off the Somali coast and west coast of India, regions well known for upwelling systems. The scyphomedusae, on the other hand, show maximum concentration off Bombay and Calcutta coasts, for reasons unknown to us for the present.

The polychaetes have been studied from all the HOE stations in detail. In all, 32 species belonging to 3 families were found from the Indian Ocean. Three new species were recorded. The distribution of polychaetes shows their abundance particularly off the East African and Saudi Arabian coasts, and also in the Bay of Bengal. One of the remarkable results of the IIOE work on zooplankton is that some groups like *Ostracoda* and *Amphipoda* show patterns of distribution highly significant for locating shoaling fishes. These groups generally occur away from the upwelling systems and it is quite possible that large shoals of sardines and mackerels may also be found near such groups. The study of ostracods of southwest coast of India showed the occurrence of 14 species. Their vertical distribution in relation to thermocline showed that while some species move across the discontinuity layer,

others do not cross this layer during their vertical movements. A new species of ostracod, has been recorded from the Malacca Strait.

Work on copepods during the year was directed towards studying the ecology of various species. For studying the distribution of *Pleuromamma indica,* the data collected from the upper 200 m and from other depths deeper down the Indian Ocean were analysed. In addition to the area at the mouth of the Gulf of Oman, this species is also found from the Bay of Bengal. Attempts were made to study the integumental organs in the genus *Gaussia* (Copepoda) on the theory that number and arrangement of these organs have taxonomic significance. While analysing copepods belonging to the family *Scolicithricidae,* a number of specimens (males and females) belonging to the genus *Scottocalauns* were obtained. On comparing these IIOE specimens with the published descriptions of other species of *Scottocalanus,* good agreement was found with *Scottocalanus securifrons* (T. Scott, 1893) and also with *Scolecithrix cuneifrons* Willey, 1918. Based on this, a paper was prepared assigning the IIOE specimens to the older *Scottocalanus securifrons* with an account on its distribution and redescription. *Scolecithricella tropica* Grice was also reported for the first time from the Indian Ocean.

Acartidae is widely distributed both in the offshore and inshore waters of the Indian Ocean. The Cochin backwaters harbour nearly 11 species of the family. Statistical analysis of the co-existence of various species in the Arabian Sea showed that *Acartia dana* and *A. negligens* formed an inseparable combination, while other species showed no such relationships. A new species *Acartia bowmani* was described from the Arabian Sea."

Among the family *Corycaedae,* the genus *Urocorycaes* reveals three distinct patterns of distribution in the Indian Ocean. In general, the northern Arabian Sea and the southern sub-tropical gyre of the Indian Ocean are either sparsely populated by or almost devoid of *Urocorycaeus* spp.

The harpacticoid copepoda have been sorted out from a representative selections of stations spread over the entire Indian Ocean. The IIOE collections form the source material. The preparation of distribution maps for the group as a whole and for the individual species is progressing. Along with the mapping of the geographical areas of occurrence, the numerical abundance at different stations is being studied, and the associated ecological parameters (salinity, temperature, and dissolved oxygen) are being examined.

Further work on amphipods relates to the families *Oxycephalidae, Anchylomeridae* and *Paraphronimidae.* It was noted that the juveniles of the oxycephalids are miniature adults, contrary to the earlier view. *Paraphronimidae* is represented in the Indian Ocean by three species.

Work on the Decapoda of the Indian Ocean is continuing. A systematic revision of the penaeid prawns of India,

based on collections made earlier has been made. The manuscript on taxonomy and distribution of penaeid prawns of India along with seven plates is ready for publication.

The Phyllosoma are the unique looking pelagic larvae of the lobsters. Of the total of 84 larval specimens present in the zooplankton collections of IIOE, 51 belong to the *Palinuridae* and 33 to *Scyllaridae*. The larval series of *Palinuridae* contain phyllosoma stages of most of the commercially important spiny lobsters of the Indian Ocean region. The larval stages of some of the species like *Panulirus polyphagus* and *Puerulus sewelli* are being described for the first time. The species with the maximum number of larval specimens in the collections is *Panulirus versicolor*. A detailed account on this is now ready for publication. The paucity of larvae in the samples from near the coastal areas of India and Shri Lanka is a strange feature noticed in the distribution of the larvae.

The *Aristaeinae* are represented in about 1500 samples and their analysis is not complete. The analysis of the samples carried out till now have revealed that the larvae of a species, probably *A. semidentatus* of the Genus *Aristeus* are the most abundant group of *Aristaeinae* represented in the Indian Ocean. Larvae, and in a few cases adults also, of five species belonging to 3 genera have so far been separated. The group *Solenocerinae* is fairly well represented does not present such new information on larval studies. Five species and probably a variety is represented in the larval collection. The group *Pandalidae* have been analysed completely and the species representation of two genera have been thoroughly studied and results published.

Larvae of the sub-family *Penaeinae* have been analysed and grouped under nine genera. Studies on larval stages of *Penaeopsis* and *Funchalia* have been completed. The early post-larval stages of *Funchalia* from the Indian Ocean have been described. These descriptions are considered an important contribution to our knowledge of decapod larvae. Distribution charts of different species of chaetognaths in the Indian Ocean are under preparation. The IIOE collection include 19 species of which 15 are epiplanktonic, 3 mesoplanktonic and one bathyplanktonic.

The species composition clearly indicates the identity of the Indo-Pacific chaetognath fauna. Endemism seldom occurs among chaetognaths and *Sagitta bombayensis* is an example for this. This species is restricted to the coastal waters of India and has not so far been recorded elsewhere. Of the 4 genera represented in the collections, the genus *Sagitta* is the most widely distributed group showing the maximum species diversity. In almost all the samples analysed different maturity stages of the common species were noticed suggesting that breeding is continuous in these tropical waters. Dependant on the prevailing monsoon, there is a shift in the maximum population of chaetognaths towards the east during the southwest monsoon and to the west during the northeast monsoon period. The northwestern part of the Arabian Sea sustains the maximum density for this group. Further investigations indicate that chaetognaths, which occupy the tertiary level in the food chain, need

more time for their development and so the places of their maximum abundance appear at a greater distance from the centres of upwelling.

Detailed study of the family-wise distribution of fish larvae of the IIOE collections showed that about 83% of the larval population belonged to the deep sea and bathypelagic fishes in the Arabian Sea. Myctophids and gonostomids form the major resources of the oceanic zone. But in spite of the dominance of these two families, there are fairly large resources of thunnids, scomberomorids, gempulids coryphaenids, labrids, synodontids, trichiurids and engraulids in the offshore waters as is evidenced by the distribution of their larvae.

Studies on the seasonal fluctuations in the distribution of eggs and larvae of flat fishes in relation to hydrographical parameters in the Cochin Backwaters have been made. The eggs and larvae were found to occur in the estuary during the premonsoon period but not during the SW monsoon period. However, during the south-west monsoon period, larvae belonging to very early stages were found at the marine end (Fairway buoy) of the estuary. The continued or prolonged existence of very low salinity appears to restrict the distribution of flat fish larvae. In the post-monsoon period also the eggs and larvae were not found in regions of very low salinity. Larvae of 5 species of fiat fishes were obtained in the collections taken from the estuary. From the data it is seen that each species has a spawning time of its own in this estuary.

The striking feature in the distribution of phoronid and brachiopod larvae in the Indian Ocean is their discontinuous distribution. The larvae of *Phoronida* prefer relatively low salinity waters while the brachiopod larvae have a high tolerance to changes in salinity. An assessment of the quantitative distribution of copelates, salps and doliolids in the Indian Ocean indicates that the northwestern part sustains the maximum density for these pelagic tunicates.

The IOBC maintains nearly 3000 zooplankton samples collected systematically by the UNDP Pelagic Fishery Project during the last 3 years. These samples constitute one of the largest and best made in the coastal waters of the peninsular India and cover an area of great fishery potential. Their study would be important in assessing the distribution and potential of India's west coast pelagic fisheries. So far, 1000 samples have been analysed. Based on the biomass data supplied by IOBC, a report was prepared by the Pelagic Fishery Project. Preliminary results indicate that a fairly dense belt of plankton occurs all along the west coast during Aug.-Sept. in offshore areas, about 14 km from the shore, and that the occurrence of shoals of mackerels, oil sardines, etc., coincides with the high density of zooplankton.

6. Ecological studies on the environmental preferences, species association, abundance and diversity

To study the effect of different hydrological factors influencing the variation in the abundance of copelata population, multiple regression analysis was employed. The coefficient of correlation

between the abundance of copelata with each of the factors, salinity, temperature, oxygen and oxygen temperature were calculated and tested for significance. All correlations were worked out by taking the maximum values reported in the IIOE data. It was found that temperature was not having any significant correlation with abundance, while oxygen and temperature showed a significant correlation. To study the coexistence of the species of euthecosomes over space, correlation matrices were constructed. It was found that the species group in which the maximum number of species coexisting seem to be in the south African Sea. The spatial and seasonal variations of the zooplankton organisms of the backwaters from Cochin to Alleppey were found to be controlled chiefly by salinity. Higher abundance of most of the groups and species were during the high saline pre-monsoonal period. Statistical analysis of the data collected showed that in most groups, the mean abundance varied significantly over months. Certain groups showed very high significance while others were just significant.

7. Experimental studies on secondary production

Animals which largely feed on primary producers are collectively known as secondary producers. It is well known that a major portion of the organic production in the sea comprises of primary and secondary producers and only a small percentage of this is reaching the tertiary level of production and becomes useful to man in the form of fish, crustaceans, molluscs, etc.

The aim of this project is to collect more information on secondary producers, their life history, growth rates, biochemical changes, etc. and to attempt massculture of some of them, so that they could be used as food for mariculture experiments and may ultimately help in marine farming of harvestable animals.

An efficient circulation system of seawater for maintaining the cultures of zooplankton in the laboratory has been developed. A constant temperature room is under construction for experimental work. Several attempts were made to locate hardy planktonic animals, capable of withstanding laboratory conditions during different experiments. Amphipods, shrimp larvae, copepods, cladocerans, polychaetes, etc., are some of the groups being tried for culture work.

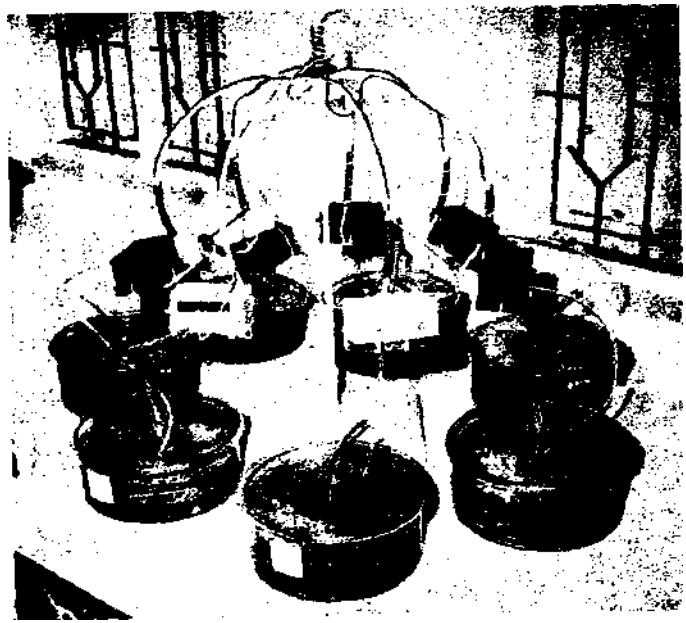
2.42 Bioenergetics and marine aquaculture

1. Environmental physiology in relation to culture

The major questions in aquaculture at present are whether the growth rate of the cultivable animals could be improved and generation time reduced so that maximum output could be achieved. Agriculturists have greatly succeeded in introducing special crops with all the above characteristics and it is hoped that a similar development will be introduced in aquaculture also. For this, a knowledge of the factors governing their growth, reproduction and survival is essential.

Attempts were made in this direction by trying to grow some of the economi-

cally important prawns in the laboratory. The following three aspects of environmental physiology are under study in respect of prawrs, *Penaeus indicus* and *Metapenaeus dobsoni* as these two are commercially important and quite abundant in the backwaters of Kerala. Studies are being carried out in simple aquaria specially designed for this purpose.



Aquaria for studying the influence of the environmental factors on prawns

(i) *Studies on growth in relation to salinity: Penaeus indicus* spends its early life in the backwater where it is exposed to wide diurnal and seasonal changes in salinity but later on it migrates into the sea as adult. Clearly its physiological requirements are different from backwaters to the sea and as they grow in the backwater, they gradually develop stenohalinity along with other possible physiological changes. Hence the effect of salinity on the growth of post-larvae and the larger juveniles may vary, as these require different salinity optima in spite of the fact that they live in extreme euryhaline conditions. Different sized individuals of *Penaeus indicus* were, therefore, exposed to three different salinities.

The results showed striking differences in the salinity preferences of post-larvae and larger juveniles. The post-larvae recorded faster growth in low saline waters, which decreased with increasing salinity. The reverse trend was noticed with larger prawns, and their salinity optima were found to be higher. Thus it appears that the salinity preferences gradually increase with their stay in backwater.

(ii) *Effect of food on the growth rate:* Post larvae of *Metapenaeus dobsoni* of nearly equal weights were given different amounts of food in specially designed aquaria provided with biological filters. The results showed that much higher growth rate is attained in the laboratory than those obtained in natural conditions and that food plays an important role in controlling the growth. Other important factors including the role of hormones will shortly be taken up in detail with a view to obtain larger prawns in a reasonably short period.

(iii) *Conversion efficiency in relation to asymptotic size :* Preliminary experiments were done to know whether species with a larger asymptotic size will exhibit a greater food conversion efficiency. Results seem to indicate that they possess a higher efficiency. Detailed work is in progress to confirm this hypothesis.

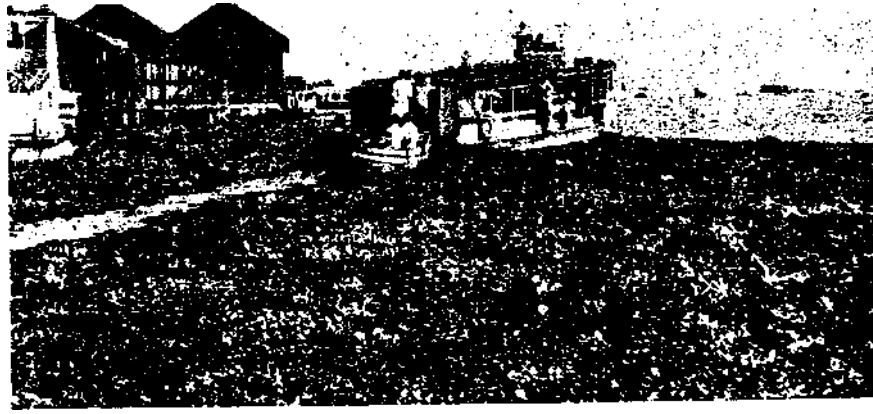
2. Bioenergetics, system analysis and biodegradation

Aquatic systems are highly complex. Since a knowledge of some of these systems involves the study of many animals and plants against a background of changing environmental conditions, it can be best studied on individual species, to begin with and on its growth, development and feeding habits etc.

(i) *Life history of a copepod :* A harpacticoid copepod (*Nitocra* sp.) occurring in the Cochin Backwater was cultured in the laboratory on a diet of detritus supplemented with phytcplankton. Its life cycle was found to include six naupliar and five copipodite stages. Development from egg to adult took place within 17-19 days. The culture is being maintained in the laboratory for the past nine months.

(ii) *Studies on the oyster.* Crassostrea *sp.* : Ecological studies on the oyster *Crassostrea* sp. is also in progress. Estimation of its production in the estuary, spawning and growth, biochemistry of the flesh are some of the important parameters being studied.

(iii) *Ecological studies on 'African Payal' in Kerala Backwaters :* There has



'African paya', *Salvinia* sp. in Cochin Backwaters. Picture shows the obstruction caused to the water transport.

been a phenomenal increase in the abundance of freshwater weeds, particularly *Salvinia* sp. in the backwaters of Kerala, in recent years and this has posed a serious problem both for navigation and fisheries. Besides, it is hampering agricultural operations.

Under a new project at the Regional Centre, Cochin, studies on the ecological aspects of this weed was taken up in 1974. Regular monthly sampling of the floating weed showed that 11 categories of organisms belonging to 5 phyla inhabit the weed mat. Copepods, mainly harpacticoids and cyclopods were numerically the most abundant (over 32,000 per sq. metre). Bivalves and amphipods contributed to the bulk of the biomass and polychaetes, ostracods and gastropods are the other dominant groups. A comparison of the abundance of the fauna of the level bottom with that of the weed mat was made. The decaying weed mat and the associated detritus seem to provide an attractive feeding environment, though temporary, for some of the organisms.

(iv) *Biodegradation studies:* A general study of the bacterial flora of the Cochin Backwater has been taken up as also degradation rates of plankton, weeds and oil.

Quantitative and qualitative studies of the bacteria of the infesting weed *Salvinia* sp. in the Cochin Backwaters have yielded interesting results. Average total aerobic bacterial count ranged between 200-260 per g weed. So far, 15 strains were isolated and of these 2 were found to be gram positive. These grew very fast in the culture medium and produced yellow pigmentation. Most of the gram negative strains belonged to *Pseudomonas* spp.

Bacterial strains capable of decomposing oil (crude and octane 93) were isolated from the Cochin Backwaters using oil - sea water agar medium. Degradation of oil was done in the laboratory using an isolated bacterial strain. Complete degradation of oil took place in 15-20 days, and the final product was not extractable in benzene.

3. Coastal aquaculture

Baseline information of the ecology, growth and breeding behaviour of cultivable molluscs, has been collected. Studies on the ecology and growth of clams and mussels in estuaries, bays and coves in Goa, Vengurla and Karwar revealed that in *Meretrix casta* the growth rate was 2-3.5 mm/month, whereas, in *Paphia malabarica,* the growth rate was 5 mm/month. Salinity and suspended organic matter are the limiting factors. The annual yield of a clam *(P. malabarica)* bed at Verem was estimated to be 1 tonne of meat/ha. The growth studies on mussel *(Mytilus viridis)* showed the rate of 7.3-8 mm/month under natural conditions and 8.6 mm/month under culture conditions.

Studies on the life cycle of a peacrab *(Pinnotheres vicajii)* which heavily infest the commercially important clam, *Paphia malabarica,* have been completed. The results indicate that a prolonged infestation adversely affects the normal growth of the clam meat.

Work on the raft culture of green mussels and rope culture of seaweeds have been initiated.

Studies on the seasonal changes in the caloric content and biochemical constituents of edible fishes and moll-

uses have been undertaken to evaluate the efficiency of food conversion. The findings are important for obtaining maximum yield in aquaculture programmes.

Rearing experiments

Three important species of copepods were reared and these are being maintained in the laboratory. Mass scale culture of 4 species of phytoplankton is also being attempted.

In the waters of Bombay, an assessment of biological resources was initiated. Observations were made at a number of stations around Bombay and at Murud Janjira on Konkan coast to study the distribution and ecology of marine fauna. After assessing the ecological conditions and the behaviour of nearshore marine forms, it is intended to culture the marine forms like oysters, edible marine bivalves and prawns in the laboratory. Initial experiments on this have been conducted and a gastropod snail *(Cerithium morus* Lamarck) was bred and reared until its metamorphosis was completed in the laboratory.

2.43 General

Biochemical taxonomy : Serological and electrophoretic studies on grey mullets from the estuaries of Goa, revealed significant differences in total solids and protein in *Mugil cephalus* (13.2 and 9.1 g/l00ml) and *M. parsia* (12.6 and 8.2 g/100 ml). Electrophoretic studies on the eye lenses of *Sardinella fimbriata* and *S. longiceps* did not show significant differences. Electrophoretic studies on the eyelens protein of the mackerels around Goa waters during February-April, 1974, revealed 2 populations in the mackerel stock.

Haemoglobin studies on the cat-fish *Tachysurus caelatus* proved the existence of two distinct populations based on haemoglobin polymorphisms in the cat-fish stock. Racial studies involving morphometry and meristic characters on the fiat fish *Brachiurus orientalis* from Mandovi and Zuari estuaries are in progress.

Cytogenetical studies on 17 species of calanoids have helped to establish the cytotaxonomical relationship on the intra- and inter-generic levels.

Two species of closely resembling copepods, viz., *Acartia clausi* and *A. longiremis* received from St. Mary Bay, Canada, were studied cytogenetically and their specific identtiy was established.

2. INS Darshak Investigations

Biological investigations carried out during the INS *Darshak* Expedition can be summarized as follows :-

Primary productivity :- The studies included (a) rate of carbon assimilation using ^{14}C at 59 stations (b) estimation of pigments (chlorophyll *a, b, c* and carotonoids) as 80 stations and (c) phytoplankton cell counts at 80 stations from five standard depths.

The area between Lat. 24° 01' and 17°30'N, Long, 73° and 60.51'E was covered during the Expedition. During the second cruise, the variations in surface chlorophyll *a* and carotenoids were 0.12 to 1.90 mg/m^3 and 0.19 to 2.56 MSPU/m^3 respectively. Further work is in progress.

Zooplankton: During five cruises, the zooplankton samples were collected using vertical hauls of the Indian Ocean Standard Net, from 185 stations. The maximum depth was 200 m. Detailed qualitative analysis is in progress.

A new location between 65 and 69° E and 21 and 24°N with high zooplankton biomas of 0.6 ml/m^3 was observed. Ostracods dominated the night collections. Gradual increase in zooplankton biomass from January to April, was noticed in the Gulf of Cambay and also around 24° N and 60° E.

Benthos: Qualitative distribution of macrobenthos (81 stations) of the north-eastern Arabian Shelf (between Lat. 24 and 16°N and Long. 74 and 66°E) was studied for the depth range of 20-140 m. The benthic fauna was rich with average, value of 7 g/m^2. Benthic biomass distribution showed a gradual decrease with increasing depth. A north-south decline in the biomass was also observed. Nine different faunal groups, constituting the bottom populations, showed patchy distribution in relation to depth and area. Polychaetes and bivalves were the dominant organisms. The abundance of sestonophages on the inner shelf and those of detritophages on the middle and outer shelf, indicates the richness of food material. It was observed that the nature of substratum, dissolved oxygen content and richness of suspended organic matter played an important role in the distribution of the fauna.

3. Pollution studies

Around Bombay : As an extension of the sponsored project on the disposal of sewage and industrial effluents from Bombay City, monitoring of some pollutants around Bombay City was undertaken. Studies included the determination of some parameters like ammonia concentrations and other pollutants. Chemical composition of the effluents was also determined and possible ways of minimizing their effect were suggested. Periodic observations were made at 5 stations located on the western part of Bombay, 3 stations in the harbour region and 7 stations in the Thana creek.

Preliminary findings indicates that ammonia is the main toxic substance on the west coast of Bombay having its source in the domestic sewage released in the area. In the Thana creek, on the other hand, it was mainly the industrial effluent which was responsible for the pollution. As expected, pollution due to petroleum products was observed in Thana and harbour regions. Bioassay tests on the effluent have also been conducted.

At the request of Maharashtra Water Pollution Board, another investigation on pollution in the Thana creeck and Bombay harbour area were started from December 1974 in collaboration with the Indian Navy, the National Environmental Engineering Research Institute, Nagpur and the Maharashtra Water Pollution Control Board. Preliminary findings have indicated that the Thana creek is deficient in dissolved oxygen because of the discharge of the industrial effluents.

Oil pollution

(i) *Tar ball deposition :* Studies on the magnitude of tar ball deposition on the beaches along the central west

Damaged oil tanker TRANSHURON lying abondoned on the northern tip of Kiltan Atoll. The shalloness of the area where it ran a ground is clearly indicated by the breaking waves.

coast of India (17°-13°N) showed varied intensities of deposition at different tidal levels. Observations made during 1974 revealed that the tar ball deposition is maximum at the high tide Jevel and the maximum average value was 196.29 g/m^{-2} .

Thin layer chromatography studies revealed that the composition of tar balls is similar to that of crude oil although the former has less volatile components which get evaporated when the crude oil gets degraded in the sea.

(ii) *Laccadivt oilspill:* On September 26, 1974, an oil tanker SS *Transhuron* chartered by the United States Navy, ran aground at Kiltan Island at about 73ºE and 11°30'N. It was carrying about 18,000 tonnes of furnace fuel oil. As a result of the rupture of tanks, about 3,500 tonnes of oil leaked. The spilled oil was seen in the sea adjoining the island, in the lagoon and along the intertidal area of the sandy beach. Considerable mortality of marine animals was reported. Studies are being continued on the effects of the spilled oil on the ecology of the region.

(iii) *Pollution studies in Cochin backwaters :* The project was started with a view to monitor the present status of pollution in the Cochin Backwaters. Preliminary work has already yielded interesting results. Organic pollution to a considerable extent exists in the Cochin Backwaters and the extent of pollution in some of the areas is well above the tolerance level of the estuarine fauna. Control operations are necessary.

2.5

oceanographic instrumentation

Research and developmental work in marine instrumentation began in 1972. The following main programmes were taken up:

1. Development of marine electronic system with special reference to oceanographic data acquisition through telemetry and digital instrumentation.

2. Maintenance and calibration of oeeanographic instruments available at the Institute.

3. Development of workshop facilities for R & D programmes.

The progress made in these three areas is given below :

1. In marine electronic systems, the organizational work has been completed and literature survey has been done. Work has been initiated to develop an Inductive salinometer / Electromagnetic current meter, a Multichannel FM buoy telemetering system and a turbidity meter. The results of this work will lead to self sufficiency and import substitution of several oceanographic instruments very soon.

2. In the field of maintenance and calibration of oceanographic equipment, several instruments such as power supplies, current-flow meter, STD meter, pH meter, Densitometer, Xerographic machine, etc. were serviced and repaired. Two power supplies were fabricated for use in the Institute. Servicing of Oscilloscopes and power supplies for Postgraduate Education and Research Centre and Goa Medical College, Panaji were also carried out.

3. The organization of the workshop was speeded up during the year. New machinery such as HMT Precision Lathe, HMT Universal Milling Machine and other working materials were acquired during the year. About 125 jobs of varying nature were undertaken and completed. Some of the works completed include fabrication of instrument chassis, handwinch, secchi disc, displacement transducers, vane float assembly and anchors for samplers. Repairs of gauges, vane samplers, binoculars, gas regulators, etc. have also been carried out in this workshop.

New staff recruited during the year has joined and several new programmes have been initiated.

2.6

data, publications & information

The activities of the Planning and Data Division have been four-fold during the course of the year:

(i) Planning,
(ii) Publications,
(iii) Information, and
(iv) Processing utilization of oceanographic data.

The Division played an important role in the formulation of the projects of the Institute and compiled them in the form of a booklet "Projects 1975" of NIO. Further efforts are underway to monitor, evaluate and cost the various projects. These efforts will help the Institute in exercising the necessary control over the different types of activities and shall give the scientific staff a right direction. An analysis, based on well known principles of management, of SWOT was made in respect of the the Institute and the findings were sent to the CSlR.

The Publications and Information Section of the Division compiles, processes and publishes the different types of information of the Institute. A notable contribution in this direction has been the introduction of new format for *Mahasagar*, the Bulletin of the National Institute of Oceinography. The new format will pre-dominantly include research papers and short notes, thus providing an effective and efficient medium for the publication of scientific findings in the field of oceanography. The Annual Report for the year 1973 has already been published in 1974.

The information relating to the activities of the Institute was attended to in three different ways. Firstly, by attending to the visiting parties from different parts of the country. In all, 30 parties of students/trainees from professional and academic institutions were attended to and they were informed about the organizational structure, research activities, findings and their utility, etc. of the Institute. About 800 visitors were directly benefitted with this type of service. The second type of information work was attended to through postal and telephonic communications. A large number of letters from different organizations and individuals were replied. Lastly, mass media such as newspapers, scientific periodicals, radio, etc. were also used with a view to informing people about oceanography and the activities of the Institute. In all, 10 news releases were issued to the news agencies for their coverage through the new spapers.

Monthly Summaries to the Cabinet were compiled and sent regularly to the Publications and Information Directorate of the C. S. I. R. for their onward transmission to the Cabinet. In all, 1l

different items showing the findings of the Institute were sent during the year.

In the field of oceanographic data utilization, efforts were made to develop efficient system for processing and dissemination of oceanographic data. Physical and chemical data for about 1,500 stations were transferred to the punch cards. Processing of biological oceanographic data was initiated during the year. The activities in this field will grow at a faster rate soon after R. V. *Gaveshani* is commissioned for regular cruises in the sea.

Oceanographic data collected during INS *Darshak* Expedition 1973-74 were processed and these were submitted in the form of a data report to the Indian Navy.

2.7

sponsored projects

During the year under review, investigations under five sponsored projects were carried out. All the five projects were undertaken at the request of various government and private agencies.

2.71 Shoreline and adjoining sea at Loliem (Goa)

This project, sponsored by the Government of Goa, Daman & Diu, aims at obtaining information on the hydrography, currents, waves, bathymetry, suspended sediments, bottom sediments, shoreline stability, etc., in connection with possible selection of Loliem as the site for setting up an atomic power station. Monthly observations are being carried out on the above parameters. The studies conducted so far have shown that the beach at Loliem is highly unstable, the bottom topography of the sea adjoining Loliem has a seasonal slope of about 1.5 m/km and the circulation in the region is influenced by the tides.

2.72 Beach and nearshore environment at Sinquerirm (Goa)

This project is sponsored by the Indian Resort Hotels Ltd., Bombay, in connection with the construction of a beach resort hotel near Sinquerim. A photographic method was attempted to bring out wave refraction and diffraction patterns in the study area and it was found useful in locating submerged rock outcrops in and around the proposed salt water swimming pool. Beach profiles for different months at the different portions of Sinquerim beach revealed that the region is fairly stable.

2.73 Survey of Mahisagar Estuary (Gujarat)

The project was undertaken at the

Beach at Loliem with 2 m thick sand cover in January.

Beach erosion at Loliem during the south west monsoon exposing these ocky substratum.

Semi-enclosed beach at Sinquerim proposed to be developed into a salt-water swimming pool

request of the Government of Gujarat. The hydrographic survey was conducted for locating a suitable site for the discharge of industrial wastes from the industries near Baroda City. It was concluded from the survey that it would be desirable to treat the industrial wastes before they are discharged into the estuary as the volume of water available during the low tide is not very high and the ecology of the area is likely to be affected adversely.

A view of the Beach Resort Hotels near the Sinquerim Bay

2.74 Bathymetric and hydrographic survey off Tarapur (Maharashtra)

This project was carried out at the request of the Tarapur Atomic Power Authority, Bombay. The aim of the project was to investigate the possibilities of constructing a submarine pipeline to discharge warm water from the Atomic Power Plant after cooling the reactor which may also be slightly radio

active. But the rich biota of zooplankton and fishery observed in the area suggested no appreciable ill effect on the marine environment in the region off Tarapur. Further, the bathymetric survey indicated a very rough bottom which would not facilitate construction of a submarine pipeline. The project was, therefore, postponed and the report on ths collected data will be submitted to the TAPA during February 1975.

2.75 ZAC sponsored project (Goa)

This project sponsored by the Zuari Agro-Chemical factory in Goa was started from February 1974. The effects of Urea, Ammonia and their decomposition products on the marine life are being studied under this project. Studies on the effects of urea on the growth of marine algae have been completed and at present toxicity bioassay studies of urea and ammonia on fishes are in progress. One paper on the toxic effects of urea on two species of fishes has been sent for publication. In addition to these studies, observations on the hydrographic parameters of Velsao beach are also being carried out.

3

administrative set-up

3.1 Executive Committee

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

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

9. Accounts Officer, National Institute of Oceanography, Panaji (Goa). — "

3.2 Scientific Advisory Committee to the Executive Committee

1. Shri K. A. Varugis, Managing Director, Zuari Agro Chemicals, Zuari Nagar (Goa).

2. Prof. D. B. Wagh, Director, Bombay University Post-Graduate Centre, Panaji (Goa).

3. Shri R. P. Rai, Director of Industries & Mines, Government of Goa, Daman & Diu, Panaji (Goa).

4. Shri P. K. Eapen, Head, Fisheries Division, Tata Oil Mills Co. Ltd., H & C. Lane, Karuvelipady, Cochin-5.

5. Prof. B. N. Ghosh, Head, Department of Chemistry, Bombay University Post-Graduate Centre, Panaji (Goa).

6. Prof. R. L. Mehrotra, Principal, Government College of Engineering, Farmagudi, Ponda (Goa).

3.3 Budget

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

	Budget	*Sanctioned (Final grant Rs. in lakhs)*	*Actual (Rs. in lakhs)*
1.	Recurring	31.880	31.936
2.	Capital	58.665	59.480
	Total	90.545	91.416

3.4 Scientific and Technical Staff

Director
Dr. S. Z. Qasim

A Divisions at the Headquarters

1. Physical Oceanography Division

Head of the Division
Dr. V. V. R. Varadachari

Scientists
Dr. J. S. Sastry
Shri L. V. Gangadhara Rao
Shri C. S Murty
Dr. G. S. Sharma
Shri T. K. Sivadas
Shri P. K. Das
Shri M. J. Varkey
Shri P. G. Kurup
Shri C. K. Gopinathan

Senior Scientific Assistants
Shri Thomas Cherian
Shri K. K. Varma

Junior Scientific Assistants
Shri P. S. Joseph
Shri G. Narayanaswamy
Shri V. Kesava Das
Shri V. Ramesh Babu
Shri A. Balachandran

Senior Research Fellow
Shri M. Yeerayya

Junior Research Fellows
Shri N. Bahuleyan
Shri K. Gurunadha Rao
Miss Shubha Sathyendranath
Shri Albert D. Gouveia
Shri Gerald Delaney

Geophysics Unit

Scientist
Shri T. C. S. Rao

Senior Scientific Assistant
Shri D. Gopala Rao

Junior Scientific Assistant
Shri G. C. Bhattacharya

2. Chemical Oceanography Division

Scientists
Shri C. V. Gangadhara Reddy (Officer-in-charge)
Dr. R. Sen Gupta
Shri S. P. Anand
Shri V. N. Sankaranarayanan
Shri S, Y. S. Singbal

Senior Scientific Assistants
Shri S. N. D'Souza
Miss Solimabi
Dr. M. D. Zingade

Senior Research Fellows
Shri S. B. Kamat
Shri S. P. Fondekar

Junior Research Fellows
Miss S. S. Naik
Shri M. D. Rajagopal
Shri S. W. A. Naqvi

3. Geological Oceanography Division

Head of the Division
Shri H. N. Siddiquie

Scientists
Dr. M. G. Anantha Padmanabha Setty
Shri P. S. N. Murty
Shri R. R. Nair
Shri Madhusudana Rao Ch.

Senior Scientific Assistants
Shri R. M. Kidwai
Shri M. V. S. N. Gupta
Shri B. G. Wagle
Dr. V. Narayanan
Shri F. Almeida
Shri N. H. Hashimi
Shri Victor Rajamanickam
Shri A. Narendranath

4. Biological Oceanography Division

Head of the Division
Dr. S. N. Dwivedi (on deputation to CIFE, Bombay)

Scientists
Dr. K. Radhakrishna (Officer-in-charge)
Dr. A. H. Parulekar
Shri R. M. S. Bhargava
Dr. M. Sakthivel
Dr. A. G. Untawale
Shri V. P. Devassy
Dr. (Miss) Aditi Pant
Dr. (Miss) Sumitra Vijayaraghavan
Dr. N. G. K. Karanth

Shri S. C. Goswami
Shri P. M. A. Bhattathiri

Senior Scientific Assistants
Shri S. A. H. Abidi
Shri R. A. Selvakumar
Shri K. Kameswara Rao
Shri S. A. Nair
Shri P. G. Jacob

Junior Scientific Assistants
Shri C. T. AchuthanKutty
Shri V. M. Abdul Hakkim
Shri N. B. Bhosle
Shri S. N. Harkantra

Pool Officers
Dr. (Mrs.) Usha Goswami
Dr. S. Krishnan

Retired Scientist
Shri K. Virabhadra Rao

Junior Research Fellows
Mrs. Krishnakumari
Shri X. N. Verlencar
Miss P. A. Lokabharathi
Shri Z. A. Ansari
Shri M. V. Mohideen Wafar
Shri T. Balasubrainanian
Miss Clazy Lucia D'Silva
Miss Shantha Nair

5. Planning and Data Division

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

Senior Scientific Assistant
Shri M. K. Antony

Junior Technical Assistants
Shri P. Venugopal
Shri S. P. Sharma
(Proof Reader)

6. Instrumentation Division

Scientists
Shri P. E. Sankaranarayanan
(Officer-in-charge)
Dr. B. A. E. Desa

Senior Scientific Assistant
Shri K. K. M. Rafique

Senior Technical Assistant
Shri S. Ranganathan

Junior Technical Assistant
Shri Md. Wahidullah
Shri V. M. Date

Junior Scientific Assistant
Mrs. Vani B. Peshwe

B. Regional Centre of NIO, Cochin

Officer-in-charge
Dr. T. S. S. Rao

1. Indian Ocean Biological Centre

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

Senior Scientific Assistants
Shri P. N. Aravindakshan
Shri Jacob George
Dr. George Peter
Shri V. T. Paulinose
Dr. (Mrs.) Vijayalakshmi R. Nair
Shri T. Balachandran
Smt. C. B. Lalithambika Devi
Shri P. S Gore
Shri T. C. Gopalakrishnan
Dr. V. Santhakumari
Shri K. K. Chandrasekharan Nair

Junior Scientific Assistants

SnH. P. P. Meenakshi Kunjamma
Sint. Rosamma Stephen
Shri P. Haiidas
Shri P. N. Nair

Pool Officer

Dr. Mrs. Saramma Abraham

Retired Scientist

Shri L. R. Kasturirangan

Senior Research Fellow

Shri M. Madhupratap

Junior Research Fellows

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

2. Physical Oceanography Unit

Scientists

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

3. Biological Oceanography Unit

Scientists

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

Junior Research Fellow

Shri S. R. Sreekumaran Nair

C. Regional Centre of NIO, Bombay

Scientists

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

Senior Scientific Assistants

Shri V. Josanto
Shri R. Kasinathan
Shri K. Govindan

Junior Scientific Assistants

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

Junior Research Fellow

Shri A. A. Shaikh

4. Library

During the year 1974, the Headquarters Library was shifted to the new premises of the Library Block. About 600 items including books and technical reports were added during the year. Journal subscription rose to a total of 200 and about 50 journals were received as gift or on exchange basis.

Additional facility provided during the year was the inclusion of a microfilm reader and the purchase of a number of microfilm copies of books and reprints.

Inter-Library Loan facilities were extensively used by the Scientists of the Institute. Books and journals on loan were also sent to the other libraries as well as to the Regional Centres at Bombay and Cochin.

The Library was also the recepient of £ 1000 worth of books and journals as gift from the British Council under the ODM Book Programme.

5. Awards, Honours, Memberships of various Committees.

Dr. S. Z. Qasim, was awarded *Padmashri* by the President of India on

26th January, 1974 for his outstanding contribution in the development of Marine Sciences in India.

.....was awarded Rafi Ahmad Kidwai Memorial Award by the Indian Council of Agricultural Research in July 1974.

..... served as

— Member, Board of Governors, Indian Institute of Technology, Bombay.

— Member, Board of Governors, Institute of Science, Bombay.

— Member, Governing Body of the Indian Council of Agricultural Research.

— Member, Indian National Commission for Cooperation with UNESCO.

— Member, National Committee on Environment Planning & Cooperation.

— Chairman, State R & D Committee for Small Scale Industries.

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

Dr. M. G. Anantha Padmanabha Setty served as

— Member of Study Group No. 2 of Working Group No. 10 on International Geodynamics Project.

— Member of Executive Council of Indian Society of Earth Scientists.

— Member of Executive Council of Micropalaeontological Society of India.

— Sessional Chairman : IV Indian Colloquim on Micropalaeontology and Stratigraphy, Dehra Dun.

Dr. B. N. Desai, served as

— Member of NCST Committee on Oeanographic Instruments.

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

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

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

— Departmental Member on Deep Sea Fishing Advisory Committee.

Shri P. E. Sankaranarayanan has been nominated by the Mysore University as an expert member of the syllabus drafting committee for the new B. E. degree course in Instrumentation.

Shri T. C. S. Rao was awarded a 'Certificate of Merit' to the paper entitled 'Crustal Features of the Ocean Bottom off Kathiawir Coast' by Indian Society of Earthquake Technology, Roorkee.

Shri George Peter was awarded Ph. D. degree by Kerala University for the thesis entitled 'Studies on the Pelagic Polychaetes of the Indian Ocean'.

6. Deputations

Dr. S. Z. Qasim attended the meeting of the United Nations Environment Programme at Nairobi (Kenya) as one of the delegate from India from 10th to 20th February, 1974.

— attended the UNESCO Advisory Panel for the International Biological Centres at Singapore from 2nd to 6th March, 1974.

— attended the meeting of the Senior Advisory Group at the UNEP Headquarters at Nairobi (Kenya) from 2nd to 6th September, 1974.

— visited the various oceanographic laboratories in France and attended the Second International Colloquia on the Exploitation of Oceans at Bordeaux from 22nd September to 5th October, 1974.

Dr. V. V. R. Varadachari participated in the programme on 'Management of Research' organized by the Administrative Staff College of India, Hyderabad from 22nd to 30th November, 1974.

Dr. T. S. S. Rao, Officer-in-charge, Regional Centre of NIO, Cochin, was on extra-ordinary leave from July 1973 to June, 1974 to participate as a Visiting Professor in the Multinational Project on Marine Sciences of the OAS Regional Scientific and Technological Development Programme at Cumana, Venezuela, South America.

Dr. S. N. Dwivedi, Head, Biological Oceanography Division, joined as Director, Central Institute of Fisheries Education, Bombay on deputation from NIO.

Dr. V. S. Bhatt, attended the Workshop and Training Course for Scientists in the field of Industrial Liaison, Information and Extension from December 23 to 28 at SITRA, Coimbatore.

Shri C. S. Murty was deputed for participation in the course on 'Hydraulic Dredging' organized by the Central Water and Power Research Station, Khadakwasla, Poona, from 30th Dec. 1974 to 11th January, 1975.

The deputation of Shri S. A. H. Abidi, SSA, to Tanzania Government as Fisheries Officer has been extended upto June 1975.

Dr. V. Santhakumari, SSA, was on deputation from 29.3.74 to 10.6.74 to attend the International Training Programme in Marine Science conducted by the Duke University, Marine Laboratory, Beaufort, North Carolina, U.S.A.

Shri T. C. Gopalakrishnan, SSA, was on deputation for 9 months from 9.10.73 to work at the Smithsonian Institution, Division of Crustacea, Washington D.C., U.S.A. under UNESCO Regular Programme Fellowship in Marine Sciences (Planktology).

Shri B. G. Wagle, SSA, Was deputed to Indian Institute of Photo Interpretation, Dehra Dun for training in air-photo interpretation for geomorphology.

Shri K. Kerala Varma, SSA, was deputed for participation in RANOSP (Radiological North Sea Programme) on board German Research Vessel F. S. *'Meteor'* from 21.10.74 to 21.11.74 under UNESCO Shipboard Training Fellowship.

Shri S. Ayyappan Nair, SSA, was awarded a Soviet Research Fellowship for two years for training in USSR in Fisheries Management and Fish Culture. He proceeded to USSR in the first week of December 1974.

Shri K. K. M. Rafique, SSA, has been deputed for higher training in Workshop Technology to Norway.

Shri Abraham Pylee, Senior Laboratory Assistant, attended the Winter School in 'Coastal Engineering, Harbour Planning and Design' organized by the Department of Applied Mechanical and Hydraulics, Karnataka Regional Engineering College, Suratkal from 2.12.74 to 28.12 1974.

Shri K. S. Purushan, Senior Laboratory Assistant has underwent training in Biochemical analysis at Central Institute of Fisheries Technology, Cochin from 2.1.74 to 16.1.74.

Shri K. S. Purushan, S.L.A., S. R. Sreekumaran Nair, J. R. F., Simon John, J.R.F. and V. Baby, J.R.F. participated in the Summer Institute in Coastal Aquaculture at C.M.F.R.I., Cochin organized by I.C.A.R., from 10.6.74 to 9.7.74.

Shri E. V. Radhakrishnan, J.R.F. went for training in Microbiology at Central. Institute of Fisheries Technology, Cochin from 16.7.74 to 20.8.74.

Shri M. Vijayan, J.R.F. and Miss K. N. Remani, J.R.F. underwent training in chemical analysis at Central Institute of Fisheries Technology, Cochin from 4.10.74 to 20.10.74.

Shri A. J. Pires and P.H.M. Bashir were deputed to the IBM World Trade Corporation Bombay for attending the 'A-1 IBM Basic Machine Course' from 29.9.74 to 6.11.74.

7. Meetings, Exhibitions, Seminars and Symposia

Dr. V. V. R. Varadachari participated in the Seminar on Coastal Dynamics at Visakhapatnam on 29th September 1974 and presented a paper entitled, 'Coastal dynamics and coastal zone management'.

— participated in the annual meeting of the Indian Academy of Sciences at New Delhi in November 1974.

Shri H. N. Siddiquie attended Seminar on Solid Earth Geophysics at the National Geophysical Research Institute, Hyderabad from 27th to 28th Dec. 1974.

— participated in the progress meeting of R. V. *Gaveshani* at Garden Reach Workshop on 15th Jan. 1975.

Dr. J. S. Sastri participated in the Seminar on Coastal Dynamics at Visakhapatnam on 29th September, 1974 and presented a paper entitled, 'A mathematical model for the evaluation of the warm water jet characteristics'.

Dr. M. G. Anantha Padmanabha Setiy attended the symposium on Antarctic Biology (SCAR & IUBS) Washington D. C. from 26-28 August, 1974.

— participated in IVth Indian Colloquium on Micropaleontology and Stratigraphy, Dehra Dun from Dec. 29-31, 1974.

Shri S. P. Sharma attended the Refresher Seminar on Information Service to Business and Industry sponsored by DRTC and INSDOC at Bangalore from 2-9 December, 1974.

The Biological Oceanography Division participated in Fisheries exhibition (Sept. 1974) at Panjim organized by the Federation of Fisheries Cooperatives of Goa.

The Institute participated in the exhibition of Exposition 1974 held at Panjim from November 1974 to Jan. 1975.

The Regional Centre of NIO, Cochin participated in the Science Exhibition of the Central School. Cochin-20 from 7th to 8th December, 1974.

A symposium on preliminary results of the investigations carried out during INS *Darshak* expedition, 1973-74 was held on 12th August, 1974 at the Chemistry Hall of the NIO at Goa in which scientists of the NIO participated.

8. Colloquia and Special Lectures

Colloquia (in Goa)

Speaker	*Subject*	*Date*
1. Dr. S. Z. Qasim	Marine Science capabilities in different regions of the world	19.4.74
2. Dr. J. L. Bose	Organic marine chemicals of importance	5.7.74
3. Dr. N. Natarajan	Recent Researches in Porto Novo	15.7.74
4. Shri L. V. G. Rao	Temperature and Salinity structures in the Arabian Sea — a preliminary assessment from the records of STD profiling system	15 7.74
5. Shri M. J. Varkey	Light penetration characteristics of a few selected locations in the Arabian Sea	12.8.74
6. Dr. S. Z. Qasim	Highlights of oceanographic activities in France	31.10 74
7. Dr. C. S. Mason	Ocean Engineering and Instrumentation in the Bedford Institute	21.11.74
8. Dr. D. R. Sikka	Air-Sea interaction studies under Global meteorological experiments	7.12.74
9. Dr. Oscar E. Weser	Deep Sea Drilling Project	10.12.74

Colloquia (in Cochin)

Speaker	*Subject*	*Date*
1. Mr. J. A. Bartle	(i) On the existence of subspecies of planktonic organisms-their differentiation, ecological significances and implications for sample design	5.3.74
	(ii) The distribution of oceanic sea-birds especially with respect to their food	6.3.74
2. Prof. J. E. G. Raymont	Some aspects of the Biochemistry of zooplankton	9.4.74
3. Dr. Marta Vannucci	Sorting Centres	10.9.74

Special Lectures

1. Dr. B. N. Desai, Officer-in-charge, NIO, Bombay, delivered special lectures to Post-graduate classes 1974-75 of South Gujarat University on

Fisheries Biology and Biological Oceanography.

.....delivered lectures to the trainees of Central Institute of Fisheries Education, Bombay,

2. Dr. A. B. Wagh, Scientist, NIO, Bombay, delivered lectures on Marine Zoology to post-graduate students of Bombay University in the academic year 1974-75.

.....gave lectures to the trainees of Central Institute of Fisheries Education, Bombay.

3. Shri P. E. Sankaranarayanan Scientist, NIO, Goa delivered a series of six lectures on oceanographic instrumentation systems at the Electrical Engineering Department, Karnataka Regional College, Surathkal, Mangalore (Dec. 1974).

9. Radio Talks

Speaker	*Date*	*Subject*
Dr. S. Z. Qasim	19-3-1974	Oceanography
Dr. S. Z. Qasim	4-7-1974	Minerals from the Sea

10

publications

10.1 Publications of the Institute

1. Annual Report 1973
1. Quarterly bulletin of the Institute, *Mahasagar, Vol* 6, Nos. 3-4.

10.2 Papers published by staff

Achuthankutty, C. T. and R. A. Selvakumar, 1974. Net for sampling micro and macro zooplankton. *Mahasagar—Bull. natn. Inst. Oceanogr.,* 7 (3 & 4): 208-215.

Ansari, Z. A., 1974. Macrobenthic production in Vembanad lake. *Mahasagar-Bull. natn. Inst. Oceanogr.,* 7 (3 & 4): 204-207.

Ansari, Z. A. and M. D. Rajagopal, 1974. Distribution of mud phosphates in the Cochin Backwater. *Mahasagar-Bull. natn. Inst. Oceanogr.,* 7 (3 & 4): 149-155.

Antony, M. K., D. Panakala Rao and V. N. Sankaranarayanan, 1974. Studies on the monsoonal flow of the Mandovi estuary. *Mahasagar—Bull. natn. Inst. Oceanogr.,* 7 (1 & 2): 69-72.

Balachandran, T., 1974. Dowicil '100' - a fixative-cum-preservative for zooplankton. *Mahasagar—Bull. natn. Inst. Oceanogr.,* 7 (1 & 2) 107-109.

Balachandran, T., 1974. On fixation and preservation of gelatinous plankton. *Mahasagar—Bull. natn. Inst. Oceanogr.,* 7 (1 & 2) : 111-117.

Balachandran, T., 1974. A note on fixation and preservation of calcareous zooplankton. *Curr. Sci.,* 43(5): 153-154.

Balachandran, T., 1974. On methods of collection, handling and storage of zooplankton in tropics. *Curr. Sci.,* 43(5): 154-155.

Balachandran, T. 1974. Phenoxetol as a good sorting medium-cum-preservative for zooplankton in the Tropics. *Curr. Sci.,* 43(12): 380-381.

Balasubramanian, T., 1974. Seasonal variations in chlorophyll-a of some tropical environments. *Mahasagar-Bull. natn. Inst. Oceanogr.,* 7 (3&4): 216-222.

Balasubramanian, T. and M. V. M. Wafar, 1974. Primary productivity of some fringing reefs of south-east India. *Mahasagar-Bull. natn. Inst. Oceanogr.,* 7 (3 & 4): 165-174.

Bhargava, R. M. S. and S. N. Dwivedi, 1974. Diurnal variation in phyto-plankton pigments in Zuari estuary, Goa. *Indian J. mar. Sci.,* 3(2) : 142-145.

Chandrasekharan Nair, K. K., Jacob George and T. S. S. Rao, 1973. Distribution and relative abundance of *Paraphronimidae* in the Indian Ocean. *Indian J. mar. Sci.,* 2(2) : 116-121.

Devassy, V. P., 1974. Observations on the bloom of a diatom *Fragilaria oceanica* Cleve. *Mahasagar—Bull. natn. Inst. Oceanogr.,* 7 (1 & 2) : 101-105.

Devassy, V. P. and P. M. A. Bhattathiri, 1974. Phytoplankton ecology of the Cochin backwaters. *Indian J. mar. Sci.,* 3(1) : 46-50.

D'Silva, C. and X. N. Verlencar, 1974. Toxicity bioassay of urea on two fishes. *Mahasagar—Bull. natn. Inst. Oceanogr.,* 7 (3 & 4) : 171-182.

Dwivedi, S. N., 1974. Multiuses of the coastal zone and marine environment along the west coast of India. *Colloque International sur Eexploitation des Oceans, Bordeaux (France)* 5, Bx Ca 114, 1-22.

Dwivedi, S.N., B.N. Desai, A.H. Parulekar, V. Josanto and M.D. George, 1974. Oil pollution along Gujarat coast and its possible source. *Mahasagar—Bull. natn. Inst. Oceanogr.,* 7(1 & 2): 91-94.

Dwivedi, S. N. and M. R. Menezes, 1974. A note on the morphometry and ecology of *Brachirus orientalis* (Bloch and Schneider) in the estuaries of Goa. *Geobios,* 1 : 80-83.

Dwivedi, S. N. and A. H. Parulekar, 1974. Oil pollution of beaches along Indian coasts. *Proc. I0C-WM0 Symp. & Workshop on Marine Pollution Monitoring (Petroleum),* Washington, D. C, 101-105.

Dwivedi, S. N., A. H. Parulekar, S. C. Goswami, and A. G. Untawale, 1974. The ecology of mangrove swamps of the Mandovi estuary, Goa. *International Symp. Biol. & Management of Mangroves,* Univ. of Hawaii, Honolulu: 112-119.

Fondekar, S.P. and C.V.G. Reddy, 1974. Arsenic content in the coastal and estuarine waters around Goa. *Mahasagar—Bull. natn. Inst. Oceanogr.,* 7(1 & 2): 27-32.

George Peter, 1974. On a new species of *Lopadorhynchus* (Pelagic polychaeta) from the Indian Ocean. *Mahasagar—Bull. natn. Inst. Oceanogr.,* 7(1 & 2) : 95-96.

George Peter, 1974. Distribution of pelagic polychaetes in the north-west Australian sea during Winter. *Indian J. mar. Sci.,* 3;2) : 180-181.

Gopalakrishnan, T.C., 1974. A review of the Copepod *Scqttocalanus securifrons* (T. Scott) and a note on its synonym *Scolecithrix cuneifrons* Willey (Calanoida; Scolecithricidae). *Proc. Biol. Soc. Washington,* 87(26): 273-282.

Gopalakrishnan, T.C, 1974. A note on the occurrence of *Scolecithricella tropica* Grice (Calanoida : *Scolecithricidae*) in the Indian Ocean-a new record. *Mahasagar—Bull. natn. Inst. Oceanogr.,* 7(1 & 2): 97-98.

Gopinathan, C. K. and S. Z. Qasirn, 1974. Mud banks of Kerala: their formation and characteristics. *Indian J. mar. Sci.,* 3(2): 105-114·

Gore, P. S., 1974. Bacteria in the inshore environment at Karwar and Vengurla. *Fish. Tech.,* 11(1): 34-42.

Goswami, S. C. and S. Y. S. Singbal, 1974. Ecology of Mandovi-Zuari-estuaries - Plankton community in relation to hydrographic conditions during monsoon months, 1972. *Indian J. mar. Sci.,* 3(1): 51-57.

Goswami, Usha and S. C. Goswami, 1974. Cytotaxonomical studies on some calanoid copepods. *Nucleus,* 17: 109-113.

Hashimi, N. H., 1974. Selenite crystals in the sediments off Saurashtra coast. *Mahasagar—Bull. natn. Inst Oceanogr.,* 7 (3 & 4): 195-199.

Jacob, P. G. and S. Z. Qasim, 1974. Mud of a mud bank in Kerala, south-west coast of India. *Indian J. mar. Sci.* 3(2): 115-119.

Krishna Kumari, L. and K. Virabhadra Rao, 1974. Life cycle of the pea crab, *Pinnotheres vicajii* Chhapgar, infesting the clam, *Paphia malabarica. Indian J. mar. Sci.,* 3(2): 165-l72.

Lalithambika Devi, C.B. and K. P. Balakrishnan, 1974. Larvae of some flat fishes from a tropical estuary. *Proc. of the symp. on Early Life Histroy of Fish held at Oben, Scotland :* 677-684.

Murthy, P. S. N. and M. Veerayya, 1974. Studies on the sediments of Vembanad Lake, Kerala State. Part III - Distribution and interpretation of bottom sediments. *Indian J. mar. Sci.,* 3(1): 16-27.

Nair, R. R., 1974. Holocene sea levels on the western continental shelf of India. *Proc. Indian Acad. Sci.,* 79(B): 197-203.

Nair, Vijayalakshmi R., 1974. Discontinuity in the larval distribution of phoronida and brachiopoda in the Indian Ocean. *Curr. Sci.,* 43(21): 676-678.

Nair, Vijayalakshmi, R. and H. Krishna Iyer, 1974. Quantitative distribution of copelates, salps and doliolids (Pelagic tunicates) in Indian Ocean. *Indian J. mar. Sci.,* 3(2) : 150-154.

Parulekar, A. H. 1974. Studies on the intertidal ecology of Anjidiv Island. *Proc. Indian natl. Sci. Acad.,* 9B: 611-630.

Parulekar, A. H. and S. N. Dwivedi, 1974. Benthic studies in Goa estuaries. Part I - Standing crop and faunal distribution in relation to bottom salinity and substratum in the estuary of Mandovi river. *Indian J. mar. Sci.,* 3(1): 46-51.

Paulinose, V.T., 1974. Decapod crustacea from the International Indian Ocean Expedition : The species of *Funchalia* (Penaeidae) and their post-larvae. *J. nat. Hist.,* 8: 433-443.

Peter, K. J., 1974. An appraisal of the larval fishes of the Arabian sea. *Seafood Export J,.* 6(6): 47-49.

Peter, K. J., 1974. Seasonal variation of Ichthyoplankton in the Arabian Sea in relation to Monsoon. *The early life history of fish.* J. H. S. Blaxter (Ed), Springer-Verlag, Oben, Scotland.

Purushan, K. S. and T. S. S. Rao, 1974. Studies on upwelling off the south-west coast of India. *Indian J. mar. Sci.,* 3(1) : 82-84.

Purushan, K. S., T. Balachandra Menon and M. Sakthivel, 1974. Zooplankton abundance off the Kerala Coast during February and April 1970. *Mahasagar—Bull. natn. Inst. Oceanogr.,* 7 (3 & 4) : 156-164.

Qasim, S. *Z.,* 1974. Ocean research in India. *Colloque International sur l'exploitation des Oceans, Bordeaux (France).* 5, Bx Po 7, 1-3.

Qasim, S. Z. 1974. Conditions for the protection of marine environment. *Colloque International, sur l'exploitation des Oceans, Bordeaux (France).* 5, Bx Ca 310, 1-15.

Qasim, S. Z., and D. C. V. Easterson, 1974. Energy conversion in the shrimp, *Metapenaeus monoceros* (Fabricus), fed on detritus. *Indian J. mar. Sci.,* 3(2) : 131-134.

Qasim, S. Z., P. N. Nair and P. Sivadas, 1974. Oil spill in the Laecadives from the oil tanker *'Transhuron'. Mahasagar—Bull natn. Inst. Oeeanogr.,* 7(1 & 2): 83-89.

Qasim, S. Z., Sumitra Vijayaraghavan, K. J. Joseph and V. K. Balachandran, 1974. Contribution of microplankton and nannoplankton in the waters of a tropical estuary. *Indian J. mar. Sci.,* 3(2)146-149.

Rajagopal, M. D., 1974. On assimilation and regeneration of phosphorus in two different environments. *Mahasagar—Bull. natn. Inst. Oeeanogr.,* 7(3 & 4): 142-148.

Rao, Ch. M., P. S. N. Murty and C. V. G. Reddy, 1974. Partition patterns of copper in the sediments of the western continental shelf of India. *Indian J. mar. Sci.,* 3(1): 12-15.

Rao, D. Gopala and T. C. S. Rao, 1974. Textual characteristics of sediments of Mormugao Bay, central west coast of India. *Indian J. mar. Sci.,* 3(2) : 93-98.

Rao. K. Kameswara, 1974. Ecology of Mandovi and Zuari estuaries : Distribution of foraminiferal assemblages. *Indian J. mar. Sci.,* 3(1) : 61-66.

Rao, K. Kameshwara, 1974. The comparative toxicities of organophosphorus and carbamate pesticides. *Mahasagar—Bull. natn. Inst. Oeeanogr.,* 7 (1 & 2) : 79-82.

Rao, L. V. G., Thomas Cherian, K. K. Varma and V. V. R. Varadachari, 1974. Hydrographical features of the inner shelf waters along the central west coast of India during winter, spring and summer. *Mahasagar—Bull. natn. Inst. Oeeanogr.,* 7(1 & 2): 15-26.

Sakthivel, M. 1974. A new species of *Cresseis* (Gastropoda, mollusca) from the Laccadive seas. *Curr. Sci.,* 43:619-620.

Sakthivel, M. and P. Haridas, 1974. Synchronisation in the occurrence of *Trichodesmium* bloom and swarming of *Cresseis acicula* Rang (Pteropoda) and *Penilia avirostris* Dana (Cladocera) in the area off Cochin. *Mahasagar—Bull. natn. Inst. Oeeanogr.,* 7(1 & 2): 61-67.

Sankaranarayanan, P. E., 1974. A wide band Sanky phase shifter for phase sensitive detectors. *Int. J. Electronics,* 36(1): 35-40

Sankaranarayanan, P. E., 1974. Constant amplitude ramp generation with operational amplifiers. *Electronic Engg.*, 46 (559): 19.

Santhakumari, V. and N. Balakrishnan Nair, 1974. The commensalic ciliates of *Nausitora hedleyi*: Survival in seawater in relation to infectivity. *J. mar. biol. Ass. India*, 14(2): 872-875.

Saraswathy, M. and N. Balakrishnan Nair, 1974. The influence of salinity on tropical estuarine shipworm *Nausitora hedleyi* Schepman. *Hydrobiologia*, 44: 397-412.

Sen Gupta, R. and V. N. Sankaranaraynan, 1974. Pollution studies off Bombay. *Mahasagar—Bull. natn. Inst Oceanogr.*, 7(1 & 2): 73-78.

Simon John, 1974. A note on the abnormality in a crab larva. *Mahasagar—Bull. natn. Inst. Oceanogr.*, 7(1 & 2) : 99-100.

Srivastava, P. S. and P. G. Kurup, 1974. An experimental study for the determination of frictional resistance on a model boat under different mud concentrations. *Mahasagar—Bull. natn. Inst. Oceanogr.*, 7 (3 & 4) : 183-188.

Sumitra Vijayaraghavan, K. J. Joseph and V. K. Balachandran, 1974. Preliminary studies on nannoplankton productivity. *Mahasagar — Bull. natn. Inst Oceanogr.*, 7(1 & 2): 125-129.

Swamy, A. S. R. and Ch. Madhusudana Rao, 1974. Boron in the modern deltaic sediments of the Krishna river and its offshore region, east coast of India. *Mahasagar—Bull. natn. Inst. Oceanogr.*, 7 (3 & 4) : 182—194.

Thomas Cherian, L. V. Gangadhara Rao and K. K. Varma, 1974. Hydrography and suspended sediment load of the oceanic and estuarine waters adjoining Mormugao Harbour during early summer. *Indian J. mar. Sci.*, 3(2): 99-104.

Untawale, A. G. and S. Ayyappan Nair, 1974. Ecology of sand dune vegetation in relation to beach stability at Miramar, Goa. *Mahasagar—Bull. natn. Inst. Oceanogr.*, 7(1 & 2) : 41-51.

Varadachari, V. V. R., C. S. Murty and V. N. Sankaranarayanan, 1974. Physical characteristics of waters and water mass off the west coast of India during late spring. *Indian J. mar. Sci.*, 3(1): 1-4.

Veerayya, M. and P. S. N. Murty, 1974. Studies on the sediments of Vembanad Lake, Kerala State, Part III - Distribution and interpretation of bottom sediments. *Indian J. mar. Sci.*, 3.(1): 16-27.

Wafar, M. V. M., 1974. Nematocysts in four species of corals. *Mahasagar—Bull. nain. Inst. Oceanogr.,* 7(1 & 2): 119-123.

Wagle, B. G. and F. Almeida, 1974. A mega-porphyritic dolerite intrusion at San Pedra, Goa, *Curr. Sci.,* 43(12): 378-380

10.3 Popular articles and reviews

Alagarswami, K. and S. Z. Qasim, 1974. What are pearls and how are these produced? *Seafood Export J.,* 6(1) : 1-10.

Bhargava, R. M. S., 1974. Proceedings of the Symposium on Living Resources of the Seas around India, CMFRI, Cochin (India). *Mahasagar—Bull. natn. Inst. Oceanogr.,* 7(1 & 2): 132-133 (Book review).

Bhatt, V.S., 1974. World Fisheries - Alarms and new hopes. *Seafood Export J.,* 6(2) : 13-19.

Bhatt, V. S., 1974. Future World Fisheries : Exploitation at the lower trophic level. *Fisheries and Sea Wealth,* 1(1): 21-25.

Bhatt, V. S. 1974. Fishes of Kuwait by Batsuzo Kuronuma and Yoshitaka Abe, 1972. *Mahasagar—Bull. natn. Inst. Oceanogr.,* 7(1 & 2): 131-132 (Book Review)

George, M. J., 1974. International Indian Ocean Expedition Plankton Atlases of the Indian Ocean. *Seafood Export J.,* 6(1): 109-113.

Gopalan, U. K., 1971. Seafood from human waste. *Seafood Export J.,* 6(5) : 33-36,

Jacob, P. G., 1974. Fish silage - a valuable product from fish waste and trash fish. *Seafood Export J.,* 6(12): 39-42.

Kurup, P. G., 1974. Indian Ocean. *Vijnana Kairali,* 5(10) : 1094-95. (Book review in Malayalam).

Narayana Swamy, G., 1974. The Call of Neptune. *Harpa Goesa.* 6: 29-30.

Narayana Swamy, G., 1974. The Tides (in Malayalam) *Sastragati,* 38: 37-43.

Parulekar, A. H., 1974. Aquaculture-the farming and husbandry of freshwater and marine organisms. By John. E. Bardach, John H. Ryther and William O. Mclariney. Wiley Interscience. *Mahasagar—Bull, natn Inst. Oceanogr.,* 7 (3 & 4) : 226-228. (Book Review).

Sen Gupta, R., 1974. Marine Chemistry. Edward D. Goldberg (Ed.) The Sea, Volume 5 : Wiley Inter Science. *Mahasagar—Bull. natn. Inst. Oceanogr.*, 7 (3 & 4) : 223-225 (Book Review).

Thomas Cherian, 1974. The quest within the blue. *Horpa Goesa*, 5(10) : 1094-1095.

Thomas Cherian, 1974. Fresh water from Iceberg (in Malayalam). *Vijnana Kairali*, 6(5): 422-425.

Wafar, M. V. M. 1974. Proceedings of the Symposium on Corals and Coral Reefs (Mukundan, C. and C. S. Gopinadha Pillai (Eds.). *Mahasagar—Bull. natn. Inst. Oceanogr.*, 7(1 & 2): 134-136. (Book review).

10.4 Reports prepared by the staff

Sl. No.	*Contributors*	*Report*	*Year*	*Sponsored by*
1	A. H. Parulekar, A.G.Untawale, Surendra Kumar and S. N. Dwivedi	Feasibility report on Anjidiv Island for developing as a tourist resort.	1974	Govt. of Goa, Daman & Diu.
2	S.N. Dwivedi, R.M. Dhawan and V.K. Dhargalkar	Feasibility report for the development of Sinquerim beach as a tourist resort.	1974	Indian Resort Hotels, Bombay.
3	S.N. Dwivedi, P.S. Gore, R.M.S. Bhargava and S.R. Rajguru	Feasibility report on the development of a tourist resort at Siridao beach, Goa.	1974	M/s V. S. Dempo & Sons and Govt. of Goa, Daman & Diu.
4	S.Z. Qasim and V.V.R. Varadachari	National report for India on research activities in Physical Oceanography (1971-74).	1974	National Institute of Oceanography, India.
5	Planning & Data Division	Initial Report and Data File of INS *Darshak* Oceanographic Expedition.	1973-74	
6	V. S. Bhatt	Status report of Industrial Liaison, Information and Extension Services.	1974	
7	H.N. Siddiquie, R.B.Whitmarch, O.E. Weser and D.A. Ross.	Initial Reports of the Deep Sea Drilling Project, Vol.23 (Colombo, Ceylon to Djibouti, F. T. A. I.) National Science Foundation U. S. Govt. Printing Office, 1180 pp.	1974	National Science Foundation, National Ocean Sediment Coring Programme, U.S.A.

Sl. No.	*Contributors*	*Report*	*Year*	*Sponsored by*
8	H.N. Siddiquie and T.K. Mallick	Report on the investigation of the calcareous sand deposits in the lagoons of the Laccadives. Rep. Geol. Surv. Ind., 30 pp.	1973	
9	M.G. Anantha Padmanabha Setty	Summary of the contributions to Indian Micropalaeontology and Stratigraphy by the National Institute of Oceanography (CSIR).	1974	

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 :

A. Headquarters

	Telephone Number	*Telegraphic Address*
National Institute of Oceanography Post N.I.O. Dona Paula, Goa		
1. Physical Oceanography Division	2923	OCEANOLOGY PANJIM
2. Chemical Oceanography Division	2923	—do—
3. Geological Oceanographic Division	2923	—do—
4. Biological Oceanography Division	2923	—do—
5. Data and Documentation Division	2923	—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	—do—	—do—
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