NATIONAL INSTITUTE OF OCEANOGRAPHY GOA-INDIA

ANNUAL REPORT

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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 year 1976 has been significant to the Institute for the following reasons :

(a) The Institute acquired its first research vessel and commissioned it for oceanographic research. In all. 13 cruises were undertaken in the Arabian Sea and Bay of Bengal and as a result considerable information was gathered on the seas around India.

(b) The Institute carried out a substantial amount of sponsored research during the year with a total revenue of Rs. 37.5 lakhs which amounts to about 25 per cent of the budgeted expenditure of the Institute. The sponsored projects, related to various types of surveys in the sea. have opened new avenues for the utilization of indigenous technology available at the Institute. Some of the important sponsored projects are: (i) the survey of pipeline route from Bombay High to Bombay for the Oil and Natural Gas Commission, (ii) hydrographic survey and water quality studies in and around Bombay for the Bombay Municipal Corporation, (iii) hydrographic features off Karwar and Mangalore for the Ballarpur Industries and Mangalore Fertilizer Ltd. respectively, to determine suitable points for the discharge of effluents.

(c) The R & D activities under 18 institutional projects were intensified during the year to develop the essential know-how to be used by the industries and public sector undertakings.

A break-through was achieved in the rope culture of green mussels in Goa where growth rate was accelerated by 60 per cent. The annual production achieved was as high as 60 kg/m^2 against 1 kg/m^2 under natural conditions.

New grounds of prawns were located along the east coast of India. An improved solar still was developed for desalination of sea-water which gave a high yield of freshwater with a low initial cost

(d) The activities of the two Regional Centres of the Institute at Cochin and Bombay were reorganised and a new Regional Centre was established in Waltair to cater to the needs of the east coast of India (Bay of Bengal). A new Ocean Engineering Division was also started in the Institute during the year.

(e) The Institute provided essential facilities to academic and research institutions in the country and organized workshops and symposia on important subjects such as project management in CSIR laboratories, navigation in oceanography, bioenergetics and warm water

zooplankton. The last symposium was sponsored by UNESCO/SCOR.

(f) The construction of a tower to accommodate storm/cyclone warning radar was also started. This marks the beginning of the future collaboration between NIO and India Meteorology Department (IMD) which will provide the radar and manpower at their own cost.

(g) The Institute actively participated in the international matters related to oceanography. The Director, NIO was nominated as one-man delegation to the Executive Council of Intergovernmental Oceanographic Commission for its meeting held in Bergen, Norway. He was elected Chairman of the Working Committee on Training, Education and Mutual Assistance (TEMA) of IOC.

(h) The Institute also completed the first phase of Project sponsored by the United Nations Environment Programme (UNEP).

DIRECTOR

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research activities

2.0 Oceanographic cruises of Research Vessel 'Gaveshani'

During 1976. R.V. *Gaveshani* made 13 cruises including two trial cruises and four other cruises which were devoted to sponsored projects. The vessel covered more than 16000 line kilometres and occupied 291 stations for oceanographic investigations. A summary of the work done in different cruises is as follows :

First cruise

The first cruise comprised of two trial cruises for testing the oceanographic equipment and the performance of the vessel. The first trial cruise was upto Angria Bank. The geophysical equipment, specially the magnetometers and sparker were tested along the cruise track and all physical, chemical, biological and geological equipments were tried at different stations during the cruise. The trials of life boats and work boats were also carried out.

The second trial cruise which was undertaken off Goa upto a depth of about 2000 m was also used for testing several other equipment. The two cruises clearly showed that some improvements were necessary in the working system of the ship and the necessary modifications were made after each cruise.

Second cruise

After the two trial cruises, the first regular cruise of 17 days was undertaken to Bombay High and Gulf of Kutch. This cruise was mainly geological and geophysical in nature and was devoted to the study of bathymetry, magnetics, sub-bottom profiling and collection of bottom samples of the area.

Hydrographic casts, current measurements and sound velocity observations were also made at several stations. Twelve hour observations on current in the Bombay High area were undertaken en route to Gulf of Kutch. In all, 61 stations were covered during this cruise. Of these, 34 stations were along the Goa and Bombay coasts and 27 stations were in the Gulf of Kutch. Different types of samples, snapper, corer, dredges and grabs were tried and adequate bottom samples were obtained. Huntec Hydrosonde was also operated during the cruise along selected tracks. Several runs by sub-bottom profiling system were made in the Gulf of Kutch and the quality of records was found to be good with penetration up to 59 m into the sea bed. According to the data, the rocks occurred along the eastern part of Gulf of Kutch, whereas the other areas were devoid of rocks. The sediment thickness in the eastern Gulf was of the order of 20 m. Magnetic intensity was

recorded along 800 line km of the cruise track.

Investigations on chemical and biological oceanography included the measurements of trace elements, nutrients, C^{14} uptake, zooplankton sampling and benthic sampling at different stations during the cruise.

Third—Sixth cruises for survey of proposed submarine route from Bombay High to Bombay

A survey of the 160 km long pipeline route from Bombay High to Bombay (BFL-Bombay Floating Light) was carried out during 3rd, 4th, 5th and 6th cruises by R.V. *Gaveshani.* These four cruises were undertaken from March 21 to May 24 along the proposed oil pipeline route. The cruises were carried out at the request of Oil and Natural Gas Commission.

Third cruise

The third cruise lasted for 11 days from March 21 to April 1, 1976 and was devoted to the collections of physical and chemical data such as currents, temperature, salinity, nutrients and sound velocity. In addition, biological data on primary productivity, pigments, nannoplankton. particulate organic carbon, phytoplankton, zooplankton, benthos were also collected at different stations. Some useful meteorological data were also obtained.

Fourth cruise

The fourth cruise was devoted to position fixing by Shoran, bathymetry, side scan sonar survey and sub-bottom profiling. The 21-day cruise continued from 11 April to 1 May 1976. From the findings of this cruise, recommendations were made for further work in the next cruises.

Fifth cruise

During the fifth cruise, the survey was continued along several lines. Some of the lines were resurveyed. It was observed that the sea bed between Bombay High oil field and west of Bassein oil field is largely covered with sand. It also has a thin clay cover with occasional thick patches of clay in some areas. The area showed an uneven topography marked by small scale topographic irregularities and sand waves. Further east, towards the Bassein oil field, the sand was found overlain by clay which attained a maximum thickness of 20-25 metres and generally represented a smooth topography.

Sixth cruise

The sixth cruise was a multi-disciplinary in nature and included geologists, chemists and biologists. During this cruise, grab, snapper and core samples were collected along the proposed pipeline route from Bombay High to Bombay. The other objective of the cruise was to conduct some cross profile surveys and also of the well-heads with the side scan sonar in the Bombay High area. Core samples were taken for soil tests and for sedimentoiogical, microbenthic and microbial studies. Surface and bottom water samples were analysed on the ship itself for dissolved oxygen, pH, Eh and conductivity. Interstitial water

was extracted from the sediments and analysed for inorganic phosphate, nitrate, nitrite, pH and conductivity. This cruise was the last in the series for the survey of submarine pipeline route.

Seventh cruise

The seventh cruise was planned to study the oceanographic features of the northern Bay of Bengal and coastal waters along the east coast of India, from Calcutta to Visakhapatnam. The cruise started on 24 August and ended on 2 September 1976. In all, 24 stations were worked during the cruise for circulation of water, thermocline characteristics, water masses, mixing, upwelling and light and sound propagation for a better understanding of the oceanographic characteristics of the region. Data on primary productivity, nutrients and trace elements were also collected.

Eighth cruise

This cruise was undertaken in the shelf and adjacent waters along the east coast of India from Visakhapatnam to Madras and covered 52 stations

Hydrographic casts were made at 45 stations. Of the 45 casts. 15 were shallow casts (200 m). and 30 were deep casts (upto 1500 m).

Water samples were collected for the various chemical analyses such as salinity, pH, dissolved oxygen, nutrients and alkalinity. Seventeen shallow BTs (0-14 m) and 29 deep BTs (0-275 m) were taken at all the stations barring a very few shallow stations where the depth was less than 35 m. Work on biological oceanography included the measurement of C^{14} uptake, zooplankton sampling and the collection of benthos at different stations. Meteorological data on barometric pressure, wind (direction and speed), air temperature, humidity, sea state and sea surface temperature were also collected. Work on geological oceanography included the physico-chemical nature of the bottom sediments. During the cruise, high concentration of the larvae of prawns and lobsters were collected in the shelf and slope regions, between Kakinada and Machilipatnam.

Ninth cruise

This cruise was undertaken in the shelf and adjacent waters of the Bay of Bengal and lasted 10 days.

Hydrographic casts were made at 14 stations, of which 8 were shallow (below 200 m). Four shallow BTs (0-140 m) and 11 deep ones (0-275 m) were operated at all stations. Other work included the measurements of nutrients, dissolved oxygen, trace elements. C^{14} uptake, particulate organic matter, phytoplankton counts, zooplankton biomass and benthos. Data on suspended particulate matter and on the physico-chemical nature of the bottom sediments and meteorological data on barometric pressure, wind, air temperature, humidity, sea state and sea surface temperature were also collected.

In this cruise also, rich concentrations of the larvae of prawns and lobsters were obtained in the sea off Pondicherry The area offers a good potential resource for prawns and lobsters and demand further

Tenth cruise

This cruise was along the south west coast of India in the Lakshadweep Sea. A total of 32 stations were occupied and at every station BT observations, hydro - graphic cast and plankton hauls were taken. At one station, between Kalpeni and Andreth islands, several adults of shrimps including gravid females of various sizes were found in all of the plankton hauls, from 500 m to the surface. At a depth of 500 m at a station in the shelf-edge, a heavy load of suspended material was observed in the filtered sample. Bottom samples around the abondaned oil Tanker *"Trans Huron"* were also collected near Kiltan Island.

Eleventh cruise

After the completion of 10 cruises, discussions were held on various electronic systems and operational problems. It was decided to have flexibility in the cruise programmes so that sufficient time could be allotted for getting acquainted with the operation of the equipment to calibrate the systems, particularly the laboratory salinometers and install CTD System on *Gaveshani.*

Thus this cruise was planned from 7-11 November 1976 and the CTD system was tested from 10 m to 1000 m depth. At each station, the Rosette sampler with the sensors were lowered and records of salinity, temperature were obtained as a function of depth. At the completion of this cruise, the scientists fully mastered the working of CTD system.

Twelfth cruise

This cruise was of 14 days duration from Marmugao to Port Okha in the shelf region of the north-west coast of India.

The work consisted of meteorological observations, bathythermograph data, hydrographic cast, operation of CTD system, zooplankton collection from the Indian Ocean Standard Net and phyto-plankton counts. Samples from different depths were also collected for the estimation of urea in sea water. Collections for the determination of macrofauna, microfauna and organic carbon in the sediments were also made.

Thirteenth cruise

This cruise was conducted from 7-18 December 1976. In all, 29 stations were worked along the west coast of India, from Marmugao to Cape Comorin.

At each station, hydrographic cast, BT observations, plankton hauls, snapper samples for collections of benthos were made. Data were collected with a view to determine the seasonal and spatial variatitns of mixed layer, thermocline characteristics and to assess the biological productivity potentials at various trophic levels.

Off Trivandrum coast, mortality of fish belonging to the genus *Balisters* was noticed which was associated with patches of *Trichodesmium* bloom. A special station *was* selected in this area and data on environmental parameters were collected to investigate the causes of fish mortality.

Preliminary findings

The preliminary findings of different cruises are as follows :

Certain areas of the Gulf of Kutch have uneven and rugged topography. This may be due to outcrops of various types of limestones, some of which are probably phosphate bearing. Although the phosphate concentration in the limestones is low for economic exploitation (about 1%) it is considerably higher than the average concentration of phosphate normally occurring in the shelf sediments.

In the area, from Bombay High to Bombay, currents showed periodic reversal with the tides at all the depths surveyed. Thermal structure also showed a small variation with depth.

A general warming of the surface waters from north to south in the Bay of Bengal was seen in August-September. Surface nutrients were quite low. Primary productivity and phytoplankton pigments were also low. Zooplankton collections from IOSN showed very high concentrations of prawn larvae between Kakinada and Machilipatnam and off Pondicherry. Lobster larvae were also present in substantial quantities in the collections. In the Lakshadweep Sea, decapod larvae and post-larvae of shrimps (deep sea prawns) were found in abundance.

In the Cape Comorin region, low concentrations of dissolved oxygen were observed at shallow depths (150 m). Mortality of fish was noticed in an area off Trivandrum coast associated with patches of *Trichodesmium* bloom.

A detailed report based on 3rd, 4th, 5th and 6th cruises of *Gaveshani* was prepared and submitted to the Oil and Natural Gas Commission.

2.1

physical oceanography

2.11 Studies on ocean atmosphere interaction with special reference to seas around India *(Project No. 701)*

1. Energy exchange between the sea and the atmosphere
2. Prediction of storm surges at various places along the east coast of India
3. Studies on wind driven circulation in the Indian Ocean

2.12 Studies on physical processes occurring in the seas around India *(Project No. 702)*

2.13 Studies on land-sea interaction and nearshore circulation with application to coastal zone management *(Project No. 703)*

1. Studies on beaches of Goa
2. Studies on the shoreline and the adjoining sea at Loliem, Goa
3. Oceanographic survey off Narara Bet, Gulf of Kutch
4. Hydrographic survey off Bombay
5. Hydrographic studies in the inner harbour, Cochin
6. Oceanographic studies off Trivandrum

The main activities of the Physical Oceanography Division during the period undar report were to have the oceanographic survey of the shelf and adjoining areas off the Indian coast on board *R.V. Gaveshani* for studying the physical processes. The Division also entered into a new phase of development during this period by initiating work on coastal and ocean engineering and building up of capabilities in this field to achieve short and long term objectives of the Institute in this important area. The work in progress and findings under each project are as follows :

2.11 Studies on ocean atmosphere interaction with special reference to seas around India

Under this project, work on the development of an improved model wave energy oscillator has been accelerated. Collection of oceanographic and meteorological data at Dona Paula Jetty at synoptic hours as part of IGOSS programme were continued during the year. These can be summarised as follows:

1. Energy exchange between the sea and the atmosphere

(a) Making use of the facilities available during the survey in the Gulf of Kutch, the nature and variations of small scale features in the vertical temperature and salinity structures were studied. It was found that surface temperature undergoes a diurnal variation, the fluctuations in temperature and salinity are smaller during the neap tides as compared to those during the springs and the fluctuations in temperature and salinity do not strictly coincide with the tides. An examination of the relevant factors indicated that the large tidal range associated with the exposure of the intertidal flats, the evaporation of water and the heating determine the observed micro-fluctuations in the vertical structure of temperature and salinity.

(b) To understand the phenomenon of lowering of the sea surface temperature during the monsoon season, an analysis of bathythermograms in the zonal belt at 10°-15°N was carried out for the months of May, June and July. These studies revealed that during May and June, the sea surface temperatures are quite high. In July, a lowering of SST ranges from 1°C to as much as 4.5°C in certain squares. An analysis of the relevant factors showed that the effects of spreading of upwelled water, a strong development of the surface layer by the wind action coupled with the disappearance of thermocline are the probable causes.

(c) Under the investigation entitled 'advection-diffusion phenomenon in the Indian Ocean', a comprehensive study of the hydrological characteristics and the transequatorial transport in the Western Indian Ocean was carried out. It was found that the salinity minimum in the Antarctic Intermediate Waters progressively increases from less than 34.5%O at 26°S to greater than 34.8 %o at 10°S and the thickness of the salinity minimum layer increases to north. This is conspicuously absent over most of the equatorial region. The thickness of the sub-tropical water decreases towards the north. The studies further revealed that the south equatorial current, as it approaches Malagassy, splits into three branches. The northern and southern branches merge with the clockwise and anticlockwise cells respectively. While the central branch flows towards the African Coast and enters the Somali Basin causing the salinity minima.

2. Prediction of storm surges at various places along the east coast of India

Under this investigation, evaluation of storm surges at Sagar, Paradeep and Visakhapatnam has been made during the periods of intense cyclonic activity in 1971 and 1972 in the Bay of Bengal. Further analysis is in progress.

3. Studies on wind driven circulation in the Indian Ocean

The computation of wind stress in the sub-tropical Indian Ocean was continued. Curl of the wind stress for the period March-June and September-November between 5°N and 5°S was evaluated for studying the influence of

the wind distribution on the equatorial jet in the Indian Ocean. The work is in progress.

2.12 Studies on physical processes occurring in the seas around India

Major activity under this project has been the collection of field data through several oceanographic cruises on board, the newly commissioned research vessel *Gaveshani*. Studies on the thermal structure and circulation in the north-western Indian Ocean with the ISMEX oceanographic data were completed. A study on spectral characteristics of temperature and salinity in the depth domain was also initiated. Investigations on the optical properties of the waters in the nearshore and offshore regions of Goa are in progress.

Field data were collected on board R.V. *Gaveshani* during ten oceanographic cruises in the continental shelf and the adjoining areas of the seas off the Indian Coast. In all, about 240 stations were occupied over the western continental shelf from Goa to Okha, the Laccadive Sea and the eastern continental shelf and the adjoining sea. At each of these stations, bathythermograph and hydrocast were operated in order to obtain information on various physical parameters like temperature, salinity and density. At 39 stations, CTD system was operated and continuous records of temperature and salinity against depth were obtained. The data are being processed and analysed for investigating the various physical processes occurring in these areas.

Preliminary examination of the data indicated the presence of isothermal layer on the western shelf from Goa to Okha during February-March. During September, in the shelf and the adjoining waters between Visakhapatnam and Palk Strait, a general increase of surface temperature from north to south and a mixed layer of thickness varying between 20 m and 50 m were observed. During December, in the sea off the coast between Mormugao and Trivandrum, nearly isothermal shelf waters with temperature around 29°C and mixed layer with thickness varying from 50 to 75 m were encountered.

Studies on the thermal structure and circulation from the data collected during the Indo-Soviet Monsoon Experiment revealed some interesting features. The tongue of cold water of the Somali upwelling, located in May, in the south-western Arabian Sea, extends northward and eastward and is present throughout the central Arabian Sea between 11°N and 15°N during June-July. The anti-cyclonic vortex located in the central part of the southern Arabian Sea between 8°N and 12°N in May, intensifies and extends southwards significantly by June-July in association with the spreading of upwelled water from the Somali coast into the central Arabian Sea.

Using the continuous profiles of temperature and salinity with depth (obtained with STD Recorder) for a few selected stations in the northern Arabian Sea, a study on the spectral characteristics of these parameters has started. For this purpose, a computer

programme with the option to choose high pass filters of length up to 50 points was developed. Calculation of spectra of temperature, salinity and delta$_t$ was completed for a few stations. Preliminary results indicated the presence of two to three peaks in the spectrum.

As a part of the studies on the optical properties of the waters off the Goa coast, photometric studies at 6 stations along a section (near 12/m line) off the central Goa coast (from Baga to Velsao) for a period of one year were conducted. Preliminary examinations of the data indicated that the waters in this area exhibit variations in the attenuation coefficient over a wide range (from about 0.1 per metre soon after the monsoon to about 2.9 per metre before the onset of the monsoon). Since September 1976, observations are being carried out along a section running perpendicular to the coast from Dona Paula upto 60 m line to study the seasonal variation in optical properties of water.

2.13 Studies on land-sea interaction and nearshore circulation with application to coastal zone management

Under this project, studies were carried on several beaches of Goa. Findings of the studies carried over are given here as under :

1. Studies on the beaches of Goa

Studies on the changes that take place on the beaches of Goa together with the wind and wave data indicated that the erosion-accretion transition was dependent upon the time derivatives of wave heights. Erosion and accretion occurred during the growth and decay stages of the waves. Over a time scale of a tidal cycle, the beaches showed depleting tendencies when acted upon by the rising stages of the tide together with the locally generated waves due to strong sea breeze. On a time scale of seasons, the loss of beach sediments was considerable when the wave energy was spread over a wide spectrum and relatively less when the energy is concentrated at a particular frequency.

2. Studies on the shoreline and the adjoining sea at Loliem, Goa

(a) Beach profile studies at Loliem, Goa and studies on the wave refraction along a 35 km stretch of shoreline from Cape Ramas to Karwar revealed some interesting features. The beach at Loliem was found to undergo erosion from the middle of May to August and deposition from September to November. It was relatively stable from December to first half of May. Maximum sand cover was observed during April when the width of the beach was about 40 m. Most of the sand cover was removed by the end of June. At Loliem, during the southwest monsoon season, swell waves of about 3 m were frequent and the predominant directions of wave approach were between 240° to 330° and the predominant period between 5 second to 11 second. From the wave refraction studies. Loliem is found to be located in a region of diverging littoral currents for waves of all periods approaching from 240°. Wave of 5 second to 8 second

periods approaching from 270° are found to cause southerly transport while those with higher periods cause divergence. In respect of waves approaching from 300° only 5 second period waves are found to cause uniform southerly transport, while those of other periods cause diverging littoral currents.

3. Oceanographic survey off Narara Bet, Gulf of Kutch

From the analysis of data it was found that water in the Gulf region gets warmer from about 21°C to 28°C whereas salinity increases from 35.8‰ to 37.0‰ during this period. Considerable changes in these parameters occur during the month of March. The silt charge and the transparency of water vary rather irregularly and bear no correlation with the tide. The water column is nearly homogeneous with depth and the microstructure of the water is primarily a result of evaporation and the tidal condition.

4. Hydrographic survey off Bombay

In the month of March, one hourly measurements of temperature and currents at the surface, sub-surface levels and the periodic collection of water samples from different depths for the chemical analysis were made for 48 hours at each of the four stations located along the proposed submarine pipeline route from Bombay High to Bombay. The salient features observed during this study are given below :

The surface temperature varied between 25.2°C and 28.6°C. The temperature distribution showed two isothermal layers each of 15 to 20 m thick at the surface and near the bottom. The near bottom temperatures varied from 24.7°C at the farthest offshore station to 27.5°C at the station close to the shore. The currents showed a tidal behaviour super-imposed on a net northerly flow and the maximum speeds were of the order of 50 cm/sec. The salinity of the waters varied within a narrow range of 35.1 ‰ to 35.6 ‰.

5. Hydrographic studies in the inner harbour Cochin

Extensive field data on the hydrographic parameters, sediment load and currents were collected from thirty stations in the inner harbour of Cochin Port for a period of one year and studied. In the monsoon season, there was a strong salinity gradient from the bottom to the surface during the flood tide. This feature was absent during the ebb. Salinity at all levels increased gradually as the post-monsoon season advanced and attained maximum value exhibiting homogeneous character during the pre-monsoon months. During the monsoon and post-monsoon seasons, a two layer flow became evident during the flood tide. Typical values at the harbour mouth during the flood tide were 100 cm/sec downstream in the surface layer and 60 cm/sec upstream near the bottom. However, during the ebb tide, downstream flow was predominant in the monsoon and post-monsoon seasons. The suspended load was found to be highly variable. At the harbour entrance, the suspended sediment load (average

for one year) showed a progressive increase from 25 mg/l at the surface to 45 mg/l near the bottom.

6. Oceanographic studies off Trivandrum

These studies were started in November, 1976 in connection with the determination of a suitable discharge point and laying a submarine pipeline for the disposal of the effluents into the sea from a factory at Trivandrum. Monthly observations on beach profiles, beach sediment characteristics, littoral drift, currents and hydrographic parameters in the adjoining sea are being carried out.

2.2

chemical oceanography

2.21 Chemical studies in the coastal and offshore waters in the Arabian Sea and the Bay of Bengal
(Project No. 301)

1. Chemistry of pharmacologically active components from marine flora and fauna.
2. Cycle of phosphorus, nitrogen and some biologically active trace metals in the estuarine, inshore and offshore waters along the west coast of India.
3. Studies on the interrelationship between nutrients, oxygen and the biochemistry of plankton.
4. Distribution of oxygen in the offshore and coastal waters of the Arabian Sea and Bay of Bengal.
5. Carbon dioxide system in the offshore and coastal waters of the Arabian Sea and Bay of Bengal.
6. Carbohydrates in the coastal and estuarine waters of Goa.
7. Arsenic cycle in the coastal and offshore waters of Goa.
8. Studies on calcium phosphate saturation in sea water.
9. Regeneration of nutrients from plankton and sediments in the marine and estuarine environments.
10. Calcium carbonate precipitation in the sea and estuarine waters.

2.22 Investigations on desalination of sea water
(Project No. 303)

Research activities in the Chemical Oceanography Division during the year 1976 are related to three projects of which "Protection of marine environment and monitoring of pollutants" forms a part of the Task-Force No. 101 and has been given later on in this report. The various investigations carried out during the year under report pertain to:

(a) the distribution and interrelationship of inorganic and organic constituents of the estuarine, coastal and offshore waters of the Arabian Sea and Bay of Bengal; (b) chemistry of pharmacologically active components of marine plants and animals; (c) chemical aspects of marine pollution; and (d) on the design and improvements of solar desalination units:

The following are the important features of the investigations:

2.21 Chemical studies in the coastal and offshore waters in the Arabian Sea and the Bay of Bengal

Chemical studies were conducted during the regular oceanographic cruises of R.V. *Gaveshani* in coastal and offshore areas of the Arabian Sea and Bay of Bengal. The data are being processed to understand the horizontal and vertical distribution and interrelationships of various chemical constituents in relation to physical processes and biological productivity of the sea.

Preliminary analysis of the data indicates that during February to March the waters in Gulf of Kutch and off Bombay have high concentrations of nutrients such as phosphates and nitrates. Maximum concentrations were observed in the Gulf of Kutch. Metal, concentrations (copper and zinc) in the surface waters off Bombay coast were 2-10 folds higher than in the Gulf of Kutch.

A study of the distribution of dissolved silicon in the Arabian Sea. between Gulf of Kutch and Cape Comorin, was made during November-December. In the offshore regions, deep waters up to 1500 metres showed high concentrations of silicate and the surface waters were depleted of the same probably due to its utilization by phytoplankton. The surface waters of the inshore regions showed relatively higher values of silicon indicating the influence of land drainage.

The nutrient concentrations along the east coast of India, in general, were relatively low during the period August-October, especially in the upper 50 m followed by sharp gradients of increasing concentrations towards deeper waters. Upwelling feature in the Bay of Bengal, particularly south of Visakhapatnam was noticeable from the distribution of chemical parameters.

Estimation of fluoride in the northern Indian Ocean gave an average concentration of 1.31 (± 0.01) mg/l and a F/Cl ratio of 6.84 (± 0.01) x 10^{-5}, The Ca/CI ratio in the area was 0.02229 (± 0.000005). In the Bay of Bengal this ratio seems to be influenced by river runoff while in the Arabian Sea the outflow from the Red Sea increases the ratio. The Mg/CI ratio is observed to be 0.06631 (±0.00003). Neither the river runoff nor the Red Sea outflow seem to have any influence on this ratio. The ionic specification of fluoride in this area is 41.6% F^- 53.1% MgF^+ and 2.3% CaF^+. Concentration of magnesium appears to be the controlling factor in the speciation.

1. Chemistry of pharmacologically active components from marine flora and fauna

A total of 35 marine plants and animals were collected and extracts were prepared from them for pharmacological screening. Of these, *Hypnea musciformis* was found to be CNS stimulant and diuretic, whereas *Caulerpa racemosa, Zooanthus (Gemnaria* sp.) and the coral *Pocillopora domicornis* exhibited hypotensive activity. Isolation of the active constituents from these extracts is in progress.

Fifteen compounds have been isolated from the neutral fraction of methylene chloride extract of *Dictyota dumosa.* Structural elucidation of these compounds is under investigation and spectroscopic data is being collected for this purpose.

Methanolic extract of *Chaetomorpha antennina* deposited inorganic halogen compounds (1.5 g/kg) in which bromide is present in significant quantities. Further work on the bromine content of this seaweed with a view to its commercial exploitation is being carried out. Iodine content of different seaweeds from the Goa coast is also being studied for the purpose of commercial exploitation of seaweeds at the request of Goa Government.

2. Cycle of phosphorus, nitrogen and some biologically active trace metals in the estuarine, inshore and offshore waters along the west coast of India

Laboratory experiments were conducted to understand the kinetics of biodegradation of area. A survey of urea decomposing bacteria in the marine environment was also carried out. The sediments as well as water samples were collected and analysed for total heterotrophic bacteria and urea decomposing bacteria. The number of bacteria in the sediments varied from 10^4 to 10^6 cells/gm and in the water column from 10^2 to 10^4 cells/ml. From the total heterotrophic bacteria,· about 10% were found to decompose urea.

Samples were collected and analysed for nitrification and nitrate reduction processes. A polluted area (Velsao, near the effluent area of Zuari Agro Chemicals) and a non-polluted (off Marmugao) areas were surveyed. Ammonia concentration was found to be very high both in the polluted and unpolluted areas (6 to 8 µg-at/l). But the concentration of urea was found to be high in the effluent discharge area (4 to 12.0 µg-at/l).

The decomposition and the resultant ammonification were found to be very slow. Only after 45 days, ammonification became high resulting from 13.0 to 44.4 µg-at/l of ammonia. The production of ammonia in polluted Waters was relatively slower than in the other area and the ammonia did not exceed more than 10 µg-at/l. Ammonia oxidation was found to be almost normal, after a lag phase of 4 to 5 days. But the rate and quantity of ammonia oxidation was very slow. In the first 30 days, the nitrite oxidation was quite fast in unpolluted water (maximum nitrate production was upto 22.20 µg-at/l), nitrate reduction was observed in unpolluted waters and not in the polluted area.

Although the ammonia oxidation and nitrate oxidation occurred simultaneously, the former was slow and whereas the latter was comparatively high.

3. Studies on the interrelationship between nutrients, oxygen and the biochemistry of plankton

The relationship between nutrients in water and in plankton (carbon, nitrogen and phosphorus) was determined earlier based on the studies in the coastal

waters and laboratory cultures. This year the work was extended to offshore and deeper parts of the sea in the Arabian Sea and Bay of Bengal specially on the organic matter in the sub-oxic regions. The data collected on Board INS *Darshak* and R.V. *Gaveshani* are being utilized for this work.

4. Distribution of oxygen in the offshore and coastal waters of the Arabian Sea and Bay of Bengal

The observations made during the cruises of R.V. *Gaveshani* are being processed and analysed for the temporal and spatial variations of oxygen in *the* coastal and offshore waters of the Arabian Sea.

5. Carbon-dioxide system in the offshore and coastal waters of the Arabian Sea and Bay of Bengal

The data collected earlier in the northern Arabian Sea is being finalised for the carbon-dioxide components in the coastal and offshore waters. Recently considerable data were collected during the cruises of R.V. *Gaveshani* in the coastal and offshore waters of the Bay of Bengal, between Calcutta and Point Calimere. and the same is being processed.

6. Carbohydrates in the coastal and estuarine waters around Goa

Carbohydrate which is a part of organic matter in the marine sediments serves as a source of food for benthic fauna and bacteria. In the beaches it is utilised by the intertidal fauna especially by molluscs as a source of food during the low tide. The above work was undertaken to study the distribution of various forms of carbohydrates in the intertidal zone.

During the premonsoon period, the total carbohydrate in the sediments at the high tide level varied from 83 to 434 µg/gm; in the mid-tide level from 115 to 582 µg/gm, and in the low-tide level from 71 to 260 µg/gm. There was no systematic trend in their distribution during this period. However, during the monsoon period, there was a slight increase in the concentrations, and the carbohydrates in general showed a decreasing trend from high to low tidal levels. The large variations encountered within the zone were related to the beach profile, textural characteristics of the sediments, the extent of their utilization by the animals, their synthesis by the intertidal flora and their decomposition by bacteria. Soluble carbohydrates in the sediments were quite low (4-36 µg/gm in pre-monsoon and 0-11 µg/gm in monsoon) suggesting that bacterial activity in the sediments is low.

Analysis of the core samples (15 cm length) showed that in the coarse sediments, carbohydrates are distributed uniformly throughout the entire column, but in the case of fine grain sediments their concentration is low in the deeper areas indicating that the texture and compactness of the beach is important in controlling the retention of carbohydrate components.

Under this investigation the work was also carried out on the particulate organic matter, of which carbohydrate is an important constituent. Particulate organic matter is an important source of food for marine organisms at different trophic levels. The present study relates to the data collected from the Zuari estuary and coastal waters of Goa. Organic matter in both estuarine and coastal waters showed a marked variation. In the estuarine waters, the values ranged between 0.6 and 5.3 µg/l and in the coastal waters between 0.9 and 4.7 µg/l. High values in the estuarine waters were noted during the monsoon period because of the allochthonous organic matter settled to the bottom during the later part of the monsoon (August). In September, however, there was a rapid increase in the level of organic matter which was mainly autochthonous in origin. Lowest concentration was observed during November and December. The concentrations show a slight increasing trend during the pre-monsoon period. In the case of coastal waters, lowest concentrations were recorded during the premonsoon season.

7. Arsenic cycle in the coastal and offshore waters of the Arabian Sea and Bay of Bengal

A survey of total arsenic concentrations was carried out in certain areas of the northern Indian Ocean to evaluate the extent and the magnitude of its occurrence in the Bay of Bengal, Gulf of Mannar and south-eastern Arabian Sea. The concentration of total inorganic arsenic varied from less than 1 µg/l to 18.75 µg/l - the average concentration being 2.55 µg/l. In general, the arsenic concentrations in the surface and bottom waters of the Arabian Sea were less than those in the Bay of Bengal and Gulf of Mannar. This may be due to greater absorption of arsenic in the fine clay particles of the Bay of Bengal and Gulf of Mannar. Most of the not detectable values of arsenic appear to be in the oxygen minimum layer. At the sea surface, the arsenic content was high but it decreased in the oxygen minimum layer and again increased along with the oxygen content in the bottom waters.

Nineteen sediment samples from ten different stations were collected off Bombay in May 1976. Surface sediments were collected using a snapper and the corer by a piston-gravity corer. In general, arsenic content in the sediments varied between 3 7 to 10.1 ppm. High values of arsenic were observed in the nearshore region which was as a result of land discharge. Arsenic concentration also varied with the texture of the sediments. Clay and silty clay were found to retain higher concentrations, whereas clayey sand retained low concentrations of arsenic. A comparison of arsenic in the surface sediments with those of deeper sediments (cores) showed that the surface sediments are more enriched with arsenic than the bottom sediments. This was probably as a result of diagenetic activity within the sediments.

8. Studies on calcium phosphate saturation in sea water

Water samples collected from the Bombay High and the Gulf of Kutch areas during the cruises of R.V. *Gaveshani* were analysed to study the degree of saturation of sea water with calcium phosphate. The waters in these areas were found to be supersaturated. The degree of supersaturation was higher in deeper layers than at the surface. It was also noted that the waters off Bombay High are more supersaturated than those in the Gulf of Kutch. The higher values are attributed to the high pH and total inorganic phosphate concentration in the Bombay High area.

9. Regeneration of nutrients from plankton and sediments in the marine and estuarine environments.

Using the oceanographic data collected during the International Indian Ocean Expedition (IIOE) and the Indo-Soviet Monsoon Experiments (ISMEX). the process of regeneration of phosphorus and nitrogen in the Bay of Bengal and the Arabian Sea has been studied.

The oxidative fraction of phosphorus was found to increase progressively up to a depth of 1500 m. After this depth it decreased. Near the equator, in deeper waters, the values of reserved fraction ranged between 40% and 50% of the inorganic phosphorus concentration. This fraction was found to decrease gradually towards the north reaching 32% along the latitude 16°N. Unlike the phosphate, the fractions of nitrate were greatly influenced by the processes such as nitrification and denitrification. A loss of nitrate at depths between 150 m and 1000 m was observed. Even in the presence of considerable amount of oxygen, the nitrate values showed anomalies, at stations south of 2°N which suggests that the processes in these layers are related to biological activity and the loss of nitrate due to denitrification is not so pronounced north of 2°N.

10. Calcium carbonate precipitation in the sea and estuarine waters

Extensive observations were made in the coastal and offshore waters of the Bay of Bengal, from Calcutta and Point Calimere, during the R.V. *Gaveshani* cruises. The data are being processed to delineate the regions of calcium carbonate undersaturation, saturation and supersaturation.

2.22 Desalination of sea water

Under this project a new unit of modified design and materials was developed. The design shows that the side walls when fabricated of the same material (glass in the present case) as the top cover, help in increasing the fresh water yield by about 50%. This also reduces the initial cost of constructions to half. Some of the findings of the study conducted during the year are as under:

Experiments to study the optimum angle of inclination of the top cover to avoid tripping of fresh water into the saline basin were conducted. The most suitable angle of inclination, was found to be 19°-21°.

Lamp black and charcoal powders were found to be better absorber of solar radiation and thereby increasing the output of fresh water substantially. A prototype based on the above findings gave an average fresh water yield of 3.75 litre/m^2/day during the post-monsoon months.

2.3

geological oceanography

2.31 Geological and geophysical surveys to assess the petroleum and mineral prospects of the western continental margin of India

Under this project some special features of the work done during the period are as follows :

(a) Magnetic intensity and bathymetric data totalling 640 line km collected during the cruises of R.V. *Glomar Challenger* (Leg. 23). R.V. *Vema* (19) and R.V. *Conrad* (9), between Lakshadweep and southwest coast of India, were analysed. The study indicated that the submerged terrace and the bathymetric high are regional features. The general trend of the magnetic anomalies indicated that the major trends in the basement relief suggest block faulting in this region.

(b) Continuous shallow seismic reflection, bathymetric and magnetic surveys were carried out on board R.V. *Gaveshani* (Cruise II) during February-March 1976 in the Gulf of Kutch. The preliminary analyses of these records indicate that the recent clay (10 m thick) cover the eastern Gulf of Kutch. The rest of the Gulf is largely devoid of recent sediments. The recent sediments are underlain by a hard reflector which could be Deccan Trap or Mesozoic sedimentary rocks. Punwara and some other shoals comprise of dead coral reefs, the southern margin of these shoals is probably marked by a WNW-ESE fault.

(c) A geomorphological map (1 : 1-million) of the western continental margin was prepared, mainly from the echograms collected during INS *Darshak* cruises. The map demar-

cated the shelf break, slope and sea mounts. The areas of even and uneven topography on the sea shelf, scraps and relict reefs were identified and on the slope, ridges, depressions, benches and notches have been shown. The map will provide the basic information on the geomorphology of the western continental margin.

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

(a) Samples collected during the cruises of INS *Darshak* and R.V. *Gaveshani* in the Gulf of Kutch region were taken up for a detailed geochemical study. Estimations of calcium and magnesium carbonates, phosphates, titanium and manganese carbonates, phosphates, titanium and manganese have been completed, and the maps have been drawn showing their distribution patterns in the surficial sediments. Analysis of the other elements, such as aluminium, nickel, copper, cobalt and zinc are in progress.

(b) The work related to the studies on distribution pattern of the suspended load in the waters of the Bay of Bengal (70 stations) and Arabian Sea (50 stations) is also in progress.

2.33 Sediments of the western continental margin of India

The textural analysis and C.F. analysis of sediments from the Gulf of Kutch and the preparation of maps showing the distribution of various parameters, were completed. The results indicate that the Gulf is a high energy tide dominated environment, influenced by sediment contributions from the Indus river.

Based on the preliminary investigations on the four deep sea cores from the south-eastern Arabian Sea supplied by Lamont Doherty Geological Observatory, two nannoplankton biostratigraphic zones of *Emiliania huxleyi* and *Geohydrocapsa oceanica* zones were identified. Two new species *Geratolithus perch-nielsenae* and *Neoangulolithina qasimii* and a new genus *Neoangulolithina* were described. $CaCO_3$ determination from all the cores at an interval of 40 cm was also completed.

2.34 Foraminifera as indicators of high organic carbon and pollution in the marine environment

Under this project, sixty-five samples from the intertidal region all along the Goa coast and forty samples from the Cola Bay at a depth of 10.5 m, where effluents of the fertiliser factory (M/s. Zuari Agro-Chemicals Ltd.) are discharged, were collected. The findings, based on laboratory work, are as follows:

(a) The organic carbon content of the sediment for all the samples was found to vary from 0.034% at Caranzalem to as high as 0.253% at Betul and in the polluted environment from 0.161% to 3.979%.

(b) Pollution studies using foraminifera as indicators in the Cola Bay, Goa were completed. The foraminiferal abundance in the polluted environment was noted. Calcareous perforate fora-

minifera were found to be very abundant in relation to other types of the living organisms. *Ammonia beccarii* and its variants, were very abundant while *Elphidium poyeanum, Calcarrina calcar* and *Quinquelocilina seminulum* were common, and *Brizalina striatula* and *Gavelinopsis complanata* were rare.

(c) Furthermore, the relative sensitivity of the benthonic foraminifera in relation to pollutants in the marine environment revealed that certain species restrict themselves to the least affected zones while the others respond negatively to the outfall area. The environmental stress thus caused as a result of dispersion of pollutants seems to indicate the relative sensitivity of tolerance of benthonic foraminifera.

(d) It was also found that the organic carbon in the sediment is inversely proportional to the abundance of the benthonic foraminiferal populations.

2.4

biological oceanography

2.41 Studies on primary, secondary and tertiary levels of the food chains (Project No. 201)

1. Primary production
2. Extracellular products of planktonic algae
3. Secondary production
4. Benthic production
5. Biodegradation of organic matter and biochemical investigations
6. Ecology of estuaries
7. Ecology of mangroves and their uses
8. Ecology, production and related aspects of sandy beaches of Goa, Karwar and Mangalore
9. Experimental studies on primary production with special reference to the formation of algal blooms
10. Use of radioactive isotopes in studies on production and decomposition processes

2.42 Coastal Aquaculture (Project No. 202)

1. Aquaculture in the waters of Goa, Cochin and Bombay
2. Laboratory and field studies on bioenergetics of some marine and estuarine animals
3. Environmental physiology in relation to culture and population dynamics
4. Experimental studies on the optimum survival condition and identification of early larval stages of commercially important species of prawns and fish

2.43 Biogeography of the zooplankton of the Indian Ocean (Project IMo. 203)

1. Systematics, zoogeography and ecology of zooplankton
2. Studies on the environmental preference, species association, abundance and diversity

2.44 Ecological, developmental and experimental studies on plankton (Project No. 204)

1. Experimental studies on secondary production

2.41 Studies on primary, secondary and tertiary levels of the food chains

1. Primary production

Studies were conducted on light penetration, primary productivity, chloro-

phyll-a, phaeophytin, quantitative and qualitative analysis of phytoplankton, distribution of particulate and dissolved organic carbon in the Arabian Sea and Bay of Bengal. Data were collected from 66 stations during the eight cruises of R.V. *Gaveshani.* Primary productivity in the Bay of Bengal, during August-September, as measured at 29 stations using radiocarbon technique, varied from 279.3 to 2.7 $mgC/m^2/day$ with an average of 40.6 $mgC/m^2/day$ at the surface and from 606.0 to 49.0 $mgC/m^2/day$ with an average of 275.0 $mgC/m^2/day$ in the column. Phytoplankton production was found to be very low in the Bay of Bengal.

2. Extracellular products of planktonic algae

Observations were undertaken in mangroves, estuarine and nearshore regions of Goa and also along the southwest coast of India. Extracellular fixation varied with depth and with the conditions of incubation of the samples. The results showed that 0 to 60% of freshly fixed CO_2 during photosynthesis is lost by the algae. Dissolved carbohydrates (DCHO) present in the inshore waters of Goa has a relationship with phytoplankton production. Glycollic acid was present in all the samples of the Arabian Sea and it may be related to photo-respiration of phytoplankters. The glycollic acid released per cell varies depending on the shape of the growth curve, chlorophyll-a organic carbon ratios in *Chlorella, Synechocystis* and mixed culture of both these organisms.

3. Secondary production

Studies on the secondary production were conducted in the Arabian Sea and Bay of Bengal where zooplankton samples were collected during R.V. *Gaveshani* cruises. The biomass varied from 2-110 ml per m^3 in the Bay of Bengal. Few areas with appreciable quantities of juvenile of prawns were located in the Bay of Bengal indicating their breeding grounds.

Zooplankton samples were also collected from 5 stations in the inshore waters of Goa between Baga and Velsao for the possible locations of breeding, grounds of prawns. The study revealed that the breeding grounds of most of the prawns *(Penaeus* and *Metapenaeus* spp) are off Baga and Sinquerim. The peak abundance of larvae was in January and February with a secondary peak in April/May. Detailed studies on the abundance and distribution of each species are in progress.

Sediment samples were collected from the slope region of the Arabian Sea and these were analysed for pelagic foraminifera. Planktonic forms present in the samples varied within narrow limits. The lower continental slope sediments were richer in the concentration of foraminifera than the upper slope deposits. Dissolution effect on some of the forms was also studied in the samples from deeper regions of the Arabian Sea. The species which were resistant and or susceptible to dissolution were identified. Ecological signi-

ficance of this phenomenon and other related features were recorded.

Benthic foraminifera were studied from 21 sediment samples collected during November-December 1976 from the Lakshadweep Sea. Preliminary studies indicated that species such as *Sorites marginalis* (Lamarck). *Amphistegina radiata* (Fichtel and Moll). *Peneroplis pertusus* (Forskal). *Planorbulina medeterranensis* (D'Orbigny), *Calcarina calcar* (D'Orbigny) and *Cymbaloporetta squammosa* (D'Orbigny), were dominant.

4. Benthic production

Bottom samples collected from the Arabian Sea (Gulf of Kutch, Bombay High, Konkan and other regions of the southwest coast and from the Bay of Bengal — between Paradip and Nagapattinam) were analysed for qualitative and quantitative distribution of meio- and macro-fauna. Biomass and population density in the Bay of Bengal were not very different from those of the Arabian Sea. Macro to meio-fauna ratio were 4:1 in biomass and 1:3500 by faunal density in the Bay of Bengal whereas in the Arabian Sea the ratios were 1:2 and 1:16,000 respectively.

During the course of study a new species of *Umbonium* (mollusca) was recorded from Madh Island (near Bombay) and this has been named as *Umbonium qasimi.*

5. Biodegradation of organic matter and biochemical investigations

While working on oil degradation a fungus, *Fusarium* sp. was isolated. This fungus grew well in the kerosene. Bacterial populations from the sea bottom and beaches were also investigated. Comparative toxicity of ammonium compounds and heavy metals were also investigated. To determine the kinetics of bioaccumulation of the heavy metals in marine organisms, long-term exposure experiments *are* underway.

Morphometric and electrophoretic studies of the serum and eyelens proteins of four commercially important fishes were completed.

6. Ecology of estuaries

Studies were conducted in Mandovi and Zuari estuaries of Goa with a view to determine the location of young prawns. Penaeid prawns, *viz. Metapenaeus dobsoni. M. moncceros, Penaeus merguiensis* and *Parapeneopsis stylifera* were more abundant in the Zuari estuary as compared to Mandovi Larvae of *M. dobsoni* were most abundant and this species appears to breed throughout the year. The larvae of *P. merguiensis* and *P. stylifera* occurred only at the mouth of the estuary, while larvae of *M. monoceros* penetrated more in the upper reaches of Zuari estuary than in the Mandovi estuary, because of higher salinity occurring in the former throughout the year.

A view of the mangrove swamp in Goa

7. Ecology of mangroves and their uses

Studies on decomposition of mangrove foliage showed that protein content increases due to colonization of microbial flora as the foliage decays, while carbohydrate and lipid percentages decrease. Monthly variations in protein, carbohydrates and lipids in the foliage of 7 species of mangrove were studied for determining the feasibility of protein extraction. Studies on the use of detritus pellets made from mangrove leaves as feed for fish and shrimps are in progress. The distribution of magnesium, manganese and iron in the mangrove leaves was investigated. Under the programme, entitled, management of mangrove ecosystem, experiments were successfully carried out on survival, growth and transplantation of seedlings.

8. Ecology, production and related aspects of sandy beaches of Goa, Karwar and Mangalore

Studies on beach productivity which started in 1975 were completed during the year. Results were analysed in order to define factors which control population dynamics and energy flow in a range of representative intertidal

environments which were unpolluted. Experimental studies to assess the potential effects of pollutants in the tropical intertidal zone were conducted to determine the oxygen consumption in relation to grazing rates and on the effects of sublethal concentration of copper on oxygen consumption in *Mytilus viridis.* Copper concentration of 10.50 and 100mg-Cu/l had no effect on the rate of oxygen consumption during the first 3 hours after the exposure. Tropical species of mussels seem to exhibit metabolic temperature compensation.

9. Experimental studies on primary production with special reference to the formation of algal blooms

Phytoplankton species *Tetraslmis gracillis, Monochrysis, Chorella salina, Synechocystis* and *Nitzschia* were isolated. Mass scale culture were maintained and used for various studies. Different media involving nutrients, salinity etc., were tested on these species.

10. Use of radioactive isotopes in studies on production and decomposition processes

Primary productivity studies are being conducted using radioactive carbon. Four thousand ampoules of this isotope were procured for these studies. A team of scientists from the Bhabha Atomic Research Centre, Bombay inspected the laboratory for assessing the radioactive safety measures undertaken by NIO. So far no contamination was detected by them. It has been ensured that all the liquid and solid radioactive wastes are disposed off as per the existing regulations.

2.42 Coastal aquaculture

1. Aquaculture in the waters of Goa, Cochin and Bombay

(a) *Aquaculture In the waters of Goa:* Experimental raft culture of green mussels and edible oysters development and rearing of shrimps and culture of fishes were successfully undertaken and assessment and utilization of seawed resources were made under this project. The rope culture technique for green mussels *(Mytilus viridis)* on rafts was standardized and informations on the ecology, biology, nutritive value and economics were obtained. Some of the important findings of the experimental mussel culture on rafts are as follows:

(i) Growth rate could be accelerated by 60% on ropes hanging from rafts.

(ii) Marketable size was attained in five months as against one year in natural beds.

(iii) The annual production was as high as 60 kg/m^2 against 1 kg/m^2 in natural beds.

(iv) Mussel meat had a high value of protein (56.03%) and calories (5.9460 kcal/gm dry wt).

(v) The technique ensured high monetary returns from low investment with an overall profitability of about 181%.

Experimental studies were conducted to determine the optimum controlled conditions for the survival of larvae of three economically important species of prawns, *viz., Macrobrachium rosenbergii, M. idella* and *M. idae.* The larvae reared in filtered to sterilized sea water of 12-16%O salinity, 7-8 pH, 26.5-27.5° C temperature, 12-14 hours of photoperiod and controlled aeration at the rate of 4-8 bubbles/second gave better survival. Feeding in lesser quantities and at frequent intervals showed a positive effect on survival. Based on these results the larvae of *M. rosenbergii* were successfully reared upto 7th stage with 100% survival in the early stages and 50% in later stages. Infection was one of the main causes of mortality and to a certain degree it was overcome with antibiotics and other chemicals. Cheaper larval feeds were developed replacing *Anemia* which is a conventional food.

As regards fish culture, larvae and juveniles of *Etroplus suratensis* and *Mugil cephalus* were reared in the fish farm.

In seaweed culture efforts were made to investigate :

(i) *The effect of seaweed extract on higher plants:* It was found that extracts of seaweeds at lower concentrations act as growth stimulants.

(ii) Ecology of Ulva reticulata in Chapora Bay (Goa): This investigation included the ecology, biology, biochemistry, cytology, hydrology and the effects of organic pollutants on seaweed resources.

(iii) Seaweeds of Maharashtra coast: To evaluate the seaweed resources, a preliminary survey was undertaken in November-December at 9 predetermined sites.

(iv) Effects of toxic compounds on seaweed growth: Effect of copper sulphate, mercuric chloride and zinc sulphate showed that higher concentrations of these substances increased the rate of decomposition of the seaweeds.

(b) Aquaculture in the waters of Cochin: In view of the importance of live food for aquaculture, attempts were made to culture selected species in tanks using different substrates such as coarse sand, fine sand and silt mixed with different concentrations of organic matter. Introduction of an amphipod, *Corophium triaenonyx* raised the food resource of a system from the negligible level to 200 g/m^2 in the course of 89 days. Similarly, a bivalve *Paphia* sp. produced an additional biomass of 50 g/m^2. These animals preferred a mixed substratum of sand and silt and formed good food for shrimps and bottom fishes.

(i) Mass culture of a copepod: Studies were made on the effect of various items of food such as detritus, *Chlorella,* shrimp-head-meal and a compound diet on the production of harpacticoid copepod, *Nitocra spinipes.* Their rate of multiplication was found to be related

to some extent with the protein content of the diet. Among the test diets, maximum density of population (9.750 individuals/litre) was attained in 35 days with *Chlorella.* But the highest production (11.100 individuals/ litre) was recorded when the copepods were fed on shrimp head meal for a period of 56 days. Culture medium of 25%O salinity was most suited for this species.

(ii) Studies on edible oysters in Cochin backwaters: Natural growth rate of oysters during February-May was found to be lower (0.34 mm/day) this year than those of the previous years. The newly settled spats, were found to be killed when they got covered with silt originating from dredging and other human activities. However, encrustations of oysters in the intertidal region in the Cochin harbour area were also found to be low. A bamboo raft was installed in the Cochin harbour area in May 1976 for aquaculture. In order to ascertain the season of spatfall of oysters various collectors made of rope tiles wood and concrete were suspended and weekly observations were made. Oyster spats measuring 2 mm to 6 mm were seen to settle on the collectors by the end of December 1976.

Monthly analysis of samples was carried out for the whole year to study the accumulation of metals like Fe, Cu, Mn and Zn in the oyster *Crassostrea madrasensis.* Of the four metals, the accumulation of Zn was found to be the highest (12,500 ppm dry weight) and those of Cu, Fe and Mn was 210 ppm, 1600 ppm and 170 ppm respectively. These figures indicated that the accumulation of metals in the oysters in the Cochin backwaters has exceeded the permissible levels for human concumption.

(c) Aquaculture at Bombay: Raft culture for edible oysters has been initiated at Marve and the experiments are being continued.

2. Laboratory and field studies on bioenergetics of some marine and estuarine animals

These investigations included the seasonal variations in the caloric content and biochemical composition in three bivalves (*Mytilus viridis, Crassostrea cucullata* and *Donax incarnatus)* and four species of fish *(Sardinella longiceps, Lactarius lactarius, Otholithus ruber* and *Rastrelliger kanagurta)*. The female bivalves had more caloric content than the males and both sexes had high caloric content during the pre-spawning phase which appears to be the ideal period for harvesting.

The effect of compounded and natural feeds on the growth of *Metapenaeus monoceros* indicated that the feeds having about 60% of protein gave the best result on growth. In terms of growth increment for the first 15 days, *Artemia salina* and the feed prepared using a Japanese formula were found to be most effective.

3. Environmental physiology in relation to culture and population dynamics

Artificial diet was not very much preferred by the prawns as they were eating them only in smaller amounts in comparison to certain animal food such as earthworms.

A stable compound diet was developed for feeding the prawns. Their food habit indicated a preference for isopods and more fleshy amphipods. Duration of feeding ranging from 2 to 4 hours was found to be enough. It was also seen that the preying efficiency of prawn was adversely affected in the areas with thick layers of mud at the bottom.

2.43 Biogeography of the zooplankton of the Indian Ocean

1. Systematics, zoogeography and ecology of zooplankton

Fifty-one species of hydromedusae were identified from the zooplankton collected off Cochin. *Aglaura hemistoma, Liriope tetraphylla, Solmundella bitentaculata, Eucheilota menomi* and *Cytaeis tetrastyla* were the most abundant species. *A. hemistoma* was found in all the collections. *A. hemistoma, L. tetraphylla* and *S. bitentaculata* showed congregation above the thermocline. However, most of the species were distributed throughout the water column and the thermocline did not seem to act as a barrier in their distribution.

Amphipoda: Mates and females of the species of the family *Paraphrominidae (Paraphromina gracilis, P. crassipes* and *P. clypeata)* were recorded from the Indian Ocean. Some of the females of *P. gracilis* and *P. crassipes* were examined and these were found in maximum numbers in the Arabian Sea during both south-west and north-east monsoon periods. They were totally absent to the north of 15°N latitude in the Bay of Bengal, south-eastern side and western side of the Arabian Sea except from 2 stations to the south of Socotra Island from where the maximum numbers of specimens were recorded. During both the seasons 110° E meridian showed their fair density. They largely occurred in between latitudes 10°-20° N and 10°-20° S.

P. crassipes was rare in the Arabian Sea, western Indian Ocean and eastern Indian Ocean. In the Bay of Bengal, the species was obtained frequently during the south-west monsoon and the highest number of specimens were collected from a day time haul. During the north-east monsoon, the species were more abundant during the day than at night. The latitudinal distribution of *P. gracilis* showed their maximum occurrence in between latitudes 10° - 20° N during the seasons.

Copepoda: Copepod families Eucalanidae, Euchaetidae, Scolecithricidae, Candaciidae, Centropagidae, Temoridae, Aetidiiae, Heterohabdiade occurred almost all over the Indian Ocean, though scantily in the southern areas. Pseudo-

diaptomidae and Tortanidae were present in less than 3% of the total stations analysed. Among the genera, *Pleuromamma, Lucicutia, Undinula, Haloptilus, Calanopia, Labidocera, Pontellina, Pontella, Pontellopsis, Calanoides and Metridia* were identified in the samples. *Pleuromamma* was the most abundant genus and *Metridia* occurred in lowest number. The order of occurrence was in the sequence given above. The last 7 genera were present at less than 50% of the stations analysed and the last 2 were at less than 2% of the stations.

Systematic account of the following 12 species of the genus *Haloptilus* was prepared. The species were *H. longicornis, H. paralongicirrus, H. spiniceps, H. ornatus, H. oxycephalus, H. macronatus, H. austini, H. fertilis, H. chierchiae, H. bulliceps, H. acutiforms* and *H. fons.*

Numerical data for the common 8 species were subjected to statistical analysis using t-test. For this, the Indian Ocean was divided into four regions, namely, Arabian Sea, Bay of Bengal, S.E. Indian Ocean and S.W. Indian Ocean.

H. paralongicirrus and *H. oxycephalus* showed significant result at 5% level in S.W. Indian Ocean during the period April, 15 to October, 15. *H. ornatus* showed significant result at 5% level between day and night collections in the Bay of Bengal during April 16 - October 15. The number of specimens in the day collections were more as compared to night collections.

H. paralongicirrus showed significant difference between Arabian Sea and S.W. Indian Ocean and Arabian Sea and Bay of Bengal at 1% and 5% levels respectively; the Arabian Sea having more number of specimens than the S.W. Indian Ocean and Bay of Bengal.

H. spiniceps showed significant result at 1% between the Arabian Sea and S.W. Indian Ocean. *H. ornatus* gave a significant difference between the Arabian Sea and the Bay of Bengal (5%) and S.W. Indian Ocean and Bay of Bengal (1%). In all these cases, the Bay of Bengal showed more count than the other three regions.

51 species of calanoid belonging to 14 genera were encountered in the UNDP samples, but not more than 19 species were encountered at a time. Copepod density and species diversity were interpreted in relation to the hydrographic conditions. Copepod density was highest during the premonsoon months. *Eucalanus monachus* was the most abundant species and occurred throughout the year. *Undinula vulgaris* was abundant but was absent during the upwelling period. The copepod density remained high in the upwelling period due to the swarm of *Temora turbinata.*

Studies on the diversity index indicate that the population at the shelf stations is a more physically controlled community and those at the slope a more biologically accommodated community.

Flatfish Larvae: Flatfish larvae were found to be present only in 12.4% of the IIOE samples. The larvae were more abundant in the collections from the Bay of Bengal than in the Arabian Sea or from any other part of the Indian Ocean. Statistical analysis of the data showed a negative correlation with salinity and oxygen. The larvae of *Psettina brevirictis, Bothus bleekeri,* and *Grammatobothus polyophthalmus* were identified.

2. Studies on the environmental preference, species association, abundance and, diversity

A multiple regression model was used for the prediction of planktonic forms with exoskeleton (Crustacea and Mollusca excluding Heteropoda other than Atlantidae.) Displacement volume of these planktonic organisms contained in 68 standard samples collected during IIOE at various stations were utilised for the development of the regression model. The coefficient of correlation between the displacement volume of these forms with each of the variables like temperature, salinity, phosphate, phosphorus, nitrate nitrogen and oxygen were calculated. For the calculation of the coefficient of correlation, maximum values reported in the IOBC Handbook, Vol. 2. 1971 were used. All the coefficient of correlations were found to be significant, the level of significance varied between 5% and 0.1%.

It followed from the analysis of variance that all the regression coefficient were significant ($p<0.001$) indicating that the fitted model was capable of explaining a significant part of the variability in the biomass of planktonic forms with exoskeleton. The variability explained by the fitted model was 40%. The part of the variability unexplained by the regression model may be due to the other variables which were not included in the model.

Though all the variables reported in the IOBC Handbook, Vol. 2 were included in the model, still a large part of the variability was found to be unexplained. The relative importance of the variables included in the prediction model showed that salinity is a prominent factor in the prediction of biomass followed by nitrogen, temperature, phosphorus and oxygen.

To study the coexistence of 18 species belonging to Copepoda group, data from the Cochin backwaters were subjected to statistical analysis. Correlation matrices for the coexistence of the species over space and time were constructed. Significant positive correlation can be taken as an index of the existence of that species alone. It was found that 13.73% of the coefficient of correlations were significant; the significant levels varied between 5% to 0.1%. 4.58% of the coefficient of correlations were positive and significant, indicating that there were no widespread coexistence of the species over space compared to that in time. To separate the species which coexist over time and space dendrograms were drawn using the correlation matrices. Using dendrograms, the species which coexist significantly over time and space are listed as follows:

Group of species co-existing over time

1. *Eucalanus monachus—Centropages furcatus—Labidocera pectinata-Euchaeta wolfendini.*
2. *Undinula vulgaris—Temora stylifera—Temora discaudata—Labidocera acutifrons.*
3. *Undinula darwini—Euchaeta marina*
4. *Centropages calaninus—Temora turbinata.*

Group of species co-existing over space

1. *Temora stylifera—Temora discaudata—Candacia discaudata.*
2. *Undinula vulgaris—Rhincalanus nasutus.*
3. *Rhincalanus cornutus—Euchaeta concinna.*
4. *Eucalanus monachus—Labidocera acutifrons.*

Co-existence of planktonic organisms along the south-west coast of India.

The data obtained from 133 Bongo net collections made from the inshore and offshore waters off Calicut, Cochin, and Quilon during the period from January to December 1972 were utilized for the analysis. Significant coexistence was observed between very few groups. The clusters which showed coexistence were Copelata, Cladocera, Euphausiacea and Coelenterata. The coefficient of correlation of the different groups with salinity, temperature and oxygen showed that Chaetognatha and Copelata were significantly positively correlated with salinity while Cephalopoda was significantly negatively correlated with salinity. Polychaetes and medusae showed a positive correlation with temperature. But none of the groups showed any significant correlation with the oxygen.

Variability of Hydromedusae from Aroor and Cochin Backwaters

Statistical analysis of the plankton collections made at 48-hour intervals from Aroor during the highly saline pre-monsoon period showed that in all the growing stages, the adults of *P. phialidium bunescens* were positively correlated with salinity while none of them was significantly correlated with temperature. Stages I and II of *Eutima commensalis* were significantly correlated with salinity and temperature. In the III and IV growing stages, males and females, of *E. commensalis* increased with the increase in salinity. But in the case of *E. ceyloneus* and *B. virginica* the abundance of the species decreased with the increase in salinity.

2.44 Ecological developmental and experimental studies on plankton

1. Experimental studies on secondary production

The benthic communities under secondary production were mainly constituted by amphipods, polychaetes, isopods, alphids and bivalves. Gammarid amphipods and polychaetes played important roles in the ecosystem of Cochin backwaters and the protein rich bivalves formed an important seasonal fishery.

These showed marked seasonal changes in response to the highly fluctuating hydrographic conditions of this area. The highest number of Gammarid amphipods (Corophium sp.—50000 to 180000 animals/sq. m) and polychaetes (Diopatra sp.—80 to 250 animals / sq.m) were observed during December. They were abundant near the mouth of the estuary during fairly high salinity conditions (22%O to 26%O). Extensive beds of bivalves (Meritrix sp.) were located south of Venduruthy bridge. The bivalves were present in large number during March and April.

The energy content of benthic organisms were estimated in view of their prominent rule in the food chain and their caloric contents are given below :

Animal	*Range in caloric values Cal I g dry wt*
Corophium triaeonyx	3600—4100
Diopatra naeopolitana	3900—5600
Ciralana fluviatilis	6500—7200
Meritrix casta	4500—5000
Acartia sp.	4500—5000

Major biochemical constituents of some benthic organisms, namely *Corophium triaeonyx. Diopatra naeopolitana, Ciralana fluviatilis, Meritrix casta* and *Alpheus rapax* were estimated. The estimated values as percentage of dry weight ranged as follows:

Major biochemical constituents of some benthic organisms

Animal Groups	*Range as % dry weight*		
	Carbohydrate	*Protein*	*Lipid*
Amphipods	8.1—10.9	56.3—60.9	0.8— 1.6
Polychaetes	4 2—19.0	43.0—72.2	1.5—24.5
lsopods	5.2—8.0	5.7—8.6	61.1—67.7
Bivalves	7.7—10.3	43.2—63.0	13.1—14.8
Alpheus	5.6—5.9	46.8—41.1	6.5—7.5

No regular seasonal changes were noticed in the various biochemical components.

2.5

oceanographic instrumentation

2.51 Development of marine instrumentation system (Project No. 601)

2.52 Development of calibrating and testing facility including service, maintenance and workshop (Project No. 602).

Both the projects have been continued from the previous year. The progress made during the year is as follows:

2.51 Development of marine instrumentation systems

Under this project, work was carried out on a wind velocity sensor, signal displaying telemetry, electromagnetic current meter, conductive salinometer and data logging system. A wind velocity sensor was developed for the measurement of wind velocity.

In the development of buoy telemetery system, improvements were made on the signal display system of the shore unit and in the existing multiplexer part of the system. Multiplexer using I.C.s were developed to reduce the size and power consumption. Fabrication of the buoy structure is being carried out in the workshop.

The development of a bench model of electromagnetic current meter is under completion. Calibration linearity (simulated) and stability checks have already been carried out. The sensor is waterproof. Arrangements are being made to compare its performance with the other mechanical type of current meters. Field trials are in progress.

The development of a inductive salinometer for laboratory use has made a considerable headway. The core used for the basic sensor being temperature and pressure sensitive, it was utilised for compensating these effects. A 'sampling cell' using acrylic pipe was developed. The cell has been improved in its design in such a way that the core is not immersed in the water, instead the water runs around the core through the acrylic pipes. Using this cell, temperature compensation for 35%O equivalent conductivity has been successfully achieved. This

laboratory type instrument is aimed at an accuracy of ± 0.02% or even better when it reaches its final form.

A similar inductive salinometer being developed for *in situ* measurements for depths upto 100 m also has similar temperature effect of the core material. In this case, as the sensor has to be immersed in water, efforts are being made to give compensation for the heating effect as well as temperature/ conductivity by using a copper resistance thermometer. The basic problem of temperature and pressure effects on the core is yet to be solved.

The development of a data logging system for R.V. *Gaveshani* has been initiated. The data logging system is being designed to record oceanographic parameters on a teleprinter and to provide an acurate timings system for oceanographic measurements on board R.V. *Gaveshani.*

The system will consist of (i) one master clock. (ii) repeaters, (iii) one punch programmer with a punch, (iv) power supplies and interconnecting cabling and on-line operation and (*v)* a special purpose computer.

The design and development of the master clock has been undertaken during this year. Its testing has already been completed and a prototype model is being made. The clock operates with 1 MHz quartz crystal. A three digit decimal calendar indicating Julien days, hours, minutes and seconds displayed on LED display units has been fabricated. The logging system is expected to be completed by 1979.

2.52 Development of calibration and testing facility including service, maintenance and workshop

During the year a group of technical staff has been trained to undertake the various types of jobs under this project. The following work was undertaken during the year:

(a) Calibration and testing of the electromagnetic current meter were carried out. The development work was started and many mechanical parts were fabricated in the workshop. An electronic circuit using photo-electric cells to measure the velocity of the carriage was developed and tested. The whole system is expected to be ready by the end of 1977.

(b) The calibration set-up designed and developed here for the calibration and testing of conductivity cell and electrode type salinometer consists of a stainless steel water bath; the temperature cycling being achieved by circulating hot or cold water around it. The same set-up can also be used for calibrating other salinometers which are under development.

(c) Using a dynamometer and calibration bench, several electronic and mechnical type of warp-tension meters were calibrated for the Central Institute of Fisheries Technology, Cochin. The same set-up was also used for testing the breaking strength of electric cables.

The installation, servicing and maintenance of air-conditioners, refrigerators

and water-coolers were carried out in accordance with the requirements of the Institute.

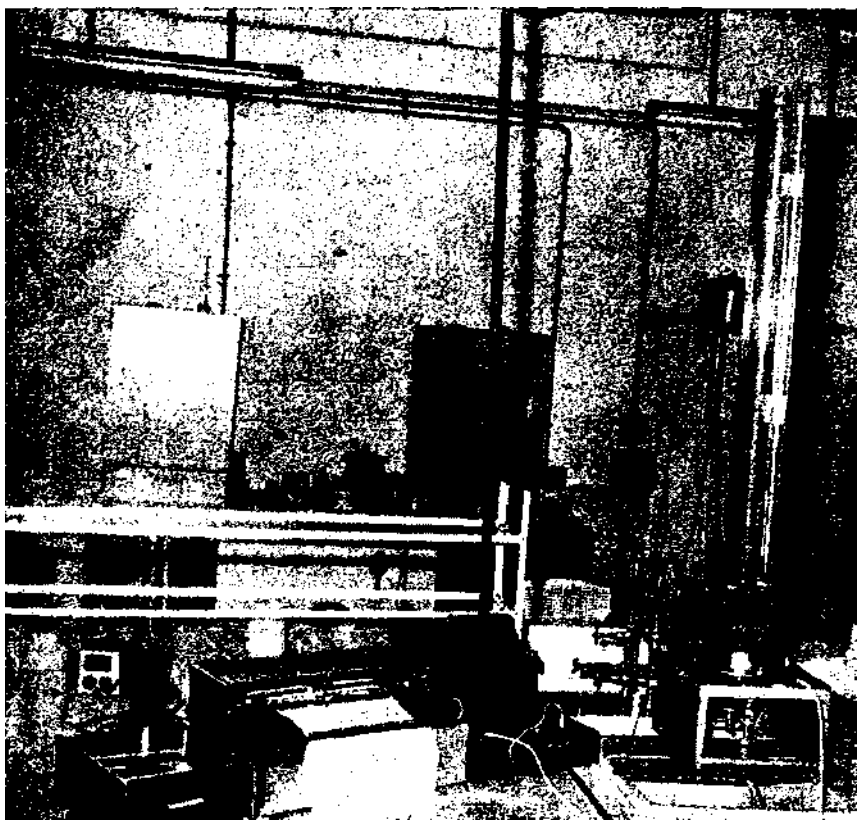
Electroplating facility was started in the Institute during the year. The anodising and dyeing of front panel plates were undertaken.

The prototype group, fabricated printed-circuit-boards for the current meter, laboratory salinometer, tide and wave recorder and sensors of *in situ* salinometer types of transformers for power supplies and measuring instruments were also fabricated.

The photography group undertook all the work of field photography, microfilming, slide making, photomicrography, etc.

Moreover, services were rendered to different sponsored projects, the group also assisted in bringing out a brochure and a folder on R.V. *Gaveshani.*

The workshop fabricated different components as per the given requirements and also carried out repairs of scientific equipment as well as automobiles. The important jobs carried out



Sedimentation balance developed by the Institute

were (1) fabrication of a platform of buoy telemetry, (2) sparker assembly for the sparker and boomer unit, (3) housing for electro-magnetic current meter, (4) plastic and brass zooplankton bottles, and (5) sea bed corers and catchers, etc.

The workshop also undertook repairs of mechanical parts of the side scan sonar equipments, magnetometer, centrifuge and departmental vehicles. The workshop has also remodelled an old vehicle into a pick-up.

The drawing group attended to the drawing work related to various projects.

The service and maintenance group gave necessary support to various Divisions of the Institute. It participated in all major sponsored projects for the maintenance of sophisticated geological-geophysical equipments such as magnetometer, side scan sonar, sub-bottom profiler, etc. The equipment from various outside organizations were also serviced and maintained by the group on nominal charges.

2.6

planning, publications, information and data

The Planning and Data Division (Indian National Oceanographic Data Centre) has the responsibility of Planning, Publications, Information and Data processing work at the Institute. During the year a greater emphasis was laid in each area of its activities such as data processing, quick publication of results of research and development of information facilities. Planning and monitoring of various projects were undertaken as per the instructions received from CSIR.

The Indian National Oceanographic Data Centre was declared by the Intergovernmental Oceanographic Commission (IOC) as a Depository Centre for oceanographic publications and documentation for India.

A brief account of the work done is given below:

2.61 Planning

The NIO Projects which were planned and initiated during 1975 were under constant monitoring and evaluation. All changes that took place during the year were incorporated and an updated mimeographed publication was issued during the year.

A study on growth of manpower and expenditure of the Institute during the past 10 years was carried out. NIO project-plans and project-budget were prepared. Different types of informa-, tion required by the Planning Division of CSIR were transmitted from time to time.

2.62 Publication

During the year under report several publications were processed, edited and published by the Division. These are as follows:

(i) *Mahasagar*—Bulletin of the National Institute of Oceanography. Vol. 8. Nos. 1-4.

(ii) Annual Report of the Institute for the year 1975.

(iii) 13 cruise reports of R.V. *Gaveshani.*

(iv) 3 brochures—one each on National Institute of Oceanography. R.V. *Gaveshani* and Sponsored Projects undertaken by the Institute.

(v) A folder on the Institute giving general information.

In addition to this, technical advice and assistance was rendered to the committee constitued for publishing abstracts on UNESCO/SCOR/NIO Symposium on 'Warm Water Zooplankton'. Work was also initiated to produce volumes of "Collected Reprints" of the Institute.

2.63 Information

Three main items of work were undertaken :

1. Indian National Directory of Marine Scientists

There was a long standing need for such a directory for which necessary information was compiled and computer listings were produced. The information was passed on to the secretariat of the FAO/IOC sponsored Aquatic Sciences and Fisheries Information System (ASFIS) for its incorporation in the International Directory of Marine Scientists.

2. Indian directory of marine research projects

This is probably the first effort of its kind in the field of marine sciences. Most of the projects in operation at the marine-based organisations were obtained and the abridged information is being transferred to punch cards for the preparation of listings.

3. Information requirements in marine sciences in India

A survey of the information requirements, as expressed by marine scientists and technologists, was completed and the data are being processed.

4. Participation in Marine Environmental Data Information Referral System (MEDI)

In accordance with the recommendations of the Intergovernmental Oceanographic Commission, the Data Centre participated in this programme. Input registration forms were completed and sent to the Coordination Centre for MEDI at IOC Secretariat in Paris. The Scientist-in-Charge, Planning and Data Division is one of the three members of IOC Group of Experts on MEDI which has an advisory function for the development of this referral system.

5. Information activities

In addition to these activities, the information group of this Division attended to various activities related to the Institute, specially for popularisation of oceanography through mass media, such as newspapers, radio talks, television programmes etc. Besides, a large number of visitors, student parties and technical querries of multi-nature were also attended to.

2.64 Acquisition, processing, evaluation and management of oceanographic data

This year, with the commissioning of R.V. *Gaveshani* and additional commitment because of a number of sponsored projects, there was an inflow of large amount of oceanographic data for processing at the Division. This necessitated the use of a computer which was arranged with the Tata Institute of Fundamental Research,

Bombay. The facilities of IBM 407 at M/s Zuari Agro-Chemicals were also utilized on regular basis. In addition, DCM 1101 Microsystem was acquired and used for various jobs.

Main jobs carried out during 1976 in the field of oceanographic data processing and management are given below:

1. Development of Computer Programmes

The following programmes tor DEC-10 System were developed for processing of oceanographic data:

(i) *GEPROS*—**General Processing of Physical Data**—This programme involves computation of sigma-t and specific volume anomaly.

(ii) *INTPOS*—**Interpolation of Spline fits**—This programme interpolates temperature and salinity at standard depths.

(iii) *SESIAN*—**Sediment *Size* Analysis**—This programme computes continuous parabolic interpolation of the sediment and gives the classification of sediments as given by Lord Breslaus and computes statistical parameters such as mean, mode, median, standard deviation, skewness and kurtosis.

(iv) *MAGMER*—This programme computes distance between the magnetic points and their positions. The sub-routines compute horizontal, vertical and total magnetic force for a given epoch according to spherical harmonic coefficients of the International Geomagnetic Reference Field.

(v) UTSHOR—This programme converts the coordinates from *UTM* to *Shoran* values and vice versa.

(vi) *UTGEO*—This programme converts UTM to geographical coordinates and vice versa.

(vii) *SUNVEL*—This programme calculates sound velocity using Wilson's Formulae.

The following programmes were developed and preserved on magnetic cards for the DCM 1101 Microsystem:

(i) Computation of Sigma-*t*

(ii) 3-Point lag range interpolation

(iii) Conversion of UTM to SHORAN coordinates

(iv) Conversion of SHORAN to UTM coordinates

(v) Conversion of UTM to Geographical coordinates

(vi) Conversion of geographical to UTM coordinates

(vii) Tidal corrections by the least square method

(viii) Polynomial curve fitting of degree η

(ix) Computations of statistical parameterwise: mean, mode, median, standard deviation, correlation coefficient, etc.

(x) Solution of simultaneous equation of degree n *(n*—9)

2. Processing of data on Cochin Harbour project sponsored by Cochin Port Trust, Cochin

A special format conforming the needs of the sponsoring agency was developed and the data were transferred to the punch cards and several sets of listings were produced.

3. Processing of fish catch data from Exploratory Fisheries Project (Bombay Base)

At the request of the Director, Exploratory Fisheries Project, Bombay, data pertaining to fish catch from 1970-75 were processed and listings were provided. The work involved the development of a suitable format, transfer of the data to punch cards, verification and preparation of computer listings.

4. Transfer of MONEX data collected by USSR during 1973 from listings to punch cards

The physical and chemical data collected under the MONEX by the USSR was transferred to punch cards for storage at the Data Centre

5. Processing of polution data on project sponsored by Bombay Municipal Corporation

The Data Centre has been transferring pollution data on a format developed for punch cards. The work is being continued. Listings can be provided now as per the requirements.

6. ROSCOP (Report on Observations / Samples Collected by Oceanographic Programmes) as recommended by WC / IODE of the IOC

As our contribution to the International Oceanographic Data Exchange (IODE) of the Intergovernmental Oceanographic Commission, ROSCOP forms were completed to provide inventory of the cruises of R.V. *Gaveshani* to the World Data Centres A and B

7. Development of formats for station location and compilation of summary of observations for cruise reports

Standard formats were provided for the presentaion of reports pertaining to different cruises of R.V. *Gaveshani.* The formats developed for the station and summary of observations are specifically aimed at locating different types of data collected during different cruises and will provide a good reference for the acquisition of data for their storage at the Indian National Oceanographic Data Centre.

8. Plotting of biological data

Plotting of different parameters of biological data received from NODC, Washington and other data available at the INODC was done for further analysis of the distribution characteristics of living organisms in the Indian Ocean.

2.7

interdisciplinary task forces

2.71 Protection of marine environment and monitoring of pollutants (Project No. 101)

1. Marine environmental monitoring along the Goa coast
2. Marine environmental monitoring along the Bombay coast
3. Marine environmental monitoring in the waters off Cochin
4. Oil pollution along the Indian coast
5. Chemistry and interaction of pollution in the coastal and estuarine waters of the west coast of India
6. Determination of heavy metal concentration in marine organisms with special reference to animals consumed as seafood
7. Bacteriology and biodegradation of pollutants

2.72 Oceanography of waters around Lakshadweep (Project No. 102)

2.71 Protection of marine environment and monitoring of pollutants

During the year, work on all the investigations could not be carried out fully, since many of the scientists had to be away on *Gaveshani* cruises. The investigations which have been continued in part or in full are as follows:

1. Marine environmental monitoring along the Goa Coast

Data collected from Velsao Bay where the industrial effluents from Zuari Agro Chemicals are discharged, were processed. The chemical composition of water in the Velsao Bay showed high values of ammonium compounds. There also seems to be accumulation of some of these pollutants in the region which was probably because of the effluent discharged from the fertilizer factory.

2. Marine environmental monitoring along the Bombay coast

Regular monitoring of the petroleum residues was made from Juhu and Versova beaches. Very heavy deposition

of tar-balls was observed during the monsoon of 1976 at Versova beach.

3. Marine environmental monitoring in the waters off Cochin

Areas of intense pollution have been identified in the Cochin backwaters and some remedial measures were suggested. Oxygen consumption of the bottom waters of polluted areas was 12 to 13 times higher than that in the barmouth area, where pollution is minimum. During the low tide BOD_5 was higher than at the high tide and high sulphide content to a maximum of 4.92 mg/litre was observed at the bottom of polluted stations. Analysis of the fauna collected during the season indicated that according to the differences in the range of abiotic factors, the distribution of the bottom fauna of the estuary can be divided into three types. 1) those which favour pollution, 2) those which are somewhat indifferent to pollution, 3) those which totally avoid pollution. It has been found that polychaetes are the most pollution tolerant group of benthic animals in the estuary *Prinospio polybranchiata* belonging to the family Spinodae probably acts as an indicator species of pollution.

An incidence of mortality of the fish *Ambassis gymnocephalus* due to cumulative effect of pollution from the industrial source in the Cochin backwaters has been reported. The factory effluents carrying a heavy load of ammonia at the rate of 432-560 ppm which is far above the accepted lethal limit of 2.5 ppm, is poured into the estuary together with many other pollutants such as acids and alkalies in large quantities. These have changed the hydrographic condition of the backwaters and have created toxic conditions causing mortality of the animals in the area.

Samples of industrial effluents received from the Kerala State Board for Prevention and Control of Water Pollution, Trivandrum in August 1976 and Kerala State Drugs and Pharmaceuticals Ltd., Alleppey in September 1976 have been analysed and reported.

4. Oil Pollution along the Indian coast

Under this programme, four beaches were regularly studied. They were Malvan in Maharashtra and Arambol, Polem and Cansaulim in Goa. The deposition of tar balls started in the month of May, i.e., with the onset of SW monsoon. The tar-balls disappeared in September—October. The frequency of observation was every 9th and 10th day during this period. Tar-balls were minimum in Maym i.e. from 0.17 to 6.24 g/m^2 and maximum in the month of July. i.*e.* from 15.6 to 32.74 g/m^2. The other related environmental parameters were also studied and it was found that wind speed had effect on the deposition.

Apart from the four beaches mentioned above, tar-ball deposition was also monitored at Calicut, Cochin and Trivandrum. The maximum tar accumulation was observed during July (165 $g/6m^2$) and minimum during December (less than 5 $g/6m^2$) at Cherai beach. Moreover, floating oil slicks were recorded in the Arabian Sea and the Bay of Bengal with the help of Indian shipping companies.

Oil pollution (tar balls) on a beach along the coast of Trivandrum

This investigation is now concluded as per the outline of the original programme. The final report, to be submitted to IGOSS is under preparation.

An experiment with different brands of Indian made polyurethane foam to test their capacity as absorbants for oil spills at sea was carried out. Results obtained so far are quite encouraging.

5. Chemistry and interaction of pollutants in the coastal and estuarine waters of the west coast of India

Environmental parameters such as temperature, pH, salinity, alkalinity, specific conductivity, dissolved oxygen, percentage saturation of dissolved oxygen and total carbon dioxide content for different months were determined in the Binaga Bay (Karwar) at different stations to locate a suitable discharge point for the effluents discharged by Ballarpur Paper Mills factory.

6. Determination of heavy metal concentrations in marine organisms with special reference to animals consumed as seafood

The results of analysis of arsenic, copper, zinc and manganese in the coastal waters as well as in seaweeds, fishes, crustacean and molluscs have been processed. It has been observed

that among the seaweeds *Sargassum tenerrimum* and *Padina tetrasomatica* are more efficient in accumulating the metals. From the analysis it is evident that the high degree of variability in the bioaccumulation of different metals, exhibited by the marine organisms, suggests the need for detailed studies on some more species of economic importance.

Some seaweeds and fishes have been analysed for some heavy metals from the Binaga Bay, Karwar.

7. Bacteriology and Biodegradation of pollutants

Laboratory experiments carried out to study corrosion of concrete in the estuarine and marine waters by *Thiobacilli* sp. isolated from fixed station in Cochin backwaters, have been completed. Some aspects of isolation, culture and assessment of their physiological abilities such as oxidation of thiosulphate to sulphate and to sulphuric acid has been reported. The final oxidation products like sulphuric acid has been qualitatively estimated. Although the sulphuric acid produced is weak it can corrode concrete because of its surface cumulative effect with time. The study has practical application in checking the microbial corrosion of large concrete structures before they are introduced into the estuary.

2.72 Oceanography of waters around Lakshadweep

In the lagoons of Kavaratti, Suheli and Agatti Atolls, the following studies were conducted :

(a) Evaluation of phytoplankton productivity with special reference to nannoplankton.

(b) Estimation of secondary (zooplankton) production.

(c) Foraminiferal assemblage in the lagoon and the beaches of all the three atolls mentioned above.

(d) Hydrographic studies in the lagoon and the open sea surrounding the atolls.

(e) At Suheli diurnal changes in oxygen were monitored for the evaluation of total productivity of the reef.

(f) Diurnal changes in dissolved carbohydrates were also studied in relation to phytoplankton production both at Kavaratti and Agatti lagoons.

Projects on turtle farming in the atolls, establishment of a national park and installation of a floating breakwater to prevent the erosion were recommended for consideration of the Lakshadweep Administration.

2.8

sponsored projects

2.81 Oceanographic survey off Narara Bet

This project, sponsored by Engineers India Ltd., New Delhi and initiated towards the end of year 1975, was completed in 1976. Data on temperature, salinity, pH, silt load and turbidity were collected over tidal cycle at 5 stations off Narara Bet (Gulf of Kutch) at weekly intervals from January to April 1976 and the report has been submitted to the sponsors.

2.82 Hydrographic studies in the inner harbour of Cochin

This project was undertaken at the request of Cochin Port Trust in May 1975 and completed in April 1976. Extensive field data on hydrographic parameters, sediment load and currents were collected from 30 stations in the inner harbour area of Cochin Port for a period of one year. Final report has already been submitted to the sponsors.

2.83 Siltation studies at Verem Goa

This project was undertaken at the request of Indian Navy to find out the effect of siltation on new jetty and boat

pen to be constructed at Verem (Mandovi estuary). Collection of the data on currents and suspended material concentration in the Verem Bay was continued till July 1976. The data are being processed and analysed.

2.84 Hydrographic features off Mangalore Coast

This project has been sponsored by Mangalore Chemicals and Fertilizers Ltd., to determine a suitable point for the discharge of their treated industrial effluents in the sea off Mangalore.

Observations on beach profiles, ocean currents and hydrographic parameters for a period of one year were completed and the data are being processed and analysed.

Preliminary analysis indicated the diminishing influence of tides on currents in the offshore direction upto a distance of about 2 km beyond which strong seasonal currents were encountered. The water column was almost stable throughout the year.

2.85 Hydrographic features off Karwar

This project was also taken up for the location of a suitable discharge point for the disposal of chemical effluents from the Caustic Soda Factory of Ballarpur Industries Ltd., Karwar, the sponsors of the project.

The survey of the sea off Ballarpur Industries Ltd., at monthly intervals over a period of one year was completed in October 1976. The data on currents and other parameters are being processed and analysed. Final report locating the discharge point 3.5 kilometre away from the coast has been suggested.

2.86 Survey of the proposed submarine pipeline route from Bombay High to Bombay

A survey of the 160 km long submarine pipeline route from Bombay High to Bombay Floating Light (BFL) was sponsored by the Oil and Natural Gas Commission. Bathymetric, side scan sonar, shallow seismic and magnetic surveys were carried out over a thousand line kilometres along different lines. *Shoran* was used for position fixing during the survey.

A low sandy ridge along the route marks a major change in the geomorphology and sediment. It separates the recent sediments of the inner shelf from the relict sediment of the outer shelf. The route lies over an even and gently sloping sea bottom. The area is marked by a series of low ridges and depressions with small topographic irregularies and sand waves.

The sea bottom in the vicinity of BFL to Bassien PF is carpeted by acoustically transparent thick clay with a prominent reflector. Gaseous sediments at shallow depth are suspected at the northern limits. Towards the sandy ridge, clay thickness decreases westwards where the relict colitic sand occurs at the surface. Further west, towards the Bombay High, the entire area is covered by relict sands with uneven topography and sand waves.

Visit of Parliamentary Sub-committee for the use of Hindi. The distinguished visitors showed keen intrest in the NIO's work for pipeline surveys.

Analysis of the bottom water, sediments and the interstitial water samples indicates oxidising environmont with micro-reducing characteristics. Iron, sulphur and hydrogen sulphide producing bacteria are also present in certain areas. Sediments, rich in organic matters in some area, appear to be conducive to the growth of fouling organisms. The pipeline route passes through an important fishing area where about 500 to 700 boats operate regularly.

The topography being smooth, the routing of the pipeline in this area is not likely to offer any serious problem except for suspected gaseous sediments at shallow depth along some lines. At greater depths uneven relict topography. sand-waves and sandy strata may cause some difficulty. The detailed survey report along with recommendations on the most suitable route has been submitted to ONGC.

The second phase of the survey was extended in the Bombay Harbour area and the work was carried out from a shallow draft boat and the positions were obtained from sexteant fix of shore objects.

Preliminary examination of the records obtained showed that bottom conditions in the area vary considerably. The bottom sediments consist of clay, sandy clay, clay and sand with broken shells in some places. These sediments occur

over the reflectors which represent rocks probably Deccan Traps. The side scan sonar records indicate clearly the extent of this rocky area along the route. The shallow seismic records also indicate steep scarps which may be minor faults depicting some neotectonic events.

2.87 Hydrographic survey and water quality studies in and around Bombay

The project was sponsored by Environmental Engineering Consultants on behalf of Bombay Municipal Corporation. Work was initiated in the month of May 1976 and will continue till August 1977. A total of 31 stations were fixed in inshore and offshore areas.

These stations were fixed with marker buoys and continuously recording current-meters were deployed for offshore monitoring at three depths at each station. The measurements at other stations were taken with manual current-metres and each station was studied at least once in a month for a complete tidal cycle. Continuous tide gauge racorders were installed at Mahim bay, Thana and Bassein creeks. The meteorological stations were installed on land as well as off Bandra to compare the wind velocity and wind direction data. Surface dye dispersion and float studies were undertaken to determine the path of possible outfall and rate of mixing. This study is to be extended at the bottom level of the water column also.

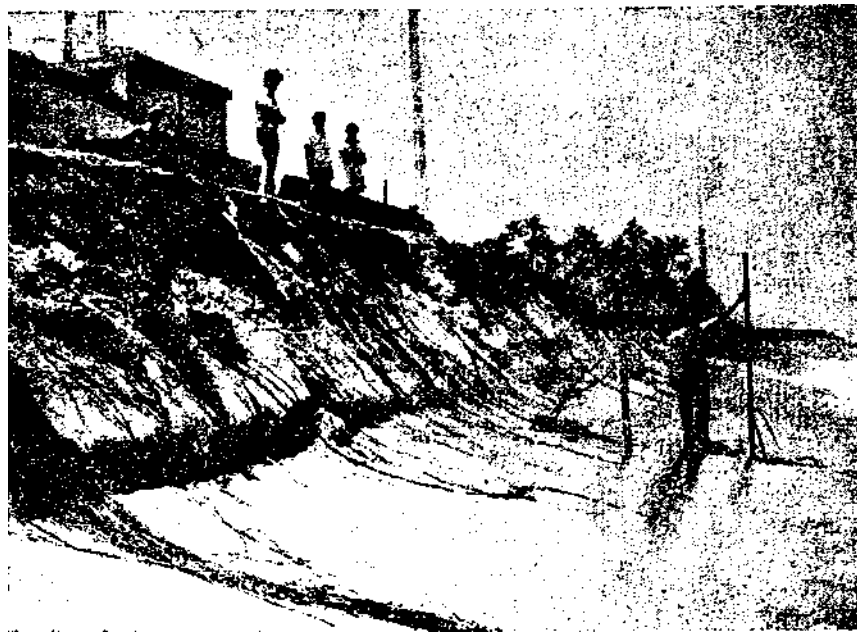
Chemical parameters like salinity, pH, oxygen, COD, BOD, total phosphorus, reactive phosphate, nitrate, nitrite, ammonia, sulphate and boron are under regular monitoring along with the toxic heavy metals like arsenic, mercury, copper, zinc and lead. Substantial pollution at some localized centres like Mahim Bay were noticed where the oxygen level often falls to zero and anoxic conditions exist. Definite presence of toxic metals was observed in the marine environment. The sewage samples from eight different sewage treatment plants were also analysed for toxic metals.

2.88 Environmental studies in relation to erosion at Thumba

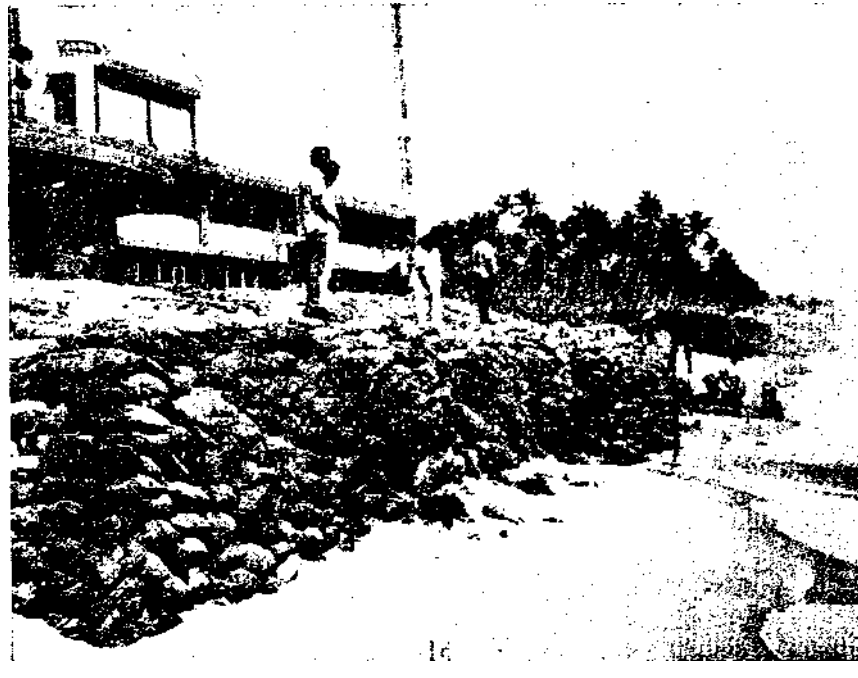
This work was sponsored by the Vikram Sarabhai Space Centre (VSSC) and the an of this project was to study the environmental factors responsible for the erosion of the beach at Thumba, where important installations such as control centre, rocket launching pads and communication centre are located.

During the month of July 1976. severe erosion was noticed reducing the beach width by about 50 metres. To safeguard the building of the VSSC at NIO's suggestion, a frontage of sand filled bags was constructed at vulnerable points as a temporary measure, which was found to be effective in combatting the forces for further erosion. By the end of August progressive accretion of the beach was observed.

The preliminary analysis of the wave records indicated that during the premonsoon season, the wave period varied between 10 to 12 seconds with wave



Severe erosion of the Thumba Beach (Trivandrum).



Sand filled bags dumped in front of the VSSC Control Tower.

height between 43 and 73 cm whereas during monsoon season the wave period was 10.5 to 14 seconds with a height of 105 to 150 cm. During the post-monsoon season the wave period was 8 to 10 seconds with wave heights of 44 to 64 cm. The littoral currents observed had a speed range of 10 to 50 cm/second along the north-west direction.

2.89 Investigation on current and temperature from Bombay High to Bombay

The project on measurement of salinity, temperature and currents in the Bombay High Region was sponsored by the Oil and Natural Gas Commission. Fathometric profiling in some regions of the Bombay High and Nava Sheva for the construction of submarine pipeline were undertaken. Monthly observations on temperature, salinity and currents were made from October 1976 and will be continued for a year in the Bombay High region and Angria Bank off Ratnagiri.

2.810 Location of lost well heads in the Bombay High Oil-fields

Side scan sonar surveys (about 300 line km) were carried out in the Bombay High area to search for the lost well heads. The ocean bottom was smooth in this region which facilitated the search and several good records were obtained depicting (i) marks of spuds supporting the Drilling Vessel, *Sagar Samrat,* (ii) interconnecting 8 inch pipelines, (iii) submerged platform and (iv) Shenandoah, flare tower and the interconnecting pipeline. The records obtained on different lines showed four orderly spaced white marks along with anchor drag marks. This facilitated narrowing down the area of location and the well head was identified.

2.811 Survey of the submarine pipeline routes in the Bombay Harbour Area

During November and December 1976, a survey of the submarine pipeline routes in the Bombay Harbour area was carried out for the Oil & Natural Gas Commission. This was an extension of the survey done earlier by NIO from Bombay High to Bombay. The survey included echosounding, side scan sonar records, shallow seismic profiling followed by bottom sampling and coring. During the survey, position fixing was done by sextant from shore objects.

On preliminary examination of the records it was found that the bottom conditions in the area vary considerably. There were wide variations in the bottom sediments along and across the lines. The bottom sediments largely consisted of clay, sandy clay, clay and sand with broken shells in some places. These sediments lie over reflectors which represent rocks, probably Deccan Traps. Exposure of rocks (Deccan Traps?) were seen in the records from the Thal Shoal and the shore ends of the pipeline route at Karanja and Butcher Islands. The side scan sonar records indicate clearly the extent of this rocky area along the route. The shallow seismic

record also indicated some steep scarps which may be minor faults depicting some neotectonic events.

2.812 Consultancy services

Besides the several sponsored projects carried out during the year, many consultancy jobs were undertaken for the different private and public sector undertakings free of cost.

2.9

international projects

2.91 United Nations Environment Programme (UNEP)

The project entitled "Marine Environmental Monitoring and Marine Living Resources Assessment Programmes for the Indian Ocean Region" was sponsored by the United Nations Environment Programme (UNEP). Under the first phase of this project, 63 marine science centres were visited and 133 scientists, technicians and administrators were contacted in Bangladesh, Burma, India, Indonesia, Malagasy Republic, Malaysia, Mauritius, Philippines, Seychelles, Singapore, Shri Lanka and Thailand.

Moreover, informations were collected about several other institutions in Brunei, Cambodia, Maldives and Pakistan from the office of the Intergovernmental Oceanographic Commission of UNESCO, Paris, and Fishery Resources and Environment Division of FAO, Rome. The entire material was consolidated in consultation with Dr. Stjepan Keckes. Programme Coordinator for UNEP in Geneva and the final report on the Survey of Institutional Capabilities has been submitted to the United Nations Environment Programme headquarters in Nairobi.

Further work has been undertaken for the preparation of a Directory of Marine and Environmental Research Centres in the Indian Ocean Region.

2.92 Integrated Global Ocean Station System (IGOSS)

Work on the Indian participation in the Marine Pollution (Petroleum) Monitoring Pilot Project (MAPMOPP) of IGOSS was continued. Observations were carried out systematically on deposits of petroleum residues as tar balls on ten beaches between Bombay and Trivandrum. Besides, observations on oil slicks and other floating pollutants in the open sea along the oil tanker route in the Arabian Sea and along the Indian coast were also carried out utilising the data provided by the ships of the Shipping Corporation of India and the Scindia Steam Navigation Co. Ltd. Copies of the Indian National Report for 1976 under this project have been submitted to the Working Committee for IGOSS of IOC and other agencies.

3

administrative set-up

3.1 Executive Committee

1. Dr. S. Z. Qasim — *Chairman*
   Director
   National Institute of Oceanography
   Dona Paula (Goa)

2. Shri K. R. Ramnath — *Member*
   Chairman & Managing Director
   Hindustan Shipyard
   Visakhapatnam (A.P.)

3. Dr. A. K. Ganguly
   Director (Chemical Group)
   Bhabha Atomic Research Centre
   Trombay, Bombay.

4. Shri V. L. N. Sastry
   Chief Geophysicist
   Oil & Natural Gas Commission
   12th Floor, Express Tower
   Nariman Point, Bombay.

5. Dr. J. S. Sastry
   Scientist 'E'
   National Institute of Oceanography
   Dona Paula (Goa).

6. Shri P. E. Shankaranarayanan
   Head, Instrumentation Division
   National Institute of Oceanography
   Dona Paula (Goa).

7. Shri T. C. S. Rao — *Member*
   Scientist-in-Charge
   Regional Centre of NIO
   Andhra University Campus
   Waltair (A.P.)

8. Administrative Officer — "
   National Institute of Oceanography
   Dona Paula (Goa).

9. Accounts Officer
   National Institute of Oceanography
   Dona Paula (Goa).

Invitee to the Executive Committee Meeting

Director General, SIR or his nominee and *Chairman, CSIR* Coordination Council for Physical and Earth Sciences.

3.2 Scientific Advisory Committee for NIO

1. Dr. S. Z. Qasim
   Director
   National Institute of Oceanography
   Dona Paula (Goa).

2. Director
   Industries & Mines
   Government of Goa, Daman & Diu
   Panaji (Goa)

3. Shri R. L. Chowgule
   Director. M/s. Chowgule & Co.
   Vasco-Da-Gama (Goa).

4. Dr. G. S. Sharma
   Prof. of Physical Oceanography
   University of Cochin
   Cochin.

5. Shri S. D. Soman
   Head, Health Physics Division
   Bhabha Atomic Research Centre
   Trombay, Bombay.

6. Dr. K. Venkoba Rao
Head, Marine Geology Group
Geological Survey of India
Calcutta.

3.3 Cruise Planning and Programme Priorities Committee for R.V. Gaveshani

The third meeting of Programme Priorities and Cruise Planning Committee for R.V. *Gaveshani* was held at 10:30 hrs on 26th November, 1976 in the C.S.I.R. building, Rafi Marg, New Delhi. The Agenda papers of the meeting were circulated on 9th November, 1976. The following were present :

1. Prof. Y. Nayudamma — *Chairman*
Director-General SIR, New Delhi.

2. Dr. A. K. Ganguly — *Member*
Director, Chemical Group
Bhabha Atomic Research Centre
Bombay.

3. Dr. D. Srinivasan — "
Director
Naval Physical & Oceano-
graphic Laboratory
Naval Base. Cochin.

4. Cdr. C. S. Dandekar — "
Dy. Hydrographer
Naval Hydrographic Officer
Dehradun.

5. Dr. M. N. Qureshy — "
Director

D.S.T.

New Delhi.

6. Dr. V. L N. Sastry — "
Chief Geophysicist
ONGC Offshore Project
Bombay.

7. Dr. A. Chandra — "
Ministry of Petroleum &
Chemicals
New Delhi

8.	Dr. V. R. Venkoba Rao Director, GSI Calcutta.	*Member*
9.	Prof. P. C. George Jt. Commissioner Ministry of Agriculture and Irrigation, New Delhi	"
10.	Shri H. R. Laxminarayan Dy. Development Adviser, Ministry of Shipping & Transport, New Delhi	"
11.	Mr. K. N. Johry Head, ISC, CSIR. New Delhi.	"
12.	Commodore I. K. Puri Adviser, NIO CSIR, New Delhi	"
13.	Dr. S. Z. Qasim Director, NIO Dona Paula, Goa.	*Convenor*

Dr. Pant of Indian Meteorological Department, Capt. Kambata, SCI, and Dr. Silas, CMFRI (ICAR) regretted their inability to attend the meeting due to pressing engagements and cancellation of flights.

The Chairman welcomed all the members attending the meeting and particularly extended a warm welcome to those who had to travel a long distance to attend this meeting.

Item 1 of the Agenda was then taken up. Dr. Qasim gave a summary of the various cruises undertaken by R.V. *Gaveshani* which had performed extremely well during the last few months and had covered practically all the programme during the period under review. She carried out her task in adverse weather conditions both in the Bay of Bengal and in the Arabian Sea. Weather data were regularly communicated by the vessel to the Meteorological Dept., which was appreciated by them. Rich grounds of shrimps off the East Coast were found during the cruise VIII between Vizag and Madras and areas of deep sea prawns were identified near Lakshadweep during cruise X.

During the ship's stay in Goa the new CTD system was fitted on the vessel with the help of Canadian Experts and successfully tried out upto 2000 metre

depth on a trial cruise. The ship undertook cruise XII from Bombay to Okha and covered about 45 oceanographic stations

R.V. *Gaveshani* has carried out 12 research cruises in about 10 months. The ship has been fully utilised and most of the systems are working. The ongoing work continued in the proposed cruise plan. The ship undertook ONGC priority project in January 1977. The NIO Regional Centre in Vizag has been established and the strength of its scientific staff will soon be increased.

Professor George felt that the exploratory work on new fishing grounds should be re-checked to obtain further details.

Dr. Qasim explained that the information was based on plankton hauls from 200 metre depth to the surface using the Indian Ocean Standard Net. This was one of the standard procedures followed all over the world for the living resources survey and on such surveys many resources atlasses have been prepared.

The Chairman stated that any valuable information obtained should be shared by the concerned agencies and the relevant organizations should be brought into the picture. He also indicated that we should be careful regarding the data of defence, political and commercial importance. Cdr Dandekar, Dr. Srinivasan and others fully endorsed the views expressed by the Chairman.

Items 2, 3 and 4

The proposed plan for the cruises during January-June 1977 for R.V. *Gaveshani* was discussed. Dr. Qasim elaborated the objectives of the cruises and the participation of other organizations in the programme. The interest shown by the Physical Research Laboratory, Ahmedabad for participating in cruises XVIII, XIX and XXI was indicated. The Committee expressed the view that as far as possible, the needs of the other laboratories may he taken into account.

Dr. Srinivasan suggested the operation of sound velocity meter in conjunction with the CTD to obtain a profile for its use in the SONAR design work.

A general discussion followed on the cruise plan suggested by NIO and each cruise was discussed and approved. Dr. Ganguly suggested that the unclassified data should be made available to user agencies. Dr. Qasim explained that the cruise reports circulated to members are only for information and that processing of oceanographic data is in progress. Details are available in the Data Centre of NIO and any institution interested may contact the Data Centre. The Chairman said that the raw data should not be made available. He further stated that as far as possible processed scientific information should be made available to the users and for scientific publications as required. However, the data should come under some discipline as it is the property of the nation. In the case of sponsored research or project work the compiled data should be made available to the client and this data should not be released to others without the permission of the client.

Cdr. Dandekar expressed the defence needs of the data and suggested that NIO should help in the processesing of raw data.

Mr. Laxminarayan, Dy. Development Adviser from the Ministry of Transport indicated the requirements of his Ministry for the Gulf of Kutch survey. The work would include current observations and wave readings at selected stations. This was agreed to as a project and should be taken up by NIO on a contract basis. He also stated that his Ministry was interested in the wave climate studies of the East Coast. The Chairman felt this could also be taken-up as a sponsored work.

Dr. Srinivasan suggested the use of a shipboard wave recorder for such studies. Commodore Puri said that the new research vessel will be provided with this recorder.

Dr. Venkoba Rao gave details of the future GSI work in different cruises. He was particularly, appreciative of the hospitality expressed to his colleagues during the earlier cruises by NIO. He also suggested that before the next meeting a circular letter asking for the requirements of different agencies should be issued and their programme should, as far as possible be reflected in future plans. He also suggested the issue of agenda papers well in advance.

Dr. Sastry gave the requirements of the ONGC work. He said that the ship would be required in December / January for about three weeks. The date would depend on the arrival of Shoran Receiver from Singapore. He said that additional survey work for the new production platform may be required in April. The details of this would be known in late March 1977 and should be taken up on a priority basis in April 1977. The ship will be required for about 3 weeks.

The Chairman said that due consideration would be given to the ONGC work and any work of national importance would be given priority. He, however, suggested that the ONGC should indicate its long term projections so that the programme should be finalized well in advance because interruption in the ongoing cruises upsets the plan of work.

Dr. Chandra wanted coring samples to be undertaken at 50 km intervals instead of 100 km apart in Cruise XVII and XVIII along the West Coast, as Kerala and Laccadives were important for gas/ oil resources. If possible a representative of the ONGC should visit NIO to examine the samples after collections.

Dr. Sastry required test coring for the study of absorbed hydrocarbon gases. Dr. Ganguly indicated that limited facilities can also be made available for sample analyses in his laboratory.

The rest of the programme and manning by the various participants was agreed to with minor alterations.

The cruise programme was approved by the Committee. The following suggestions were made regarding the participation.

Participation of various agencies in Cuises XIV to XXI

Cruise XIV — to be undertaken jointly between NIO and GSI and cost of the shiptime to be shared by the two institutions.

Cruise XV — One Scientist from GSI to go on board. One Scientist from BARC to go on board.

Cruise XVI — Two Scientists from GSI to go on board.

Cruise XVII — Two Scientists from GSI to go on board. Grab samples from the sea bed to be sent to BARC.

Cruise XVIII — To be undertaken jointly between NIO and GSI. Two Scientists from NPOL to collect reverberation data on board.

Cruise XIX — Premonex Cruise to be undertaken jointly between NIO and IMD.

Cruise XX — Premonex Cruise to be undertaken jointly between NIO and IMD.

Cruise XXI — Premonex Cruise to be undertaken jointly between NIO and IMD.

The Committee also approved in principle the participation of PRL scientists in cruises XVIII, XIX and XXI. but since no details were available, it was decided that the Director NIO should get the details from Prof. Lal directly.

Regarding the Premonex cruises XIX, XX and XXI. Dr. Srinivasan suggested that another meeting of a small group should be held to work out the details of these cruises. He said that either he or his representative will attend the meeting in Goa. Representatives from the IMD and Navy may also be asked to participate in this meeting along with NIO scientists.

The meeting adjourned with a vote of thanks to the Chair.

3.4 Budget

The Budget of the Institute for the year 1975-76 was as follows :

	Budget	**Actual**		
		(Rs. in lakhs)		
1.	Recurring	Non Plan	Plan	Total
		64.503	4.047	68.550
2.	Capital	1.433	92.054	93.487
	Total : 65.936		96.101	162.037

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
(Deputy Director)

Scientists

Dr. J. S. Sastry
Dr. B. U. Nayak
Shri L. V. Gangadhara Rao
Shri C. S. Murthy
Shri P. K. Das
Shri M. J. Varkey
Dr. P. G. Kurup
Shri C. K. Gopinathan
Shri N. M. Anand

Senior Scientific Assistants

Shri K. K. Varma
Shri P. S. Joseph (on deputation to Japan)
Shri V. Ramesh Babu
Shri V. Kesava Das
Shri C. L. Waghray

Junior Scientific Assistants

Shri Albert D. Gouveia
Shri P. Chandramohan

2. Chemical Oceanography Division

Scientist Incharge

Shri C. V. Gangadhara Reddy

Scientists

Shri S. P. Anand
Dr. R. Sen Gupta
Shri S. Y. S. Singbal

Senior Scientific Assistants

Shri S. N. D'Souza
Miss Solimabi
Shri S. P. Fondekar
Shri S. B. Kamat

Junior Scientific Assistants

Miss S. S. Naik
Shri S. W. A. Naqvi
Shri M. D. Rajagopal
Shri R. S. Topgi

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 Ch. Madhusudhana Rao
Shri D. Gopala Rao
Shri M. Veerayya

Senior Scientific Assistants

Shri M. V. Shankaranarayana Guptha
Shri G. Victor Rajamanickam
Shri R. M. Kidwai
Shri B. G. Wagle
Shri F. Almeida

Shri A. N. Nath (on deputation t0 West Germany)
Shri N. H. Hashimi
Shri G. C. Bhattacharya
Shri A. L. Paropkari

Senior Technical Assistant

Shri K. L. Kotnala

Junior Mechanical Assistant

Shri R. S. Bongade

4. Biological Oceanography Division

Scientist- in charge

Dr. M. J. George

Scientists

Dr. K. Radhakrishna
Dr. A. H. Parulekar
Shri R. M. S. Bhargava
Dr. A. G. Untawale
Shri V. P. Devassy
Shri S. C. Goswami
Dr. (Miss) Aditi Pant
Dr. (Mrs.) Sumitra Vijayaraghavan
Shri K. J. Peter
Shri P. M. A. Bhattathiri
Shri S. S. Shastri
Shri P. N. Aravindakshan
Shri Jacob George
Dr. George Peter
Shri V. T. Paulinose
Dr. (Mrs.) Vijayalakshmi R. Nair

Senior Scientific Assistants

Shri S. Ayyappan Nair
Shri P. G. Jacob

Junior Scientific Assistants

Shri C. T. Achuthankutty
Shri S. N. Harkantra
Mrs. L. Krishnakumari
Shri Z. A. Ansari
Shri M. V. Mohideen Wafar
Shri S. R. Sreekumaran Nair

5. Planning and Data Division

Scientist-in charge

Dr. V. S. Bhatt

Scientists

Shri D. Panakala Rao
Shri S. A. H. Abidi

Senior Scientific Assistants

Shri M. K. Antony
Shri J. S. Sarupria

Junior Scientific Assistant

Shri Avinash Chandra

Junior Technical Assistants

Shri P. Venugopal
Shri S. P. Sharma (upto 8-6-1976)

(Proof Reader)

6. Instrumentation Division

Hend of the Division
Shri P. E. Sankaranarayan

Scientists

Shri T. K. Sivadas
Dr. B. E. D'sa
Shri M. R. Nayak

Senior Scientific Assistants

Shri K. K. M. Rafique (on deputation to Norway upto 29-12-76)
Shri C. Rameshu
Shri S. G. Diwan

Senior Technical Assistant

Shri S. Ranganathan

Junior Scientific Assistant

Mrs. Vani B. Peshwe

Junior Technical Assistants

Shri Md. Wahidullah
Shri V. M. Date
Shri E. Dias
Shri S. Chellam

Junior Mechanical Assistant

Shri T. B. Suryakant

B. Regional Centre of NIO, Cochin

Scientist-Incharge

Dr. T. S. S. Rao

Scientists

Dr. M. Krishnankutty
Shri V. S. Rama Raju
Dr. R. V. Unnithan
Shri V. N. Sankaranarayanan
Shri H. Krishnan Iyer
Shri P. Udaya Varma Thirupad
Dr. P. Sivadas
Shri U. K. Gopalan
Shri P. Gopala Menon
Shri B. M. Panikkar
Dr. M. Saraswathy
Shri T. Balachandran
Smt. C. B. Lalithambika Devi
Shri K. Kameswara Rao

Senior Scientific Assistants

Shri P. S. Gore
Shri T. C. Gopalakrishnan
Dr. V. Santhakumari
Shri K. K. Chandrasekharan Nair
Shri G. Narayana Swamy

Junior Scientific Assistants

Smt. P. P. Meenakshi Kunjamma
Smt. Rosamma Stephen
Smt. U. P. Saramma
Shri P. Haridas
Shri T. Balasubramanian

C. Regional Centre of NIO, Bombay

Scientist-Incharge

Dr. B. N. Desai

Scientists

Dr. M. D. Zingade
Shri V. Josanto

Senior Scientific Assistants

Dr. R. Kashinathan
Shri K. Govindan
Shri M. M. Sabnis

Junior Scientific Assistants

Shri M. D. George
Shri P. V. Sathe
Shri R. V. Sharma

4

library

The Library continued to expand during the year and about 600 books were added. These include about 100 books received as gifts from the British Council Library. In addition, the library received another 300 technical reports.

150 journals were regularly subscribed and the journals received as gratis or on an exchange of our Bulletin *'Mahasagar'* have gone up to 100 this year. Thus about 250 periodicals were received in the library regularly during the year.

The inter-library loan service was continued and more than 40 exchanges were made. Also a special loan service from the United States Information Service, Bombay was started this year.

Reading material on zooplankton was compiled and distributed to the delegates of UNESCO/SCOR/NIO Symposium on "Warm Water Zooplankton".

The following two new services were introduced during the year:

1. *Aquatitles* : A fortnightly title list prepared from the journals received during the preceding fortnight.

2. *New Arrivals* : A monthly list giving details of books and journals received in the previous month.

The two new services are being appreciated by the scientific staff.

5

awards, honours & membership of various committees

1. *Dr. S. Z. Qasim* was elected as Fellow of Indian Academy of Sciences. He was also elected as Fellow of the Indian National Science Academy.

Dr. Qasim acted as :

— Chairman, Indian National Scientific Committee for Oceanic Research.

— Member, National Committee for Environmental Planning and Coordination

— Member, Indian National Commission for Cooperation with UNESCO

— Chairman, Working Committee on Training, Education and Mutual Assistance (TEMA) of IOC/ UNESCO.

2. *Dr. V.V.R. Varadachari* was elected as a Member of the E.C. of the Indian Geophysical Union.

3. *Dr. J.S. Sastry* was nominated as a member of the Indian Ocean Panel for SCOR Working Group 47.

Dr. Sastry was also nominated as Co-Chairman for mixed layer studies in the Arabian Sea.

4. *Dr. B.N. Desai and Shri S.A. H. Abidi* have been elected to the Managing Committee and Editorial Board of the Indian Fisheries Association of India from 1976-77.

5. *Shri P. E. Shankaranarayanan* served as member of the committee for purchase of equipment/machinery for College of Engineering, Goa and Government Polytechnic, Panaji-Goa.

6. *Dr. M. G. Anantha Padmanabha Setty* served as member of Study Group No. 2 of International Geodynamics Commission, 1972-78.

He is also appointed as Ph.D. examiner for Aligarh Muslim University, Aligarh.

7. Shri P.G. Kurup was awarded Ph.D. degree in Oceanography by the Cochin University for his thesis, entitled, 'Studies on the physical aspects of the mud-banks along the Kerala Coast with special reference to the Purakad mud-bank' under the guidance of Dr. V. V. R. Varadachari, Head, Physical Oceanography Division of NIO, Goa.

8. *Shri T.K. Sivadas* was awarded by Invention Board Award for development of Warp Load Master.

6

deputation

1. *Dr. S. Z. Qasim* was deputed to New York to participate in the meeting of Working Group on Training. Education & Mutual Assistance (TEMA) of IOC/ UNESCO. He also visited Bedford Institute of Oceanography, Dartmouth. Nova Scotia, Canada from 3 to 15 April, 1976.

— was deputed to Bergen, Norway as leader of Indian delegation for the 7th session of the Executive Committee of IOC held at Norway from 21 to 26 June 1976.

2. *Dr. V. V. R. Varadachari* participated in a UNESCO sponsored seminar and workshop on 'Co-operative Investigation of the North & Central Western Indian Ocean' held at Nairobi from 25 March to 2 April 1976 as invited speaker to the seminar and members of the workshop.

3. *Dr. M. G. Anantha Padmanabha Setty* was deputed to attend a seminar on coastal sedimentation at Madras organised by ONGC/GSI during March 1976.

— was deputed to attend Sixth Colloquia on Micro-paleontology and Stratigraphy at Benaras, during December 1976.

— was deputed to attend International Paleontological Conference at Lucknow during December 1976 to January 1977.

4. *Dr. R. Sen Gupta* was deputed to a total of eleven countries in the Indian Ocean region and three countries in Europe and to the east coast of India in order to collect data on Marine Environmental Monitoring and Marine Living Resources Assessment for the Indian Ocean region sponsored by UNEP. He carried out his journey in three span — 7 March to 14 April, 27 April to 25 May and 26 August to 23 September 1976.

5. *Dr. V.S. Bhatt* was deputed to Paris to attend the meeting of Ad hoc Group of Experts Marine Environmental Data and Information Referral System (MEDI) of the IOC/UNESCO from 26 to 30 April 1976.

— was deputed to attend first Indo-US Joint Seminar on Information Resources in the area of energy, environment and natural resources held at Washington USA from 2 to 20 October, 1976.

— was deputed to CSIR New Delhi to participate on Budget discussion held in the month of November 1976.

6. *Shri L.V.G. Rao* was deputed to France under the CSIR-CNRS Exchange Programme from 2 September to 22 December 1976. He also participated in the observations programme on board BORHA-2 (Bouy Laboratory in the Mediterranean Sea).

7. *Shri T.K. Sivadas* was deputed for six months under NORAD fellowship to Norway for training in the field of Marine Instrumentation from September 1976 to March 1977.

8. *Shri V.N. Sankaranarayanan* was deputed to participate in the cruise of USSR R.V. *'Dmetry Mendeleiv'* as UNESCO shipboard Trainee in the S.W. Pacific and S.E. Indian Ocean during February-March 1976. He also visited CSIRO laboratories at Cronulla, Sydney and the Department of Fisheries and Wildlife at Perth, Australia.

9. *Dr. A.H. Parulekar* was deputed to United Kingdom under the British Council-CSIR Scientist's exchange programme from September 1975 to February 1976.

10. *Dr. P. G. Kurup* was deputed to attend the international course on 'Environmental aspects of coastal engineering' held at Pune from 31 May to 26 June 1976 sponsored by UN/ UNDP and Government of India/ CWPRS.

11. *Shri N. M. Anand* was deputed to participate in the Diamond Jubilee Symposia on 'Modelling Techniques & Instrumentation' held at CWPRS Pune, 29-30 November 1976.

12. *Dr. (Mrs.) Vijayalakshmi Nair* was deputed to USA under the Fellow ship Scheme of UNESCO from October 1975 to April 1976.

13. *Dr. M. D. Zingde and Shri N. B. Bhosle* were deputed to USA for the training course in oil pollution monitoring Integrated Global Ocean Station System (IGOSS) organized jointly by UNESCO/ IOC and WMO from 26 October to 1 December 1976.

14. *Shri A. Rajachandran and Shri Avinash Chandra* were deputed to attend training programme in 'Project Budgeting and Costing' organized by CSIR at New Delhi from 5 to 7 July 1976.

15. *Shri S. Ranganathan* was deputed to CEERI, Pilani, for training on the operation and maintenance of Transreceivers from 29 to 31 October 1976.

16. *Shri S. A. Nair* was deputed to participate in the summer school for biologists on design and analysis of experiments organized by Indian Statistical Institute & Bidhanchandra Krishi Vishwavidyalaya, Kalyani from 16 May to 19 June 1976.

17. *Shri S.G. Dalal and Shri S.R. Bhat* attended a 3-week course in 'Computer Programming and Numerical Methods' at Indian Institute of Tropical Meteorology, Pune from 1 to 22 March 1976.

18. *Shri C.L. Waghray and Shri P. Chandramohan* participated in the winter school programme on 'Wave Dynamics

and Offshore Structures' held at IIT, Bombay from 6 to 31 December 1976.

19. *Shri T. K. Ramankutty* was deputed for training to the Pilot Plan of NAL, Bangalore from 24 May to 17 June 1976.

20. *Shri R. Monteiro* was deputed for training to the Automobile Service Section of NAL, Bangalore from 3 to 19 May 1976.

21. *Shri P. Sisupalan* was deputed for training in glass blowing at NCL, Poona from 3 March to 2 June 1976.

22. *Shri R. Prabhakar and Shri M. G. K. Goudar* were deputed to IIT, Bombay, for training in Fibre Glass Moulding from 16 to 28 February 1976.

7

meetings, exhibitions, seminars & symposia

1. *Dr. V. V.R. Varadachari* participated in the final meeting of the Committee on Meteorological Changes held at Delhi in December 1976.

2. *Regional Centre of NIO Cochin* participated in the Fisheries fair and exhibition at the Integrated Fisheries Project Cochin in March 1976 and in the exhibition at the Central Institute of Fisheries Technology. Cochin in June.

3. *Dr. M. G. Anantha Padmanabha Setty* presented a key note address at the fifth colloquia on Micropaleontology and Stratigraphy at Aligarh.

4. *Shri P. E. Sankaranarayanan* presented a paper, entitled, 'Electronics in Oceanographic Research' in All-India seminar on Modern Trend in Marine Electronics held at Institute of Electronics and Engineering, London (IEE) during 2-3 April 1976.

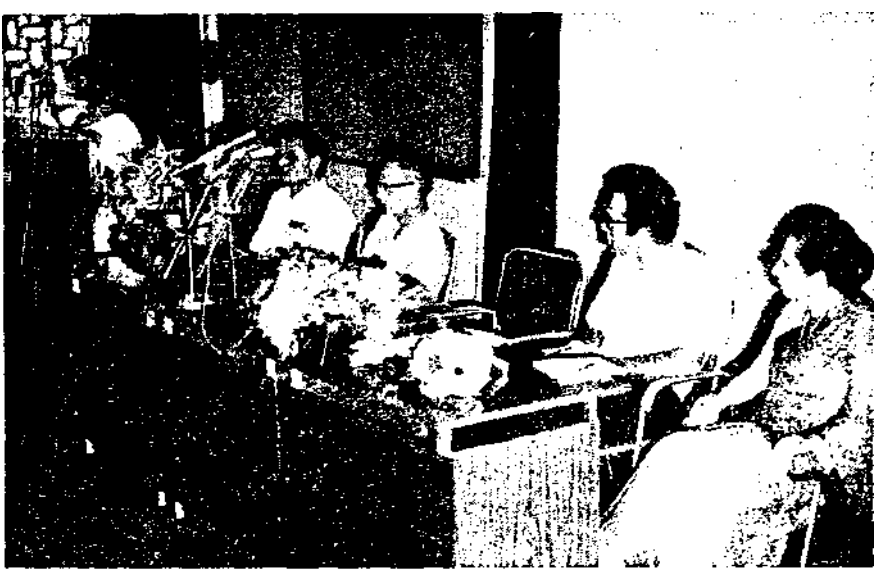
5. *Shri L. V. G. Rao* participated in the symposium on Tropical Monsoons organized by Indian Institute of Tropical Meteorology, Pune from 8 to 10 September 1976.

6. *The Council of Scientific and Industrial Research* organized a Workshop-cum-Training Programme on R & D Project Management at the NIO, Goa from 19 to 30 January, 1976. About forty scientists from different laboratories of CSIR participated in the Workshop.

7. A four day Workshop on *Navigation in Oceanography* was organized at the NIO from 14 to 17 January 1976. Dr. D. E. Wells of the Bedford Institute of Oceanography and the Department of Surveying Engineering of the University of New Brunswick delivered a series of lectures in the Workshop and several key papers were presented from different organizations. Key papers and Lectures presented at this Workshops will appear in *Mahasagar,* Vol. 10, Nos. 3 & 4,1976.

8. An All India Seminar on *Bioenergetics* was organized at NIO. Goa, jointly by the NIO. Madurai University, Madurai, and University Grants Commission, New Delhi, from 12 to 14 July, 1976. The papers presented in this Seminar highlighted the interdisciplinary approach towards solving the problems of energy transactions in biological system.

CSIR Management Training Programme was inaugurated by Prof. Y. Nayudamma (second from right) at N.I.O. in February 1976. Other in the photo are (L to R) Shri P. S. Nagpaul, Prof. A. Rahman. Dr. S. Z. Qasim and Shri N. Chowdhury.



Mrs. Sashikala Kakodkar, Chief Minister of Goa, Daman & Diu inaugurating UNESCO / SCOR / NIO Symposium on Warm Water Zooplankton at the Institute.

9. The first expert committee meeting on the *'Mangrove Ecosystem of India'* under the auspices of the Department of Science and Technology. New Delhi was held at the Institute from 11 to 13 October 1976 The Committee discussed various aspects of mangrove ecosystem and put forth various suggestions for future research as well as conservation of dwindling mangrove forests.

10. The third sub-committee of Parliament on Official Language visited NIO on 16 October 1976 to review the progress made in the use of Hindi. The visiting MPs were taken around the Institute.

11. A six-day symposium on *Warm Water Zooplankton* was held at the National Institute of Oceanography, Goa from 14 to 19 October, 1976. About 20 delegates from abroad and 57 delegates from various research Institutions in India participated.

Shri P. N. Haksar, Vice-President, CSlR, inspecting the current meter developed by the Institute.

8

colloquia and special lectures

Colloquia

	Speaker	Subject	Date
1.	Dr. S. Z. Qasim	Highlights of IOC Meeting at New York and its impact on us here at NIO	22.4.1976
2.	Prof O. P. Varma	Some observations on the mineral resources of Goa	9.6.1976
3.	Dr. J. S. Driver	Wave Instrumentation	8.7.1976
4.	Dr. S. Z. Qasim	Zooplankton Studies in 1976	27.8.1976
5.	Prof. M. Shankara Rao	Global circulation pattern of the atmosphere and the draughts	20.10.1976
6.	Dr. B. U. Nayak (Group disscussion)	Coastal Engineering, its perspectives and prospects	28.10.1976
7.	Dr. Neil Oakey	A Study of oceanic turbulence and microstructure	5.11.1976
8.	Dr. C. L. Bretschneider*	Wind wave, storm surges, and wave forces	9.11.1976
9.	Shri C. S R. Anjaneyulu	Some aspects of ship management	11.11.1976
10.	Dr. Tim Dauphinee	Principles and practice in oceanographic instrumentation	12.11.1976
11.	Dr. Y. Ramanathan	Numerical weather prediction	19.11.1976
12.	Dr. C. V. Subramanian	Fungi and man	25.11.1976
13.	Shri J. S. Sarupria Shri Avinash Chandra & Shri S. G. Dalal (Group discussion)	Some aspects of computer applications for oceanographic data processing	23.12.1976

(* Lecture was delivered at Regional Centre of NIO, Cochin.)

8.2 Special lectures

Besides the colloquia given above some routine lectures were organized in different disciplines in their respective divisions. The following three lectures were also delivered at the Institute:

1. *Dr. B. U. Nayak* delivered two lectures on 'Problems in marine pipeline projects' and 'Elastic similarity models as a tool for offshore Engineering Development' at IIT, Bombay on 30-12-76 during winter school programme on Wave Dynamics & Offshore Structures.

2. *Shri T. K. Sivadas* delivered a series of lectures on 'Electronic equipment for fishing industry and testing and measuring instruments to monitor the performance of fishing gear.

3. Training Course in NIO on the maintenance of SATNAV System for the staff of Oceanographic Instrumentation Division was arranged (20-12-76 to 2-1-77) by the engineers of M/s. Blue Star, Bombay.

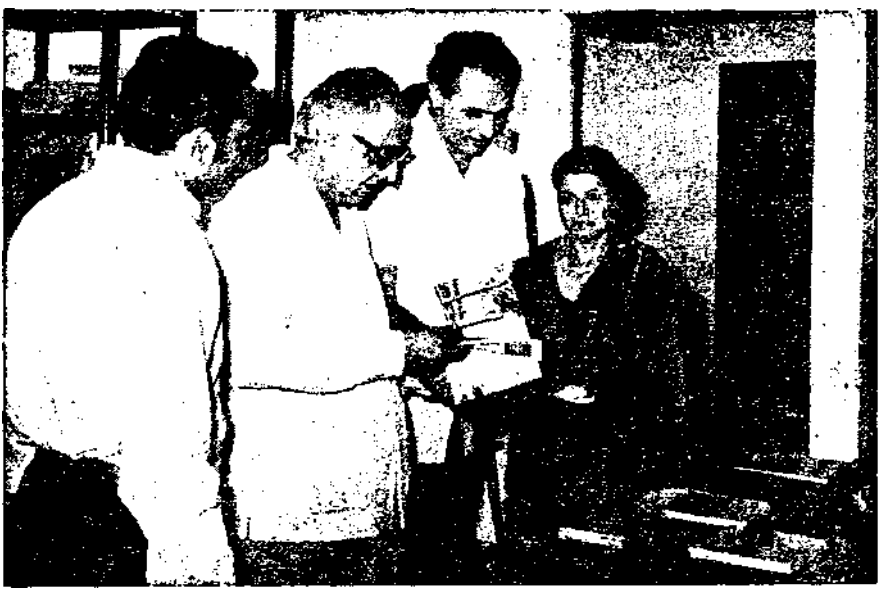
9

radio talks

Speaker	*Date*	*Subject*
Dr. S. Z. Qasim	11-1-76	A Decade of achievements in oceanography
Dr. S. Z. Qasim	5-6-76	Keeping our oceans clean
Dr. S. Z. Qasim	5-6-76	World Environmental Day
Dr. S. Z. Qasim	9-12-76	Submarine pipeline survey

10

visit of vice-president CSIR



Shri P. N. Haksar, Vice President, CSIR going through the recent publications of the institute

Shri P.N. Haksar, Vice-President of Council of Scientific & Industrial Research, New Delhi and Deputy Chairman, Planning Commission, Government of India visited NIO on 1 st November, 1976. During his visit he showed a very keen interest in the work done at the institute and discussed the various problems with the scientists. He was appreciative of the progress achieved by the Institute in all the fields of oceanography.

11

publications

11.1 Publications of the Institute

1. Annual Report 1975
2. Quarterly bulletin of the Institute, Mahasagar, Vol. 8, Nos. 1-4
3. Brochure on Sponsored Projects undertaken by NIO upto 1976
4. Brochure on the activities of NIO
5. Folder on the activities of NIO
6. Brochure on R.V. *Gaveshani*
7. Folder on R.V. *Gaveshani*

11.2 Papers published by staff

Abraham. S. and Gopalan, J. K.	1976	Growth of an estuarine herpacticoid copepoid **Nitocra spinipes,** Boeck, cultured in the laboratory. **Bull. Dept. Mar. Sci., Univ. Cochin, 7(2)** : 309-318.
Achuthankutty. C. T.	1976	Ecology of sandy beach at Sancoale. Goa : Part I - Physical factors influencing macrofaunal production. **Indian J. mar. Sci., 5** (1) : 91-97.
Achuthankutty, C. T. and M. V. M. Wafar	1976	Ecology of sandy beach at Sancoale. Goa: Part 11 - Population model and productivity of **Emerita holthuisi,** Sankolli. **Indian J. mar. Sci., 5(1) :98-102.**

Achuthankutty, C. T. and S. Ayyappan Nair	1976	A new species of sergestid shrimp, **Acetes orientalis** (Crustacea, decapoda. sergestiidae) from Goa, central west coast of India. **Hydrobiologia, 48(3)**: 233-239.
Antony, M. K.	1976	Wave refraction studies off Calangute beach, Goa with special reference to sediment transport and rip currents. **Indian J. mar. Sci., 5(1)**: **1-8.**
Bhandare, M. V. and R. Sen Gupta	1976	The efficiency of Indian polyurethane foams in absorbing spilled oil. **Mahasagar Bull. natn. Inst. Oceanogr., 9(1 & 2**) : 67-69.
Bhargava, R. M. S. and S. N. Dwivedi	1976	Seasonal distribution of Phytoplankton pigments in the estuarine system of Goa. **Indian J. mar. Sci., 5(1) : 87-90.**
Bhattathiri, P. M. A.. V. P. Devassy and R. M. S. Bhargava	1976	Production at different trophic levels in the estuarine system of Goa. **Indian J. mar. Sci., 5(1) : 83-86.**
Bhosle, N. B.	1976	Variation of haemoglobin in **Otolithus ruber** (Cuv. **&** VaL). **Mahasagar - Bull, natn. Inst. Oceanogr., 8(3 & 4**) : 199-202.
Bhosle, N. B.	1976	Study of protein denatruation by electrophoresis from different layers of eye lens of jewfish **Sciaena macropterus** Bleeker). **Mahasagar - Bull. natn. Inst. Oceanogr., 9(1 & 2**) : 45-49.
Bhosle, N. B., V. K. Dhargalkar, S. G. P. Matondkar and Sayeeda S. Bukhari.	1976	Biochemical composition of mangrove leaves from Goa. **Indian J. mar. Sci.,** 5(2) : 239-240.
Dalal, S. G.	1976	Interrelationship between environmental parameters and foraminiferal species in Mandovi and Zuari estuaries. **Mahasagar - Bull. natn. Inst. Oceanogr., 9(1** & 2) : 91-93.

Das, Hari Pada	1976	Feeding experiments on grey mullet, **Mugil cephalus L. Mahasagar - Bull, natn. Inst. Oceanogr.,** 9(1 & 2) : 79-81.
D'Silva, C. and X. N. Verlencar.	1976	Relative toxicity of two ammonium compounds found in the waste of fertilizer plants. **Mahasagar - Bull, natn. Inst. Oceanogr.,** 9(1 & 2) : 41 -44.
Fondekar, S. P. and R. Sen Gupta.	1976	Arsenic content in waters of ports of the northern Indian Ocean. **Indian J. mar. Sci.,** 5(2) : 235-237.
Gopalan, U. K. and S. E. S. Nair	1976	Ecological studies on the floating weed, **Salvinia auriculata** in Cochin back-waters and adjacent areas. Part I - Associated fauna. **Bull. Dept. mar. Sci., Univ. Cochin.,** 7(2) : 367-375.
Gouveaia, A. D., P. S. Joseph and P. G. Kurup.	1976	Wave refraction in relation to beach stability along the coast from Cape Ramas to Karwar. **Mahasagar - Bull, natn. Inst. Oceanogr.,** 9 (1 & 2) : 1 1 - 8 .
Hashimi, N. H. and R. R. Nair.	1976	Carbonate components in the coarse fraction of western continental shelf (Northern Part of India). **Indian J. mar. Sci.,** 5(1) : 51-57.
Kamat, S. B.	1976	Carbohydrates in the estuarine and coastal waters around Goa **Indian J. mar. Sci.,** 5(2) : 232-234.
Kurup, P.G. and Abraham Pylee	1976	Mode! studies on the movement of sand under different orientation of a break-water. **Mahasagar - Bull. natn. Inst. Oceanogr.,** 9 (1 & 2) : 1-5
Kurup, P.G., P.S. Joseph and V. V. R. Varadachari.	1976	Nearshore circulation in the sea off Velsao, Goa **Mahasagar - Bull. natn. Inst. Oceanogr.,** 9(1 & 2) **:** 7-10.

Murty, C. S., P. K. Das R. R. Nair. M. Veerayya and V. V. R. Varadachari	1976	Circulation and sedimentation processes in and around the Aguada Bar., **Indian J. mar. Sci.,** 5(1) : 9-17.
Naik, Sugandhini and R. Sen Gupta.	1976	Chemical oceanography of the Arabian Sea. Part II - Equilibrium of inorganic nitrogen system. **Indian J. mar. Sci.,** 4(2) : 141-144 (1975).*
Nair, N. B. and V. Shanthakumari	1976	Observations on the parasites and associates of the woodboring molluscs and crustaceans of the southwest coast of India. **Corrosion Marine Fouling, Paris 1.**
Nair, R. R.	1976	Unique mud-banks of Kerala, southwest of India. **Bull. Amer. Assoc. Petrol. Geol.,** 60(4) : 616-621.
Nair, S. S. R. and M. Krishnankutty	1976	Note on the varying effects of salinity on the growth of the juveniles of **Penaeus indicus** from the Cochin Backwaters. **Bull. Dept. Mar. Sci., Univ. Cochin.,** 7(1) : 181-184 (1975)
Nair, Vijayalakshmi R.	1976	Species diversity of chaetognaths along the equatorial region of the Indian Ocean with comments on the community structure **Indian J. mar. Sci.,** 5(1) : 107-112.
Narayana Swamy, G.	1976	Changes in Miramar-Caranzalem beach, Goa, during the period of shoaling in Aguada bar. **Mahasagar - Bull. natn. Inst. Oceanogr,,** 9 (1 & 2) . 19-22.
Narayana Swamy, G. V. Kesava Das and M. J. Varkey	1976	Wave characteristics of Goa for the period, November to May. **Mahasagar - Bull. natn. Inst. Oceanogr.,** 9 (1 & 2) : 63-66.

Pant. A. and G. E. Fogg.	1976	Uptake of glycollate by. **Skeletonema costatum** (Grev) Cleve in bacterized culture. **J. Exp. mar. Biol. Ecol.,** 22 : 227-234.
Pant, A., R. M. S. Bhargava and S. C. Goswami.	1976	Nannoplankton, total phytoplankton and zooplankton standing stock., measurements in Goa waters. **Indian J. mar. Sci.,** 5(2) :
Pant. A. and V. P. Devassy.	1976	Release of extracellular matter during photosynthesis by a **Trichodesmium** bloom. **Curr. Sci..** 45(13) : 487-489.
Parulekar. A. H.. G. V. Rajamanickam and S. N. Dwivedi.	1976	Benthic studies in Goa estuaries. Biomass and faunal composition in the Zuari estuary. **Indian J. mar. Sci.,** 4(2) : 202-205 (1975).*
Parulekar. A. H.. S. A. Nair, S. N. Harkantra and Z. A. Ansari.	1976	Some quantitative studies on the benthos off Bombay. **Mahasagar - Bull. natn. Inst. Oceanogr.,** 9(1 & 2) : 51-56.
Premchand. K. and J. S. Sastry.	1976	Hydrological characteristics and the transequatorial transport in the west Indian Ocean. **Indian J. mar. Sci.,** 5(2) : 169-178.
Rajagopal. M. D., Sumitra, Vijayaraghavan and L Krishna Kumari.	1976	Nutritive value of the rock oyster. **Crassostrea cucuilata. Mahasagar - Bull. natn. Inst. Oceanogr.,** 8(3 & 4) : 203-205 (1975).*
Ramesh Babu, V. L. V. . G. Rao, M. J. Varkey and P. Udaya Varma.	1976	Temperature distribution in the upper layers of northern and eastern Arabian Sea during Indo-Soviet Monsoon Experiment. **Indian J. Met. Hydrol. Geophys.,** 27(3) : 291-293.
Ramesh Babu, V. and J. S. Sastry.	1976	Hydrography of the Andaman Sea during late winter. **Indian J. mar. Sci.,** 5(2) : 179-189.

Rao, Ch. M. and G. V. Rajamanickam.	1976	Distribution of suspended matter in waters of the north-western shelf of India. **Indian J. mar. Sci.** 5(1) : 124-125.
Rao, Ch. M., G. V. Rajamanickam, P. S. N. Murty and C. V. G. Reddy.	1976	Partition pattern of iron in the recent sediments of the northern half of the western continental shelf of India. **Indian J. mar. Sci.,** 5(1) : 46-50.
Rao, Ch.M. and M. G. Anantha Padmanabha Setty.	1976	Distribution of iron, manganese, cobalt and nickel in sediment cores of the north-eastern · Arabian Sea. **J. Geol. Soc. India,** 17(2) : 232-261.
Rao, D. Gopala.	1976	A preliminary interpretation of two gravity profiles on the continental shelf margin west of Bombay (India). **Mar. Geol.,** 22 : 731-735.
Rao, K. V., L. Krishna-kumari and P. Sivadas.	1976	On three rare doridiform nudibranch molluscs from Kavaratti Lagoon. Laccadive Islands. **J. mar. biol. Ass. India,** 16(1) : 113-125.
Rao, K. V., L Krishna-kumari and S. Z. Qasim.	1976	Aquaculture of green mussel, **Mytilus viridis** - L. spawning, fertilization and larval development. **Indian J. mar. Sci.,** 5(1) : 113-116.
Rao, L. V. G., Thomas Cherian, K. K. Varma and V. V. R. Varadachari.	1976	Hydrographic conditions and flow pattern in Cumbarjua canal, Goa. **Indian J. mar. Sci.,** 5(2) : 163-168.
Rao, T. C. S. and G. C. Battacharya	1976	Aeromagnetic anomalies in the Bengal Fan. **Indian J. mar. Sci., 5(1)** : 117-118.
Reddy, M. P. M.	1976	Wave refraction in relation to sediment transport tendency along the west coast of India. **Indian J. mar. Sci.,** 5(2) : 152-162.

Royan, Joseph P.	1976	Effect of light on the hatching and growth of **Artemia salina. Mahasagar - Bull. natn. Inst. Oceanogr.** 9(1 & 2) ; 83-85.
Sankaranarayanan, P. E.	1976	Digital phasemeter employing switching mode operated current sources. **Electro-Technol.**
Saraladevi, K.	1976	Record of **Halptilus austini** Grice (Copepoda : Calanoida) from the Indian Ocean. **Mahasagar - Bull. natn. Inst. Oceanogr.** 9(1 & 2) : 75-77.
Sen Gupta, R., M. D. Rajagopal and S. Z. Qasim.	1976	Relationship between dissolved oxygen and nutrients in north-western Indian Ocean **Indian J. mar. Sci.,** 5(2) :
Sen Gupta, R., V. N. Sankaranarayanan, S. N. DeSouza and S. P. Fondekar	1976	Chemical oceanography of the Arabian Sea. Part III - Studies on nutrient fractions and stoichiometric relation-ships in the northern and the eastern basins. **Indian J. mar. Sci.,** 5(1) : 58-71.
Siddiquie, H. N. M. Veerayya, Ch. M. Rao, P. S. N. Murty and C. V. G. Reddy	1976	Deep sea drilling project site 119 on the Laccadive ridge. **Indian J. mar. Sci.,** 5(1) : 18-34.
Siddiquie, H. N. and R. N. Sukheswala.	1976	Occurrence of Rhyolitic tuffs at deep sea drilling project site 219 on the Laccadives ridge. **J. Geol. Soc. India,** 17(4) : 539-546.
Singbal, S. Y. S.	1976	Diurnal variations of some physico-chemical factors in the Mandovi estuary of Goa **Mahasagar** - **Bull. natn. Inst. Oceanogr.,** 9(1 & 2) : 27-34.
Singbal, S. Y. S., S. P. Fondekar, and C. V. G. Reddy	1976	Chemical characteristics in the in-shore waters of Velsao Bay. Goa. **Mahasagar - Bull. natn. Inst. Oceancgr.** 9(1 & 2): 35-40.

Sumitra Vijayaraghavan	1976	Extracellular liberation of dissolved carbohydrates by **Criscosphaera carterae** and **Coccolithus-huxleyi. Mahasagar - Bull. natn. Inst. Oceanogr.,** 9(1 & 2) : 71-74.
Untawale, A. G. and A. H. Parulekar.	1976	Some observations on the ecology of an estuarine mangrove of Goa. **Mahasagar - Bull. natn. Inst. Oceanogr.,** 9(1 & 2) . 57-62.
Varkey, M J. and V. Kesavadas	1976	Light transmission characteristics of the northern Arabian Sea during December-May. **Indian J. mar. Sci.,** 5(2) : 147-151.
Veerayya, M., Ch. M. Rao, P. S. N. Murty and C. V. G. Reddy	1976	Distribution of iron, manganese and titanium in sediments of DSDP Site 220 in the south-eastern Arabian Sea. **Indian J. mar. Sci.,** 5(1) : 35-40.
Verlencar, X. N.	1976	Effect of urea on marine phytoplankters. **Indian J. mar. Sci.,** 5(1) : 132-133.
Vijayan, M., K. N. Remani and R. V. Unnithan	1976	Effects of organic pollution on some hydrographic features of Cochin backwaters. **Indian J. mar. Sci.,** 5(2) : 196-200.
Wafar, M. V. M. Sumitra Vijayaraghavan and L. Krishnakumari.	1976	Seasonal changes in the nutritive values of the green mussel, **Mytilus viridis** Linne. **Indian** J. **mar. Sci.,** 5(2) 252-254.
Zingde, M. D., S. Y. S. Singbal, C. F. Moraes and C. V. G. Reddy.	1976	Arsenic, copper, zinc and manganese in the marine flora and fauna of coastal and estuarine waters around Goa. **Indian J. mar. Sci.,** 5(2) : 212-217.

11.3 Popular articles and reviews

Bhatt, V. S.	1976	Aquatic Sciences and Fisheries Information Resources in Marine Sciences in India. **Proc. US-India Seminar on Information in Energy, Environment and Natural Resources, Washington, DC.**

Bhatt, V. S.	1976	Oceanography in service of common man. **Jour. of Industry & Trade,** 25(9) : 45-47.
Bhatt, V. S. and Avinash Chandra.	1976	Rashtriya Samudra-Vigyan Sansthan ka Samudra Vigyan ki Samasyayon ke Nirakaran mein yog (in Hindi). **Vigyan Pragati,** 8(281) **:** 250-255.
Bhattacharya, G. C.	1976	Oil exploration and geophysics. **Sci. Forum,** 1.
H.arkantra, S. N.	1976	Shell fish culture **Silver Jubilee Souvenir of Aghanashani Teerada Meenugarara Sahakari Sangha Ltd.,** Tadri (N.K.). Karnataka
Jacob. P. G.	1976	Origin of life on earth — some new views **Sastragathi,** 51 : 31-35.
———	1976	It is the turn of the turtles **Science Reporter,** 13 (2) 86-89.
———	1976	From here to immortality. **Science Reporter,** 13(2) **:** 103-104.
———	1976	The vast wealth of oceans **Science Reporter,** 13(3) : 185-186.
———	1976	Marine turtles — a little known oceanic resources **Vijganakairali,** 8(1) 31-35.
——	1976	Ancient dead bodies speak **Sastra-gathi,** 55 : 29-34.
———	1976	Living resources of the oceans — promises for tomorrow Vidyakaumudi, 7(7) : 70-77.
———	1976	Less known living resources of the Indian Ocean. **Jour. of Industry & Trade,** 26(9) : 42-44

————————	1976	A note on the smallest and biggest useful fishes. **Open Science,** 24-25
Rao, T. S. S.	1976	Plankton from our sea. . **Science Reporter.** 13(10) : 587-591
Swamy, G. N.	1976	Sea water— Part I & II**. Sastragathi,** 54 & 55 : 23-30 & 41-56. .
Unnithan, R. V.	1976	Pollution problem in the backwaters of Kerala. **Seafood Export Journal,** 8(6) : 31-36.

* *These papers could not be incorporated in the NIO annual report 1975 due to various reasons.*

11.4 Reports prepared by the staff

Contributors	Report	Year	Sponsored by
Parulekar, A. H. and A. G. Untawale.	Report on flora and natural history of Pirotan Island in the Gulf of Kutch	1976	The world wildlife Fund-Indian National Appeal
Parulekar, A. H., Varkey, M. J. and T. W. Qureishi	Observations on some physico-chemical parameters in the Cumbarjua Canal in relation to effluent discharge from CIBA-GEIGY, Corlim, Goa	1976	Ciba -Geigy, Goa.
Nayak, M. R., V. Subramaniam, and P. E. Sankaranarayanan.	Working of the satellite navigation system CMA-722A during the period May 3, 1976, on R.V. *Gaveshani,* June 1976. No. INST-76-02.	1976	
Rama Raju, V. S., P. U. Varma and R. Pylee.	Hydrographic observations in the inner Harbour of Cochin port for harbour development works, NIO Regional Centre, Cochin, Repot No. 1/76,Vol. 1 &2.	1976	Cochin Port Trust Cochin
Rao, D. Gopala	Location of lost well heads in the Bombay High Oil-fields, 7 Plates pp. 1-9	1976	Oil and Natural Gas Commission, India.
Scientists of NIO (Coordinator - H. N. Siddiquie)	Survey of the proposed submarine pipeline from Bombay High to Bombay Vol. 2, Seabed Surveys	1976	"
Coordinator R. Sen Gupta	Report on the marine environmental monitoring and marine living resources assessment programme for the Indian Ocean Region. Phase I. Survey of Institutional capabilities (UNEP Project FP 1301-75-01/512)	1976	United Nations Environment Programme
"			

Contributors	Report	Year	sponsored
Anonymous	Research and Development needs of Industries in Goa—Joint Project of CSIR and Directorate of Industries & Mines Govt of Goa, Daman & Diu.	1976	
Co-ordinator A G. Untawale	Preliminary report on seaweed resources of Konkan Coast. NIO/CSMCRI coordinated project.	1976	
Co-ordinator P. E. Sankarnarayan	Instrumentations on board R V. *Gaveshani* until the end of June 1976 No. INST-76-03.	1976	
Scientists, NIO	Survey of R & D requirements of Industries in Goa, Daman & Diu.	1976	
Co-ordinator V. V. R. Varadachari	Report on the studies of physical parameters of the shoreline and the adjoining Sea at Loliem, Goa.	1976	Government of Goa, Daman & Diu.
Co-ordinator J. S. Sastry	Report on oceanographic survey off Narara Bet, Gulf of Kutch		Engineers India Ltd,, New Delhi
Co-ordinator J. S. Sastry	Report on the survey of the proposed submarine pipeline route from Bombay High to Bombay. Vol. 1 - Hydrographic survey.		Oil & Natural Gas Commission, India
Co-ordinator V. V R. Varadachari	A National report on physical Oceanography and marine geo-physics for progress in geophysics.	1976	

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