NATIONAL INSTITUTE OF OCEANOGRAPHY GOA-INDIA

ANNUAL REPORT

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NATIONAL INSTITUTE OF OCEANOGRAPHY
(Council of Scientific *&.* Industrial Research)
DONA PAULA - 403 004
GOA, INDIA

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General Introduction

In 1978, emphasis on the utilization of technology available at the Institute by the user community was continued. The Institute's research and development programmes included 23 projects, of which 6 were started during this year. Priority was given to the All India Coordinated and Rural Development Projects.

During the year under report, Research Vessel *Gaveshani* completed 19 cruises covering about 317 stations and 18,000 line kilometres in the Arabian Sea and Bay of Bengal. These cruises, besides enhancing our knowledge of the Indian Ocean, will form the necessary input to the various R and D projects related to marine living and non-living resources, and on physical and chemical processes as well as environmental conditions of the seas around India.

Twelve projects sponsored by the public and private undertakings were undertaken and the total financial input received by the Institute under these projects was Rs. 43 lakhs. The main areas of work were similar to those of the previous year, *i.e.* pipeline routes and related surveys in the sea, pollution control and coastal protection. In addition, advice and consultancy services were provided to many organizations.

The Institute extended its cooperation to several international organizations, *viz.* IOC, FAO, UNESCO and UNEP by participating in their activities related to marine resources, environmental research, pollution control, scientific information and data management.

During the year, an important addition to the infrastructure facilities was a third generation Computer TDC - 316 from ECIL, Hyderabad. This would greatly facilitate the processing, storage, retrieval and dissemination of oceanographic data and information.

An Indo-US Workshop on Oceanography sponsored by the Department of Science and Technology, was held in the Institute.

The Regional Centre, Waltair was further strengthened during the year with the necessary equipment and manpower to facilitate R and D work. A piece of land was also acquired at the Andhra University Campus, Waltair for the permanent building of this Centre. Similarly, the other Regional Centres at Bombay and Cochin were also provided with better equipment and facilities for work.

DIRECTOR

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Research Activities

2.0 Oceanographic cruises of Research Vessel *'Gaveshani'*

During the year under report R.V. *Gaveshani* completed 19 cruises covering 317 stations and 18000 line kilometres in the Arabian Sea and Bay of Bengal. Of these, 13 cruises were undertaken in the Arabian Sea and 6 in the Bay of Bengal.

Cruises in the Arabian Sea

Five of 13 cruises in the Arabian Sea were devoted to the survey of oil pipeline routes from Bassein to Gujarat and Bassein to Tarapur and Hajira. One cruise was undertaken in collaboration with the Geological Survey of India for the preparation of surficial geological map of the continental shelf of India. Five cruises were devoted to the geological studies of the continental shelf and slope of west coast of India. One multi-disciplinary cruise was on the oceanography of Laccadive Sea. Another short cruise was undertaken for preliminary shipborne compatibility test of the Omega upsonde system in collaboration with the Space Applications Centre, Ahmedabad.

Cruises in the Bay of Bengal

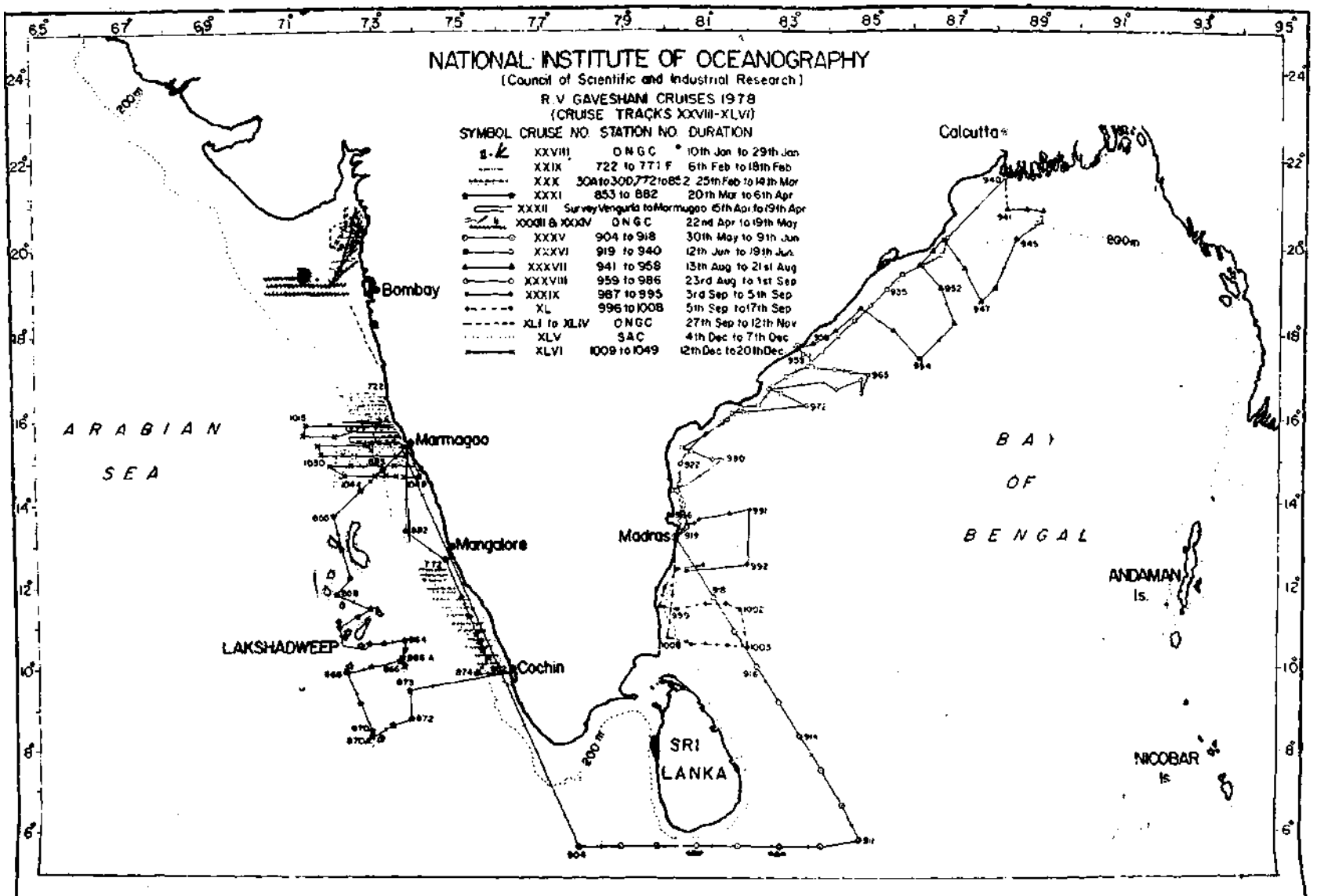
Of the 6 cruises in the Bay of Bengal, 5 were multidisciplinary and included the study of oceanographic conditions of the Bay of Bengal. One cruise was on the study of pollution along the oil tanker route from south of Sri Lanka upto the mouth of the Strait of Malacca.

A brief summary of the work done in different cruises is as follows:

Cruise 28

The 20 days cruise from 10th to 29th January was organized for the survey of oil pipeline routes from Bassein to Gujarat and shallow seismic survey in the Bombay High oilfields for designing of platforms.

More than 300 line km of echosounding, side scan sonar and shallow seismic surveys were carried out along the pipeline routes from Bassein to Navapur, Daman and Hajira and along the southern Bombay High region. The surveys revealed that the depth along the route from Bassein to Navapur varied from 14 to 55 m, and is characterised by even topography and is largely covered by clays. Along the route from Bassein to Daman, the depth varied from 8 to 52 m. The route towards the shore end was marked by uneven topography and had sandy bottom. The first 84 km were marked by even topography, while the rest had uneven hard strata. The north-eastern area of Bombay High was covered with 1-4 m of clay overlying sands.


NATIONAL INSTITUTE OF OCEANOGRAPHY
(Council of Scientific and Industrial Research)
R.V GAVESHANI CRUISES 1978
(CRUISE TRACKS XXVIII-XLVI)
SYMBOL CRUISE NO. STATION NO. DURATION
XXVIII O N G C 10th Jan to 29th Jan
XXIX 722 to 771 F 6th Feb to 18th Feb
XXX 30A to 300, 772 to 852 25th Feb to 14th Mar
XXXI 853 to 882 20th Mar to 6th Apr
XXXII Survey Vengurla to Marmugao 15th Apr to 19th Apr
XXXIII & XXXIV O N G C 22nd Apr to 19th May
XXXV 904 to 918 30th May to 9th Jun
XXXVI 919 to 940 12th Jun to 19th Jun
XXXVII 941 to 958 13th Aug to 21st Aug
XXXVIII 959 to 986 23rd Aug to 1st Sep
XXXIX 987 to 995 3rd Sep to 5th Sep
XL 996 to 1008 5th Sep to 17th Sep
XLI to XLIV O N G C 27th Sep to 12th Nov
XLV S A C 4th Dec to 7th Dec
XLVI 1009 to 1049 12th Dec to 20th Dec
Calcutta
Bombay
Marmagoo
Mangalore
Cochin
Madras
LAKSHADWEEP
ANDAMAN Is.
NICOBAR Is.
SRI LANKA
ARABIAN SEA
BAY OF BENGAL
200m
200 m
65° 67° 69° 71° 73° 75° 77° 79° 81° 83° 85° 87° 89° 91° 93° 95°
24° 22° 20° 18° 16° 14° 12° 10° 8° 6°

Cruise 29

This cruise was undertaken jointly with the Geological Survey of India (GSI) from 6-18 February. The main objective was to collect geological and geophysical data on the continental shelf between Ratnagiri and Vengurla. This was the first attempt for surficial geological mapping of the continental shelf of India.

About 2,000 line km of echosounding, 1,000 line km of side scan sonar and shallow seismic and 1200 line km of magnetic surveys were carried out. The surveys indicated that the shelf from the shore to a depth of about 50-60 m is characterised by even topography and is covered by clays, and beyond this depth relict oolitic sands occur and these are characterised by a series of ridges appearing in groups of 10 or more, which were confirmed to be relict coral reefs or coral limestones.

Cruise 30

This 18-day cruise was conducted from 25 Feb to 14 March and included the survey of continental shelf and slope between Kasargod and Cochin along thirteen traverses normal to the coast, spaced at approximately 20 km intervals and extending from 20 to 1000 m depth. About 2200 line km of echosounding, 770 line km of sub-bottom profiling, 875 line km of side scan sonar and 2000 line km of magnetics were carried out in this survey. 81 stations for bottom sampling, 29 stations for bathythermographic observations and 6 stations for reverberation studies were occupied. In addition, one section off Vengurla which was covered during the 29th cruise of R.V. *Gaveshani* was repeated for side scan survey to understand the relationship between false echoes recorded earlier and the thermocline. Four stations were occupied along this section for BT observations.

Echo-sounding, sub-bottom profiling and side scan surveys have clearly indicated the presence of an underwater ridge (with its height varying from 6 to 10 m) between 85 and 100 m water depth. Its presence along most of the traverses covered during the survey, suggests that it is a continuous feature extending from Kasargod to the southern-most end of the surveyed area. Sub-bottom profiles have indicated that the thickness of the sediment in the nearshore regions is of the order of 25 to 40 m and that the outer shelf is covered by sandy sediments with a 2 to 3 m thick layer of clay. Magnetic surveys revealed a large wave length anomaly centred along the shelf edge. Bottom sampling showed that the sea bed upto 50 to 60 m depth and beyond 150 m depth is carpeted with fine-grained sediment while the region in between 60-150m depth is covered by coarse-grained sediment. Studies on the thermal structure of the waters indicated that the thermocline was sharper in the southern part as compared to the northern part. Further, from a preliminary examination of the temperature profile worked out in the regions where false echoes were recorded by side scan sonar, the depth of the thermocline was found to coincide with the depth of false echoes in respect of most of the stations.

Cruise 31

This cruise was undertaken from 20th March to 6th April with a broad objective of studying the oceanography of the Laccadive Sea (Lakshadweep.)

During the cruise, 2645 line km were covered and 30 stations were worked. In all 347 samples were collected and 2530 analyses were made on board. Since the cruise was multi-disciplinary in nature the various parameters such as salinity, dissolved oxygen,

petroleum hydrocarbon, dissolved particulate matter, heavy metals, zooplankton biomass, dry and wet bulb temperature, atmospheric pressure, sea state, sea surface temperature, etc., were studied. At Kavaratti and Minicoy lagoons collections of some corals and other material were made for the extraction of tissue homogenate to determine their pharmaceutical properties.

Some of the important findings of this cruise were: (i) an abundance of the larvae of red prawns between the depths of 200 and 500 m and (ii) deposition of tar balls along Kavaratti lagoon.

Cruise 32

As a part of institute's programme of geological and geophysical surveys of the continental shelf, this cruise of 5 days from 15-19 April was undertaken to carry out sampling on the continental shelf extending from south of Ratnagiri to Mangalore. About 260 line km of echosounding, 490 line km of side scan sonar and 430 line km of shallow seismic surveys were carried out.

The depth in the area surveyed varied from 20 to 300 m and shelf break occurred between 115 and 125 m. The inner shelf was found to be covered by clays, thin seaweeds while the mid shelf had acoustically opaque and presumably compact sand. The outer shelf was marked by uneven topography.

Cruise 33

Earlier, at the request of Oil and Natural Gas Commission, three surveys of the pipeline route from Bassein to Tarapur and Hajira in Gujarat were carried out. However, in these surveys not much work could be done northeast towards the shore. Consequently, it was decided to devote cruise 33 for the survey of shoreward extension of the earlier surveys, i.e. from Erangal to Hajira.

This 14-day cruise started on 22nd April and ended on 4th May. In this cruise- about 750 line km of echosounding, side scan sonar and sub-bottom profiling were covered. These were followed by dredging, grab sampling and coring. The depth in the area ranged from 16 to 18 m at the shore approaches of the pipeline route and more than 65 m at the SE end of the connecting pipeline routes to Bassein river platforms. The nearshore areas showed an uneven topography.

Cruise 34

This cruise was planned with a dual objective of completing the surveys conducted earlier for the development of Bombay High and for commencing the work on the- priority project by National Committee for Science & Technology (NCST) entitled "Sedimentological, geochemical and microbiological studies on the continental shelf between Bombay High and Kutch".

The cruise commenced on 6th May for a duration of 14 days. About 200 line km of echosounding and shallow seismic profiling were carried out along eight NS profiles on the south Bombay High. The depth in the area varied from 65 to 85 m. The northern part of the area showed an even topography with about 1-3 m of clay underlain by sand.

Under the NCST Project more than 480 line km of echosounding, side scan sonar and shallow seismic profiling were carried out. The depth in the area ranged from 35 to 90 m, the region from 35 to 65 m was found to be clay-covered (about 20 m thick) which decreased in thickness towards west and finally disappeared at about 65 m.

Cruise 35

This cruise was largely devoted to chemical oceanography with special reference to pollution studies along the oil tanker route from south of Sri Lanka upto the mouth of the Strait of Malacca. The 11-day cruise started on 30th May and ended on 9th June. In all 18 stations up to 3,500 m depth were worked and the analysis of petroleum, chlorinated hydrocarbons and heavy metals in water, plankton and sediments was carried out at 15 stations. Observations were also made for oil slicks and other floating pollutants.

In all 1532 analyses on different parameters such as salinity, oxygen, pH, fluoride, urea-nitrogen, etc. were carried out on board the vessel. A study on the dampening effect of Bengal of waves near mud-bank located off Alleppey was also carried out enroute.

Cruise 36

This cruise started on 12th June and ended on 19th June 8 (days). It was in the Bay of Bengal to collect data from 22 stations from Madras to the Sand Heads (Calcutta).

During the cruise, close sampling at the mouth of the rivers Krishna, Godavari, Mahanadi and Ganga waters was done at 22 stations covering a distance of 1876 line km. In all 135 samples were collected using Nansen bottles and 17 samples using Van Dorn bottles and 1079 analyses were carried out on board. The parameters estimated were salinity, oxygen, pH, phosphate phosphorus, nitrate-nitrogen, nitrite-nitrogen, ammonia-nitrogen, urea-nitrogen, silicate-silicon and fluoride. The water samples were also preserved for the analysis of trace elements and hydrocarbons. Besides these, at all the stations, meteorological observations comprising wind speed and direction, dry and wet bulb temperatures, atmospheric pressure, sea surface temperature, sea state, weather, clouds, visibility, etc., were also made.

Cruise 37

This cruise was in continuation of the earlier multidisciplinary cruises in the Bay of Bengal and was devoted to the study of the oceanographic conditions in the coastal areas from Calcutta to Visakhapatnam.

The 11-day cruise was from 11-21 August. Data on various parameters such as salinity, oxygen, pH, productivity at 11 selected stations were collected. Besides these, meteorological observations were also made from all the stations.

Cruise 38

The 10-day cruise from 23 August to 1 September in the Bay of Bengal was again multidisciplinary in nature and was conducted in continuation to cruise 37. 26 stations were worked in this cruise between Visakhapatnam to Madras. General oceanography of the western part of the Bay of Bengal during the southwest monsoon was studied during this cruise.

Cruise 39

The 39th cruise was again a monsoon cruise to study general oceanography from Madras to Mahabalipuram. During this cruise which lasted from 3rd to 5th September, 10 stations were worked. Physical, chemical and biological characteristics of this region were studied.

Cruise 40

This cruise was undertaken from 5-7 September in continuation of the earlier cruises in the Bay of Bengal. During this cruise, 13 oceanographic stations were covered and samples were collected for the study of physico-chemical and biological parameters from Madras to the southern most part of India in the Bay of Bengal. The vessel returned to Goa after the completion of the cruise.

Cruise 41

This cruise was geological and geophysical in nature and was undertaken from 27th September to 3rd October in the continental shelf of the west coast. During the cruise, bathymetric and magnetic surveys were carried out along E-W tracks totalling 350 line km between Aguada and Vengurla using Satellite Navigation System and Radar fixes. The depth in the area surveyed varied from 20 to 200 m and shelf break was found to occur between 100 and 120 m. The inner and middle shelf were characterised by almost even topography, while beyond a depth of 60 m the sea bed was uneven. About 1000 line km of bathymetric and magnetic surveys were also carried out along the E-W profiles on the continental shelf between Bombay and Bombay High.

Sub-bottom profiling along the lines was also done in Bassein oilfield for selecting a suitable site for jacking up of DV *Shanandanh.* The depth in this area varied from 35 to 400 m and were marked by even topography. The area was found to be covered with 15-18 m of acoustically transparent clay overlying a hard substratum.

Cruise 42

This cruise was undertaken from 3rd to 23rd October for a detailed survey of oil pipeline route from Bassein to Gujarat. About 1434 line km of echosounding, 984 line km of side scan sonar, 984 line km of shallow seismic and 450 km line of magnetic surveys were carried out during this cruise.

Preliminary analysis of the records obtained was carried out on board and isopachs of clay were prepared. It was observed that the seabed off Umbhrat was more even than at Umbergaon.

Cruise 43

This cruise of 11 days duration commenced on 24th October and formed a part of the second phase of the survey of submarine pipeline route from Bassein to Gujarat.

During the cruise five E-W lines off Daman, two lines from Bassein to Daman and four lines in the E-W direction were covered. In all, 473 line km of echosounding, 467 line km of shallow seismic, 323 line km of side scan sonar and 355 line km of magnetic surveys were carried out on board and isopach maps of clay were prepared. The surveys

indicated that the seabed near Bassein and is characterised by clay cover and had a gentle gradient. The clay cover was found to become thin towards the coast along the lines to Daman.

Bottom sediment samples (14 nos.) collected in the areas of uneven topography and shoals off Umbhrat and Umbergaon included sticky clays mixed with pebbles, shells and brown sand.

Cruise 44

The second phase of the submarine pipeline routes from Bassein to Gujarat was completed during this cruise.

The 9-day cruise started on 4th November and ended on 12th November. During the cruise more than 336 line km of echosounding and shallow seismic profiling were carried out. The survey revealed that the area between Bassein to Daman was largely marked by an even topography and was presumably covered by clays. The area off Umbergaon, between 18 to 27 m depth was devoid of clay cover and was marked by uneven topography characterised by numerous pinnacles with an average elevation of 2.5 m.

Cruise 45

A short cruise of 4 days from 4th to 7th December was undertaken in collaboration with Space Applications Centre, Ahmedabad in the vicinity of Goa. The primary objective of the cruise was to carry out a VLF noise survey and preliminary ship-borne compatibility test of the Omega Upsonde System (Preliminary Engineering Model) developed by the Space Application Centre, Ahmedabad.

Cruise 46

The 9-day cruise from 12th to 20th December was undertaken for an intensive study of the oceanographic conditions off Goa. During the cruise a stretch of 139 km between Vengurla in north and Karwar in south was covered. In all, 41 stations were worked out at depth ranging from 20 to 2500 metres and the ship covered 1724 km. Samplings were done for the analysis of chemical parameters, plankton, bottom fauna and petroleum hydrocarbons. Observations were also made every day for the oil slicks and other floating pollutants. A Neuston net was towed at the surface to study the concentrations of floating and particulate petroleum residues (tar balls) at fixed stations.

2.1

Physical Oceanography

2.1.1 *Studies on ocean-atmosphere interaction (Project No.* 701)

1. Monsoon-77 and Monex-79 studies
2. Wind induced ocean circulation

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

1. Advection-diffusion phenomena in the .Indian Ocean
2. Wave climate

2.1.3 *Studies on the land-sea interaction and near shore circulation along the Indian coastline and their application to coastal zone management (Project No.* 703)

1. Beach changes along the Goa coast
2. Currents and siltation in Verem bay, Mandovi estuary, Goa
3. Hydrographic features of the nearshore waters off Karwar
4. Studies on the beaches of Trivandrum
5. Studies on the dynamics of the Cochin backwaters estuarine system
6. Erosion studies at Versova beach, Bombay

2.1.4 *Utilization of wave energy for shore protection and water pumping (Project No·* 704)

During the year, special features of the research activities in Physical Oceanography were (i) Installation of "Thermosalinograph" on R.V. *Gaveshani* for continuously recording sea surface temperature and salinity; (ii) Collection of a vast amount of data on waves (using the recently installed shipborne wave recorder) and other physical oceanographic parameters from the seas around India; (iii) A feasibility study on shore protection through wave energy utilization, based on the tests carried out on the specially designed Prime Mover System and (iv) Preparation for participation in the forthcoming Monsoon Experiment (Monex-79) and installing special instruments on RV *Gaveshani* for special studies to be carried out during Monex-79.

2.1.1 Studies on ocean-atmosphere interaction

1. Monsoon-77 and monex-79 studies

The BT data collected on board the Russian research vessels during Monsoon-77 have been analysed. Depth temperature profiles at three hourly intervals were plotted- These data show that the mixed layer deepens from about 40 to 90 m in a time span of about one week in late June. The sea surface temperature decreases by about 2°C which is asso-

ciated with the deepening of surface layer. An analysis of the processes and forces responsible for deepening of the mixed layer is in progress.

In connection with the Institute's participation in the forthcoming Monsoon Experiment (Monex-79), the Monex Management Committee of the Government of India sanctioned Rs. 45 lakhs towards the expenses for equipment and cruise operation. R.V. *Gaveshani* is being suitably equipped with the necessary instruments for making special observations during the expedition. Detailed planning for the proposed oceanographic studies was carried out during the year.

2. Wind induced ocean circulation

Wind induced circulation in the northwestern Indian Ocean was derived from solutions of a vertically integrated vorticity equation relating planetary vorticity, lateral stress curl and the curl of the stress exerted by the winds on the sea surface. An empirical expression for the variation of the stress values in the northwestern Indian Ocean has been derived using wind data from the K.N.M.I. Atlas. For a triangular basin model based on this empirical expression, the above solutions were found to account for many of the gross and a few detailed features of the general monsoonal circulation in the northwestern Indian Ocean.

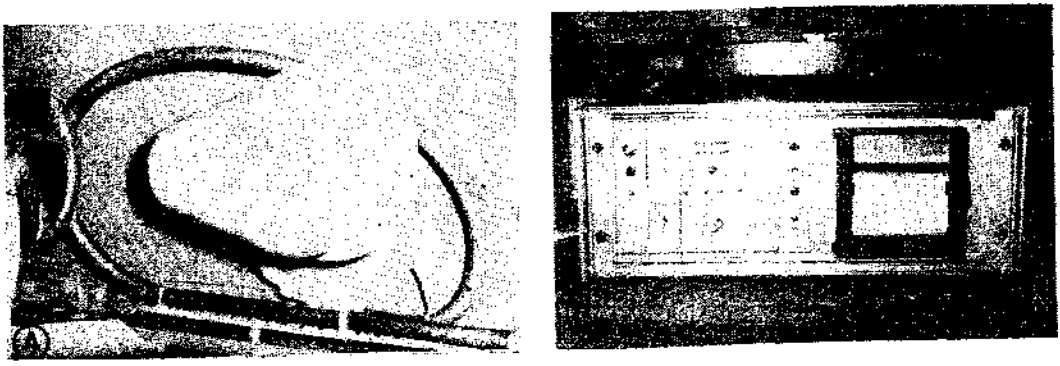
2.1.2 Studies on physical processes in the seas around India

Collection of field data including the wave data employing the newly installed shipborne wave recorder, during several oceanographic cruises of R.V. *Gaveshani* formed the major activity under this project. A significant development in the data collection programme was installation of "Thermosalinograph" (an instrument for recording the sea surface temperature and salinity continuously) on *Gaveshani*. As this instrument could be used while the ship was sailing, a quick survey of sea surface temperature and salinity over a vast area could be achieved. Studies on the water masses, circulation, sound velocity structure and fine structure of temperature and salinity in the waters of the northern Indian Ocean were carried out through model studies. Studies on the characteristics of waves and wave power in the open ocean areas of the seas around India were carried out and investigations on the temperature distribution and structure of currents in the northern Indian Ocean based on "Monsoon-77" data, were initiated.

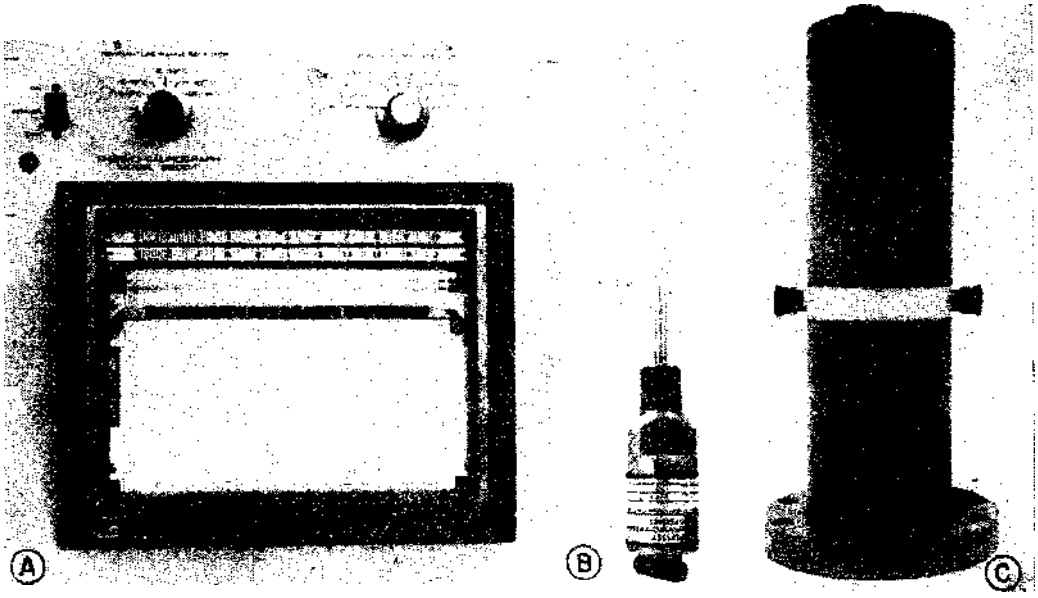
Field data were collected from R.V. *Gaveshani*, during eight oceanographic cruises (Cruise Nos. 30, 31 and 35-40) in the seas around India including the Laccadive Sea. Measurements of physical parameters were carried out at more than two hundred stations. Wave recorder, bathythermograph and hydrocast were operated and data on surface meteorological parameters were recorded at most of the stations. At 4 stations occupied in the Laccadive Sea, continuous profiles of temperature and salinity were obtained employing CTD System upto 1400-2000 m depth. Data collected during these cruises are being processed and analysed for physical oceanographic features.

1. Advection-diffusion phenomena in the Indian Ocean

(i) *Intrusion of Red Sea and Persian Gulf waters :* During the year, studies on the intrusion of Red Sea and Persian Gulf waters as they spread southwards were taken



Shipbome wave recorder installed in RV G*aveskani* : (A) Transducer and (B) Recording unit.



Thermosalinograph installed in RV G*aveshani*: (A) Recording unit, (B) Temperature sensor and (C) Salinity sensor.

up. After determining the thermohaline indices of these water masses, mixing triangles have been constructed to study the proportions of each of the water masses involved in the mixing process. Further analysis is being carried out to study the nature of isopycnal and vertical mixing. Simultaneously, a study on the effects of the non-linear pressure-volume-temperature properties of the water on the potential energy distribution in the North Indian Ocean has been initiated.

(ii) Spectral characteristics: The spectral characteristics of fine structure in the northern Arabian Sea were studied using the vertical profiles of temperature and salinity obtained by STD recorder at a few selected stations. The observed series were partitioned into mean and perturbation series using a high pass filter. The spectra of the high pass filtered data were computed by auto-correlation method. The spectral densities of temperature and salinity were found to decrease with increasing wave number and exhibited a power dependence of about -3 at the lower wave numbers. There seems to be some difference in the processes responsible for fine structure near the mouth of the Persian Gulf and further east.

(iii) Structure of water masses off the west coast of India: Studies on the structure of water masses based on the hydrographic data collected from R.V. *Gaveshani* during the 16th cruise (March 1977) covering the continental shelf and slope areas of the west coast of India, revealed that the Arabian Sea high salinity water spreads southwards as a core along the west coast at a depth of about 90 m. Low salinity equatorial water ($S = 34{\cdot}2‰$) intrudes into the southeastern Arabian Sea at a depth of about 200 m. At the surface, a transition zone separating the northern high salinity-low temperature water and the southern low salinity-high temperature water, is found between 13°N and 16°N latitudes.

2. Wave climate

Wave data obtained using a shipborne wave recorder at 34 stations off the southern coast of India between Visakhapatnam and Mormugao during the 23rd and 24th cruises of RV *Gaveshani* in September and October 1977, were processed and the wave characteristics were evaluated. Wave power at each station was computed from the significant wave height and zero-crossing period. Although September/October is the period of comparatively low wave activity, the computed wave power per one metre of wave crest was found to exceed 5 kW at some stations off the southern tip of India and north Malabar Coast. Lowest wave power (of 1.3 kW) was recorded at a station southeast of Madras.

2.1.3 Studies on the land-sea interaction and nearshore circulation along the Indian coastline and their application to coastal zone management

Investigations under this project were carried out partly from the headquarters and partly from the regional centres at Cochin and Bombay.

1. Beach changes along the Goa Coast

The beach at Miramar, at the mouth of the river Mandovi (Goa), was monitored for the period June 1977 to June 1978 at fortnightly intervals. The southern end of the beach which is about 175 m wide, showed erosion over the entire beach-face from late June to early September. By late September, a berm developed at a distance of about 80 m from the reference point and shifted shoreward to about 60 m from the point

by late May. During the period September to May, there was a gradual deposition near the berm and on the seaward side of the berm there were cyclic changes of deposition and erosion. The beach face was generally broad except for the period September to February when a bay existed near Miramar.

The beach face in the middle section was narrower (about 100 m wide) than the southern side. The berm was at about 70 m from the reference point in June and was eroded during the monsoon months. After the monsoon, it reappeared at about 75 m from the reference point and persisted till late May in 1978. During this period there was a general deposition creating a broader berm and a cyclic erosion and deposition beyond the berm.

The northern section of the beach was the narrowest (about 50 m wide). There was severe erosion in this part resulting in uprooting of trees along the shore. After the monsoon months, a berm was formed at about 25 m from the reference point which shifted gradually to about 45 m from the reference point in late April.

2. Currents and siltation in Verem bay, Mandovi estuary, Goa

Data on currents and suspended load, collected from the proposed area of the new jetty and boat pen at Verem during the period September 1975 to June 1976 were processed and analysed. Strong currents (with speeds of the order of 70 to 85 cm/sec) were encountered at the surface during the ebb, while relatively weaker currents (25 to 50 cm/sec) were recorded during the flood in the monsoon months. During the post-monsoon period also the ebb was stronger (with maximum speeds between 35 and 65 cm/sec) than the flood (which was of the order of 25 cm/sec). In the pre-monsoon months, there was no significant difference in the strength of the ebb and flood flows. Sediment load of the water in the area showed considerable variation with season and with the stage of the tide. It was relatively low (with maximum value about 25 mg/1) during October and quite high (with maximum value about 205 mg/1) during June.

3. Hydrographic features of the nearshore waters off Karwar

Analysis of the data on temperature and salinity, collected along a section of 5 stations in the nearshore waters off Karwar during the period October 1975 to October 1976, revealed that in general there was a very little change in the properties with depth- However, during September/October, a water mass of low temperature (24°C), high salinity (> 35.5%o) and low dissolved oxygen (< 3 ml/1) was encountered at depths greater than 5 m. The residual currents (or the currents after eliminating the effect of tide), computed from the data of hourly observations on currents over complete tidal cycles, taken at a selected station, showed east-southeasterly flow during September, west-south westerly flow during November, west-north westerly flow during December and north-northwesterly flow during January. The residual currents were relatively stronger (14 to 18 cm/sec) during November and December and weaker (5 to 6 cm/ sec) during September and January.

4. Studies on the beaches of Trivandrum

Beach profiles, littoral current measurements and wave observations taken at monthly intervals on Trivandrum Beach were studied during the year.

These studies indicated that the width of the beach varied from 85 m in March to 35 m in August. Also, during the fair weather season (December to May), the beach in general was wide with a width of 70 m and from June to November, its width was about 45 m. These beach changes suggest that the Trivandrum Beach generally gets eroded during the monsoon and postmonsoon months and gets accreted during the premonsoon months. Also the man-made causes of continuous discharge of effluents at Kochu Veli have resulted in beach profile changes forming tunnels, scraps, pools, etc., on the beach.

Wave data were collected with an OSPOS wave recorder at 20 m depth contour and these were analysed by using Tucker's method. The analysis revealed that the wave period ranges from 6 to 15 seconds and H_s from 30 to 80 cm during the fair weather season; and during the rough weather season, H_s exceeds 110 cm and two distinct groups of waves with periods 10 to 14 sec occur. Percentage exceedence curves for the significant wave heights H_s drawn for the monsoon, post-monsoon and pre-monsoon months show that during the monsoon period 90% of the Waves have H_s ranging from 240-250 cm. These high waves seem to be the direct cause of erosion of the Trivandrum beach during this season.

The littoral currents measured at Trivandrum beach were towards northwest during all the months except in June and July when these were towards southwest direction. Maximum velocity of the current (72 cm/sec) was observed in June. The littoral currents were very weak (5 cm/sec) during the months of January, February and March.

5. Studies on the dymamics of the Cochin backwaters estuarine system

Studies on the "Hydrographic characteristics in the inner harbour of Cochin Port" were continued as a project sponsored by the Cochin Port Trust for the development of harbour. Seasonal variations in physical characteristics, temperature, salinity, suspended sediment load and currents at the inlet of the Cochin harbour were investigated. The tidal prism for the harbour inlet was also calculated.

These studies revealed that during the southwest monsoon, under the predominant influence of the influx of freshwater into the estuary, no appreciable variation in temperature and salinity of the thin surface layer (<4 in) in relation to tide become noticeable; but the subsurface water (> 4 m) has a close relation with the tidal change. During this season significant vertical gradients in temperature and salinity become noticeable between surface and bottom layers. Prominent saline wedge also gets formed with the flood current during this season and during the cbb current, homogeneous water of low salinity(10%o) flows and occupies the entire depth of the harbour inlet.

The mean vertical salinity profiles drawn for the monsoon, post-monsoon and pre-monsoon seasons indicate that the highly stratified conditions that exist during the monsoon season gradually change to partially mixed and homogeneous conditions during the post and pre-monsoon periods apparently due to the decreasing river flow and increasing tidal influence.

The highest current (174 cm/sec) was observed in the surface layer of the inlet during the ebb flow of the spring tide in the postmonsoon season.

The tidal prism at the inlet was found to vary between 9.5×10^6 and 132×10^5 m^3 depending upon the inflow of freshwater and the consequent exchange of tidal flow across

the inlet. The tidal prism in the premonsoon season, when the freshwater addition to the backwaters is the least, was found to be 31.5 x 10^6 m^3

Preliminary studies on the stability of the inlet have indicated that the effect of the Thanneermukkam Bund on the Cochin harbour is mainly on the reduction of flow through the inlet during the premonsoon season which results in the reduction of maximum tidal velocities which leads to increased siltation in the harbour area.

6. Erosion studies at Versova beach, Bombay

Beach profiling and studies on sediment transport were undertaken at Versova beach which gets severely affected at certain time of the year. The areas of heavy erosion have been identified and marked. An experimental beach section has been selected for arresting this erosion using various methods and some method of arresting the erosion may be found after the next monsoon.

2.1.4 Utilization of wave energy for shore protection and water pumping

Based on the field studies carried out during the year on the satisfactory functioning of the prime mover systems of the wave energy oscillator, a feasibility report, entitled, "wave energy oscillator - A new concept in shore protection and coastal engineering" has been prepared. In this report, existing shore protection and coastal engineering measures have been briefly reviewed and a brief summary of the available methods for the extraction of wave energy presented. These studies have revealed that the proposed wave energy oscillator system would be effective in extracting the wave energy in the nearshore and breaker regions and consequently it could become an effective and economic method for shore protection.

A wave powered sea water pump is being developed as a part of this programme.

2.2

Chemical Oceanography

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

1. Cycle of phosphorus and nitrogen compounds in the Bay of Bengal and in inshore waters of Cochin
2. Urea degradation in sea water
3. Distribution of oxygen in coastal and offshore waters of the Bay of Bengal
4. Calcium carbonate precipitation around Kavaratti Atoll (Laccadives)
5. Silicon in the Bay of Bengal
6- Calcium phosphate saturation in the Bay of Bengal
7. Variation in the calcium content of the waters of Laccadives
8. Association of copper with dissolved matter in Mandovi and Zuari estuaries
9. Regeneration of phosphorus from zooplankton
10. Desalination of sea water
11. Organic constituents of sea water

2.2.2. *Drugs from the sea (Project No.* 404)

1. Screening of extracts from marine organisms for biological activity
2. Bromine content in seaweeds
3. Seasonal variation in the carrageenan content of *Hypnea musciformis*

The main research activities under Chemical Oceanography during the year 1978 were centred around two projects: (i) Chemical studies in the coastal and offshore waters of the Arabian Sea and Bay of Bengal and (ii) Drugs from the sea.

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

Studies on the distribution and interrelationship of inorganic and organic constituents were continued in these waters using RV *Gaveshani.* Some of the findings are summarised below:

(a) Laccadive Sea: Laccadive Sea is demarcated by 8° and 14°N and 71°30' and 74°E in the Arabian Sea. Temperature, salinity, dissolved oxygen, phosphate-phosphorus, nitrate-nitrogen, nitrite-nitrogen, ammonia-nitrogen, silicate-silicon, calcium, magnesium, fluoride and heavy metals in the water were studied.

The salient feature observed was the upwelled water which brings in nutrient-rich water to the surface in the vicinity of the islands. Variations in these nutrients in the surface layers indicate that their rate of uptake is largely regulated by photosynthetic production- Two oxygen minima at 200 m and 500 m were observed south of 11°N. The absence of nitrate-nitrogen and concentrations of about 0.5 µg-at/l of phosphate-phosphorus in upper 75 m were observed during March-April. Statistical treatment of the data confirmed the limiting effect of nitrate-nitrogen on photosynthetic productivity. Oxidative ratios for AOU: C: Si: N: P were calculated and these were found to be 263: 98:36:17:1 by atoms indicating a close agreement with similar values obtained earlier from the Arabian Sea. About 45% of nitrate-nitrogen probably undergoes denitrification between 150 m depth and the AOU maximum layer.

Calcium concentrations agreed well with the earlier observations from other areas of the Arabian Sea but higher magnesium and lower fluoride concentrations were recorded in the Laccadive Sea.

(b) Bay of Bengal: Observations were made in the Bay of Bengal along the oil tanker route at 5°30'N upto 85°E longitude and the nnorthwest towards Madras. Several stations along the 200 m isobath from Madras to Sandheads were also worked.

In the deeper regions of the Bay of Bengal, there was one thick oxygen minimum layer from about 100 to 800 m. Denitrification was also observed at the same depth and was of the similar order as in the Arabian Sea. There was, however, an excess of nitrate and phosphate in the surface layers in the area south of 8°30'N. North of this, the top 75 m of water was found to be devoid of nitrate. Phosphate-phosphorus was present at all depths. Observations were also taken at different river mouths in the Bay of Bengal. Samples of plankton and fish were also collected for the examination of heavy metal concentrations in them. The analyses have been completed and processing of the data is in progress.

A rare phenomenon was observed in the Bay of Bengal during June. A water spout about 10-15 m high with a diameter of about 200 m was sighted at 182°8'N and 84°43″E. Water spouts are generally the result of tornados. This was interesting specially as it was on a bright sunny day.

Eighty samples, collected during the cruises of RV *Gaveshani* in the Bay of Bengal from July to September 1977, have been analysed for bromide and the data were processed. Bromide/chlorinity ratio for the surface samples from the northern Bay (000321± 0.00007) was found to be significantly lower than that for the deeper layers in this region and from the central and central-west Bay of Bengal (0·00343±0.00005). The matter is close to the oceanic value (0.00347). This has been attributed to the immense runoff from the rivers. The riverine water is apparently poor in bromide as compared to chloride.

1. Cycle of phosphorus and nitrogen compounds in the Bay of Bengal and in inshore waters of Cochin

(i) Phosphorus and nitrogen compounds in the Bay of Bengal: South-west monsoon data on phosphorus and nitrogen compounds in the cbastal and offshore waters of the Bay of Bengal collected during 20th and 21st cruises of RV *Gaveshani* were processed

and analysed. The vertical profiles indicated that the upper 75 to 100 m are characterised by low nutrient concentrations and high oxygen content. In this zone, the phosphate concentration ranged from 0.1 to 1.0 µg-at/l, nitrate was in negligible concentrations at the surface but showed a gradual increase upto 10 µg-at/l at 75-100m depth, and nitrite which is in extremely low concentration showed a maximum of about 1.0 µg-at/l at or just below the thermocline. This was associated with a sharp fall in oxygen concentration. Below the euphotic zone, the phosphate and nitrate increased rapidly upto a depth of about 250 m while at the same time, oxygen concentration recorded a sharp fall indicating a zone of active oxidation process where most of the organic matter undergoes decomposition leading to oxygen minimum. The concentrations of phosphate, nitrate and oxygen ranged from 1.0 to 2.0 µg-at/1, 10.0 to 20.0 µg-at/1 and 1.0 to 0.2 ml/1 respectively. Below 250 m depth the increase in the concentrations of phosphate, nitrate and oxygen was more gradual down to 100 m depth (the maximum depth of observation), phosphate increased from 2.0 to 2.5 µg-at/1 nitrate from 20 to 25.30 µg-at/1 and oxygen from 0.2 to 1.0 ml/1.

(ii) Distribution and cycling of phosphorus, nitrogen and heavy metals in the nearshore waters of Cochin: Studies on the distribution and cycling of nutrients such as phosphorus and nitrogen in the inshore waters of Cochin revealed that there is an increase in both inorganic phosphate and organic phosphorus concentrations in the waters. The organic phosphorus, mostly occurred in the particulate form with values exceeding 10 µg-at/l. The high organic phosphorus concentration observed in this region was probably due to the influence of domestic waste dumped into the area.

Nitrate (10 µg-at/l) formed the major constituent of the various nitrogenous forms, eventhough ammonia and nitrite occurred in small quantities in the environment. As the estuary is well flushed by the tides no stagnation of the water was observed in the main estuary.

Analysis of the interstitial water showed high concentration of inorganic phospate. The nitrogen fractions were either in low concentrations or were absent. There seem to be active regeneration of phosphorus from the bottom mud.

Analysis of mud samples for organic carbon, nitrogen and total phosphorus from the area showed that apart from hydrographic changes, humic material brought by the river discharge, plays an important role in the cycle of organic matter of the sediments. The ratios of C:N, C:P and N:P indicated that the degradation of organic matter is quite rapid and there are significant quantities of phosphorus contributed by sewage in the environment.

Some of the heavy metals such as copper, zinc, nickel, cobalt, manganese and iron in particulate form showed wide variations with time in the estuary. Particulate iron formed the most abundant metal (7500 µg/1). Manganese showed a range of 3.6 to 56.5 µg/1. Zinc distribution also showed a wide range and the values varied between 5 and 546.5 µg/l. Cobalt and nickel levels were low and varied from 0.5 to 2.4 µg/l and 0.8 to 6.1 µg/1 respectively. Copper values varied between 0.6 and 13.2 µg/l.

2. Urea degradation in sea water

Laboratory experiments were conducted to compare the bacterial and chemical degradations of urea and ammonia in sea water. It was found that the rate of chemical

oxidation is very slow at room temperature and the biological activity is very fast. In the first five days of bacterial degradation, the rate was found to be 0.38 µg-at/l/day and thereafter the rate of degradation became high (5.6 µg-at/l/day). During the first 24 hours, there was no bacterial degradation. On the contrary, the urea hydrolysis was very slow. The rate of chemical hydrolysis was also 0.38 µg-at/l/day during the first five days. The rate continued to be slow for the next 4 days (0.5 µg-at/l/day). No perceptable hydrolysis could be noticed after the 9th day.

The experiments on bacterial degradation showed that the added urea (20 µg-at /l) was completely hydrolysed or degraded in 8 days. However, only 20% of the total urea was hydrolysed in 8 days due to chemical oxidation. It was observed that the ammonia formed by hydrolysis of urea was not accumulating in the water sample but was simultaneously converted to nitrite by nitrifying bacteria. By the 9th day, the experiments showed that urea gave rise to 36% ammonia and 64% nitrite. By the 19th day, there was only 0.5% of ammonia and the rest was in the form of nitrite. In sterile sea water only 20% of urea was found to be hydrolysed due to chemical process under the normal sea water conditions and there was no ammonia oxidation due to chemical reaction.

3. Distribution of oxygen in coastal and offshore waters of the Bay of Bengal

Distribution of dissolved oxygen was studied in the north-western and central Bay of Bengal during the 20th and 21st cruises of RV *Gaveshani* during the south-west monsoon period. The results confirmed the observations made for the same period during the previous cruises of RV *Gaveshani* in this region. The oxygen discontinuity layer was observed at shallower depths in the coastal regions as compared to the offshore regions probably because of upwelling. In the intermediate layers the oxygen concentration dropped to very low values. This was in conformity with the previous results. Although very low (<0.15 ml/l) oxygen concentrations were observed occasionally in the intermediate layers, these were associated with significant concentrations of nitrate. Analysis for hydrogen sulphide gave negative results thus supporting the view that hydrogen sulphide does not exist when sufficient nitrate is present and that sulphide reduction commences only after the depletion of nitrate from the water column.

4. Calcium carbonate precipitation around Kavaratti Atoll (Laccadives)

Variations in the $CaCO_3$ saturation were studied inside the lagoon on Kavaratti Atoll during the 31st cruise of RV *Gaveshani*. The results showed that the water remains at least three fold supersaturated with calcite in spite of an intense rate of respiration at night, which results in a significant decrease in pH and dissolved oxygen. The concentration of calcium was found to be much lower inside the lagoon than in the open sea. This was attributed to the biological precipitation of $CaCO_3$. Using the difference in calcium concentrations between the sea and lagoon, the annual $CaCO_3$ production by the reef flat and lagoon on Kavaratti Atoll was estimated as 1×10^7 kg. This gives an average gross production of 1.4 kg $CaCO_3/m^2/yr$.

5. Silicon in the Bay of Bengal

The data on silicon are based on two cruises conducted in the Bay of Bengal. In general, silicon values at the surface were very low and varied between 0.7 and

8.0 µg-at/1. Coastal waters were rich in silicate as compared to the offshore waters. The concentrations were found to increase in the sub-surface waters below the photic zone and became very high in the deeper waters. Surface variations of silicon in the Bay of Bengal were found to be higher than those in the Arabian Sea whereas the conditions were found to reverse in deeper layers. The values ranged between 17.5 and 51.6 µg-at/l. Most of the locations showed a depletion in silicon concentration at 20-30m depth rather than at the surface and this was probably due to higher phytoplankton biomass at these depths.

6. Calcium phosphate saturation in the Bay of Bengal

The data collected during the 8th and 9th cruises of RV *Gaveshani* were processed to study the saturation of calcium phosphate in the Bay of Bengal. Three layers were classified between Visakhapatnam and Madras based on percentage calcium phosphate saturation. These are: *(i)* the upper layer (0.50 m) characterised by high pH (av. 7.86), low inorganic phosphate (av. 0.62 x 10^{-6} moles/1) and low degree of saturation (av. 35%); *(ii)* the middle layer (50-150 m) characterised by relatively low pH (av.7.75) and higher phosphate (1.30 x 10^{-6} moles/1), and percentage saturation higher than the surface layer (av.52.9%); and *(iii)* the lower layer (I50-1500m) having a low pH (av. 7.58) and high phosphate concentration (av. 2.87 x 10^{-6} mols/1) but very low degree of saturation (av. 10.5%). Though the inorganic phosphate concentration was high in the Bay of Bengal, the low pH caused a very low fraction of inorganic phosphate to be present in the trivalent phosphate (PO_4^{3-}) form.

Between Madras and Nagapatnam also the three well marked layers showed different characteristics. The surface layer (0-50m) had a high pH (av. 7.87) and relatively high phosphate (1.03 x 10^{-6} moles/1) and percentage saturation (av. 126%). The high percentage saturation observed here was mainly due to high inorganic phosphate. The middle layer (50-150 m) had a relatively low pH (av.7.70) but was rich in phosphate concentration (2.0x10^{-6} moles/l) and the percentage saturation was 103%. Below 150 m, the trend was similar to that of the water column mentioned above.

7. Variation in the calcium content of the waters of Laccadives

The concentration of calcium was determined in the samples collected from four stations in the Laccadive Sea and from the lagoons of Kavaratti and Minicoy Atolls. The calcium/chlorinity ratio for the open ocean samples was found to be 0.02168± 0.000015 with an average calcium concentration of 424.9 mg/kg. Maximum ratio was observed at about 200 m depth, below the salinity maximum, corresponding to Arabian Sea surface water mass. No increase in calcium concentration or in calcium/ chlorinity ratio was observed up to 1500 m depth, thereby ruling out the possibility of any calcium carbonate dissolution at these depths. Samples from Kavaratti and Minicoy lagoons gave much lower values of Ca/Cl ratio (002145±0.000036 and 0.02142±0.000046 respectively). These low values are apparently the result of calcium utilisation by the coral reefs.

8. Association of copper with dissolved organic matter in Mandovi and Zuari estuaries

Preliminary investigations were conducted in Mandovi-Zuari estuarine system to understand the association of copper with organic matter, as a part of the studies

on speciation of metals. The variation in the inorganic and the organically associated forms of copper along the rivers presented rather a complex picture, presumably due to the combined effect of various factors such as adsorption by suspended sediments, material contributed by domestic waste etc. In general, the copper associated with dissolved organic matter decreased from the mouth of the river to the upper reaches of the river. In the river Zuari, the values varied from 5.8 µg/l to practically nil and in the river Mandovi from 9.5 µg/l to nil. The total copper also showed a similar trend. With the onset of monsoon, the organic and inorganic forms, and the total concentration were found to decrease. The dissolved inorganic copper was more or less uniformly distributed in Zuari during July (3.5 to 4.5 µg/l). But in August and September it showed a decreasing trend from the mouth to the upper reaches (8.5 to 1.0µg/l). In Mandovi, The inorganic copper was found to be uniformly distributed indifferent months (about 7 µg/l in June, 5µg/l in July and 3 µg/l in September).

9. Regeneration of phosphorus from zooplankton

Short-term laboratory experiments to investigate the regeneration of nutrients, particularly phosphorus, during decomposition of zooplankton were conducted using selected groups of zooplankton, viz., copepods, ostracods and amphipods. The rate of regeneration at different temperatures were also studied.

Samples were incubated at 15°C and 30°C in an incubator and sub-samples were taken daily for the analysis of inorganic phosphate. ammonia-N. nitrite-N and nitrate-N. The rate of regeneration was found to be higher at 30°C with a significant release of phosphorus from 3rd to 9th day with an average rate of 0.062 µg-at PO_4^{3-}-P/l/hr whereas the samples incubated at 15°C showed significant release from 14th to 24th day with an average rate of 0.039 µg-at PO_4^{3-}- P/l/hr. Decomposition rate was maximum in amphipods followed by copepods and ostracods.

10. Desalination of sea water

(i) Solar still: To improve the efficiency of solar still, designed and fabricated earlier, some investigations were conducted on the effect of different materials and paints. It was found that an admixture of saw dust with lamp black of similar sized granules in the ratio of 1:1 increased the evaporation intensity by about 20%. The coating of black paints applied on the inner side of the glass sheet enhanced the absorption of heat energy by about 3% as compared to the coating applied on the outer side.

These observations definitely indicate that by introducing minor adjustment, the efficiency of solar stills could be substantially increased.

(ii) Solubility of metallic condensate channels in distilled water: To improve the quality of distilled water from a solar still and to reduce its cost, condensate channels of aluminium were tested. It was observed that the dissolution of aluminium in distilled water at different temperatures (30°, 60° and 90°C) showed a negative trend, i.e., 71.47 and 36 µg/l of aluminium respectively. It was therefore, inferred that aluminium channels can replace copper channels.

11. Organic constituents of sea water

(i) Distribution of some biochemical compounds in the shelf and slope sediments of Arabian Sea: Sediments samples collected from the Arabian Sea were analysed for

organic matter. The study revealed higher concentration of organic matter from the continental slope (organic carbon 13.2-62.0 mg/g, total nitrogen 1.2-6.4 mg/g, and carbohydrate 5.4-18.0 mg/g), whereas continental shelf samples were characterised by low content of organic carbon (3.6-4.8 mg/g), total nitrogen (0.32-4.4 mg/g) and carbohydrates (1.3-10.3 mg/g). A direct relationship was observed between organic carbon and nitrogen and organic carbon and carbohydrate.

(ii) Dissolved organic matter: The possibility of using UV absorption characteristics for estimating the dissolved organic matter in sea water was explored. The effect of certain inorganic compounds such as nitrate and iodide on UV absorption are being studied. The standard for estimating the quantity of dissolved organic matter (DOM) has been derived from the plankton, since the source of DOM is mainly plankton.

Another investigation on the bioassay of Vitamin B_{12} has started. For this purpose, an axenic culture of diatom *Cyclotella nana* Clone 1-13, has been obtained from the University of California, San Diego, USA and maintained at present in NIO laboratory. Standardisation of the method for estimating Vitamin B_{12} in sea water has been done. Further studies are underway.

2.2.2 Drugs from the sea

1. Screening of extracts from marine organisms for biological activity

Sixty-five marine organisms (plants and animals) were screened. Out of the new species examined, two coral specimens showed promising anti-fertility activity. Based on the preliminary screening reports, detailed studies were taken up on selected marine organisms which showed promising results. Thus fractionation of *Codium elongatum* (antiviral), *Gemmaria* sp. I and II (hypotensive and toxic respectively), *Chondria armata* (hypotensive) and the corals, *Porites lichen* and an unidentified one (antifertility) is being carried out to isolate the active constituents.

2. Bromine content in seaweeds

Nineteen species of seaweeds from the Goa coast were examined for bromine content using spectrophotometric method (ashing with Na_2CO_3, oxidation of bromide to bromine with chloramine-T and measuring the absorbance in chloroform at 400 and 650 nm). The bromine content, on a dry weight basis, varied from 0.024 to 0.247% for the green algae, from 0.020 to 0.400% for the red algae, and from 0.015 to 0054% for the brown algae. Only two species, *viz., Chondria armata* and *Codium elongatum* showed relatively high bromine content, 0.400% and 0.247% respectively. A large fraction of the bromine in these species appears to be organically bound.

3. Seasonal variation in the carrageenan content of *Hypnea musciformis*

Carrageenan content *of Hypnea musciformis* was found to vary from 51.6% in December to 29.2% in May. It was highest in post-monsoon months and lowest *in* pre-monsoon months. Further studies on the purity, chemical nature and biological activity of carrageenan are in progress.

2.3

Geological Oceanography

2.3.1 *Geological and geophysical surveys to assess the petroleum and mineral prospects of the western continental margin of India (Project No.* 401*)*

2.3.2 *Regional geology and manganese nodule deposits in the Arabian and central Indian Basins of the Indian Ocean (Project No.* 402)

2.3.3 *Geochemistry of sediments of the continental margin of India (Project No.* 501*)*

2.3.4 *Sediments of the western continental margin of India (Project No.* 502)

2.3.5 *Foraminifera as indicators of pollution in the marine environment (Project No.* 503)

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

During the year more than 5000 line km of echosounding, 2800 line km of side scan sonar and sub-bottom profiling and 3200 line km of magnetics were carried out and a large number of sea bed samples were collected. Preliminary results of the surveys conducted in the shelf and slope regions are as follows:

(i) Off Bombay: The depth in the slope area ranged from 35 to 90 m and in the shelf from 35 to 60 m. The sea bed was covered by clays (about 20 m thickness), which thinned out gradually at about 65 m. The sea bed beyond a depth of 65 m was marked by uneven topography with pinnacles, ridges and valleys. The sonographs indicate that the ridges and sand waves have a NW-SE direction in the outer shelf.

(ii) Vijayadurg to Vengurla: The shelf from the shore to about 50-60 m depth is characterised by even topography and is covered by clays. Beyond that depth, the sea bed is uneven and relict oolitic sands are exposed. A series of NW-SE trending ridges were recorded on the echograms and sonographs of the outer shelf. Dredging showed that these ridges are composed of corolline limestones and relict coral reefs. The sub-bottom profiles of the area indicate a very prominent reflector dipping seaward near the shore which is overlain by about 20 m thick clay. The clay thins out gradually seaward at a depth of about 50-60 m. In the nearshore area, very high frequency magnetic anomalies occur possibly due to basement at shallow depth or surficial magnetic minerals. Beyond the depth of 30 m up to the shelf edge, a series of NS trending anomalies were recorded.

(iii) Vengurla to Mormugao: The depth in the area surveyed vary from 20 to 300 m and the shelf break occurs between 115 and 125m. The inner and middle

shelf are characterised by even topography and the inner shelf is covered by clay (maximum thickness 10 m). The outer shelf is marked by uneven topography and some areas are characterised by NNE-SSW trending ridges and rock outcrops.

(iv) Kasargod to Cochin: The depth in the area range from 20 to 1000 m and the shelf break occurs between 90 and 140 m. A ridge with a relative height of 6 to 10 mis conspicuous on the shelf at 85 to 100 m depths from Kasargod to Cochin. The sub-bottom profiles indicate that the thickness of sediments in the nearshore region is about 25 to 40 m. The outer shelf is covered with sand and a thin clay (2-3 m). Along the shelf edge a large wave length magnetic anomaly was noticed.

(v) Exploration for ilmenite placers off Konkan coast: An area of about 105 km along the coast was surveyed, which includes Jaigad, Narvan, Nandivad, Ambwah and Varwada bays. More than 400 samples were collected. The sands in the beaches did not show any enrichment but the offshore areas show enrichment of heavy minerals up to a depth of about 11 m. Further laboratory analyses are in progress.

Laboratory studies of the samples collected during the earlier surveys in Kalbadevi, Mirya and Ratnagiri bays have been completed. The heavy mineral placers in these bays extend to about 2 to 5 km offshore up to about 9 to 12 m depth. The heavy minerals in the sediments range from 1 to 91% with ilmenite from 2 to 52%. The inferred reserves of ilmenite are estimated to be about 2 million tonnes.

2.3.2 Regional geology and manganese nodule deposits in the Arabian and central Indian Basins of the Indian Ocean

Literature survey has been completed and equipment for the collection of manganese nodules is being procured. Planning for the survey of manganese nodules from the central Indian Basin is in progress.

2.3.3 Geochemistry of the sediments of the continental margin of India

Studies on the distribution of various elements and its relation with $CaCO_3$ in the sediments of the northwestern continental shelf showed that *(i)* relatively higher concentration of all the elements are more associated with the terrigenous sediments than with the relict sediments of the outer shelf; *(ii)* titanium, manganese and copper exhibit regional differences from north to south; and *(iii)* manganese, nickel and copper (on carbonate free basis) tend to be enriched with clays and silty clays of the outer shelf region.

These variations may be attributed to the association of these elements with terrigenous material while the variations from north to south may be due to the differences in the mineralogy of the sediments. The studies also revealed significant contribution made by the Indus river to the shelf between Indus Canyon and Gulf of Kutch.

The outer shelf relict sediments mainly contain calcium carbonate (<5%) and the Mg content is lower than that of the inner shelf and mid-shelf sediments.

The sediments off Saurashtra and the inner shelf between Bombay and Dabhol are characterised by relatively high organic carbon content (1-2%). The fine-grained sediments of the Indus Canyon and from the Gulf of Kutch (inner shelf between Gulf

of Cambay and Bombay and the coarse-grained relict sediments of the outer shelf) are characterised by low (>1%) organic carbon content.

The distribution of phosphate indicates that the phosphate content in the sediments of the outer shelf and slope regions, between Saurashtra and Mangalore, is relatively higher (1 to 2 %) and the phosphate is mainly associated with carbonates.

Carbohydrates were estimated in the shelf sediments between Goa and Cochin. The studies indicate a higher carbohydrate content (6-12 mg/gm and 25 mg/gm) in the inner shelf and outer shelf sediments and lower carbohydrate content (6 mg/gm) in the midshelf sediments. The separation of humic and fulvic acids in the sediments from the above area has been completed and studies on the association of trace metals with the organic phase of the sediments in the form of organometallic complexes are in progress.

In collaboration with the Applied Geochemistry Group of Imperial College, London, various major, minor and trace elements were analysed in different phases of the sediments of the westren central Indian Ocean. The processing of the data is in progress.

2.3.4 Sediments of the western continental margin of India

The continental shelf between Vengurla and Mangalore were surveyed. About 130 grab samples collected from this area were analysed for grain size, light and heavy minerals. Topography, especially the nature of the shelf break, was classified and the inter-relationship between the bottom topography and the process of sedimentation were studied. A detailed sediment distribution map for the above area has been prepared. The distribution of nannofossils in the core samples of the western continental slope and from the Gulf of Kutch has been completed. The results indicate long distance transportation of deworked fossils on the continental slope of the Gulf of Kutch and suggest the presence of a current parallel to the western slope of India.

2.3.5 Foraminifera as indicators of pollution in the marine environment

Studies on 29 samples from the inner shelf region of Dabhol and Vengurla revealed a rich foraminiferal fauna (72 species). The benthic fauna has clearly delineated the marginal marine and open marine groups and their associations with each other. The vertical representation is thus marked by the restricted occurrence of Cibicides group at one station only and *miliolid* group at another station whereas the lateral representation is characterised by a low TSN and high TFN with mono-specific and other highly impoverished associates. The microisolation of these species has been traced to discrete factors of edaphic conditions (for Cibicides group), variation of organic matter in the sediments (for miliolid group) and low salinity and estuarine condition and high organic matter content (for *Trochammina pacifica* and *Ammobaculites agglutinans)* in the sediments. These anomalous features have been recorded.

Living/dead ratio of foraminifera from the samples collected during 17th and 18th cruises of RV *Gaveshani* from the shelf region of Vengurla to Karwar is in progress.

Twenty-eight grab and snapper samples collected during the 28th cruise of RV *Gaveshani* were analysed. 69 species of Recent forms were recorded from the inner shelf

off Daman. For the first time reworked fauna from Surat and Broach area have been encountered. Further work on their indentification is in progress.

As a part of sponsored project of the Bombay Municipal Corporation, sediment samples were collected from the Thana Creek-Bombay Harbour area for pollution monitoring and evaluation. High and low organic content between the upper reaches of the Thana Creek and at the mouth of the harbour respectively are indicative of increased pH due to pollutants discharged in the Thana Creek and of the dilution with fresh water at the mouth of the harbour. The sediment was very fine-grained and was charged with slag, burnt and baked organic matter. Corroded shell-fragments in foraminifera were recorded in the Thana Creek.

The corrosive effect on foraminifera was marked by thinning of the test wall, diminishing of ornamentation, deepening of grooves and sutures around the umbo increased pore size, widening of apertures, dissolution/destruction of last and penultimate chambers resulting in highly dull and porcellaneous appearanne (as seen in *Ammonia* sp., *Ninion* sp., *Fursenkoina* sp., *Florilus* sp. and miliolids). Notably, living specimens were totally absent.

2.4

Biological Oceanography

2.4.1 *Survey of biological resources in the seas around India (Project No.* 201)

1· Primary production
2· Extracellular production
3. Secondary production
4. Detritus production
5· Benthic production
6. Biochemical investigation
7. Mangrove ecology
8· Bloom studies
9· Microbiological studies

2.4.2 *Coastal aquaculture (Project No.* 202)

1. Aquaculture in waters of Goa
2. Aquaculture in waters of Cochin
3. Laboratory and field studies on bioenergetics of some marine and estuarine animals

2.4.3. *Biogeographical, ecological and experimental studies on phytoplankton and zooplankton from the Indian Ocean (Project No.* 203)

1. Systematics and distribution
2. Experimental studies

2.4.1 Survey of biological resources in the seas around India

1. Primary production

Productivity data were collected from 17 stations during March-April 1978 from the Laccadive Sea and from 30 stations in the Bay of Bengal during August-September 1978. In the Laccadive Sea primary production was 372 mgC/m^2 with mean column chlorophyll value 4.9 mg/m^2 and particulate organic carbon value 3.61 g/m^2, whereas, in the Bay of Bengal the corresponding values were 0 98 gC/m^2, 11.45 mg/m^2 and 15.256 g/m^2 respectively.

2. Extracellular production

In the Laccadive Sea (March-April 1978) it was notited that the extracelullar production varied from 0 to 3mg/m^3/hr representing 0 to 75% of total carbon dioxide

assimilation. Relationship between light intensity, nutrient concentration and dissolved oxygen was investigated.

The differences in the extracellular production in offshore and nearshore areas showed that the amount of extracellular matter produced per unit of chlorophyll-*a* is about 8 mgC Chl. a^{-1} hr^{-1} in offshore areas and 2 mgC Chl. a^{-1} hr^{-1} in the near-shore areas. Thus, higher chlorophyll-*a* concentrations apparently result in lower extracellular production per unit of chlorophyll-*a*. These results may also be explained on the basis of higher light intensity available to photosynthesizing phytoplankton in clearer offshore waters.

3. Secondary production

Studies, on the influence of thermocline on the distribution of zooplankters indicated higher biomass, mainly contributed by copepods, chaetognaths and decapod larvae, above the discontinuity layer.

An analysis of samples from shelf waters along the central west and south-west coast of India showed high biomass values in the region between Mangalore in the north and Alleppey in the south. Fish eggs, fish larvae and decapods were found in high abundance between Trivandrum and Tuticorin.

A 'monotone' plankton swarm consisting of the chaetognath, *Sagitta enflata* and the ostracod *Cypridina dentata* was observed off the Maharashtra coast. Another large swarm of tunicates *(Dolioletta gegenbauri, Thalia democratica* and *Oikopleura longicauda)* was also observed off Nagapattinam (south-east coast) in September 1978, with a density of $1260/m^3$.

Other studies included the estimation of organic carbon in estuarine zooplankton, breeding ecology of chaetognaths in Goa estuaries and bathymetric distribution of chaetognaths in the Indian Ocean.

Zooplankton studies in the Lakshadweep Sea (March-April 1978) indicated an unusual abundance of gravid females of red bathypelagic prawn *Acanthepyra sanguinea.*

Distribution and abundance of penaeid larvae and post larvae in estuaries and nearshore regions of Goa is being studied.

4. Detritus production

In the Laccadive Sea detritus contributes about 90% of the total particulate matter. The contribution of phytoplankton and zooplankton in the suspended matter was found to be very low.

5. Benthic production

Quantitative and qualitative studies on macro and meiofauna of the Arabian Sea, Bay of Bengal and beaches and estuaries of Goa, were undertaken. Some of the findings are as follows:

(i) Arabian Sea: Biomass in shallow areas (20-50m) between 18° and 20°N was found to be very high (0.22-600.12 g m^{-2}) with macro to meio population density ratio of 1:1111.

Abundance and distribution of meiobenthos in shallow (<15m) sub-tidal region of Karwar was investigated. 70% of the fauna occurred in the top 2 cm layer. Total number of animals ranged between 1022 and 1250/10 cm^2 with an average value of 1098/10 cm^2.

(ii) Bay of Bengal: A survey of the benthic fauna was carried out during the 35th and 36th cruises of RV *Gaveshani* in May/June 1978. High faunal density (2 x 10^5-11 x 10^6) and rich biomass (8.885 g m^{-2}) were observed in the depth range of 20-220 m, especially off Mahanadi and Hooghly river openings.

(iii) Benaulim beach, Goa: Studies on production ecology revealed that the annual requirement of carbon for the macrofauna was 2574.4 gC m^{-2} transect. Three feeding types, *viz,·* feeders on plankton and suspended matter, deposit feeders and scavangers and predators were identified. The abundance of each feeding types exhibited striking seasonal fluctuation and seems to be largely related to southwest monsoon.

(iv) Estuaries of Goa: Effects of dredging on the repopulation of bottom fauna in the Cumbarjua canal are being studied.

6. Biochemical investigation

Electrophorograms of serum and eye lens proteins of some commercially important fishes were studied. In all the species except *Sardinella longiceps,* distinct patterns were obtained. Two types of patterns recorded in *S. longiceps* were independent of size, and possibly indicate the presence of more than one race. Studies on serological correspondence of eye lens proteins by antiserum action in rabbits suggested that morphologically similar fishes have more common antigens than the dissimilar ones.

7. Mangrove ecology

Effects of three different refined petroleum products on the fruits of *Rhizophora mucronata* and *Avicennia qfficinalis* were investigated. General damage such as burning, yellowing and wilting of the leaves associated with root damage was observed.

While studying the production ecology of a scagrass, *Halophila beccarii* growing in mangroves, high biomass (26.44 g m^{-2}) was recorded in October. Nitrate concentration was maximum (7.02 µg at/1) in July, phosphate (2.21 µg at/1) in November and carbohydrate (476.78 mg/g) in May and again in August.

Heavy metal concentration in the foliage of seven species of mangroves was studied and it was observed that in spite of the high concentration of iron and manganese, no adverse effects were noticed on the foliage.

The aerial photographs of seven estuaries of Goa were used for studying the distribution of mangroves. Mangrove soil showed very high population of bacteria (1764 x 10^3/ g dry wt) and fungi were 15.24 x 10^3 / g dry wt. The dehydrogenase activity was very high in the soil.

8. Bloom studies

Studies on different aspects of bloom were continued. A diatom bloom in combination with *Trichodesmium* sp. was observed in the vicinity of Cochin barmouth.

Observations on *Trichodesmium* phenomenon in Goa waters revealed that it is a source of enrichment, especially during the premonsoon season, resulting in high phosphorus and nitrogen concentration in the bloom and adjacent waters. Such an enrichment promotes the growth of other organisms.

Zooplankton associated with *Trichodesmium* bloom was also studied. The bacterial flora associated with the bloom were low at the initial stage but attain a peak at the decaying stage of the bloom. The population was of the magnitude of 3.6 x 10^4/ml unlike in non-bloom area where it was 3.96 x 10^2/ml.

9. Microbiological studies

Studies on bacterial population and their activity in the Arabian Sea revealed their decrease with the increasing depth. Population varied from nil to 10^3/ml. Fat hydrolysers were found to be sparse in the surface layer. Terrestrial and marine forms with a density of $1x10^2$ - $1x10^6$/g dry wt dominated the population in the sediments. Physiological activity was high in the sediments as compared to water column. Clay and clayey sand probably promoted the high population density of microbes.

Bacterial biomass in the Laccadive Sea was $159.520x10^8$ µg carbon. The annual cycle of bacterial carbon was estimated to be $498.25x10^{10}$ µg carbon. Population density had two maxima, one at the surface and the other at 500 m depth.

Bacterial population in the Zuari estuary of Goa was high between January and March whereas in the Mandovi estuary, high counts were encountered from March to June. Hydrogen ion concentration was seen to play an important role in bacterial distribution.

2.4.2 Coastal aquaculture

1. Aquaculture in waters of Goa

(i) Raft culture: Dimensional relationship between different morphometric and meristic characters of green mussel *(Mytilus viridis)* grown on ropes and those from the natural populations were determined. Ratios were found to be significantly different in these environments. Shell depth was noted to be a useful.parameter for estimating biomass. Weight parameters showed consistently higher values for raft grown mussels.

Studies on the growth of weaving mussel *(Modiolus metcalfei,* Hanley) on floating rafts and a comparison with those found in the natural bed revealed that rope grown animals had a growth rate faster than those of the natural population and attainment of marketable size was quicker in the population grown on rafts.

(ii) Clam culture: Studies on the ecology and growth of commercially important clams, *viz. Villorita cyprinoides* in Colvale river; *Paphia malabarica* in Mandovi and Chapora estuary; *Meretrix casta* in Mandovi-Cumbarjua canal-Zuari estuarine system and *Donax incarnatus* from sandy beaches of Goa, have been initiated as a prerequisite for starting commercial culture of these species.

(iii) Shrimp culture: An indigenously formulated compounded dry diet pellets were experimentally assessed for physical stability and biological evaluation in paleo-

monid and penaeid prawns. The diet is highly water resistant, consumable and assimilable and can also withstand a wide range of salinity.

(iv) Seaweed studies: Distribution and seasonal abundance of commercially important seaweeds were studied. In all, 50 species were recorded, of which 28 species have been reported for the first time.

Studies on trace metal concentration in 75 species of marine algae from central west coast of India were carried out for assessing the effect of pollution on marine flora. Maximum concentration of manganese (1737 ppm), iron (39496 ppm) and copper (96 ppm) was found in *Sphacila furcigera.* High concentration of zinc (295 ppm) was found in *Rhizocolonium* sp. It was observed that filamentous forms have higher concentration of trace elements than the thalloid forms.

2. Aquaculture in waters of Cochin

(i) Ecological studies of certain natural and impounded nursery grounds of prawns in the Cochin back waters: Tidal ponds located at the southern end of Ramanthuruthu Island near the Cochin barmouth have certain unique ecological features particularly, relevant for the culture of prawns. These ponds are very rich in selected species of benthic organisms such as tanaidaceans and a few species of amphipods, all highly preferred as food by the growing juveniles of prawns which enter the ponds with the tide. A detailed physico-chemical and biological study of the environment was, therefore, taken up to understand the ecological factors of an ideal nursery ground for prawns. The study was initiated in June 1978 and will continue for 12 to 15 months.

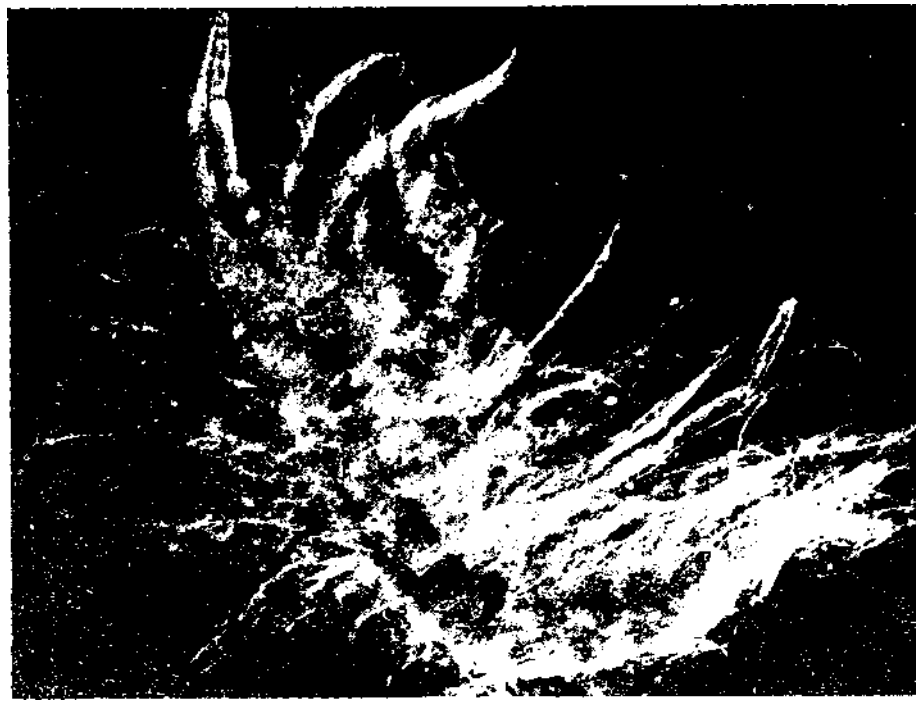
Fortnightly samples of the water, mud phytoplankton, zooplankton, benthos and prawns for the various estimations are being collected. Analysis of mud indicates the active regeneration of inorganic phosphates. Water is rich in nutrients and is therefore also very rich in phytoplankton. Zooplankton is poorly represented in all the ponds the cause for which is yet to be known. The few species of benthos and prawns together constitute the tertiary producers in the ecosystem and they are often present in great abundance. The ecosystem therefore is a simple one with a comparatively short food chain and is ideally suited for the growth of detritus feeders and prawns.

Five species of prawns are generally present in the samples taken from these ponds with *Penaeus indicus* and *Metapenaeus dobsoni* as the most abundant species. The natural growth of *P. indicus* in these ponds could not be studied from the samples collected so far since this species is very heavily fished. The size distribution of *M. dobsoni* is being analysed. Experiments on the growth of prawns kept in cages are being carried out to study the effect of crowding.

(ii) Experimental studies to evolve improved methods of shrimp culture in paddy fields: Introduction of certain simple culture techniques such as deeper and elaborate canal systems, nursery ponds, elimination of weeds and predators and supplementary feeding proved successful in stepping up shrimp production. The possibility for the retrieval of undersized juveniles from bag nets, reintroducing them into the nursery ponds inside the fields and growing them to commercial size—a technique hitherto unknown to the rural shrimp farmers of Kerala was successfully demonstrated. In the context of the present day depletion of natural stocks of prawns, the fanners were made to realize the importance of conservation of undersized juveniles of shrimps.

Improved method of paddy-cum-shrimp culture. Picture shows retrieval of undersized juveniles for reintroduction into the nursery pond, set inside the paddy field.

Fungal infection on tiger prawn, *Penaeus monodon.* The infection caused by the fungus *Leptolegnia marina* can be seen as dark patches.



Amphipod, *Gammarus* sp. infested by the fungus *Achlya* sp.

Head region of Tanaeidacean, *Apseudes chilkensis* infestd by the ciliate *Zoothamnium rigidum.*

The application of the aforesaid technique in some selected paddy fields in Vyapeen island (Kerala) has indicated that the shrimp yield could be stepped up by more than 50% from that of the traditional practices. In the improved method the range of yield varied between 800 and 1000 kg/ha whereas it was about 650-700 kg/ha in the traditionally operated farms.

Further, in contrast to the usual dominance of slow growing and less valuable species like *Metapenaeus dobsoni* in the traditional systems, the improved operation resulted in enhanced production of *Penaeus indicus* - a fast growing and more commercially valuable species. The economics of the operation of the improved system was worked out in detail.

Experimental studies also revealed that the improved operation facilitates the increased production of quality shrimps and fuller utilization of juvenile shrimps entering the paddy fields. It does not seem to influence the basic productivity of the fields.

The new technique has attracted a wide public interest and pamphlets containing necessary hints for successful operation of paddy-cum-shrimp-culture were prepared and supplied to interested parties.

Investigations are being continued to gather further information on shrimp culture. This is being done in cooperation with the shrimp farmers at Kumbalangi and Narakkal, Kerala State.

(iii) Studies on the influence of a muddy substratum on the preying efficiency of prawns: Previous studies on the feeding behaviour and preying efficiency carried out on *Metapenaeus dobsoni* were extended to *Penaeus indicus.* The results indicate that *P. indicus* as compared to *M. dobsoni* is more adapted to muddy substrata.

(iv) Effect of eyestalk extract on the growth of prawn: Eyestalk extract from *Penaeus indicus* of size ranges 20-25 mm and 70-80 mm were injected on both these size groups of the species to study the effect of extract on the growth. The results indicate that the extract obtained from both small and large size prawns have a marked effect in enchancing the growth rate but maximum effect was noticed when the extract from prawns of a particular size range is injected to prawns of the same size range.

(v) Studies on the parasites and diseases of shrimps and other Crustaceana Mycosis in shrimps: Patches on the integuments of some of the tiger prawns *Penaeus monodon* collected from Cochin backwaters were found to be caused by heavy fungal infection. Two species of fungi (Phycomycetes), namely *Saprolegnia parasitica* and *Leptolegnia marina* were isolated from the patches. Laboratory tank studies revealed that the infected shrimps die in 14-32 days. Similar fungal infection was also observed in amphipods and tanaeidaceans which form the forage organisms of shrimps. Experimental studies showed that about 70-90% of the smaller organisms get infected in 3-5 days. There was no recovery once the animals got infected by the fungi.

Studies have indicated that the fungal infection (mycosis) can lead to serious decline in the yield of prawns.

(vi) Protozoan associates of shrimps: Some of the protozoan associates such as *Zoothamnium rigidum, Lagenophrys cochinensis* (Peritrich ciliates), *Stentor coeruleus*

(Heterotrich) and a microsporidean were noticed on commercial shrimps and other crustaceans such as amphipods and tanaeidaceans. The protozoan associates were experimentally proved to be potentially harmful to their hosts.

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

(i) Laboratory studies: Studies on food conversion efficiency in a fish *Etroplus suratensis* using different pelleted food indicated low conversion efficiencies mainly due to lack of animal proteins in the diet.

Feeding experiments with the shrimp *Metapenaeus monoceros* using pelleted diet (25-87% proteins) revealed that assimilation efficiency did not vary significantly with the size of the shrimp or the diet but the conversion efficiency varied significantly. Natural feeds, such as *Artemia salina*, detritus and trash fish gave better results than the artificial feeds.

(ii) Field studies: Studies on the production and nutritive value of detritus in a tropical estuary (Dona Paula point) revealed that the production remains fairly constant practically throughout the year. Detrital load mainly originating from mangrove vegetation had a higher nutritive value. Caloric value ranged from 173 to 6057 cal/g dry wt (mean= 1238 cal/g dry Wt). The available detrital energy in the estuary was similar to that of phyto- and zooplankton and thus formed a potential energy source for tertiary production.

2.4.3 Biogeographical, ecological and experimental studies on phytoplankton and zooplankton from the Indian Ocean

1. Systematics and distribution

Most of the systematics, zoogeography and much of the ecological studies such as species association, diversity, *etc.*, of the IIOE collection of zooplankton were completed. Detailed descriptive studies on certain important taxonomic groups such as Foraminifera, Copepoda, Decapoda and Fish eggs and larvae form one of the main works currently being undertaken under this project.

General ecological and systematic studies on zooplankton were also carried out during the year. The bathypelagic copepod of the genus, *Paraugaptilus* belonging to the family Ariellidae (Copepoda, Calanoidea) was reported for the first time from the Indian Ocean. *P. buchani* was observed from two stations between Australia and Java. The cyclopoid copepod, *Corycaeus (Corycaeus) speciousus* was observed to be one of the most common species of the genera in the Indian Ocean. Seasonal occurrence and presence of swarms of copepods like *Temora turbinata* and *Undinula vulgaris* were observed in the samples collected from south and south-east coasts of India.

In order to understand the behaviour of zooplankton, detailed studies of sensory structures are essential. A peculiar structure and a series of pores noticed on the antennule of the bathypelagic calanoid copepod *Gaussia* so far unknown in crustacea, were studied in detail and these are probably mechanoreceptors and chemoreceptors.

While examining zooplankton from the south and South-east coasts of India, the presence of Ellobiopsidae, a parasite on crustaceans, was noticed. *Ellobiopsis*

chattoni was found on certain copepods mainly on *Undinula vulgaris* and on a shrimp. Another parasite *Amallocystis fagei* was noticed on a euphausiid.

Three new species of mysids, *Siriella africana, S. intermedia* and *Anisomysis laccadina* were recorded from the Indian Ocean, the former two from the Auglhas bank and the latter two from Kavaratti and Kalpeni atolls in the Laccadives.

A large number of preflexion to metamorphosed stages of flat fish larvae present in the material of Naga Expedition proved useful in the identification of species of *Psettina* obtained from the Indian Ocean. From detailed studies of morphometric data of the larval stages and morphological differences at various length groups, a distinguishing character—the urohyal appendage was noticed for *Psettina.* This appendage is well developed in preflexion stages but becomes reduced as the larvae reach metamorphosing stage.

Twenty-seven planktonic foraminiferal species present in the sediment samples collected from the north eastern part of the Arabian Sea have been identified. Quantitative data on the frequency occurrence of the various species and the total population of planktonic forms have also been documented. The different planktonic species have been identified in relation to their dissolution characteristics and the ecological significance of the dissolution phenomena is being investigated. From their assemblage in the sediments it can be concluded that the solutionprone species belong to the genera-*Globigerina, Globigerinella, Globigerinita* and *Globigerinoides* and the solution resistant forms are from the genera *G/oborotalia, Globoquadrina, Pulleniatina* and *Sphaeroidinella.* Further work on their distribution is in progress.

2. **Experimental studies**

Successful rearing of several zooplankton organisms in the laboratory has been possible by collecting information on their optimal environmental requirements, critical stages, etc., so that such conditions could be provided in captivity. Proper design of the aquarium was found to be an essential prerequisite for the larval rearing programme.

A prototype of closed circulation system designed earlier in the laboratory for studying the early stages of life history of different zooplankton species and to assess the possibilities of large scale culiure of these organisms was further modified. Some species of amphipods such as *Quadrivisio bengalensis* and *Melita* sp., the isopod, *Cirolana fluviatilis* and the polychaete, *Diopatra naeopolitana* were successfully reared in the laboratory.

Information useful for the design of closed sea water system for culturing marine organisms was collected. An improved closed-circuit aquarium was found to have many advantages over its prototype designed earlier. Studies on the duration of larval phase under various temperature, food quality etc., of the spider crab, *Hyas araneus* and some aspects of the life histories of the amphipods *Corophium insidiosum* and *Jassa fulcata* were the other investigations carried out.

Biochemical studies of different taxonomic groups of zooplankton collected from the Cochin backwater and Laccadive Sea indicate that crustaceans in general have high protein and low carbohydrate contents while the gelatinous carnivores like tenophores and hydromedusae have relatively low protein contents.

2.5

Ocean Engineering

2.5.1 Coastal engineering studies applicable to rural development

This project was initiated during the year to undertake the R & D work for coastal protection in India with special emphasis on low-cost methods. After taking into account the coastal environment, locally available building materials, labour, etc., economical designs with guidelines are being prepared for selecting appropriate remedial measures to protect the eroding segments of the coast in different geographic areas along the cast and west coasts of India.

A wave-sled has been designed, fabricated and tested successfully. This equipment can be used for measuring beach profiles across the surf zone very economically. The equipment is designed to use the wave force for its movements in the offshore-onshore direction and is controlled by a nylon rope from the beach. Further modifications are in progress. Different types of surface and sub-surface floats are being designed for measuring water circulation pattern in the coastal areas.

Two computer programmes *(i)* analysing refraction and diffraction patterns of waves as they approach a coast from deep water and *(ii)* carrying out spectrum analyses of waves using Fast Fourier Techniques were developed for DEC-10 System and are being used for analysing the wave conditions at Bombay High and Mormugao Harbour.

Efforts are being made to develop numerical modelling techniques and computer programmes for *(i)* wave forecasting using synoptic weather maps, *(ii)* computation of storm surges based on meteorological data, *(iii)* pollutant dispersion in estuaries and coastal waters and *(iv)* computation of tidal and wind driven currents.

Rational design procedures are also being formulated for various types of coastal structures such as sea-walls, groins, revetments, breakwaters, docks, quays, dolphins, submarine pipelines, ocean outfall systems, etc.

2.5.2 Development of offshore engineering and technology for the utilization of coastal resources

Surface and sub-surface fibre-glass buoys of different sizes have been designed and are being fabricated for the development of suitable mooring systems for instal-

ling wave and current measuring instruments at different water depths. To develop a special type of mooring system using a 750 mm fibreglass sub-surface buoy for anchoring a wave-rider buoy is being fabricated. The taut mooring system between the sinker and the buoy will be used for fixing the continuous recording current meters.

Standard procedures are being developed for the analyses and presentation of current and wave data in the form of diagrams, tables and charts to make them useful for engineering design purposes. Standard procedures are also being developed for the designs of submarine pipelines, ocean outfalls, data acquisition systems mooring and anchoring at sea-bed, offshore light house, terminals, etc.

Efforts are also being made for the indigenous development of soil sampler and testing techniques for sea-bed soils. A state-of-the-art report on the sea-bed soil sampling and *in-situ* testing techniques has been prepared. Soil samples obtained from the Bombay High and off Gujarat coast are being studied and analysed for engineering properties.

2.6

Oceanographic Instrumentation

2·6·1 *Development of optical and acoustic instrumentation and system engineering (Project No.* 403)

2.6.2 *Development of marine instrumentation system (Project No.* 601)

2.6.3 *Development of buoy telemetry data acquisition system (Project No.* 602)

2.6.4 *Development of marine data logging system (Project No.* 603*)*

During the year under report, three projects were undertaken. The project 'Development of optical and acoustic instrumentation and system engineering' was taken in collaboration with CSIO, CEERI, NPL and NGRI.

The progress of the four projects carried out under the above discipline is as follows:

2.6.1 Development of optical and acoustic instrumentation and system engineering

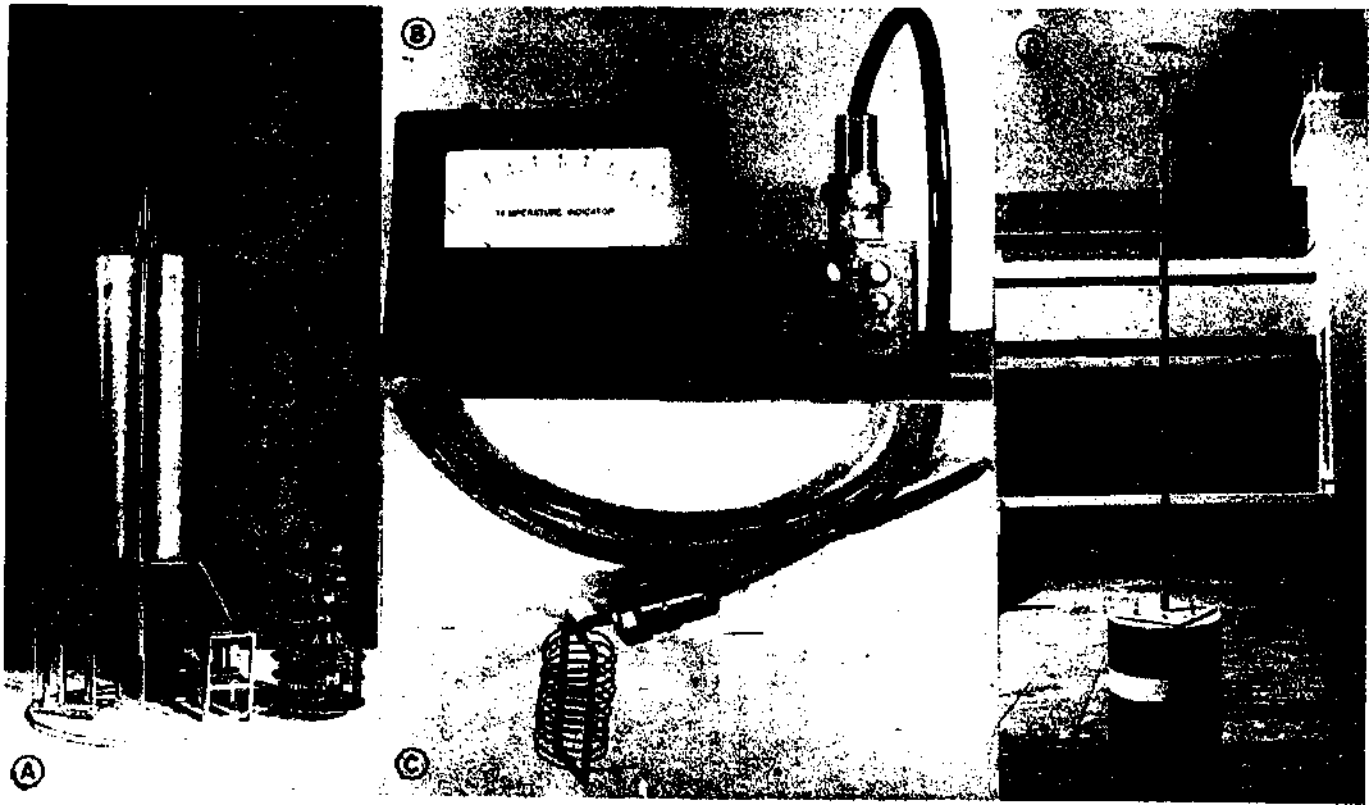
With the primary aim to excite transducers to carry analog information and transmit underwater to a receiving transducer upto 500 m away, this project was initiated late in the year. Ultrasonic transducers have been procured. The circuitry is being developed for the excitation of transducers and also for the receiving circuitry. Efforts were made to have more contacts between the scientists with sister laboratories. (NPL, CSIO) and with the various firms which are working on ultrasonic devices.

2.6.2 Development of marine instrumentation system

The progress of this project was extremely good during the year as can be seen from the following:

(i) Rotor current meters: The rotor current meter previously developed in the laboratory is now in large scale field use. Ten units have been fabricated and are being used in various sponsored project in the regional centres as well as at the Head-quarters. The unit has undergone some minor modifications, based on feed-backs from field use. A direction sensor has also been fitted to four newly fabricated units, and the current meter is now capable of measuring flow and direction according to standard specifications quite at par with the international standards.

(ii) Auto lab salinometer: This unit was changed from ferriic cores to con-ductive cell. Two prototypes have been fabricated and these, arc being extensively tested.



New instruments developed at NIO: (A) CTD system (B) Marine thermometer (C) Underwater copper resistance for buoy (D) Flash control for buoy.

(iii) In-situ Salinometer: Circuitry and its testing for the *in-situ* salinometer have been completed and fabrication of the sensors is in progress.

(iv) Marine thermometer: An accurate stable copper resistance analog meter has been fabricated which is undergoing field trials. The unit is battery operated, portable and can be operated by cables of any length. Temperature is displayed on an analog meter in four ranges with an accuracy of ±0.2°C.

(v) Sedimentation balance: This unit gives a mass response of the total sediment. Some problems have, however, been encountered with the time response of sedimentation. A full theoretical treatment has been initiated to identify the most sensitive parameters in settling the time response. Diameter of the tube, mass of the sediment, method of dispersion are being worked out as the more important parameters to be determined. The entire circuitry has been redone in the light of the various components.

(vi) Water height analyser: This is a simple system which measures the wave height and tides. A diaphram-type pressure sensor which senses absolute pressure is used to measure the height of the water column. The output (waves and tide) is displayed on an analog strip chart recorder.

The existing imported systems use accelerometer to record the waves. The accelerometer sensor is a very delicate unit and the buoy has to be carefully anchored to derive meaningful results. Hence a pressure sensor was thought to be more a convenient method instead.

In the proposed system, a pressure sensor bridge is excited by + 7.5 and - 7.5 volts. The bridge output is amplified by a data amplifier and then it is chopped by a Mosfet switch 4016. The chopped signal is further amplified and then rectified. The DC output is amplified and then final output is displayed on the recorder.

A response test was carried out by mounting the sensor in a long perspex tube. The water column over the sensor was increased in steps of 10cm, and a 4.8 mVchange was recorded for each 10 cm of water.

Fabrication of the underwater casing has also been completed and trials to record tidal variations over a 24-hour period are in progress.

(vii) Fast response thermometers: After a great deal of design work, eight thermometers have been fabricated and these are being tested.

2.6.3 Development of buoy telemetry data acquisition system

Literature survey was completed. Design and development of electronic circuits for signal conditioning and flash light control have also been completed. The development of timing and logic modules is in progress.

2.6.4 Development of marine data logging system

Design and development of one master clock was completed and those of the repeaters are in progress. Logic design of the sequence generator, using multiplexer and scanner, is also in progress for the data acquisition module.

2.7

Planning, Publications, Information and Data

The progress of the planning, publications, information and oceanographic data activities is as follows:

2.7.1 Planning

Costing, monitoring and evaluation of the R & D projects were continued. These efforts have helped the Institute in evaluating the progress achieved under each project.

Periodic reports, project budget for 1977-78 (RE) and 1978-79(BE) and a Rolling Plan for the period 1978-83 were prepared and sent to Planning Division of CSIR. A close liaison was maintained with the Planning Division and Technology Utilization Division of CSIR.

2.7.2 Publications

The Institute continued to bring out the regular publications, *viz.,* Annual Report, Cruise Reports, INODC Newsletter and *Mahasagar*—Quarterly Bulletin of the National Institute of Oceanography. The circulation of *Mahasagar* was increased considerably during the year.

The following publications were brought out during the year:

(i) Annual Report 1977.

(ii) Mahasagar, Vol. 10 (Nos. 1 to 4) and Vol. 11 (Nos.1 to 4).

(iii) Collected Reprints Vol. 4 (1972) and Vol. 5(1973).

(iv) 19 Cruise Reports of RV *Gaveshani.*

A small printing press and a binding unit were set up which helped considerably in carrying out small printing jobs such as the covers of technical reports, cruise reports, cards and other miscellaneous printing work which resulted in considerable saving to the Institute.

2.7.3 Information

During the year, a large number of technical enquiries were answered either through correspondence or orally to the interested parties. The enquiries were on varied subjects such as mussel culture, pipeline surveys and erosion problems, etc. Apart from this a large number of visitors and students parties were attended to and information about the activities of the Institute was provided. The total number of visitors including students, research fellows, trainees, scientists and VIPs exceeded 3,000.

Many maps and charts on the activities of the Institute and on the scope of oceanography were prepared for display purpose.

Monthly progress reports and relevant information pertaining to the Institute's activities were sent to CSIR.

Several activities related to information system were organized and services rendered. Some of these are as follows:

(i) Indian National Directory of Marine Scientists (INDMS): A revised and updated version of INDMS was prepared and distributed to various institutions throughout the country. The Directory contains the names of 715 scientists from 72 institutions in India and constitutes an important source in enhancing the communication and exchange of ideas among the scientists working on similar problems of marine science.

(ii) Indian National Directory of Marine Research Projects (INDMRP): A pilot Directory on Current Research Projects on oceanography, fisheries and pollution was brought out and sent to respective organizations. A revised Directory of this nature is expected to be released in early 1979.

(iii) IOC Depository Centre: The Centre was established earlier, as per the recommendations of ASFIS II. This Centre received about 50 reports from different international organizations. The Centre continued to issue the consolidated list of publications for circulation to all marine-based organizations in the country. Many books, reports and reprints were also obtained from different marine-based organisations for the IOC Depository Centre.

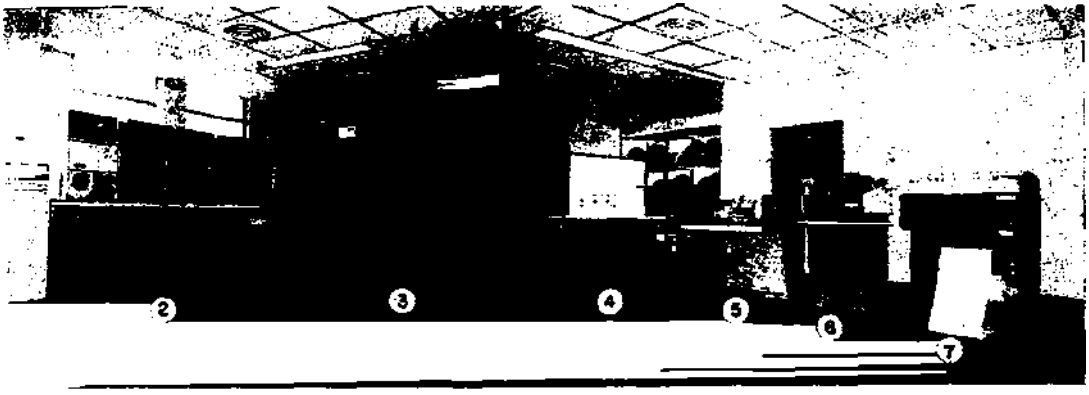
(iv) Reprographic services: This service was offered to the entire of the Institute. The literature related to different scientific projects was procured from different institutions through library and xerox copies of the desired reference material were supplied. This service was also utilized for xeroxing some of the IOC publications.

(v) Press release: Many news items related to the activities of NIO were released during the year through different media of mass communication.

(ή) News clippings: News clipping service was continued for the collection of current news on R & D activities in the field of oceanography and marine science in India and elsewhere.

2.7.4 Indian National Oceanographic Data Centre

The Institute, with the acquisition of a third generation Computer TDC-316, has entered into a new phase of development. The first phase of the system, comprising



Two views of the computer room showing 1. Mag Disc, 2. Mag Tape Drive, 3. Memory/CPU Recks, 4. Console, 5. Teletype, 6. Card Reader, 7. Line Printer

of Central Processing Unit (CPU) with 2 magnetic tape transports, a card reader, a teletype, a printer, etc., was installed during the year and started functioning.

Acquisition, processing, evaluation and management of oceanographic data

Development of computer programmes

The following programmes for the TDC-316 were developed for processing of oceanographic data:

FINCUL: This programme computes wind stress curl for the given wind speed.

STRESS: This programme computes the wind flux from surface meteorological data.

MEAN BT: This programme computes the mean BT-profile for a given set of BT profiles.

INTRP: This programme interpolates the required parameters at standard depth using 3-point Lagranges interpolation equation.

DYNCAL: This programme calculates specific volume anomaly.

ANSIG: The programmes ANSIG. developed last year, were modified so that the total magnetic intensity data could be analysed for determining the depth to the basement rock.

Besides these, the following programmes were also developed for the DCM Micro-system 1101 for:

(i) Determination of multiple and partial correlation cocfficients.

(ii) Computation of species diversity index.

(iii) Computation of salinity from R, D, T using Bennet's formula.

(iv) Computation of salinity with conductivity, temperature and depth from R, T, and P using Bennet's formulae.

(v) Computation of salinity from C, T and P using either Cox or Brown equations.

(vi) Computation of tidal heights at hourly interval.

(vii) Computation of Richardson number.

RV *Gaveshani* data

Physical, chemical and biological data collected by RV *Gaveshani* during the year 1976 have been deposited. Their processing and evaluation are in progress.

ISMEX and Monosoon data

Coastal, meteorological and radiation data for ISMEX 1973 and Monsoon 1977 collected by the Russian ships in the Indian Ocean were procured from the India Meteorology Department, Poona and these are being transformed on to the INODC format.

Pollution data

Processing of pollution data obtained under the project 'Waste Water Disposal Studies in and around Bombay' sponsored by Bombay Municipal Corporation was completed and the processed sheets were sent to the sponsorers.

INODC catalogue

Catalogue for physical and chemical data holdings at the INODC was compiled and it will be released shortly.

Plotting of data from the Exclusive Economic Zone

Statewise plotting of hydrographic and biological parameters in the Exclusive Economic Zone was started and the first series of charts on the sea off Gujarat State have been completed. Besides giving the existing information, the charts also bring out gaps in the data in different States as indicated by the blank areas in the charts. Thus the charts would play an important role in planning future cruises of the RV *Gaveshani*.

Inventory forms (ROSCOP, ROMBI, IG/GCI)

The inventory forms of ROSCOP (Report of Observations/Samples Collected by Oceanographic Programmes), ROMBI (Results of Marine Biological investigation). IG/GCI (International Geological/Geophysical Cruise Inventory) were completed for the cruises of RV *Gaveshani*.

INODC Newsletter

The second newsletter was released during the year. It contains information on the data collected by RV *Gaveshani* in ROSCOP forms along with the cruise tracks.

2.8

Interdisciplinary Task Forces

2.8.1 *Protection of marine environment and monitoring of pollutants with special reference to rural areas along the Indian Coast (Project No.* 405)

1. Marine environmental monitoring in the Arabian Sea and Bay of Bengal
2. Marine environmental monitoring along Goa coast
3. Marine environmental monitoring along Bombay coast
4. Marine environmental monitoring in the waters of Cochin

2.8.2 *Coastal studies at Waltair and adjacent areas (Project No.* 204)

2.8.3 *Oceanography of the waters around Laccadives (Lakshadweep) (Project No.* 205)

2.8.1 Protection of marine environment and monitoring of pollutants with special reference to rural areas along the Indian coast

1. Marine environmental monitoring in the Arabian Sea and Bay of Bengal

Three cruises of RV *Gaveshani* were undertaken for this purpose during the year. One of these covered some areas of Arabian Sea. The other two cruises covered half of the oil tanker route across the Bay of Bengal and the Indian coast upto Calcutta.

The region in the Arabian Sea (Laccadives) is comparatively unpolluted. But the beaches inside some of the lagoons, specially the Kavaratti lagoon had considerable deposits of tar balls.

The oil tanker route across the Bay of Bengal seemed to have much particulate petroleum residues. The concentrations of dissolved petroleum hydrocarbon were almost similar to those along the oil tanker route in the Arabian Sea. The coastal areas of the Bay of Bengal were almost free from any contamination of oil, mercury or other heavy metals.

2. Marine environmental monitoring along Goa coast

Observations on the water quality of the rivers Zuari and Mandovi were completed. Regular monthly observations at 9 stations in each of the rivers, 3 in the Cumbarjua canal and 3 in the coastal areas between Baga and Colva were conducted. The total number of parameters studied for determining the water quality is 30. The preparation of the final report is in progress but in general it can be said that so far these areas are not polluted.

A view of the Industrial Complex at Eloor (Udyogamandal) which is responsible for heavy pollution in Cochin backwaters.

Fort Cochin Beach - showing heavy accumulation of *Salvinia* on the beach.

3. Marine environmental monitoring along Bombay coast

An interesting feature was noticed and confirmed during the year. The Bombay coast appears to be highly polluted especially in the Mahim creek area. This was indicated by the levels of dissolved oxygen (D.O.) which often fell to zero mg/l and the Biochemical Oxygen Demand (B.O.D.) during the low tide which was as high as 56mg/l.

In the Thana creek metallic contamination was found to be abnormally high- Special attention was paid to mercury contamination in the bottom sediments. Mercury in the Thana creek was relatively high at the mouth of creek. High concentration of mercury probably comes from the heavy industrial dischargs in the Thana creek.

Zooplankton samples collected from different areas gave a clue to the ecology of marine environment of Bombay which has changed at a number of places because of the discharge of sewage and industrial wastes. The distribution of zooplankton was normal in unpolluted areas but in the polluted areas, although the plankton biomass was high, only a few groups which could tolerate pollution were found. Chaetognaths, copepods and medusae were the dominont groups in polluted areas.

4. Marine environmental monitoring in the waters of Cochin

(i) Pollution in backwaters: Monitoring of pollution with special reference to effluent discharge from the industrial establishments in Eloor (Udyogamandal) in Cochin backwaters was carried out. The study was undertaken for a year from monthly observations at four fixed stations. The parameters monitored were temperature, pH, O_2, chlorinity, suspended matter, BOD, COD and ammonia. Temperature was high, pH and chlorinity were found to fluctuate while no significant depletion of dissolved oxygen at any of the stations was noticed. Hence the disappearance of biota noticed especially in the main effluent discharging site at Udyogamandal was mainly attributed to the heavy discharge of industrial wastes. Suspended solids were very high and high organic load at the mouth of the backwaters gave rise to high COD values while the COD values in the industrial complex area varied a great deal depending on the effluents. COD values were low at the reference point. Ammonia as a pollutant in the effluent and at times in the water was very noticeable. Heavy loads of suspended material, high temperature, and variable pH along with high chloride and COD levels especially in the dry months seem to make the estuarine environment unsuitable for the fauna and flora.

Quantitative abundance of bacteria, *viz. Coliforms, Escherichia coli, Streptococcus faecalis* in the water and water samples from 6 stations in the Cochin backwaters was studied for a period of 12 months. Fe/FS ratio indicated that the principal source of non-coliform types of bacteria is the land-drainage. Based on the quantitative abundance and distribution of these organisms the six stations may be classified as 'intensely polluted', 'fairly polluted' and 'slightly polluted'. The study has indicated some possible hazards to public health by the consumption of edible species caught from the areas contaminated by these organisms.

Decomposition of *Salvinia auriculata* collected from Cochin backwaters was studied in the laboratory. 13 strains of bacteria were isolated from the living and

decomposing weed. Experiments on the growth-promoting effect of the weed-extract in various concentrations of five selected strains of bacteria and on a mixed culture were also conducted. Turbidity measurements gave maximum percentage concentration in 5% extract. Weight loss in the dried weed in the laboratory was 20% after 10 days and 25% after 25 days of incubation. Yield efficiency in three bacterial strains calculated for 48 hrs was 20% in the laboratory. Appreciable number of bacteria were found capable of growing well in the weed extract with sea-water. These studies showed that this weed is the primary source of organic matter in the backwaters of Cochin.

(ii) Beach pollution: Pollution studies on Cherai beach conducted earlier were extended to Fort Cochin beach for a period of one year. The data have shown the presence of indicator bacteria coming from faecal pollution. Fresh and decaying *'Salvinia* debris' also contributed to the beach pollution. Both types of pollution were pronounced during the monsoon and post-monsoon months rendering the beach unsuitable for recreational or fishing activities. During the premonsoon and late post-monsoon periods, the beach was almost free from pollution. High counts of indicator bacteria were often associated with high values of sediment load, BOD^5 and hydrogen sulphide. Bacterial counts were generally higher in the beach than in the sea water. The above study gave an assessment of the overall pollution of the Fort Cochin beach.

Beach pollution studies were also extended to the entire Kerala Coast from Vizhinjam in the south to Ezhumalal (Payyannoor) in the north. Studies on the faecal contamination of beaches have a relevance to public health hazards. Depending on the faecal contamination the beaches may be grouped into three categories, *viz.* 'highly contaminated' (Calicut, Moplah Bay, Neendakara and Vizhinjam), 'fairly contaminated' (West Hill, Alleppey and Quilon) and 'slightly contaminated' (Kovalam, Shangumukham, Payyambalam and Kappad). The criteria considered in the grouping of the beaches into the three categories were macrofauna in the water and sand, and also the counts of indicator bacteria, *viz. Coliforms (E. coli ana S. faecalis).* The study indicated broadly that none of the above beaches was free from faecal contamination except perhaps Ezhumalal.

Isolation of *Salmonella* was also made during the monsoon and post-monsoon months from several beaches of Kerala.

Analysis of sediment samples collected from the beach sand and from 5, 10 and 20 m of water along three traverses off Thumba, Trivandrum Titanium Plant (T.T.P.) and Shankhumugham, near Trivandrum, revealed the occurrence of 85 species of foraminifera belonging to 42 genera under 26 families. Based on their taxonomic assemblage, three faunal groupings were recognised, *viz.,* beach fauna at 0-1 m, near-shore fauna at 1-5 m and offshore fauna at 5-20 m depth ranges. The population size of foraminifera was higher in the premonsoon months (February and March) than in December (post-monsoon). In general, it was observed that each station studied was independent of the other in the seasonal variation of foraminiferal abundance. Indicator species (pollution-sensitive and pollution-tolerant) were identified. Miliolids which are pollution-sensitive species were relatively less numerous at the outfall area in the months of December and January than in the month of December near T.T.P. There

was a gradual increase in concentration of miliolids away from the T.T.P. outfall whereas *Ammonia beccari* variants, in contrast to miliolids, were pollution-tolerant species and were found to decrease in abundance away from the T.T.P. discharge point.

2.8.2 Coastal studies at Waltair and adjacent areas

Monthly observations for a period of 12 months were completed for beach profiling studies along Visakhapatnam beach. The profiles extended up to about 15 km along the beach covering the region from Kailasa range to Yarada hill and consisted of 24 transects. Measurements of waves were made by visual examination and the long shore current were measured using rubber balls. The data are being processed and analysed to study the erosion and silting aspects along the beach in relation to beach stability. About 996 sand samples were collected along the 24 profiles for a period of 12 months at the rate of about 85 samples per month. Nearly 570 samples covering the backshore and offshore regions were analysed for grain size. Other parameters such as sorting, skewness, kurtosis, etc., to determine the transportation of sand along the beach were analysed. Some of these samples are also being studied for heavy mineral concentrations. Wave refraction diagrams have also been constructed for different wave periods and wave directions for the coastal regions of Visakhapatnam.

2.8.3 Oceanography of the waters around Laccadives (Lakshadweep)

To determine the possibilities of culturing marine turtles, crabs, lobsters and other species of commercial importance, a pilot survey was conducted. This survey showed that Lakshadweep islands have good potentialities for large scale farming. Studies on the biology of some of these organisms have been taken up together with primary and secondary productivity of the area.

Several experiments on the growth of ovary in *Scylla serrata* (Forskal) were conducted to obtain basic information on induced spawning. It was found that eye stalk ablation accelerates maturation of the overy resulting in the spawning of some of the experimental crabs in the laboratory. Further studies on the rearing arc underway to evaluate the conditions for optimum survival and growth of the larvae.

Molluscs form an important group of the fauna in the Laccadive sea, reefs and lagoons. It was found that organisms with similar feeding habits live together in the same habitat. For example, though Neritids and Siphonarids belong to two different groups they were found to co-exist in the same zone and graze on the algae together. A study on the zonation of molluscs in Kavaratti atoll was completed.

Growth and other biological aspects of the corals along with the possible role of *Acanthaster* sp., the presence of which has been reported earlier, as a predator on corals are being investigated. As foraminifera help in the formation of coral reefs a detailed study on their distribution in the samples collected from the coral reefs and lagoons of the atolls is being conducted. The population of foraminifera ranges from 30 to 970 specimens per gram of sediment. Various species of foraminifera are being identified.

2.9

Sponsored Projects

2.9.1 *Survey of the exposed submarine pipeline from Trombay to Butcher Island (Phase I)*

2.9.2 *Remedial measures on the exposed submarine pipeline route from Trombay to Butcher Island (Phase II)*

2.9.3 *Surveys of submarine oil pipeline routes from Bassein to Gujarat*

2.9.4 *Survey for the location of well head BH 16 in South Bombay High*

2.9.5 *Shallow seismic and bathymetric surveys in South Bombay High*

2.9.6 *Wave data acquisition in Bombay High Region by Datawell Wave Rider Buoy System and analysis*

2.9.7 *Chemical analysis of water samples*

2.9.8 *Oceanographic and geophysical surveys for effluent disposal of Travancore Titanium Products Ltd., Trivandrum*

2.9.9 *Pollution and hydrographic survey of the Auranga, Ambika, Purna and Mindola rivers*

2.9.10 *Post-lay survey of the Bombay High-Uran submarine pipelines near Bassein River Platform*

2.9.11 *Survey for the Uran water intake jetty*

2.9.12 *Side scan sonar survey of Visakhapatnam outer harbour area*

2.9.13 *Studies on the possible side and mode of discharge of treated wastes into the sea*

2.9.14 *Echosounding at Coondapore Port at Mangalore*

2.9.15 *Environmental studies at Dharamtar creek*

2.9.16 *Development of oceanographic instrumentation system*

2.9.17 *Bioassay tests*

2.9.18 *Pharmacologically active substances from marine sediments*

2.9.19 *Seaweed resources of Maharashtra*

2.9.20 *Sorting of zooplankton samples*

2.9.21 *Preparation of Master Plan for pollution control in Zuari and Mandovi rivers and in coastal regions of Goa*

2.9.22 *Consultancy services*

2.9.1 Survey of the exposed submarine pipeline from Trombay to Butcher Island (Phase I)

This project was undertaken at the request of Bombay Port Trust (B.P.T.). Several pipelines laid earlier between Trombay and Butcher Island were suspected to be getting exposed. The extent of exposure was defected by employing side scan sonar

and sparker and by diving operations. Three pipelines were found to be exposed in the mid channel region where maximum current speed was of the order of 150 cm/sec. Total exposure was about 500 m, out of which about 200m length of the pipeline was found to be suspended above the bottom at a height ranging from 20 to 80 cm. The work was completed and the report was submitted to the B.P.T.

2.9.2 Remedial measures on the exposed submarine pipeline route from Trombay to Butcher Island (Phase II)

This project was in continuation of the earlier one sponsored by the same Agency. Temporary remedial measures were suggested and executed to support the exposed portions by blocking the gaps with high density polyethylene bags filled with quick setting cement and reinforcing the area with concrete blocks or stones.

2.9.3 Surveys of submarine oil pipeline routes from Bassein to Gujarat

At the request of ONGC, this project was undertaken and four different routes, i.e., from Bassein to Navapur, Tarapur, Daman and Umbhrat were surveyed. About 1,788 line km of echosounding, 1679 line km of side scan sonar and 1742 line km of shallow seismic profiling were carried out and 27 grab samples, 18 core samples and one dredge sample were collected from 32 stations. The depth in the area ranged from 7 to 65 m. Besides these, tidal and current observations in the area and extensive studies on macro, meio and microfauna were also made.

The surveys indicate that the southern area (i.e. Navapur, Tarapur to Line 54), because of its even topography with sufficient clay cover, will offer the least problem in laying a submarine pipeline. The laying of the pipeline in the northern area would involve a number of problems, *i. e.*, large stretches of uneven topography and exposures of sand and rocks along the routes. Rock exposures appear to be more common along Daman route as compared to Umbhrat route. Based on a comparative study of the four routes surveyed (Navapur, Tarapur, Daman and Umbhrat) it was suggested that the routes from Bassein to Navapur and Tarapur, because of their shorter lengths (93 and 100 km), even topography and sufficient clay cover have advantages over the other two routes. The routes from Bassein to Daman (159 km) and Umbhrat (169) km are not only longer but large stretches of these routes have uneven topography with sand and rock (Umbhrat 36 km, Daman 17 km).

However, in case it becomes necessary to select a land-fall north of Navapur/Tarapur, the following two alternatives were suggested:

(i) A route may possibly be identified from the northeastern edge of the area which has an even topography and sufficient clay cover (Daman route Line 51: Fix 590).

(ii) Further surveys may be carried out in the northern area to determine whether the sand banks, marked by intervening channels, are suitable for laying the pipeline.

2.9.4 Survey for the location of well head BH 16 in South Bombay High

The project was sponsored by ONGC. The survey indicated that the depth in the adjacent area varies from 77 to 81 but at the well head from 79 to 80 m. The sea bed

is uneven and appears to be covered with hard, presumably sandy material. The sonographs recorded spud marks of the drilling vessel at the site.

2.9.5 Shallow seismic and bathymetric surveys of the South Bombay High

At the request of ONGC, shallow seismic and bathymetric surveys were carried out in the South Bombay High Region. These studies revealed that the depth in the area ranges from 64 to 94 m. with an increase towards the west. Based on the topography the area may broadly be classified into three regions: *(i)* in the north, it is even with few variations, *(ii)* in the south, it is rugged and *(iii)* in between, it is uneven with variations of less than 5 m.

The area is broadly characterised by a series of NNE-SSW aligned depressions of about 10 m, while elevation plateaus and pinnacles rise to about 15 m. Most of the area is covered with silty sand or clayey sand and sand. The thickness of the clay increases to about 5 m in the north-eastern portion of the area. A number of reflectors are observed below the silty sand or clayey sand indicating different lithologies.

2.9.6 Wave data acquisition at Bombay High Region using Datawell Wave Rider Buoy System and analysis

This project was sponsored by the ONGC Offshore Project, Bombay. A wave rider buoy for the collection of wave data has been installed near the production platform F in Bombay High. The collected data are being analysed for determining the various wave parameters.

2.9.7 Chemical analysis of water samples

For the ONGC, water samples collected from the Bombay High regions were analysed for various chemical constituents like dissolved oxygen, sulphides, nitrogen and phosphorus compounds, iron., etc. These data were required to decide the treatment to be given to the sea water before injection into the oil wells.

2.9.8 Oceanographic and geophysical surveys for effluent disposal of Travancore Titanium Products Ltd., Trivandrum

This project was sponsored by M/s Travancore Titanium Products Ltd. The field programme of oceanographic survey of the area off Trivandrum beach was continued till April 1978 and dilution experiments using Rhodamine B as a tracer were conducted when the sea was calm and less turbulent.

Based on the bathymetric, side scan sonar and shallow seismic surveys and taking physical, chemical and biological aspects into consideration, a reasonably safe effluent discharge point was recommended to the sponsors.

2.9.9 Pollution and hydrographic survey of the Auranga, Ambika, Purna and Mindola rivers

This project was sponsored by Gujarat Water Pollution Board. Pollution loads entering into the four rivers were identified and samples were analysed for different chemical

Constituents. Tidal observations and currents over complete tidal cycles were measured at least at three locations in every river during the spring and neap tides. Water quality data were collected for the post-monsoon period. Fresh water flows were also measured. The work would continue till August 1979 and the data will be utilized to calculate the flushing time and compute allowable pollution load in the four rivers.

2.9.10 Post-lay survey of the Bombay High-Uran submarine pipelines near Bassein River Platform

This project was undertaken at the request of ONGC. Echosounding, side scan sonar and sub-bottom profiling were carried out to track the pipelines from Bombay High to Uran Submarine and near the Bassein River Platform. The survey indicated that the water depth ranges from 52 to 60 m and the sea bed is smooth and slopes gently towards south. The sea bed is covered with acoustically transparent clay varying in thickness from 21 m in the north to 10 m in the south.

The two submarine pipelines (about 100 m apart) were distinctly recorded in the echograms, side scan sonar and sub-bottom profiles at a water depth of 55 m. Along one of the tracks surveyed, the pipelines are buried at a depth of about 2m in the clay.

2.9.11 Survey for the Uran water intake jetty

More than 55 line km of echosounding and 60 line km of shallow seismic profiling were carried out in N-S and E-W grid pattern. 8 snapper, 2 dredge and 4 core samples were also collected at the request of ONGC. The surveys indicated the extension of onshore basalts to the offshore areas. The basalt is capped by 2 to 6 m of weathered zone and is probably overlained by boulders in the SW area. Isolated hyperbolic reflections in the clays also indicated boulders within the clays in this area.

The thickness of the overlying clay in a large area is 2-3 m which increases offshore. In the south-eastern part it increases to more than 8 m.

2.9.12 Side scan sonar survey of Visakhapatnam outer harbour area

At the request of Visakhapatnam Port Trust, a side scan survey was carried out. This survey showed that a large part of the area in the outer harbour is covered by sediments and is marked by dredging furrows. At places, these furrows have been partly filled with sediments. Rock exposures marked by dynamite holes were recorded in the area beyond the outer harbour channel. The sonographs revealed the presence of a number of other types of objects on the sea bed and in the outer harbour area.

2.9.13 Studies on the possible side and mode of discharge of treated wastes into the sea

The project was sponsored by the Steel Authority of India Ltd., Visakhapatnam. Oceanographic investigations were started in November 1978 in the offshore regions of Visakhapatnam to suggest suitable locations for discharging treated effluents into the sea from the proposed Steel Plant. Two profiles, one at Appikonda and the other at Gangavaram were selected for these studies. Each profile extended upto about 5 km into the sea from the coast. Monthly oceanographic observations included current measurements at various depths,

circulation studies using floats and the measurements of physical, chemical and biological parameters. The project will be continued for a period of one year.

2.9.14 Echosounding at Coondapore Port at Mangalore

At the request of the Mangalore Port Authority detailed echosounding was undertaken at the Coondapore Port.

2.9.15 Environmental studies at Dharamtar creek

Current observations over complete tidal cycles were undertaken along with diurnal studies of salinity, dissolved oxygen and pH at the request of ONGC. The information was required for ONGC-LPG intake project work. The data were analysed and report submitted.

2.9.16 Development of oceanographic instrumentation system

This project was funded by the Electronic Commission of India to develop oceanographic instrumentation system, namely *(i)* wave telemetry buoy, *(ii)* multiparameter ocean telemetering buoy and *(iii)* conductivity salinity temperature depth (CSTD) system.

Wave telemetry buoy system is being developed in two stages: *(i)* Pressure casing together with transducer and circuitry—this has been fabricated and tested in the laboratory and is now under field trials. The output is fed to a deck ship chart recorder via 5 core underwater cable. This system is sensitive to water height changes of the order of 10 cm. *(ii)* The second stage which involves compiling the output to a transmitting ultrasonic transducer and receiving the signal upto 500 m away on a floating lethered buoy which will subsequently transmit the information wirelessly to the shore. Work on this aspect is also in progress.

Development of multiparameter telemetry buoy is also in progress. CSTD system has been successfully fabricated and tested in the laboratory. Field trials are expected to be completed in early 1979.

2.9.17 Bioassay tests

This project was sponsored by the Zuari-Agro Chemicals Ltd. All the required bioassay tests were carried and a detailed report incorporating sublethal and lethal effects of the fertilizer effluent on aquatic organisms was submitted to the sponsors.

2.9.18 Pharmacologically active substances from marine sediments

This project was undertaken at the request of Hoescht Pharmaceuticals Ltd., Bombay. Sediment samples from different marine and estuarine areas were collected for determining their potential antibiotic properties. Studies covering one year have been completed during Phase I of the project .

2.9.19 Seaweed resources of Maharashtra

This project was undertaken at the request of Science and Technology Cell of Government of Maharashtra. The entire coast was surveyed and 10 stations were selected for detailed work. The abundance and availability of various seaweeds have been studied. Efforts are underway to select the few most suitable places for the cultivation of seaweeds.

2.9.20 Sorting of zooplankton samples

The Institute continued to the sorting of zooplankton samples received from CSIRO Australia. The processing of about 120 samples of total biomass of about 20000 ml was completed. Further sorting is in progress.

2.9.21 Preparation of Master Plan for pollution control in Zuari and Mandovi rivers and in coastal regions of Goa

This project was undertaken at the request of Central Board of Prevention and Control of Water Pollution. Observations on the water quality of the rivers Zuari and Mandovi were completed. The preparation of final report is in progress.

2.9.22 Consultancy services

(i) Development of marine parks in Pirotan island (Gulf of Kutch) and in coral islands (Gulf of Mannar): This work was undertaken for World Wild-Life Fund (WWF) and a report was sent to WWF incorporating the present status of flora, fauna and natural history of Pirotan along with a plan for the projection and conservation of marine resources.

At the request of WWF, a report on the natural history of 17 coral islands (Gulf of Mannar) was prepared and submitted.

(ii) Observation on coastal erosion at Temple Bay Beach Resort, Mahabalipuram : A field investigation was undertaken to inspect the coastal erosion conditions at Temple Bay Beach Resort, Mahabalipuram at the request of the India Tourism Development Corporation and a report was submitted.

(iii) Study of coastal erosion problems at Sriharikota: A field inspection tour was undertaken to investigate the coastal erosion problems at Sriharikota at the request of the Indian Space Research Organization. A proposal indicating the scope and objectives of the required study was submitted to the concerned organization.

(iv) Measurements of waves off Visakhapatnam: At the request of Visakhapatnam Port Trust, a proposal was submitted for measuring the waves by installing a Datawell Wave Rider Buoy off Visakhapatnam harbour.

(v) Design of a diffuser system and anchor system: As a follow-up of the work on sea bed survey carried out last year, the design of a suitable diffuser system, anchor system etc., for the proposed submarine pipeline for discharging the effluent from the caustic soda factory for M/s Ballarpur Industries Ltd., Binage, Karwar was submitted to the sponsors.

(vi) Static bioassay test: Static bioassay test were undertaken at the request of A.L.A. Chemical Ltd., Bombay to find out the toxic effects of oil-dispersant 'Alankromul' on marine living resources.

(vii) Kudremukh Iron Ore Project (KIO): At the request of K.I.O. Bangalore, bioassay studies on the toxicity of effluents from the iron ore slurry were carried out on marine organisms.

(viii) Marine pollution and testing: Consultancy services on the analytical aspects of industrial effluents were extended to several industrial and government agencies. Free analytical service was also given to universities, government institutions at their request on the analysis of water, pharmaceuticals, blood and spinal fluids for metals and other chemical constituents.

2.10

International Projects

2.10.1 United Nations Environment Programme (UNEP)

The directory of marine research centres in the Indian Ocean region was prepared and released under the UNEP project, "Marine Environmental Monitoring and Marine Living Resources Assessment for the Indian Ocean Region". The directory includes all the details of 78 institutions in the Indian Ocean region including 27 institutions from India.

2.10.2 Integrated Global Ocean Stations System (IGOSS)

Observations on three components of MAPMOPP of IGOSS were continued during the different cruises of RV *Gaveshani.* The components are: *(i)* oil spills and other floating pollutants, *(ii)* particulate petroleum residues and *(iii)* dissolved and dispersed hydrocarbons. The fourth component, tar on beaches was not included during this year, as a fairly extensive survey has already been completed for the year 1975 and 1976. India is the only country in the Indian Ocean region to carry out observations on all the four components.

2.10.3 International Foundation for Science, Stockholm programme on aquaculture of mussels, oysters and prawns using treated domestic sewage

An investigation on aquaculture of mussels, oysters and prawns using treated domestic sewage, was initiated under a grant received from the International Foundation for Science, Stockholm. The first series of experiments to determine the dilution of sewage and sea water to get the maximum quantity of phytoplankton was carried out during the year.

3

Technical Services

3.1 Library

During the year, 470 books were added to the Library. Of these, 105 were received as Gift from the various Indian and Foreign institutions, including 65 books from the British Council. Besides these, 700 technical reports and 81 microfilms were also added to the library. The number of rare and important reprints added during the year was 600. Library received 300 current periodicals either through subscription or in exchange to the Institute's Journal *Mahasagar*. A comprehensive catalogue of periodical holding was brought out. Inter-library loan system was continued and a large number of users from this Institute and from outside organizations availed various kinds of library facilities. The library was kept open for use to outside scientists.

The library continued to issue the monthly mimeographed report "'New Arrivals" as before. During the year the library hours have been extended upto 1900 hrs.

3.2 Geotechnical Laboratory

In order to facilitate the study of coastal and offshore sea-bed soils for a proper understanding and solving the foundation engineering problems associated. with the different types of coastal and offshore structures, a new geotechnical laboratory has been set-up in the Institute. Most of the indigenously available laboratory testing equipment have been purchased and installed after making some modifications in the existing building. Development of a wind-wave flume facility for conducting laboratory model studies according to-modern concepts and employing recently developed control equipment and techniques is in progress. Three Dutch Data well wave riders including recording system have been obtained from Norway under the bilateral technical assistance programme.

3.3 Calibration

The rotor type current meter developed in the Institute was successfully tested and calibrated.

The Electromagnetic Current Meter calibration set-up is ready for testing. The electronic time counter for the calibration purpose was successfully fabricated and tested.

A Dead-Weight pressure gauge tester was procured and it was compared with a Heiss Pressure Gauge of 0.5 kg/cm^2 accuracy. The diaphragm type Strain Gauge pressure sensors in the range 0 to 10 bar and 0 to 70 bar type were also tested on this Dead-Weight pressure gauge tester.

Calibration of 4 STD units was also completed.

A design of B.T. Calibration Chamber was finalised and items like hand operated pressure pump, heaters and pressure gauge were procured.

3.4 Service and Maintenance

The Service and Maintenance Wing of the Instrumentation Division gave full support to all the Divisions of the Institute and to the sponsored projects. The Wing was able to run and maintain all the scientific equipment on board RV *Gaveshani* and also the portable equipment used in other smaller boats. In addition to these, service to various other outside organizations was also provided.

Servicing includes the modification of circuitry on sophisticated imported equipment such as side scan sonar, hydrosonde, magnetometers, echosounder and other analytical, scientific and industrial equipment.

3.5 Prototype Services

The Prototype Group was engaged in fabrication of printed circuit board and their wiring, transformer winding and fabrication of sensors and maintenance of internal stores.

During the year, the Prototype Group completed the fabrication of P.C. Boards for C.S.T.D., C.T.D., Flash Light Control Unit, E.M. Flow Meter, Buoy Telemetry System, Rotor Type Flow Meter, Lab Salinometer, Digital Circuit, P.C. Boards, etc.

The fabrication of a sensor for E.M. Flow Meter and the fabrication of a prototype of Lab Salinometer and Power Transformer winding are in progress.

3.6 Electroplating Services

During the year, copper, nickel, chromium, cadmium anodising plating tanks and bus bar connection for the rectifier were installed in the Electroplating Section.

A number of jobs were completed for the different Divisions of the Institute which include heat sink, guards for thermometers, plating of rotor type current meter assembly, anodising of front panels for time counter, lab salinometer, wave height analyser body, Norad equipment, pulley block of ONGC, 'KBR' die, Messenger, Corer assembly, Van Veen Grab and net frames etc.

3.7 Workshop

During the year the workshop machineries were shifted to new extension. The workshop provided all facilities to the various Divisions particularly in the fabrication of : 1. Vibro Corer, 2. In-situ Temperature Sensor, 3. Piston Gravity Corer, 4. Rotor Induction Current

Meter (mechanical parts), 5. Resistance Track Compass for measuring flow direction in marine environment to an accuracy of + 3°, 6. Current meter—its calibration and fabrication of C.T.D. rigs, 7. Solar Fish Drier, 8. A flashlight buoy for use in drift current studies and Wave Height Analyser (mechanical parts) to be used for the ONGC work.

Various other routine work were attended to as a routine to give full support to R & D work. Emergency works were also attended to from time to time.

3.8 Drawing and Photography

The Drawing and Photography group was fully engaged throughout the year in the preparation of drawings, charts, hydrographic maps, civil, mechanical and electronic engineering drawings, slide making etc. of various Divisions of the institute. Work was also done for several sponsored projects.

4

Administrative Set-up

4.1 Cruise Planning and Programme Priorities Committee for R. V. *Gaveshani*

1.	Director General CSIR & Secretary to the Department of Science & Technology New Delhi.	*Chairman*
2.	Capt. M. Sethi Shipping Corporation of India, Head Office Bombay.	*Member*
3.	Mr. S.N. Batra Technical Manager SCI, Calcutta.	,,
4.	Mr. Ananthakrishan Director (Development) Ministry of Shipping & Transport New Delhi.	,,
5.	Mr. V.R. Venkoba Rao Geological Survey of India Calcutta.	,,
6.	Capt. V. Ravindranath Director (OPS) Coast Guard H.Q., New Delhi.	,,
7.	Mr. R.K. Kutkar Asstt. Wireless Adviser Ministry of Communication New Delhi	,,
8.	Mr. P. Satyanarayana Naval Hydrographic Officer Dehra Dun	,,
9.	Mr. K.R.G.K. Murty Naval Physical & Oceanographic Laboratory Naval Base, Cochin.	,,
10.	Shri. V.L.N. Sastry Chief Geophysicist ONGC Offshore Project Bombay	,,

11. Dr. K.L. Kaila — *Member*
Project Coordinator
DSS Project, National Geophysical Research Institute
Hyderabad.

12. Dr. D.K. Rakshit — "
Deptt. of Science & Technology
New Delhi.

13. Dr. V.V. Bhartiya — "
Principal Scientific Officer
DST., New Delhi.

14. Mr. K.N. Johry — "
Head, ISC
CSIR, New Delhi.

15. Dr. D. Shankar Narayan — "
Additional Secretary
University Grant Commission
New Delhi.

16. Dr. D. LaI — "
Director
Physical Research Laboratry
Ahmedabad

17. Mr. S.P. Jagota — "
Joint Secretary and Legal Adviser
Ministry of External Affairs
New Delhi.

18. Dr. E.G.Silas — "
Director
Central Marine Fisheries Research Institute
Cochin.

19. Dr. A.K. Ganguly — "
Bhabha Atomic Research Centre
Bombay.

20. Commodore I.K.Puri — "
Advisor, NIO
CSIR, New Delhi.

21. Dr. S. Z. Qasim — *Convener*
Director
NIO, Goa.

4.2 Executive Committee

1. Dr. S.Z. Qasim — *Chairman*
   Director
   National Institute of Oceanography
   Dona Paula (Goa)
2. Vice Admiral O.S. Dawson, AVSM — *Member*
   Flag Officer, Commanding Southern Fleet
   Naval Base, Cochin
3. Dr. V.V. Sastri — "
   Director R & D
   Institute of Petroleum Exploration (ONGC)
   Kaulagarh Road
   Dehra Dun.
4. Dr V.K. Iya — "
   Director, Isotopes Division
   Bhabha Atomic Research Centre
   Trombay-Bombay.
5. Shri H.N. Siddiquie — "
   Head, Geological Oceanography Division
   National Institute of Oceanography
   Dona Paula (Goa).
6. Dr. B.U. Nayak — "
   Head, Ocean Engineering Division
   National Institute of Oceanography
   Dona Paula (Goa)
7. Shri L.V. Gangadhara Rao — "
   Scientist, Physical Oceanography Division
   National Institute of Oceanography
   Dona Paula (Goa)
8. Administrative Officer — "
   National Institute of Oceanography
   Dona Paula (Goa)
9. Finance & Accounts Officer — "
   National Institute of Oceanography
   Dona Paula (Goa)
10. Permanent Invitee to the Executive Committee

    (i) Director-General, SIR or his nominee and (ii) Chairman, Coordination Council of Physical and Earth Sciences Group of Laboratories, CSIR.

4.3 Scientific Advisory Committee

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

2.	Commodore V.A. Dhareshwar General Manager Goa Shipyard Ltd., Vasco-da-Gama (Goa)	*Member*
3.	Mr. T. Tholasilingam Officer-in-charge CMFRI Sub-Station Egmore, Madras	"
4.	Dr. L.U. Joshi Senior Scientist, Modular Laboratories Bhabha Atomic Research Centre Trombay - Bombay	"
5.	Director of Industries Government of Goa, Daman & Diu	"
6.	Chairman Mormugao Port Trust, Mormugao	"
7.	Deputy Director National Institute of Oceanography Dona Paula (Goa)	"
8.	Head, Biological Oceanography Division National Institute of Oceanography Dona Paula (Goa)	"
9.	Head, Geological Oceanography Division National Institute of Oceanography Dona Paula (Goa)	"
10.	Head, Chemical Oceanography Division National Institute of Oceanography Dona Paula (Goa)	"
11.	Head, Ocean Engineering Division National Institute of Oceanography Dona Paula (Goa)	"
12.	Head, Planning & Data Division National Institute of Oceanography Dona Paula (Goa)	"
13.	Head, Instrumentation Division National Institute of Oceanography Dona Paula (Goa)	"
14.	Scientist-in-charge Regional Centre of NIO, Cochin.	"
15.	Scientist-in-charge Regional Centre of NIO, Bombay.	"
16.	Scientist-in-charge Regional Centre of NIO, Waltair.	*Member*

4.4 Budget

The Budget of the Institute for the years 1977–78 and 1978–79 were as follows :

1977–78	Actual		(Rs. in lakhs)
	Non-plan	Plan	Total
Recurring	40.101	82.798	122.899
Capital	1.799	52.211	54.010
Total	41.900	135.009	176.909

1978–79	Actual		(Rs. in lakhs)
	Non-plan	Plan	Total
Recurring	43.160	86.300	129.460
Capital	2.114	46.235	48.349
Total	45.274	132.535	177.809

4.5 Names and Designation of Staff as on 31-12-1978

Director

Dr. S.Z. Qasim

Deputy Director

Dr. V.V.R. Varadachari

Advisor NIO (Ship matters)

Commodore I. K. Puri, Chief Hydrographer, Indian Navy (Retired)

A. Divisions at the Headquarters

1. Physical Oceanography Division

Head of the Division

Dr. V.V.R. Varadachari

Scientists

Dr. J.S. Sastry
Shri L.V.G. Rao
Dr. C.S. Murty
Dr. R. Mahadevan
Shri P.K. Das
Shri M.J. Varkey
Shri C. K. Gopinathan

Senior Scientific Assistants

Shri K.K. Varma
Shri V. Ramesh Babu
Shri V. Kesava Das
Shri A.F. Anto
Shri A.D. Gouveia

Junior Scientific Assistants

Shri P.V. Sathe
Shri D.V. Rama Raju
Shri Y.K. Somayajulu

Senior Research Fellows

Shri K. Premchand
Shri V.V. Gopalakrishna

Senior Laboratory Assistants

Shri R. Nagarajan

Junior Stenographer

Shri T.P. Simon

Field Assistants

Shri A.X. Monteiro
Shri R.G.K. Gaudar
Shri V. Gawas

2. Chemical Oceanography Division

Scientist-in-Charge

Shri C.V.G. Reddy

Scientists

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

Shri S.Y.S. Singbal
Dr. S.Y. Kamat
Dr. A. Rajendran

Senior Scientific Assistants
Shri S.N. De Souza
Miss Solimabi
Shri S.P. Fondekar
Shri S.B. Kamat
Shri M.D. George
Shri S.W.A. Naqvi
Shri N.B. Bhosle

Junior Scientific Assistants
Miss S· S. Naik
Shri M. D. Rajagopal
Shri R. S. Topgi
Shri P. K. Mittal
Mrs. C. D'Silva
Shri K. Sawkar

Senior Research Fellows
Shri T.W.Kureishy
Miss S.M. Sansgiri

Junior Research Fellows
Miss A. Braganza
Miss L. Fernandes

Junior Technical Assistants
Miss C.F. Moraes
Mrs. B. Das

Senior Laboratory Assistants
Mrs. C.D. Thressiamma
Miss A. Row
Shri P.V. Shirodkar
Shri R. Noronha

Junior Stenographer
Miss L.V. Fernandes

Junior Laboratory Assistant
Mrs. V.V. Date

Glass Blower
Shri P. Susupalan

Field Assistants
Shri D.P. Bhobe
Shri L.F. Mascarenhas

3. Geological Oceanography Division

Head of the Division
Shri H.N. Siddiquie

Scientists
Dr. M.G.A.P. Setty
Shri P.S.N. Murty
Shri R.R. Nair
Shri Ch.M. Rao
Shri D. Gopala Rao
Dr. M. Veerayya
Shri G.V. Rajamanickam

Senior Scientific Assistants
Shri R.M. Kidwai
Shri B.G. Wagle
Shri M.V.S.N. Guptha
Shri F. Almeida
Shri A. Narendranath
Shri N.H. Hashimi
Shri G.C. Bhattacharya
Shri A.L. Paropkari
Shri L.V.S. Raju
Shri K.H. Vora
Shri A.R. Gujar
Shri R. Nigam
Shri S..M. Karisiddiah

Senior Technical Assistants
Shri K.L. Kotnala (Marine Surveys)
Shri M.C. Pathak („ „)

Junior Technical Assistant
Shri S.K. Nanyasi

Junior Research Fellow
Shri A. Mascarenhas

Senior Laboratory Assistants
Shri S.P. Desai
Shri A.S. Muralinath
Shri N.V. Ambre

Senior Stenographer
Shri V.N.N. Menon

Junior Cataloguer
Shri S.N. Patharpekar

Field Assistants

Shri G.R. Desai
Shri G.N. Naik

Laboratory Attendent

Shri S. Dongrekar

4. Biological Oceanography Division

Head of the Division

Dr. T.S.S. Rao

Scientists

Dr.K.Radhakrishna
Dr. A.H. Parulekar
Dr. A.G. Untawale
Shri V.P. Devassy
Shri S.C. Goswami
Dr. (Miss) Aditi Pant
Dr. (Mrs) Sumitra Royan
Shri P.M.A. Bhattathiri
Dr. (Mrs) V.R. Nair

Senior Scientific Assistants

Shri S.A. Nair
Shri C.T. Achuthankutty
Shri S.N. Harkantra
Dr. M. Madhupratap

Junior Scientific Assistants

Mrs. L. Krishnakumari
Shri Z.A. Ansari
Shri S.R. Sreekumaran Nair
Miss S.S. Bukhari
Mrs. S. Achuthankutty
Shri X.N. Verlencar

Research Associates

Dr. (Mrs) U. Goswami
Dr. J.P. Royan

Senior Research Fellows

Dr. V. Ramadhas
Shri T.G. Jagtap
Shri V.V. Agadi

Senior Laboratory Assistants

Shri V.K. Dhargalkar
Miss M. Menezes
Shri S.G. Prabhu Matondkar

Junior Laboratory Assistant

Shri K.R. Radhakrishnan

Field Assistants

Shri M.P. Gaunco
Shri S.B. Kamble
Shri S.T. Yeshwant
Shri L.B. Naik

5. Ocean Engineering Division

Head of the Division

Dr. B.U. Nayak

Scientists

Shri N.M. Anand
Dr. A.K. Jain

Senior Scientific Assistant

Shri B.A. Ramesh

Senior Laboratory Assistants

Shri C.R. Sivadasan
Shri A. Mascarenhas

Junior Stenographer

Shri M. Sivaraman

Field Assistant

Shri M .K. Tari

6. **Instrumentation Division**

Scientist-in-Charge

Dr. E. Desa

Scientists

Shri M. R. Nayak
Shri M. Manoharan

Pool Officer

Shri E. S. Desa

Senior Scientific Assistants

Shri C. Rameshu
Shri S.G. Diwan

Junior Scientific Assistants

Mrs. V.B. Peshwe
Shri H. Srikantan

Senior Technical Assistant

Shri E. Dias

Junior Technical Assistants

Shri Md. Wahidullah
Shri V.M. Date
Shri S. Chellam
Shri V. Subramaniam
Shri R. Prabhakar
Shri P. Selvam

Junior Mechanical Assistant

Shri S.B. Tengali

Senior Draftsman

Shri V.N. Mohan

Senior Laboratory Assistants

Shri K.K. Varghese
Shri O. D'Souza
Shri N.E. Govindan
Shri M.K. Premkumar

Photographic Assistant

Shri U. Sirsat

Junior Laboratory Assistants

Shri K.L. Naik
Miss P. Estrocio

Precision Mechanics

Shri V.N. Chodankar
Shri K. Ratnannavar

Tracers

Shri H.D. Punj
Shri K.G. Chitari
Shri S.A. Karim
Shri R. Uchil
Shri P.J. Pawaskar
Shri S.G. Akerkar

Fine Mechanic

Shri M. Surlekar

Junior Mechanic

Shri M.G.K. Goudar

Fitter

Shri P.P. Fernandes

Junior Fitter

Shri R. Monteiro

Painter

Shri A. Raikar

Carpenter

Shri S. Kalangutkar

Welder

Shri M.A.D. Araujo

Field Assistant

Shri A.V. Shirgonker

Workshop Assistants

Shri S. Sawant
Shri V.B. Naik

Ammonia Printer

Shri N.V. Naik

7. Planning and Data Division

Scientist-in-Charge

Dr. V.S. Bhatt

Scientist

Shri R.M. S. Bhargava

Senior Scientific Assistants

Shri J.S. Sarupria
Shri Avinash Chandra
Shri S.G. Dalal
Dr. R.K. Sharma

Junior Scientific Assistant

Shri S.R. Bhat

Proof Reader

Shri S.P. Sharma

Junior Laboratory Assistants

Miss C. Lopes
Shri B. Fernandes

Lower Division Clerk

Shri S.A. Fonseca

Key Punch Operators

Miss B.M. D'Mello
Shri K. Ramdasan
Mrs. G.S. Prabhu

Miss A.D. Pereira
Mrs. P.P. Pillai

Field Assistant

Shri S.N. Naik

Binder

Shri C.S. Sirvoicar

Khalasi

Shri B.H. Pednekar

8. Library

Senior Scientific Assistant (Documentation)

Miss M.G. Joshi

Junior Librarian

Mrs. S.H. Oka

Librarian Grade I

Shri M.V. Mudhol

Librarian Grade II

Shri C. Fernandes

Library Attendant

Shri R.S. Kurtarkar

9. R.V. Gaveshani and Boats

Executive Officer

Dr. A.B. Wagh

Bosun

Shri M.M. Khatau

Engine Driver I

Shri O.K. Balakrishnan

Engine Driver II

Shri R.R. Garudi

Deckhands

Shri R. Gonsalves
Shri V. Dawjekar
Shri N.B. Torascar
Shri V.B. Mandrekar
Shri P. J. Kankonkar

10. Administration

Administrative Officer

Shri Om Prakash

Section Officer

Shri Mastan Singh

Assistants

Shri R.P. Ahluwalia
Shri I. D'Souza
Shri K. Appalaswamy

Laboratory Supervisor

Shri R. Ravindra

Upper Division Clerks

Shri Peter D'Silva
Shri R.K. Duggal
Shri J.L. D'Mello (Cashier)
Shri Paul D'Souza
Mrs. Regina D'Silva

Junior Stenographers

Mrs. Rosy Thomas
Miss M. Cardozo

Lower Division Clerks

Shri S.R. Fadte
Shri A. Fernandes
Shri F. Lawrence
Mrs. Anny D'Souza
Miss M. Shahapurkar
Miss G. Pia F.A.F. D'Mello
Mrs. M.F. Fernandes

Receptionist

Mrs. S.E. Almeida

Telephone Operator

Miss V. D'Cruz

Junior Laboratory Assistant

Shri J. Mascarenhas

Senior Gestetner Operator

Shri R.B. Shettigar

Staff Car Drivers

Shri T. Sankaran
Shri R.T. Poi
Shri V. Martins

Shri R.P. Shet
Shri B.Naik

Driver-cum-Mechanics
Shri S. Surlekar
Shri B. Fernandes

Field Assistants
Shri M. V. Mochemadkar

Daftry
Shri V.V. Jannu
Shri S.V. Gad

Peon
Shri J. Gonsalves

Guest House Attendant
Shri P.V. Zachariah

Khalasi
Shri C. Lemos
Shri A.X. Vaz

Sweepers
Mrs. .J. Sirvoicar
Shri L. Pareira
Shri H.V. Khedekar
Mrs. A. Fernandes
Shri M.H. Naik
Shri T.O. Supataria
Shri D.C. Tang

11. Director's Office

P. A. Tech.
Shri T.R. Ramachandran

Junior Stenographer
Shri N.S. Dalvi

Field Assistant
Shri S.S. Naik

Peon
Shri P. Arlekar

12. Accounts Section

Finance & Accounts Officer
Shri A. Rajachandran

Section Officer {Audit & Accounts)
Shri V.M. Joshi

Junior Accountant
Shri K.R. Ramamurthy

Upper Division Clerk
Miss N. Fernandes

Junior Stenographer
Miss L.M. D'Cruz

Lower Division Clerks
Shri C.M. Dias
Mrs. S. Subramanian
Shri O. Sirvoicar

Peon
Shri S.B. Kurup

13. Purchase Section

Purchase Officer
Shri S.P. Mittal

Assistants
Shri K. R. Das
Shri G. Laxmanan Rao

Upper Division Clerk
Shri T.C. Fernandes

Lower Division Clerks
Mrs. V.V. Joshi
Shri K. Sivadasan

Junior Laboratory Assistant
Shri B. Fernandes

14. Stores Section

Stores Officer
Shri R.K. Nair

Stores Supervisor
Shri G.K. Gaur

Senior Store Keepers
Shri P. Gopinathan
Shri K. S. Naik
Shri F. Afonso
Shri T. K. Ramankutty

Junior Store Keeper

Shri S.G. Sanke

15. Civil Engineering

Civil Engineer

Shri George Philip

Junior Engineers

Shri R.B. Kubasad
Shri K.B. Kulkarni (Elect.)
Shri M.P. Chacko

Upper Division Clerk

Shri P.M. Unnikrishnan

Lower Division Clerk

Shri R.G. Vernekar

Works Mistry

Shri P.P. John

Plumber

Shri L. Karelkar

Pump Operator

Shri M.L. Patil

Jr. Electricians

Shri S.N. Mahajan
Shri L. Gomes

Mason

Shri M. Gawas

Meter Reader

Shri J. Amaral

Khalasi

Shri R. Cruz
Shri S. Mochemadkar
Shri S. Kotharkar
Shri V. Jogle
Shri K. Krishanyaih

16. Dispensary

Residential Medical Officer

Dr. (Miss) L. Bhandare

Nursing Sister

Mrs. T. Menezes

Compounder

Mrs. M.A. Gracias

17. Horticulture Section

Garden Chaudary

Shri N.K. Anjanappa
Shri Mohamad Ali

Malis

Shri D.B. Gauli
Shri B.L. Kuttikar
Shri K. Subba Rao
Shri S. Sirvoicar
Shri C. Kamble
Shri Z. Sahib
Shri T. Kesavappa

18. Watch and Ward

Watch & Ward Assistant

Shri S. D. Pillai

Watchmen

Shri N.T. Poi
Shri J.G. Mahle
Shri S.S. Satardekar
Shri H.N. Gaonkar
Shri S.S. Parsekar
Shri B. Sebastian
Shri D.K. Gunjal
Shri R. Gawas
Shri P. Kurup
Shri N.P. Naik
Shri E·K· Kalekar
Shri E.B. Gaikwad
Shri K.B. Dcsai
Shri R.F. Pereira
Shri M. Kerkar

B. Regional Centre of NIO, Cochin

Scientist-in-Charge

Dr. M. Krishnan Kutty

Scientists

Shri V.S. Rama Raju
Dr. R.V. Unnithan
Shri V.N. Sankaranarayanan
Shri P. Udaya Varma

Dr. P· Sivadas
Shri U.K. Gopalan
Shri P. Gopala Menon
Shri B.M. Panikkar
Dr. M. Saraswathy
Shri P.N. Aravindakshan
Shri V.T. Paulinose
Shri T. Balachandran
Mrs. 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.C. Nair
Mrs. P.P. Meenakshikunjamma

Junior Scientific Assistants

Mrs. Rosamma Stephen
Mrs. U.P. Saramma
Shri P. Haridas
Shri T. Balasubramanian

Senior Research Fellow

Mrs. K.N. Remani

Junior Technical Assistants

Shri P. Venugopal
Shri Abraham Pylee
Shri B. Narayanan
Mrs. K. Sarala Devi
Shri O. Raveendran

Senior Laboratory Assistants

Shri S. Kumaran
Shri K.S. Purushan

Senior Stenographer

Shri C.S. Krishna Pai

Stores Supervisor

Shri P.V. Raphael

Junior Stenographer

Shri K.K. Gopinathan

Upper Division Clerks

Shri P.B. John
Shri K.A. Damodaran
Shri M.A. Madhavan
Shri V.D. Manoharan

Lower Division Clerk

Mrs. S. Pillai

Staff Car Driver

Shri K.R.K. Menon

Fitter

Shri K. Gopalan

Deckhand

Shri E. Thomas

Field Assistant

Shri K.P. Xavier

Lab Attendents

Shri M.J.M. Gilbert
Shri K. Thankappan
Shri A.K. Shaji

Lab Bearer

Shri K.P. Peter
Shri K. Girijan
Shri T.K. Sudhakaran
Shri C.P. Chakkappan

Peons

Shri K.R. Kumaran
Shri M.V. Pavithran

Security Guard

Shri N. Bhaskaran

Watchman

Shri K.R. Prabhakaran

Sweeper

Mrs. A.M. Clara

C. Regional Centre of NIO, Bombay

Scicntist-in-Charge

Dr. B.N. Desai

Scientists

Dr. M.D. Zingde
Shri G.N. Swamy

Senior Scientific Assistants

Dr. K. Govindan
Shri M.M. Sabnis

Junior Scientific Assistants

Shri R.V.N. Sarma
Miss V.M. Kolhatkar
Shri A.A. Fernandes

Junior Technical Assistants

Shri S.M. Gajbhiye
Shri P.V. Narvekar

Senior Laboratory Assistants

Shri A.V. Mandalia
Shri S.N. Parab
Miss P.D. Gore
Shri N.S. Bhatt

Junior Laboratory Assistants

Shri J. Ram
Shri N. Paul Singh
Mrs. R. D'Souza
Shri S.K. Trivedi
Shri Suresh Chander
Shri B.G. Shah

Upper Division Clerk

Shri Ramkishan

Junior Stenographer

Shri P.B. Nair

Lower Division Clerks

Shri A.S. Date
Shri R.S.Tharval

Field Assistants

Shri N.M. Patel
Shri G. Chouhan
Shri C.V. Samuel
Shri B.G. Patel

Driver-cum-mechanics

Shri B.G. Chorat
Shri V.A. Chopra

Sweeper

Shri Chinubhai Patel

D. Regional Centre of NIO, Waltair

Scientist-in-charge

Shri T.C.S. Rao

Scientist

Dr. D. Panakala Rao

Senior Scientific Assistants

Shri P. Chandra Mohan
Shri K. Subrahmanyam
Shri M.M. Malleswara Rao

Junior Scientific Assistants

Shri T.V. Narasimha Rao
Shri X.T. Machado

Senior Research Fellow

Shri T.B. Babu

Junior Research Fellows

Shri A.S. Rama Rao
Shri G.R.K. Raju
Shri V. Narendra Babu

Senior Laboratory Assistant

Shri G. Hanumanthaih

Junior Laboratory Assistant

Shri P.V.V. Siva Rao

Junior Stenographer

Miss K. Radhakrishna

Field Assistants

Shri T.V.R. Prasad
Shri A. Koteswara Rao

Lab Attendent

Shri S.M. Bhasa

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Awards, honours and membership of various committees

Dr. S.Z. Qasim was elected as

President, Society for Offshore Engineering and Underwater Technology of India

Fellow, The Explorers Club, New York.

Dr. V.V.R. Varadachari served as

Member Secretary of the Indian National Committee for SCOR

- Member of the Board for Ocean Engineering Centre, I.I.T., Madras

Member of the Board of Studies in Meteorology and Oceanography, Andhra University, Waltair

- Member of the Board of Studies in Physical Oceanography, University of Cochin, Cochin

Member of the Indian National Committee for International Union of Geodesy and Geophysics (I.U.G.G.)

- Member of Marine Science Advisory Committee for Centre for Earth Science Studies, Trivandrum.

Shri H.N. Siddiquie acted as

Member, Executive Committee of the Indian Economic Geologists Association

Member, Board of Studies for Marine Geology and Oceanography, Cochin University

Member, Organising Committee for Short Term Specialist Course in Geophysical Technology, Andhra University, Waltair.

Dr. J.S. Sastry acted as

Member of the Indian Ocean Panel, SCOR Working Group 47, IOC

Member of ISI-Thermometers Sub-Committee, CDC-33.2.

Dr. B.N. Desai served as

- Member of Advisory Panel to the Planning Commission, Govt. of Gujarat

Member of Science and Technology Advisory Committee, Govt. of Maharashtra

Member of Advisory Committee, Water Pollution Prevention Board of Maharashtra

- Member of Study Group to identify the source of mercury contamination, Govt. of Maharashtra
- Member of Deep Sea Fisheries Advisory Panel
- Member of Marine Instruments Panel, National Commission on Science and Technology

- Member of Marine Disposal Committee, Indian Standards Institution

  Member, Board of Studies in Environmental Biology, University of Jodhpur

  Member, Board of Studies in Environmental Pollution, Bombay University

  Member, Task Force for Selection of Site for Fertilizer Plant at Gujarat.

Dr. M.G.A.P. Setty served as member of Sigma XI, the Scientific Research Society of North America, U.S.A.

Dr. R. Sen Gupta was nominated as Coordinator for MAPMOPP of IGOSS for the Indian Ocean Region.

Dr. T.C.S. Rao served as member for Organising Committee on 'Specialised Course in Marine Geophysical Technology' on U.G.C. sponsored scheme to the Geophysics Department, Andhra University, Waltair.

Dr. V.S. Bhatt served as

Member, FAO/IOC Panel of Experts for Aquatic Science and Fisheries Information System (ASFIS)

- Member, IOC Working Group on Marine Environmental Data and Information (MEDI)
- Member, Steering Group for International Oceanographic Data Exchange (IODE) of the Intergovernmental Oceanographic Commission (IOC), UNESCO
- Member, IODE/WC Ad-hoc Group on Marine Information Management

  Invited Member of Joint Working Group on Scientific and Technical Information of the Indo-US Sub-Commission on Science and Technology
- National Coordinator for International Oceanographic Data Exchange to deal with the matters connected with the IOC on this subject.

Shri L.V. Gangadhara Rao served as alternative member of the ISI-Thermometers Sub-Committee CDC-33.2.

Dr. C.S. Murty has been awarded the Ph.D. Degree for his thesis, entitled 'Some physical aspects of shoreline dynamics at some selected places along the west coast of India' by the University of Kerala.

Dr. A.B.Wagh acted as Member, Editorial Board of Vishwakosha (Marathi Encyclopaedia). Govt. of Maharashtra.

Dr. E. Desa served as Examiner for Industrial Electronics Course III and V Semesters. Govt. Polytechnic, Panaji.

Dr. A.H. Parulekar served as

Member, High Level Committee on Science and Technology Utilisation, Govt. of Maharashtra

Member, ICAR/Konkan Agricultural University Committee on Fisheries Research Education and Development

Member, Organising Secretary, Seminar on Prospects of Fisheries Development for Goa, co-sponsored by Govt. of Goa, Daman and Diu, Goa Chamber of Commerce and Industry and Planning Commission, Govt. of India

Member, Indian Environmental Society, New Delhi

Sectional Editor (Marine Sciences) Vishwakosha (Marathi Encyclopaedia), Govt. of Maharashtra.

Shri U.K. Gopalan served as

- Member, Board of Studies in Environmental Studies, University of Cochin
- Member, Executive Committee, Marine Biological Association, India
- Member, Executive Committee, Association of Fisheries Technologists, India

Member, Executive Committee, Kerala Sasthra Sahitya Parishad.

Dr. D. Panakala Rao was awarded Ph.D. Degree by the Andhra University, Waltair in Oceanography based on the thesis, entitled 'A comparative study of the potential productivity of the Bay of Bengal and Arabian Sea'·

Dr. M. Veerayya was awarded Ph. D. Degree by Andhra University, Waltair, based on the thesis 'Studies on the geological aspects of the beaches of Goa in relation to some meteorological and physical oceanographic factors'.

Shri M .R. Nayak served as Examiner for Industrial Electronics Course III and V Semesters, Govt· Polytechnic, Panaji.

Dr. A.K. Jain was awarded Ph.D. Degree by MT., Kanpur based on the thesis, 'Experimental and analytical investigations on a class of dynamic problems in beam foundation interaction'.

Mr Rajiv Nigam was awarded M. Phil. Degree by Aligarh Muslim University on the subject 'Recent foraminifera from Calangute beach sand, Goa'.

Mrs. Sarala Devi was awarded M.Sc. Degree of the University of Cochin for her thesis, entitled 'Studies on Haloptilus (Copepoda-Calanoidea) from the Indian Ocean'.

Shri V.K. Dhargalkar was awarded M.Sc. Degree by University of Bombay for his thesis, entitled 'Ecological studies on marine algae species *Ulva reticulata* Forskal from the Chapora Bay, Goa.

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Deputations

Dr. S.Z. Qasim was deputed to

- Australia and the Philippines on the invitation of the Australian Institute of Marine Science from 23rd June to 8 July 1978 under the auspices of Association for Scientific Cooperation in Asia (ACCA)
- F.A.O., Rome Italy to attend Tenth Session of Executive Council of Intergovernmental Oceanographic Commission from 19-23 June 1978.

Dr. J.S. Sastry was deputed to Paris to attend the meeting of the Indian Ocean Panel, SCOR Working Group 47, IOC in September 1978.

Shri H.N. Siddiquie was deputed to

- attend the Seminar on Offshore Mineral Resources at Orleans, France (23-27 October, 1978) on an invitation from GERMINAL/BRGM
  attend the International Programmetic Workshop for the planning of the Snellius II Expedition at Jakarta, Indonesia (4-7 December, 1978) on an invitation from the UNESCO.

Dr. V.S. Bhatt was deputed to attend the UNESCO Training on 'Science Editing' conducted by Publications and Information Directorate, CSIR, New Delhi from 20-28, November, 1978.

Dr. R.Mahadevan was deputed to attend the Summer School on 'Behaviour of Offshore Structures' at the Indian Institute of Technology, Madras from 29 May to 17 June 1978.

Shri S.Y.S. Singbal was deputed to attend an advanced training course in 'Marine pollution chemistry' in the Department of Oceanography, University of Liverpool, United Kingdom from January to June 1978.

Dr A.K. Jain was sent to participate in Summer School on 'Behaviour of Offshore Structures' held at IIT, Madras from 29 May to 17 June 1978.

Shri N. H. Hashimi was deputed to attend the course on 'Computer Programming and Computer oriented numerical methods' at the Indian School of Mines, Dhanbad from July 10-22, 1978.

Shri J.S. Sarupria was deputed to attend the TDC-316 Customers Software Training, Programme from 1 January to 3 February, 1978.

Shri J.S. Sarupria and Avinash Chandra were sent to attend the TDC-316 System Operation Training programme from 13-29 April 1978.

Shri G.S. Bhattacharya was deputed to West Germany under the DAAD Programme.

Shri B.A. Ramesh was sent to participate in short term course on 'Design of Offshore Structures' held at IIT, Bombay from 3-15 July 1978.

Shri S.N. Harkantra was deputed to United Kingdom for a period of three months from October 1978 under the IOC sponsored shipboard training in 'Benthic ecology'.

Shri L.V.S. Raju was deputed to attend the "Short-term specialist course in marine geophysical technology" at Andhra University, Waltair in December 1978.

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Meetings, exhibitions, seminars, symposia, talks and special lectures

Dr. S.Z. Qasim delivered

- a talk on 'Public Involvement and Tourism' at Hotel Mandovi, Panaji, Goa in March 1978
- a talk on 'Resources from the sea' at a Seminar organized by the Indian National Science Acadamy, New Delhi in April 1978
- a lecture on *'Trichodesmium* phenomenon' and a Seminar on the "Productivity of Indian Ocean" at the Australian Institute of Marine Science, Townsville, Australia
- a talk on "The Indian Ocean" at the Shivaji University, Kolhapur in October 1978
- a talk on "Future of the Oceans" at the College of Engineering, Farmagudi, Goa in October 1978
- a Validictory address on 27th November 1978 at the Conference on "Forensic Medicine' at Goa Medical College, Panaji-Goa
- two lectures on 'Problem of marine corrosion and pollution' and on 'Research and Development needs for the exploration of marine resources' at Department of Geophysics, Andhra University in December 1978.

Shri H.N. Siddiquie participated in the Indo-Soviet Symposium on 'Archean Geochemistry and comparative study of the Deccan and Siberian Traps', Bangalore from 6-10 November 1978

- attended the Annual General Meeting of the Geological Society of India at Bangalore and delivered a lecture on the "Geology of the western continental margin of India" on 11th April 1978

attended a workshop on preparation of National paper for UNCSTD at the Indian Institute of Sciences, Bangalore from 8-9 April 1978.

- delivered a series of lectures on 'Marine Geology' at University of Cochin, University of Bangalore and at the short term specialist course in Marine Geophysical Technology at Andhra University, Waltair.

Dr. B.U.Nayak, gave a series of lectures during summer school on 'Behaviour of Offshore Structures: Analysis, Design and Experiments' organised by Indian Institute of Technology, Madras in June 1978 and at Indian Institute of Technology, Bombay in July 1978 during the short term course on "Design of Offshore Structures'

presented two papers at GEOCOM-INDIA, Conference on Geotechnical Engineering held at Indian Institute of Technology, New Delhi from 20-22 December 1978.

Dr.M. Krishnan Kutty delivered a series of lectures on "Fish population and management" to the Post-Graduate students of Industrial Fisheries of the Cochin University from 2 January to 24 April 1978.

Dr. M.G.A.P. Setty, Shri M.V.S.N. Guptha and Rajiv Nigam attended the Seventh Indian Colloquia on "Micropaleontology and Stratigraphy" at Madras from 18-20 December 1978.

Dr. V.S. Bhatt attended the workshop on 'Experimental Data Handling' from November 20 to December 6, 1978 and delivered two lectures on 'International systems for the management of data and information in oceanography' and 'Indian National Oceanographic Data Centre'.

Shri P.S.N. Murty and Ch. Madhusadana Rao delivered lectures on "Marine Geology" at the University of Cochin.

Dr· E.Desa delivered a lecture on "Acoustics, echosounders and side scan sonar" at Andhra University, Waltair on 29th December 1978.

Dr.E.Desa, Shri C. Rameshu and H. Srikantam attended the seminar on "Transducers and their application" at IEEE from 26-28 November 1978.

Dr. E.Desa, Shri M.R. Nayak, M. Manoharan. C. Rameshu. S.G.Diwan and K.M.Varghese delivered special lectures on "industrial electronics" at Govt. Polytechnic Panaji, Goa.

Dr. R.V. Unnithan participated in the book discussion on "Energy for rural development, renewable resources and alternative technologies for developing countries" organized by American Centre, Madras on August 29, 1978 at Cochin.
participated in the lecture discussions on "Marine technologists and managing marine research and development" organized by United States information Centre, Madras on 4th February 1978 at Cochin.

Shri. V.S. Rama Raju, P. Udaya Varma, G. Narayanaswamy and Abraham Pylee jointly presented three papers at a seminar on 'Environmental modelling of physical oceanographic features as applied to Indian Ocean' organized by NPOL, Cochin in February 1978..

Dr. A.H. Parulekar participated in the seminar on 'Prospects of fisheries development for Goa' co-sponsored by Govt. of Goa, Daman and Diu. Goa Chamber of Commerce and Industry and Planning Commission. Govt. of India and presented a paper on 'Fisheries development for Goa' in April 1978.

Dr. A.G. Untawale participated in UNESCO sponsored seminar on "Human uses of mangrove environment and management implication" at Dacca in December 1978 and presented a paper.

Dr. Aditi Pant presented a paper on "Photosynthesis and extracellular production in marine environment" in a symposium on 'Photosynthesis and productivity' in New Delhi in February 1978 under the auspicesot Indian National Science Academy

- delivered a special lecture at Shivaji University, Kolhapur in October 1978 on 'Photorcspiration in marine algae and the production of extracellular matter'.

Shri U.K. Gopalan presented a paper in the National Symposium on 'Shrimp Farming' at Bombay in August 1978

participated in the seminar on 'World Environment' on 5th July 1978 organized by the Cochin Science Association.

- participated to study the problems of Kuttand in January 1978 organized by the Kerala Sastra Sahitya Parishad.

Shri U.K. Gopalan, P. Udaya Varma and K.S. Purushan participated in the oceanography for schools programme sponsored by the Kerala Sashtra Sahitya Parishad.

Shri M. Manoharan and E. Dias participated in the seminar on 'Service and maintenance' at CSIO, Chandigarh from 20-26 September 1978.

Dr. M. Madhupratap, Shri V.R. Nair and Dr. T.S.S Rao presented a paper on 'Ecological considerations ontropical zooplankton' at the Symposium on 'Ecology of animal population' organized by Zoological Survey of India at Calcutta in October 1978.

Dr. R.K. Sharma participated in the seminar on 'Application of Computers to bibliographical information processing : some development in India' organized by Department of Science and Technology, Govt. of India, under NISSAT Programme from 10-13 July 1978 at Bangalore.

Shri S.G. Prabhu Matondkar presented a paper on 'Study of microorganisms from man. grove swamps of Goa' at the Annual Conference of Association of Microbiologists of India at Baroda in November 1978.

The scientific staff of Regional Centre of NIO, Waltair attended the organising committee meetings on short term specialist course on 'Marine Geophysical Technology' held at Geophysics Department, Andhra University, Waltair in January and July 1978 attended the meeting held at Urban Development Authority, Visakhapatnam in connection with the visit of British Technical Cooperation Team on Urban Development on 8-9 December 1978·

An Indo-US Workshop on Oceanography sponsored by Department of Science and Technology, New Delhi for collaboration in oceanographic research between the two countries was organized during November 1978.

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Colloquia

Speaker	Subject	Date
1. Shri S. Ranganatha Rao	Small Savings	5.1.78
2. Prof. A.K. Bose	Marine natural products	27.1.78
3. Dr. N. Ramanathan	Shearing instabilities in an ageostrophic two fluid system	28.1.78
4. Prof. Peter M. Kroopnick	Stable isotopes in understanding the Ocean	3.3.78
5. Prof. Cyril Ponnamperuma	Origin of life	6.3.78
6. Dr. James D. Howard (i)	Nearshore sedimentation off Georgia Coast	7.3.78
(ii)	Estuarine sedimentation and animal-sediment relationship of Georgia Coast	9.3.78
7. Prof. Stig H. Fonselius	On recent research activities in the Baltic Sea	13.4.78
8. Shri Ashok Chandra	Solar energy, its future and prospects in India	29.4.78
9. Snri K. Premchand	The hydrological characteristics and circulation in the Western Indian Ocean	10.5.78
10. Dr. J.N. Nanda	Analysis of time series and fluctuations of underwater echoes & Origin of microseisms	19.5.78
11. Prof. O.G· Houmb	Environment and marine structures	28.5.78
12. Prof. C.V.G. Phipps *(i)*	Morphology and development of the Great Barrier Reef and South West Pacific Reefs	21.6.78
(ii)	Sand transport on the central and southern coast of east Australia	22.6.78

Speaker	Subject	Date
13. Dr. S.C. Seth	Relevance of futurology to national development	1.7.78
14. Dr. S.Z. Qasim	Visit to Australian Institute of Marine Sciences	7.7.78
15. Shri U.K. Gopalan	Improved method of paddy field shrimp fishery	23..8.78
16. Dr. T.A. Hariharan	ISRO's programme for research survey, oceanography and meteorology	1.9.78
17. Shri U. Shanker Rao	Application of low cost marine technology and economics	1.12.78
18. Prof. K. Gundersen	*(i)* Interrelationship of nitrate anomalies in the Oceans	12.12.78
	(ii) In-situ techniques of measuring biological processes in the sea	23.12.78
19. Prof. H. K. Erben	The scanning electron microscope and its application in biological and earth sciences	20.12.78
20. Dr. D.S.Cronan	Manganese nodule deposits in NW Indian Ocean	21.12.78

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Radio talks

Speaker	*Subject*
1. Dr. S.Z. Qasim	Fuel from the sea
2. Dr. B.N. Desai	Wealth of the Sea
3. Director, Staff Members of NIO and Officers of RV. *Gaveshani*	Reaching into the Sea
4. Dr. A.B. Wagh	Water pollution (in Marathi)
5. Shri R.V. Narvekar, S.M. Gajbhiye A.V. Mandalia, S.N. Parab, Miss V.M. Kolhatkar and Miss P.D. Gore	Oceanography (in Marathi)

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Visit

10.1 Visit of the Prime Minister of India

The most important event during the year was the visit of Honourable Prime Minister of India, Shri Morarji Desai, on 15 November, 1978. The Prime Minister showed a very keen interest in the work done at the Institute. He was appreciative of the progress achieved by the Institute in all the fields of oceanography. He was accompanied by his Principal Secretary Shri V. Shankar and Joint Secretary Shri Hansnukh Shah.

The Lt. Governor of Goa, Daman &Diu, Col. Pratap Singh Gill, the Chief Minister of Goa, Shrimati Shashikala Kakodkar and other Ministers, the Chief Secretary and high officials of the Union Territory of Goa were also present at the time of Prime Minister's visit.

10.2 Visit of the Minister of Shipping and Transport

Shri Chand Ram, Union Minister for Shipping and Transport visited the National Institute of Oceanography, Goa on 23 October, 1978. He was appreciative of the work done in the field of oceanography in a very short span of time. He evoked interest in the work related to harbour development in the country. Shri Chand Ram was accompanied by several Members of Parliament.

10.3 Visit of other VIP'S and Scientists

10.3.1 Headquarters, Dona Paula

Maj· Gen. M.C. Gupta, National Defence College, New Delhi

Shri B. K. Thapur, Additional Director-General, Archaeological Survey of India, New Delhi

Shri Arne Arnesen and Party, NORAD, OSCO, Norway

Shri O. N. Shapri, Indian Ambassador to Mozambique

Dr. Raghunath Singh, Chairman, Shipping Corporation of India, Bombay

Shri L. Kailasam, Geological Society of India, Culcutta

Prof. V. Bhaskara Rao, Head, Dept. of Geophysics, Andhra University, Waltair, A.P.

Shri M. A. Qureshi, Executive Vice President, IFC (World Bank) Group

Prof. O. P. Varma, Indian School of Mines, Dhanbad

Prof. C. Karunakaran, Director, Centre of Earth Sciences, Trivandrum

Prof. P. Brunn and Prof. O. G. Hoamb, Department of Port and Ocean Engineering, Norwegian Institute of Technology, Trondhom, Norway visited NIO and worked for a period of 3 months and 1 month respectively under bilateral technical assistance programme between Government of India and Norway.

Director is explaining the details of oil pipeline survey earned out by MO for the ONGC to the Honourable Prime Minister (Centre), next to P M. is Col. Pratap Singh Gill, Lt. Governor of Goa, Daman & Diu.

Director explaining one of the charts to the Honourable Prime Minister. In the picture is also seen Mis Sashikala Kakodkar. Chief Minister of Goa, Daman & Du.

Director showing a manganese nodule collected from the Indian Ocean to Honourable Minister Shri Chand Ram.

Shri Chand Ram, Union Minister for Shipping and Transport looking at some of the surveys done by NIO.

10.3.2 R. V. *Gaveshani*

Shri K.K. Ramamurthy, India Meteorological Department, New Delhi

Shri N. Sheshadri, India Meteorological Department, New Delhi

Shri A. Abraham, Member of Parliament, New Delhi

Prof. F. C. Kogler and Mr. J. Miller, Member, Appraisal Team from West Germany

Prof. Kasturibai and Party, Department of Zoology, University of Bangalore, Bangalore

Shri R.M. Agrawal, Chief Secretary, Government of Goa, Daman and Diu, Panaji

Shri J. Rameshwar Rao, Member of Parliament, New Delhi

Prof. R. Ravelle and Prof. R. Fisher, Scripps Institute of Oceanography, California, U.S.A.

Prof. D. Lal, Director, Physical Research Laboratory, Ahmedabad

Dr V. R. Venkoba Rao, Director, Geological Survey of India, Calcutta

Shri R.S. Panesar, Head, Engineering Unit, CSIR, New Delhi

Capt. P. N. Gaur, Project Coordinator, Department of Electronics, Government of India, New Delhi

Prof. K. Gundersen, Department of Marine Microbiology, University of Gothenburg, Gothenburg, Sweden.

10.3.3 Regional Centre, Cochin

Shri V.L.C. Preterz, Secretary, Ministry' of Fisheries, Colombo, Sri Lanka

Dr. A. S. Merlin, Director-General, Ministry of Fisheries, Colombo, Sri Lanka

Dr. Tilak Chandramohan, Director of Fisheries, Ministry of Fisheries, Colombo, Sri Lanka

Shri Peter Kroopnick, Department of Oceanography, University of Hawaii, Honolulu, U. S. A.

Dr. S. R. Valluri, Director, National Aeronautical Laboratory, Bangalore

Dr. S. H. Fonselius, National Board of Fisheries, Institute of Marine Research, Hydrographic Department, Fack, Gothenburg, Sweden.

Shri Charles V. G. Phipps, Associate Professor, Department of Geology and Geophysics, University of Sydney, Sydney, Australia.

10.3.4 Regional Centre, Waltair

Shri V. L. N. Sastry, Chief Geophysist, ONGC, Bombay

Shri V. R. Venkoba Rao, Director, Geological Survey of India, Calcutta

Shri M. A. Ganpath, Superintendent Geophysist, ONGC, Calcutta

Shri V. K. S. Vardhan, Dy. Director General, Geological Survey of India, Calcutta

Shri T. Vedantam, Vice Chairman, Visakhapatnam Urban Development Authority, Visakhapatnam.

Dr. N. Krishna Rao, Secretary, A.P. State Water Pollution Control Board, Hyderabad.

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Publications

11.1 Publications of the Institute

1. Annual Report 1977·
2. Quarterly Bulletin of the Institute, *Mahasagar, Vol.* 10 and 11 (Nos. 1-4).
3. Collected Reprints Vol. 4 (1972) and Vol. 5 (1973).
4. 19 Cruise Reports of R.V. *Gaveshani.*

11.2 Papers published

Achuthankutty, C.T., A. Stirling, Shanta Nair, P.A. Lokabharathi and Maria R. Menezes. 1978. Sandy beach of Baina, Goa: Its ecology and production. *Indian J. mar. Sci.,* 7(1): 23-29.

Agadi, V.V., N.B. Bhosle and A.G. Untawale, 1978. Metal concentration in some seaweeds of Goa (India). *Botanica Marina, 21(4)* : 247-250.

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Ansari, Z.A., Ayyappan Nair, S.N. Harkantra and A.H.Parulekar, 1978. Studies on dimensional relationship in green mussel *Mytilus viridis* from two environments. *Mahasagar-Bull· natn. Inst. Oceanogr.,* 11(3&4): 201-205.

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Bhatt, V.S., 1978. An assessment of information resources in marine science in India. *Lib. Sci.,* 15(1): 39-55.

Bhargava, R.M.S., P.M.A. Bhattathiri, V.P. Devassy and K. Radhakrishna, 1978. Productivity studies in the south eastern Arabian Sea. *Indian J. mar. Sci.,* 7(4) :267-270.

Bhattacharya, G.C. and N.H. Hashimi, 1978. Programme for computation of grain-size data on programmable calculators. *J. Geol. Soc. India*, 19(7): 292-302·

Bhosle, N.B. and S.G.P. Matondkar, 1978. Variation of trace metals in two populations of green mussel *Mytilus viridus*. *Mahasagar-Bull. natn. Inst. Oceanogr.*, 11(3&4): 191-193.

Bhosle, N.B., V.K. Dhargalkar and A.M. Braganca, 1978. Distribution of some biochemical compounds in the sediments of the shelf and slope regions of the west coast of India. *Indian J. mar. Sci.*, 7(3): 155-158.

Das, Hari Pada, 1978. Maturity and spawning in *Mugil cephalus* Linnaeus in Goa waters. *MaJiasagar-Bull. natn. Inst. Oceanogr.*, 11(1&2): 63—71.

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2. Report on analog marine thermometer
3. Internal report on CSTD System (E.C.)
4. Report on rotor induction current meter
5. Report on flash light control for buoy
6. Report on fast response underwater temperature sensor
7. Report on PSO for CSTD System
8. Oceanographic survey for effluent disposal and submarine pipeline route for the Travancore Titanium Products Ltd., Trivandrum
9. Survey of the Bombay Port Trust submarine pipeline from Butcher Island to Trombay
10. Echosounding at Coondapur Port, Mangalore
11. Chemical analysis of formation water samples for ONGC
12. Environmental studies at Dharamtar Creek
13. Estimation of long term and extreme value distribution of wave parameters in Norwegian waters
14. Status report on Pirotan Island (Gulf of Kutch)
15. Report on Natural History of Islands in the Gulf of Mannar, India
16. Testing the efficiency of the dispersant 'Alankromul' in the control of oil pollution in the sea
17. Bioassays for fertilizer effluents from Zuari Agro Chemical Ltd., Goa
18. Side scan sonar survey of Visakhapatnam Outer Harbour area

19· Post-lay survey of Bombay High to Uran Submarine pipelines near Bassein River Platform

20· Survey for location of wellhead BH 16 in south Bombay High

21· Surveys of the proposed submarine pipeline routes from Bassein to Gujarat

22· Marine surveys for the Uran water intake jetty

23· Computation of temperature-salinity spectra from CSTD records

24· Processed current meter data of Indo-Soviet Monsoon Experiment 1973

25· Bibliography on upwelling, 1890-1977.

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