Annual Report

1981

NATIONAL INSTITUTE OF OCEANOGRAPHY

DONA PAULA, GOA

INDIA

Cover: Manganese Nodules at Sea-bed.

ANNUAL REPORT

1981

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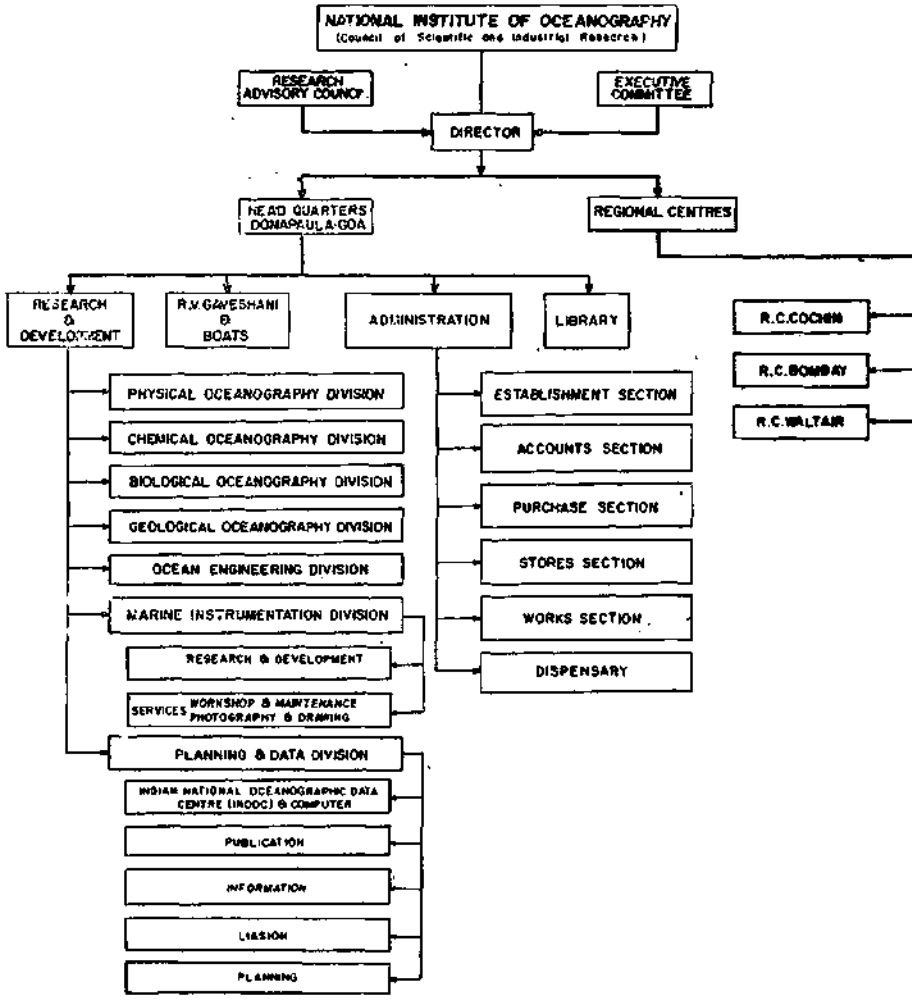
NATIONAL INSTITUTE OF OCEANOGRAPHY
(Council of Scientific & Industrial Research)
DONA PAULA-403004
GOA, INDIA

ORGANISATIONAL CHART



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Dr. S Z. Qasim

Dr V. V. R. Varadachari.

Dr. V. V R. Varadachari. Dy. Director of N.I.O. assumed charge as Acting Director of N.I.O.. on 14th May. 1981. He look over from Dr. S. Z. Qasim. who was appointed as Secretary to the Government of India. Department of Environment. New Delhi.

Dr. Varadachari (born on 1st July. 1925) is a Physical Oceanopraphcr. He obtained his D.Sc degree in Oceanography from Andhra University in 1959 and had his advanced training in Oceanography & Meteorology and M.S. degree from Florida State University. U.S A . during 1953-55. He made several significant contributions to Oceanography in India during the last three decades, as a teacher, scientist and administrator. He joined the Directorate of Indian Ocean Expedition in 1963 and was heading the Physical Oceanography Division of N.I.O. right from its inception. In 1974 he became Deputy Director of the Institute. He has more than 80 research publications and reports to his credit and he is a Fellow of the Indian Academy of Science and the Indian National Science Academy

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Director's Report

The year under report is very significant and memorable. The most successful achievement not only of NIO but of the whole Nation was the hauling up of the first sample of polymetallic nodule on January 26. 1981 and subsequently the location of massive deposits of these nodules in the western Indian Ocean. With this, India became the first country in the Third World and seventh in the world to enter the field of deep sea exploration of minerals. Encouraged by the results of this survey, the Institute is planning to extend the survey of nodules to other areas in the Indian Ocean. A major programme of exploratory mining has been drawn in collaboration with the Department of Ocean Development (DOD), Govt. of India.

RV Gaveshani, India's first oceanographic research vessel successfully completed 100 cruises since her commissioning in February 1976. She has undertaken many challenging surveys practically in all fields of oceanography throughout the year. During the year under report, she completed 17 cruises and collected data from -132 stations. She also paid a goodwill visit to Port Luis of Mauritius.

A. R & D Projects

Physical oceanographic studies indicated several interesting features of the seas around India and have also thrown light on the understanding of monsoon. The data collected during MONEX-79 was processed and sent to the India Meteorological Department.

Research activities in chemical oceanography included regular monitoring of pollution along oil tanker routes which showed an accumulation of thousands of tonnes of floating tar at any time of the year in the surface waters of the Arabian Sea. During the last three years considerable increase in floating tar has been observed all along the west coast.

A new project 'Paleoclimatic studies on the nature of the summer monsoon over India during the past 10.000 years' was taken up. A distribution map of the trace elements in the western continental margin between Mangalore and Cochin was prepared.

A unique physical phenomenon 'Dynamic Barrier Effect' was observed in the Gulf of Kutch. This is the first ever to be recorded from the oceans of the world. Further work is in progress.

An aquaculture laboratory with running sea water with assured supply of pure sea water and all modern research facilities has been commissioned. The

laboratory unique in India is expected to facilitate the R & D activities relevant to aquaculture and connected work.

Considerable information was collected on the productivity of the seas around India. A positive relationship between benthic standing crop and demersal fishery has been established. A new project on marine microbiological studies of the seas around India was initiated during the year.

To achieve self-sufficiency as far as possible, in marine instrumentation, several instruments like modified current meters, echosounder, tide gauge, oceanographic/ meteorological buoy, etc., were designed and developed. Intensive work has been taken up on micro-processor based systems for data logging.

The Regional Centre of NIO at Cochin has intensified its activities during the year. Priority was given to develop techniques for culture of prawns and to locate areas of high productivity in the seas, particularly in Wadge Bank area. The Bombay Centre has taken up a new multi-disciplinary project entitled "Waste assimilation capacity of coastal waters along the west coast of India and the impact of pollution on the marine ecosystems". Considerable amount of information on various aspects of pollution in the Bombay area was collected during the course of the year. The Waltair Centre continued its research activities in the waters off Waltair and recently completed a project sponsored by the Steel Authority of India.

B. Sponsored Projects

Twelve new projects sponsored by the public and private undertakings were taken up during the year. The Institute has also initiated a programme of underwater archaeological exploration along the Indian coast. The Tamil Nadu Government has sponsored such studies off Poompuhar. The Indian National Science Academy has provided funds for a project on All-India basis in marine archaeology.

C. Services

Planning, Publication and Information Section continued to bring out the regular publications, namely Mahasagar, Newsletter, Annual Report. Monthly Reports. Press Releases and Plan Documents. A revised Indian National Directory of Marine Scientists, an Indian National Directory of Marine Research Projects and Indian National Directory on Training and Education Facilities in Marine Sciences have been brought out. The main activities such as acquisition, retrieval and processing of oceanographic data were intensified. Several computer programmes were developed and the facilities of the computer centre were extensively used by NIO Staff and also by the public and private organizations.

The Library added 1490 books during this year. With this the total number of books has come up to 10.700. 290 scientific journals have been received on subscription"gift/exchange basis.

The Workshop. Photography. Drawing. Printing, Binding and Xeroxing groups have given their full support in the form of regular services. The main-

tenance and servicing group rendered valuable assistance in maintaining the sophisticated instruments on board RV **Gaveshani** and in the laboratory. As an experimental measure this year the maintenance group was decentralized and the concerned staff were attached to the different divisions.

D. Miscellaneous

The research activities and scientific results were published in national and international journals by the staff. As many as 125 papers, besides many technical reports were published. A large number of VIPs, scientists, engineers and technologists visited the Institute during the year.

A training course on 'Neurobiology', co-sponsored by the International Brain Research Organization of UNESCO, Tata Institute of fundamental Research, Bombay and NIO was organized at the Institute from 5 to 19 January. 1981. Forty scientists, including five from NIO. attended this training course.

A Workshop on 'Ocean Future the next 25 years' was hosted by the Institute in March 1981. This Workshop was sponsored by the Department of Science & Technology, Government of India, New Delhi. About forty senior scientists, engineers and planners from various organizations attended the Workshop.

The Institute organized a workshop on "Marine Gcosciences in the Eighties" from 10 to 13 August, 1981. About 36 scientists from different organizations participated in the Workshop to evolve research proposals and define the scientific objectives and tasks and also to co-ordinate the related projects.

The Institute played a key role in organizing 4 workshops for the newly formed Department of Ocean Development of the Government of India. The first workshop was organized at the Andhra University. Waltair. from 30 September to 1 October, 1981 on "Education, training and manpower requirements for ocean development". The second workshop was organized at NIO, Dona Paula, from 17 to 19 October. 1981 on 'Exploration and exploitation of seabed minerals, ocean engineering, marine instrumentation and ocean data management'. The third workshop was organized at Jadavpur University. Calcutta, from 21 to 22 November, 1981 on 'Ships, submersibles and base facilities'. The fourth workshop in the series was organized at the Central Institute of Fisheries Technology. Cochin on 3 and 4 December, 1981 on 'Living resources'.

The Institute hosted the Seventh Convention of Association of Exploration Geophysicists (AEG) at Dona Paula, Goa. from October 15 to 17, 1981. On this occasion, a Seminar on 'Exploration Geophysics with special reference to Exploration of Iron Ore' was organized.

The Institute organized an international seminar on 'Estuaries their physics, chemistry, biology, geology and engineering aspects' at NIO. Goa from December 7

to 11, 1981. In this 5-days seminar, co-sponsored by 13 national and international organizations. 11 experts from various countries apart from 88 Indian scientists participated.

The year ended with a glorious effort made by the Institute in organizing India's first expedition to the southern ocean and Antarctica sponsored by Department of Ocean Development, Government of India. A specially chartered ship 'MV Polar Circle' left Goa on *6* December 1981 on its cruise to Antarctica.

Many distinguished scientists participated in several workshops, symposia and seminars and presented papers. A few scientists were deputed to foreign occanograiihic research institutes under exchange programmes.

DIRECTOR

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Major Scientific Highlights

A breakthrough was achieved in the exploration of deep sea mineral deposits when polymetallic nodules were collected by RV Gaveshani, for the first time, in January 1981 from a depth of 3.5 to 4.5 km in the Western Indian Ocean. These nodules contain nickel, copper and cobalt besides manganese and iron. The concentration of nodules was found to vary from 1.1 to 5.8 kg/m^2. This density is economically attractive for mining. With this exploration, India becomes the first country among the developing nations and the seventh country in the world to have such a capability. The chemical analysis of these nodules from 10 stations shows the following concentration:

Ni - 0.427%	Mn - 18.166%	Cu - 0.168%
Fe - 15.433%	Co - 0.106%	Zn - 0.089%

Analysis of Monex-79 data has indicated that downward heat flux is an important factor and accounts for more than 50% of the total heat loss from the surface layer contributing to the lowering of sea surface temperature. Studies on oceanic mixed layers in the Bay of Bengal showed formation of three mixed layers, viz., wave-mixed, diurnal and transition layers. The wave mixed and diurnal layers showed immediate response to changes in the prevailing weather and sea state conditions.

Studies on hydrographic conditions in the east central Arabian Sea indicated the withdrawal of the equatorial water with the advance of the monsoon season.

Continuous monitoring of oil pollution along oil tanker route in the Arabian Sea indicated several fold increase in tar concentration during the last three years.

A new device has been developed for simultaneous collection of deep sea sediments and near bottom water samples.

A positive relation between benthic standing crop and demersal living resources in the shelf area off the Konkan coast has been established.

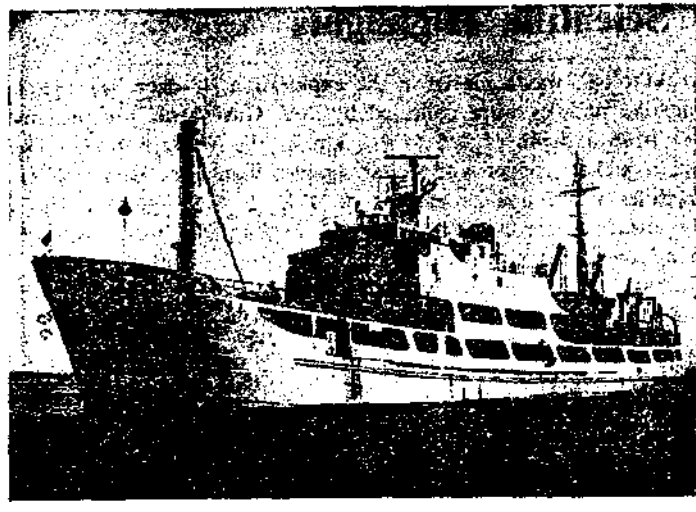
An oceanographic/meteorological data buoy has been designed and fabricated for the acquisition of parameters like wind speed and direction, air and sea surface temperature, relative humidity, etc. This is under trial in the Dona Paula Bay.

A self recording tidal instrument which works on lead acid batteries charged through solar panels was developed.

Surficial geological studies of the Direction Bank situated at 40-45 km offshore of Bombay-Murud have indicated the presence of acoustically transparent layer, which varied from 5-55 metres in thickness. Southern part of the Bank showed acoustic masking due to the presence of gases upto 15 m below the seabed.

Geochemical investigations on the sediments of western and eastern continental shelf of India have been completed. Studies on the sediment dynamics of the Gulf of Kutch and the neighbouring continental shelf has resulted in identification of a new phenomenon called 'Dynamic barrier effect'. These studies suggest that the Gulf of Kutch is better suited for tidal power generation compared to the Gulf of Cambay.

R. V. Gaveshani



The country's first research vessel **Gaveshani** of this Institute had the distinction of completing one hundred cruises successfully. She has contributed most significantly in the country's prestigious achievements like exploration of polymetallic nodules, development of offshore oilfields, location of rich fishing grounds, monitoring of oil pollution and participation in an international endeavour — MONEX 79.

Collection of nodules has put India in the group of first seven nations of the world to have achieved this distinction. In these 100 cruises the ship has covered 3526 stations along 14,000 lkm in the seas around India. The facilities on board were also utilised by about 150 scientists from other organisations.

In appreciation of her services rendered by **Gaveshani** India Meteorological Department has awarded a certificate of appreciation to **RV Gaveshani** and her officers for transmitting important weather observations most expeditiously to the nearest coastal radio station, thus enabling the forecasters to locate and track the storms. She was awarded similar certificate earlier also.

3.0

Oceanographic Cruises

During the year, **RV Gaveshani** undertook 17 cruises in the seas around India and in the Indian Ocean. Except for the two cruises, which were mainly devoted to train the scientists, all other cruises were programmed to carry out investigations cither on multidisciplinary work or physical, geological and geophysical aspects separately.

Gaveshani has been very much used for an extensive survey for seabed minerals and the exploration of polymetallic nodules in the western Indian Ocean which has put India on world map of seabed explorers.

Summary of the cruises is as follows :

Cruise 85: (Chief Scientist - Shri H. N. Siddiquie)

This two days cruise was undertaken from 12 to 13 January, 1981 for testing some of the equipment to be used in the forthcoming cruises.

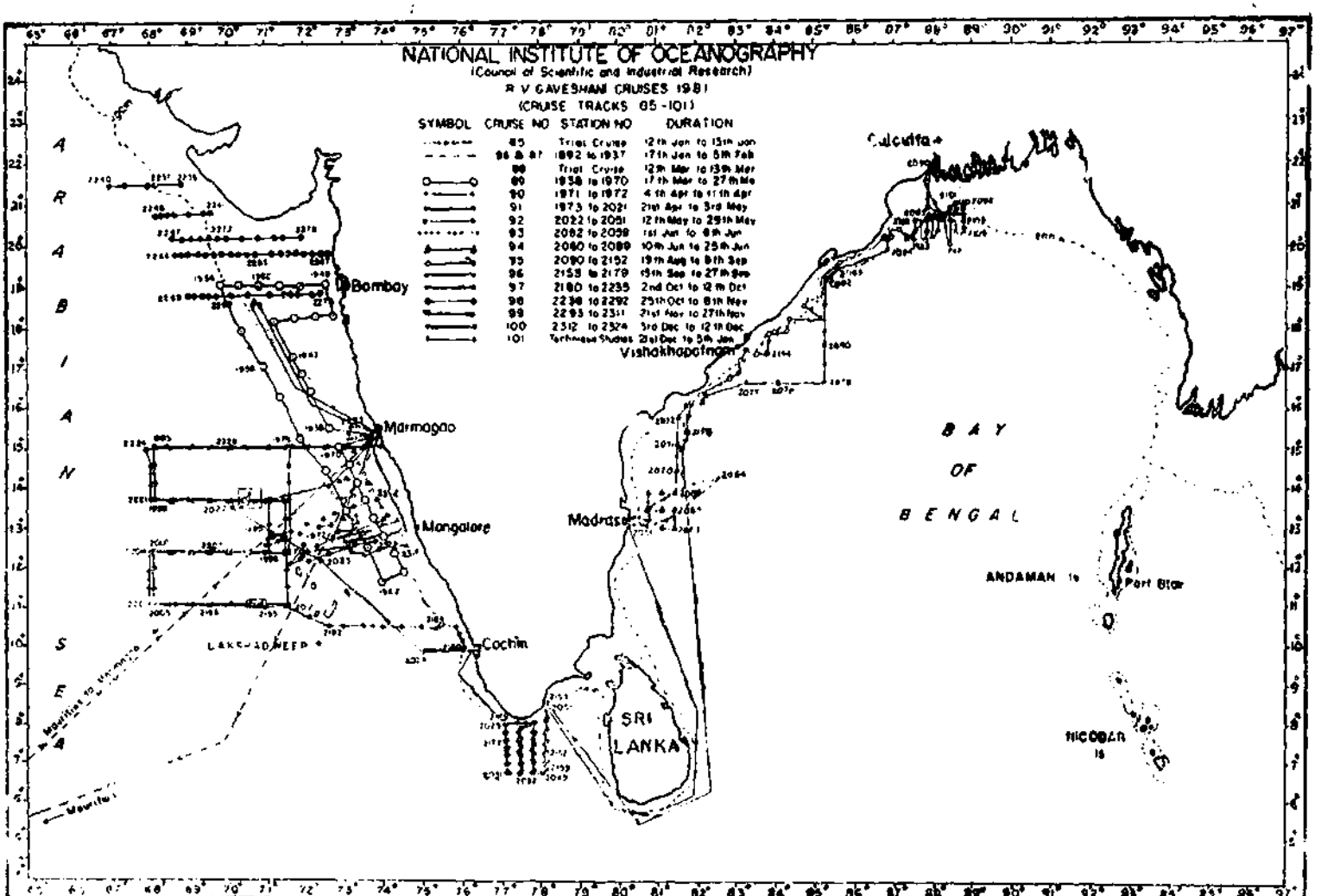
The newly-acquired Tracor II Satellite and OMEGA Automatic Navigation Systems were installed in the vessel and these were rigorously tested both in the shore laboratory and in the vessel. The Sonardyne Pinger was tested up to about 100 m depth in the upper continental slope. Two Preussag Freefall/ Boomerang grabs with a net were launched and retrieved successfully in the outer shelf. In addition, some indigenously-made (NIO) buoys were also tested in waters up to a depth of about 100 metres.

Cruise 86: (Chief Scientist — Dr. S. Z. Qasim)

The cruise of 20 days (January 17 to February 5) from Mormugao to Mauritius marked a milestone as the first deep sea oceanographic cruise and the beginning of the exploration for manganese nodules.

The vessel cruised for over 10,000 line km and over 5100 line km of echo-sounding and 5000 line km of magnetic data were collected. The sea surface temperature indicated a significant change from 2°N and 2°S with lower values at the Equator. The thcrmoclin: was deeper about 50 m at 2°N and 2°S) and shallower (about 20 m) near the Equator.

Eight hydrographic stations ranging from 2500-5100 m depth were covered and water samples were collected from standard depths. The analyses for dissolved oxygen, phosphate, phosphorus, nitrate-nitrogen, silicate-silicon, alkalinity and pH were carried out on board while 29 samples were preserved for trace metals and 12-



Cruise tracks of R V Gavcshani for the year 1981.

samples for analyses of petroleum hydrocarbon in the shore laboratory. The lower surface temperature, shallow mixed layer and high nutrient values near the equator indicate upward transport of sub-surface water. The dissolved oxygen showed a steady increase from N to S with two minima separated by a maximum. Zooplankton samples were collected from a depth of about 200 m from 12 stations to understand the faunal composition and distribution. Samples were also collected to study the trace metals and to correlate with the possible biological transfer of metals in the water overlying the manganese nodule area.

Echograms revealed that the Arabian, Somali and the Mascarene abyssal plains are vast monotonous areas of the seabed with a flat topography, except the last two which are dotted with sea mounts and hills.

Grab samples were collected at 12 stations ranging in depth from 3800-5110 m. Boomerang grabs were launched at 6 stations and 4 photo boomerang at 4 stations. The manganese nodules ranged upto 8.3 cm in size and 200 g in weight.

Cruise 87: (Chief Scientist — Shri H. N. Siddiquie)

This cruise was a continuation of cruise 86 and was planned to collect additional data on the distribution of manganese nodules in the Arabian Sea. This cruise from Mauritius lasted for 20 days, which commenced on 14th February.

Seabed samples were collected by a modified Peterson grab, which was operated 18 times at depths ranging from 3900-5800 m. Sampling indicated that the nodules were concentrated only on the slopes of the ridges between 3600-4100 m. From one of the stations more than 9.46 kg of nodules were recovered in one dredge haul. The sediment samples were found to have white to dark brown calcareous ooze.

Data on magnetic anomalies over a distance of 5000 km were also collected with Barringer Proton Magnetometer, over Mascarene basin, Seychelles-Mauritius, Somali and Carlsberg Chagos-Laccadive ridge, etc.

Besides these studies, the surface temperature study from 12 to 2°S showed a variation from 27.5-29.2°C. The depth of thermocline ranged from 10-50 km. Preliminary analysis of the hydrographic data indicated a general decrease in nutrients and an increase in dissolved oxygen towards the south in the intermediate and deep layers. Aseptic samples of manganese nodules were also collected for microbiological studies.

Cruise 88: (Chief Scientist — Shri H. N. Siddiquie)

The 2 days cruise from 12-13 March was organized off Mormugao Harbour, for the purpose of testing the equipment.

In this cruise, the equipment ORE Mud Penetrator, Magnetometer, Photo-boomerang, Underwater Camera, Echosounders, Deep Sea Winch, EPC Recorders, Satellite Navigator and Omega, which were used for the manganese nodule exploration in the 86th and 87th cruises, were tested.

Cruise 89: (Chief Scientist — Dr. R. Sen Gupta)

The cruise conducted from March 17-27, followed the same track as that of the cruise 16 of March 1977. The purpose was to monitor the changes in environmental conditions that had taken place during the last four years. It covered two-transects parallel to the coast between 12°-19° N. 33 stations were occupied for nutrients, petroleum and chlorinated hydrocarbons and heavy metals.

At 6 stations CSTD and at 33 stations Nansen casts were operated. At all the stations MBT/XBT and wave recorder were also operated. The sea surface temperature varied between 26.5 - 30.4°C. The concentrations of floating Petroleum residues were very high almost all along the track, which ranged from 0.3-112 mg/m^2.

Trichodesmium was noticed widely distributed far over about 100 nautical miles along the track.

Cruise 90: (Chief Scientist — Shri H. N. Siddiquie)

This cruise was planned for training of NIO scientists in the operation, servicing and maintenance of equipment under NORAD Assistance for the project "Geological and Geophysical Surveys."

During this 7 day cruise which was concluded on 11th April, more than 850 lkm of echosounding, 60 lkm of side scan sonar, 1050 lkm of seismic profiling and 1115 lkm of magnetics were carried out along 5 tracks. The various equipments used for training were Motorola Mini Ranger MRS-III, Precision Depth Recorder SIMRAD EKS, ORE variable frequency profiler, EG & G. 8.5 kjl Sparker and deep sea geological winch.

Cruise 91 : (Chief Scientist — Dr. D. P. Rao)

This 12 day cruise was organised from 22 April to 3 May between the latitudes 11°- 15°N and long. 68 - 73°45'E. Meteorological and hydrographical data were collected besides samples for phytoplankton, zooplankton and nutrients.

One of the important observations of this cruise was the recording of abnormally high sea surface temperatures ranging between 32 - 33.8°C in the Arabian Sea. A phenomenon probably relating to Langmuir Circulation was observed, which indicated alternate bands of mirror-like sea surface associated with high surface temperature and ripples from short intervals of distance with low sea surface temperature (SST).

High biomass value in the surface layer, which was three times higher than the normal value was observed in the area of study.

Cruise 92: (Chief Scientist — Shri V. S. Rama Raju)

This was a multidisciplinary cruise which involved oceanographic survey of the Wadge Bank (South west coast). This premonsoon survey lasted from 12 - 29th May.

Hydrographic observations were made from 20 stations on the shallow depths of the Wadge Bank and from 6 deep stations on its southern slope. At all stations zooplankton sampling was done using the H.T. net.

Preliminary examination showed the presence of colder water with low dissolved

oxygen and high concentration of nutrients in the near surface layers (close to the coast), indicating the presence of upwelling just before the onset of monsoon.

Cruise 93: (Chief Scientist — Dr. T. S. S. Rao)

This cruise was the first in the series of the All India Training Programme in oceanographic surveys, for fulfilling the future need of well-trained manpower for oceanographic research.

This cruise was conducted from 1-5 June within a small grid (13-14° N and 80-82° E) in the Bay of Bengal. A total of 14 scientists from different universities and research organizations were given on-board training in the operation of oceanographic equipment, sampling procedures, processing and analysis of data, etc., and report writing. Five scientists of this Institute formed the faculty.

Cruise 94: (Chief Scientist — Dr. R. Sen Gupta)

This cruise was mainly organised for studying the estuarine region of the major Indian rivers on the east coast of India. In this cruise of 15 days duration, which commenced on 10th June, more than 30 stations were occupied off the mouths of river Krishna, Godavari, Mahanadi and Hooghly.

Besides NIO Scientists, two scientists each from Physical Research Laboratory (PRL), Ahmedabad and Naval Physical & Oceanographic Laboratory (NPOL), Cochin, participated.

Preliminary analysis of data indicated that the surface currents varied on an average between 1 x 2 knots at 4 anchor stations. An intensive survey was undertaken within an area of 20 nm x 30 nm off Madras coast, to verify the observations made during earlier cruises of **RV Gaveshani** on pollution. Chemical studies in the coastal region near Madras showed a heavy concentration of phosphate, which was attributed to the effects of pollution.

At every anchor station. Hydrographic observations and plankton sampling were conducted every 3 hours.

PRL scientists filtered surface water samples at all anchor and deep stations and also took serial water samples off the mouths of all four rivers at approx. 500 m depth. Sediment cores were also collected at approx. 50 m water depth.

NPOL scientists used their XBT probes to record temperature during the Paradip-Sandheads run. They also tried their newly acquired INTEROCEAN direct current meter.

Cruise 95: (Chief Scientist — Dr. R. Sen Gupta)

This 19 day multidisciplinary cruise was also meant for estuarine studies. Some of the scientists were also trained on board the ship.

The ship sailed from Calcutta on 19 August with a total of 13 scientists from NIO and 5 from Geological Survey of India (GSI). Three anchor stations off Diamond Harbour, Haldia and Sagar were occupied and hydrographic observations

were carried out. Samples were also collected every 3 hours for over 12 hours to determine the suspended load content.

A total of 40 stations were worked for GSI and 37 snapper samples, 3 grab samples and 13 core samples were collected. A series of 6 water spouts were also sighted, developing one after another. The estimated height of the water spouts was between 0.5 to 0.7 km with an approximate diameter of 50 m.

Considerable tidal induced variations in all nutrient concentrations were observed for all anchor stations. Observations showed a seaward decrease in nutrient concentration for Hooghly estuary indicating the importance of removal mechanisms involved.

Diurnal changes in biological productivity at 8 anchor stations in Bay of Bengal were undertaken at every 6 hourly intervals. Sediment samples were collected from about 50 stations in the Gangetic Delta from the coastal stations in the Bay of Bengal for benthic and biochemical analysis.

Cruise 96: (Chief Scientist — Shri V. S. Rama Raju)

This cruise of 15 days, commenced on 15th September was a continuation of the pre-monsoon study involving oceanographic survey of the Wadge Bank.

The surface temperature variations along the four longitudinal sections showed marked lower temperatures at nearshore stations compared to offshore. Preliminary analysis of chemical data showed generally high nutrient concentrations in surface waters. Presence of upwelling was observed, just before the onset of monsoon.

Plankton samples off Manapad were found to be dominated by the gelatinous organisms. A wide variation in plankton abundance and species was noticed in the Wadge Bank.

Bacteriological analysis of the water samples showed a total absence of indicator organism such as **Escherichia** and **Streptococcus** and pathogen such as **Salmonella.**

Cruise 97: (Chief Scientist — Dr. D. P. Rao)

This cruise was organised to survey the Monex area between 11°- 15°N and 68°- 71°30'E with a view to understand the oceanographic conditions in the area immediately after cessation of the southwest monsoon. This cruise of 11 days duration was started on 2 October from Cochin Port.

A total of 56 stations were occupied. Of these, hydrographic observations were made at 37 stations and biological samplings at remaining stations.

One of the important findings during the cruise was that a ridge like feature raising from about 1600 m to 360 m has been observed at 12°52.8'N, 71°30'E. which is presumed to be a submerged coral reef. During the cruise, the ship covered a distance of about 3000 lkm.

Cruise 98: (Chief Scientist — Shri Ch. Madhusudan Rao)

This 15 days cruise was organized from 25 October to 8 November as a part of the NIO-ONGC collaborative programme of the NCST priority project on 'Sedimentological, geochemical and microbiological studies in the continental shelf between Bombay High and Offshore of Kutch including the Gulf of Cambay and Kutch'.

During this cruise which was planned to survey the area between Porbandar and Diu, included echosounding on all the 5 lines covering about 911 lkm ranging from 20-1500 m depth.

Seabed samples using grabs from 54 locations and cores from 4 locations have been obtained.

Bathymetric survey indicated an occurrence of shelf break between off Veraval and Porbandar around 100 to 140 m. Whereas it is very wide to the extent of 200 m depth between Daman and Bombay.

Cruise 99: (Chief Scientist — Shri D. Gopala Rao)

This 7 days cruise was organized from November 21 to 27 and was carried out in two parts, the first part was a short and multidisciplinary in nature off Goa. Second part covered the western continental shelf of India between Mormugao and Mangalore. About 900 lkm echosounding and ORE sub-bottom penetration surveys were carried out. Besides, sediments samples were collected at 18 stations in the slope regions of the study area.

Cruise 100: (Chief Scientist — Shri D. Gopala Rao)

This cruise was intended to study the major coral bank called "SESOSTRlS BANK", west of the slope region and northwest of the Lakshadweep Sea. A total of 1048 lkm of echosounding, ORE sub-bottom penetration and high energy sparker surveys were carried out. Sediment samples using the Petersson Grab and dredging bucket, were collected at 13 stations.

The underway records revealed a sub-bottom penetration of around 200-250 m, sub-bottom reflectors are continuous and reveal the structure and tectonics of holocene geology.

Cruise 101: (Chief Scientist — Dr. B. U. Nayak)

This cruise was mainly planned for the deployment of current meters, wave rider buoys, BT observations etc. An area west of Bombay High with 80 m water depth was chosen for the study and the ship sailed on 21 December from Mormugao Harbour.

A set of 4 self-recording Aanderaa current meters were depolyed with mooring system for recording current speed and direction every 10 minutes. A wave rider buoy was installed to record wave data. Hourly BT and surface meteorological observations were also carried out continuously for a period of one week with a view to study the thermal structure of water column and variation of the mixed layer depth. A surface drift buoy with a flag and improvised radar reflector fabricated on board **Gaveshani** was used successfully for determining the surface currents.

3.1

Physical Oceanography

3.1.1 Studies on ocean-atmosphere interaction

3.1.2 Studies on physical processes in the seas around India

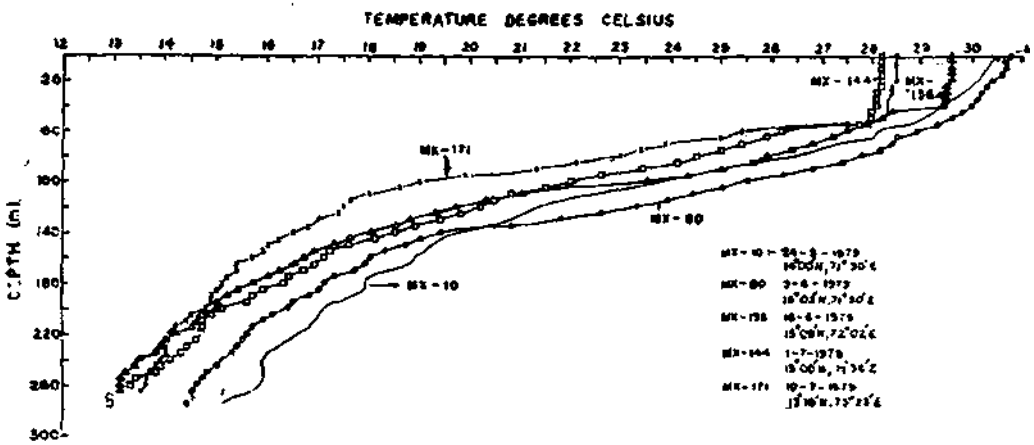
3.1.3 Studies on land-sea interaction and nearshore circulation along the Indian coastline with application to coastal zone management

The research activities of Physical Oceanography were carried out under three projects. The progress and salient features of each project arc given below:

3.1.1 Studies on ocean-atmospheric interaction

(a) Thermal structure in the cast central Arabian Sea during MONEX-79

A comprehensive study of the thermal structure of the east central Arabian Sea has been mads utilising the data collected on board **RV Gaveshani** during the MONEX-79 programme. The heat fluxes due to evaporation, effective back radiation and sensible heal during May-July, 1979 have been computed. The evaporation rates were estimated at about 0.5 cm/day during May and early June representing the pre-monsoon conditions. With the advance of a cyclone into the east central Arabian Sea. evaporation rates have increased two-fold while back radiation dc-



Temperature-depth profiles in the east Central Arabian Sea during May-July 1979.

creased considerably. A comparison of the variations in the heat storage and the heat fluxes across the sea surface showed that the downward flux of heat is considerable and exceeds 50% of the total heat losses from the surface layer. These studies thus reveal, for the first time, that the downward flux of heat is an important parameter in the heat budget studies and should be properly parameterised for incorporating in the monsoon prediction models. In the east central Arabian Sea the lowering of sea surface temperature was found primarily due to (i) downward flux of heat (55%), (ii) evaporation (33%) and (iii) the balance due to the processes of the effective back radiation and sensible heat.

An application of the 'Margules equation' to the southerly current off the west coast of India during the monsoon season has shown that the thermocline slopes upward thereby rising the isotherms close to the Indian coast and deepening of the surface layer in the western regions of the central Arabian Sea. These features are in consonant with the distribution of the wind stress curl.

(b) Oceanic mixed layer in the western Bay of Bengal during MONEX-79

The structure of the oceanic mixed layer (OML) in the western Bay of Bengal during summer monsoon was studied using an hourly BT and 6 hourly CSTD data collected at two locations during July 1979. Based on these studies OML has been divided into three sub-layers viz. (i) wave mixed, (ii) diurnal thermocline, and (iii) transition layers. The surface wave mixing, convective activity and internal wave mixing were found to be the main processes affecting the thickness of these sub-layers showing an immediate response to the changes in the atmosphere.

(c) Studies on atmospheric boundary layer during total solar eclipse

The vertical profiles of atmospheric temperature, wind and humidity observed at Raichur during the total Solar eclipse on 16 February 1980 showed that the eclipse caused a minor perturbation in the temperature in the lower layer of the atmosphere. A decrease of 1.5°C in air temperature was noticed after a few hours of eclipse.

(d) Surface meteorological observations

A continuous recording of pressure, air temperature, relative humidity, wind speed and direction at NIO campus has been continued.

3.1.2 Studies on physical processes in the seas around India

(a) Watermass structure in the Western Indian Ocean

A comprehensive study on the watermass structure in the western Indian Ocean has been carried out and some of the salient features are given below :

(i) The core layer of the Persian Gulf watermass is observed in the depth range of 250-300 m over most of the Arabian Sea with a tendency to deepen further south. The core layer salinity decreases from about 36.7‰, at its source region to about 35.1‰ near the equator. These studies show that the watermass spreads mainly along the west coast of India. Rapid transformation of this watermass due to intense vertical mixing, takes place in the Gulf of Oman. Also a nearly uniform

salinity layer in the depth range of 400-1000 m off the Arabian coast forms due to vertical mixing of this watermass with Red Sea water. Asymmetry in the distribution of properties and percentage composition of this watermass have been related to the vertical stratification of the water column.

(ii) The core layer of the Red Sea water is observed to vary from 600 to 800 m with maximum depths in the Mozambique Channel. The northern boundary of this watermass is located along a line joining the Arabian coast and the west coast of India at about 15° N. As this watermass flows out of Gulf of Aden, it gets transformed due to vertical mixing, and the core layer density increases while it flows further south. The cores of Red Sea water and the Antarctic Intermediate water come into contact between 5° and 10° S. Isopycnal mixing of these two watermasses gives rise to an extensive isohaline layer with slight increase in density.

(b) Thermodynamic transformations in the Sea

During MONEX-79, several CSTD recordings were made in the eastern Arabian Sea and the western Bay of Bengal. A few of these records have indicated step formation in the vertical temperature and salinity profiles revealing fine structure. With a view to understand these anomalous features, the various potential energy-parameters like static stability, stability due to vertical mixing of watermasses and stability due to variations in the compressibility of water parcels participating in mixing have been computed. These computations have indicated a dominance of vertical mixing in regions of negative vertical gradients of salinity.

(c) Spectra of vertical salinity and temperature profiles

An analysis of the CSTD records off the Goa coast during November 1976 shows clearly the penetration of equatorial water as a tongue of low salinity core, located around 200 m depth. Computations of the wave number spectra of vertical temperature and salinity distributions show an average slope of temperature and salinity spectra to be —2.9 and —2.6 respectively.

(d) Hydrographic conditions and circulation in the eastern Arabian Sea

Circulation and the variability of various physical parameters in the cast central Arabian Sea prior to the onset of monsoon have been studied using the hydrographic data collected during May and June 1979. The pattern of surface currents in the north showed a change in the direction of flow from south to the southeast. Small pockets of high salinity water (which could be related to the Arabian Sea High Salinity Water) were found at the surface in this area. The sea surface temperature increased by about 1°C from May to June with a general decreasing trend towards the coast.

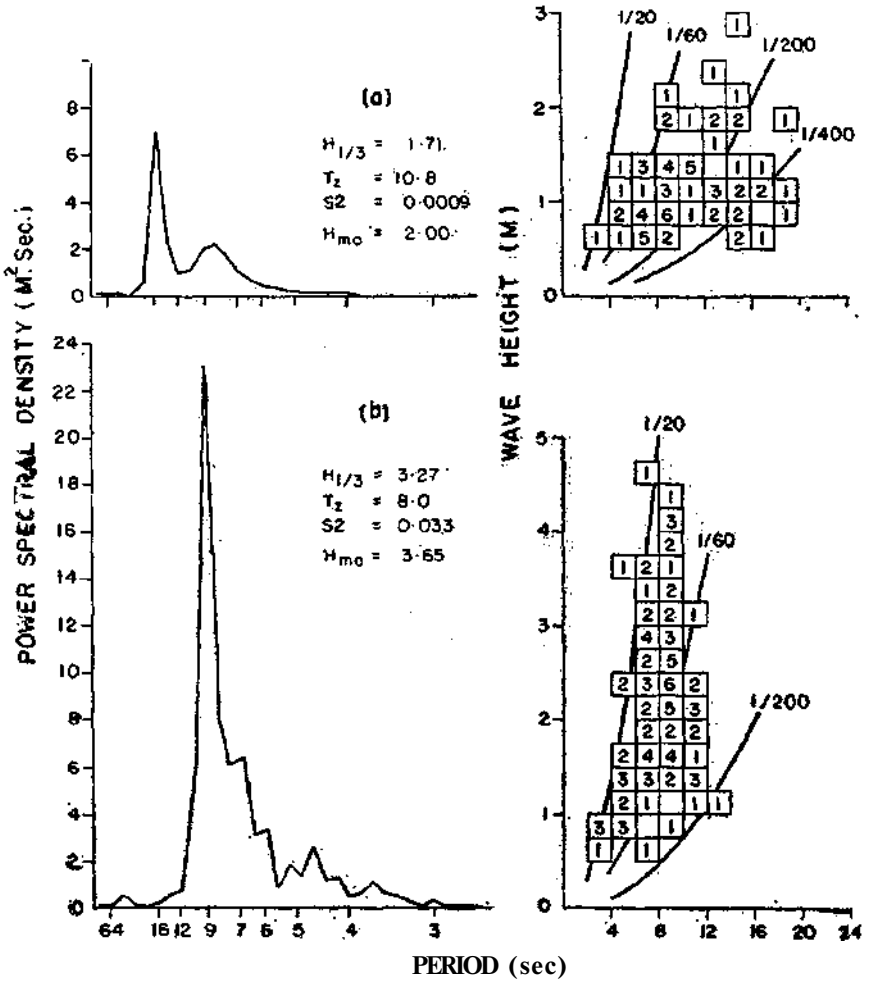
(c) Temperature structure in the western Indian Ocean

Temperature distribution in the upper layers of the western Indian Ocean during January-March was studied with the MBT and XBT data collected during 86th and 87th cruises of RV **Gaveshani.** Across the equator (2°N - 2°S), a significant variation in SST (26.8 - 28.4° C) was noticed, with the lower values at the equator. From 12° to 2°S also, SST varied over a wide range (27.5-29.2°C). The depth of thermocline varied between 10 and 50 m. Low SSTs and shallow mixed layer, coupled with high nutrient values revealed upwelling near the equator.

Minimum SST with shallowing of thermocline to about 10 m depth was observed around 9° 30'S, 57°00'E in association with a low pressure system.

(f) Wave studies

Computations of wave statistics from the wave records of the seas around India were continued during this year. Wave records have been subjected to spectral analysis. Draper's analysis and wave by wave analysis. These analyses have shown that the sienificant wave height calculated from spectral analysis over-estimates the parameter obtained by wave by wave analysis by 8%, while the zero-crossing period by spectral analysis underestimates this parameter obtained by wave by wave method by 20%.



Typical spectra of waves observed off Mahanadi during (a) calm weather and (b) disturbed weather.

An analysis of wave records of September off Mahanadi has shown, under calm condition, the occurrence of predominant swells with periods 14 to 15 sec and wave heights around 1.5m. But, when a monsoon depression was passing by, waves with periods of 7 to 8 sec and wave heights 2 to 3 m were observed. Occasionally waves of 5 to 6 m height have also been observed. These abnormal wave heights might be the result of wave-wave interactions and a comprehensive analysis is being carried out.

Off Godavari, a total number of 61 records collected during September-October have been analysed for both wave spectrum and wave by wave analysis. The weather conditions were calm. The primary peaks in the spectra existed between 10 and 15 sec and major part of the wave energy was distributed between 20 and 8 sec.

Wave conditions in the east central Arabian Sea during the onset of South-west monsoon were studied using the MONEX-79 wave data. An analysis revealed significant change in wave conditions a week before the onset of the South-west monsoon in the region. Waves with shorter periods and larger heights (exceeding 8 m) appeared in the preceeding week eventhough the wind conditions did not show any significant change. Spectral width parameters were concentrated between 0.80 and 0.90 suggesting that the waves encountered in the region were mostly generated locally. A few weeks before the monsoon, the mean zero crossing period and the mean crest period decreased and their standard deviation was also reduced. A scatter diagram relating the mean zero crossing period and the significant wave height showed some data on quite low steepness indicating that there was a substantial swell component before the onset of the monsoon in the region.

3.1.3 Studies on land-sea interaction and nearshore circulation along the Indian coast with an application to coastal zone management

Studies under this project have been carried out partly from headquarters and partly from Regional Centre. Cochin.

(i) Estuarine studies

Under this project, current measurements have been made off the mouth of Mahanadi, Godavari, Krishna and in the Hooghly rivers during pre- and post-monsoon periods. The data is under processing.

Wave refraction diagrams using computer have been constructed for Krishnapattanam area along the east coast of India for an evaluation of the nature of the wave induced longshore currents and the sediment transport patterns. Wave-shelf interaction studies are in progress.

(ii) Hydrography and nearshore circulation of Wadge Bank

The work carried out under this investigation has been reported under Regional Centre, Cochin.

3.2

Chemical Oceanography

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

3.2.2 Drugs from the sea

3.2.3 Protection of marine environment and monitoring of pollutants along the Indian Coast

3.2.4 Characteristics of the estuarine regions of major rivers of India

The work on four projects undertaken by the Division was continued and extended to hitherto less-explored areas during the year 1981. Analytical facilities were also made available to various organizations on special requests. A summary of the work carried out in different projects is given below.

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

Chemical data on oxygen, nutrients, alkalinity, pH and other major and minor constituents of seawater were collected during nine cruises of RV **Gaveshani** in the Arabian Sea, Bay of Bengal, Somali basin and Mascarene basin. The salient features are as follows :

(a) Studies on nutrients and dissolved oxygen in relation to the hydrographical features

(i) Equatorial Indian Ocean: An analysis of the data collected during 86 and 87 cruises indicated shallowing of the isothermal layer in the equatorial region and lower oxygen concentrations associated with higher nutrients at shallow depths. A similar feature indicating an upward movement of water was also observed at the station off Agalega island. The dissolved oxygen values showed a steady increase from north to south with two minima separated by a maximum. The intermediate oxygen maximum was more pronounced in the southern section. Phosphate and nitrate showed a maximum between 1000 and 1500 m with the phosphate values decreasing steadily towards the south. At most of the stations silicate, increased steadily with depth. However, at some stations, a decrease in silicate with an increase in depth was observed in deeper layers indicating the loss of silica through some hitherto unknown mechanism.

(ii) Western Bay of Bengal: During the multi-disciplinary cruises of **RV Gaveshani** in the southern Bay of Bengal, some baseline information on the chemis-

try of sea water was obtained particularly because this area is promising for an OTEC plant. All parameters showed a regular pattern of variations. Two oxygen minima were observed in the region in conformity with the earlier work. Only one nitrite maximum was observed. Higher phosphate concentrations were observed in the inshore region off Madras.

(iii) Wadge Bank: Study on the distribution of nutrients and dissolved oxygen during the two cruises of **RV Gaveshani** in May and September, 1981, indicated high nutrient concentrations in the surface layer, inorganic phosphate and nitrate were generally higher than 1 and 2 μg-at/l respectively. The values were particularly high in September in the shallow region and decreased steadily towards the deeper areas. Dissolved oxygen was not found to be very low indicating that the high nutrient concentrations are probably not due to upwelling and that a high rate of mineralization in the sediments occurs in the area.

(b) Hydrographical and hydrochemical features of the Mandovi-Zuari estuarine complex

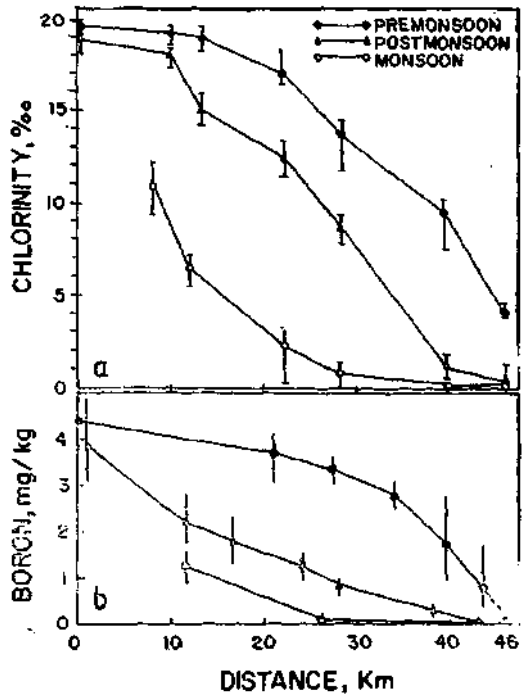
Temporal and spatial variations in various physico-chemical parameters in the Mandovi and Zuari estuarine complex were studied. A weak thermal stratification was observed at some stations during monsoon and post-monsoon season, presumably due to incomplete mixing of fresh and saline waters. During the premonsoon season, however, the difference between surface and bottom waters was negligible. Marked seasonal variation in pH was observed. Maximum nutrient concentrations were encountered during the monsoon season. Abnormally high levels of dissolved manganese and iron in water observed are probably due to the ore-bearing landmasses and the associated mining operations. Trace metals in the water exhibited no significant change during the two seasons.

(c) Studies on major constituents

(i) Calcium and magnesium in sea water and sediments: Water samples collected from nine deep stations with sampling depths extending upto 4200 m during 86 and 87 cruises of **RV Gaveshani** between latitude 8° N and 13° S showed an average calcium/chlorinity ratio of 0.02164 for all samples (127) with a standard error of ± 0.000009 and an average calcium content of 421 mg/kg. Marked geographical and depthwise variations were observed. The average ratio for individual stations decreased steadily towards south with the value of 0.02154 at the southern most station from a typical value of about 0.02170 in the northern region. It has been inferred that a high Ca/Cl ratio observed in the northern Indian Ocean is due to high calcium influx from ths rivers.

The average magnesium/chlorinity ratio for the region was found to be 0.06723 with a standard error of ± 0.000048 and an average magnesium concentration of 1300 mg/kg, which is slightly higher than the average oceanic value. No regular variations were observed either with depth or with geographical locations.

Analyses of the sediment samples for calcium have revealed the occurrence of carbonate compensation depth at shallower depths in the Arabian basin than in the Somali basin. The variations in carbonate compensation depth and Ca/Cl ratio are being studied in relation to the degree of saturation of calcium carbonate.



Variation in (a) Chlorinity and (b) Boron concentration in Zuari river in different seasons.

(ii) Boron in Zuari estuary: Dissolved boron in Zuari estuary varied from 0.02 to 5.42 mg/kg all along the estuary. Removal of a considerable amount of boron through inorganic uptake was observed during monsoon and post-monsoon maximum (20-45%) being in post-monsoon between 11 & 17‰ chlorinity. Boron behaved conservatively during premonsoon. The average input of boron from freshwater runoff in the area was estimated.

(iii) Boron in the Arabian Sea: The concentration of inorganic boron in water samples from the Arabian Sea was found to vary from 1.17 mg/kg to 4.74 mg/kg. The boron/chlorinity ratio ranged from 0.122 to 0.238 for the shallow stations, and from 0.060 to 0.241 for the deep stations with a mean value of 0.173 for the area surveyed A depthwise correlation was found between boron and primary productivity at some stations. The correlation between inorganic boron and dissolved oxygen in a vertical profile was less defined. The oxygen concentration at its minimum showed a corresponding higher concentration of boron at its maximum which might be due to the release of boron during oxidation of organic matters.

(iv) Fluoride, bromide and iodide in the Arabian Sea: In the Arabian Sea. fluoride values were found to vary from 1.32 mg/1 at the surface to 1.37 mg/1 at

1500 m depth. F/Cl value ranged from 6.5 x 10^{-5} to 6.83 x 10^{-5}. Bromide was found to bear a fairly constant ratio with chlorinity (0.003474). Bromide concentrations ranged from 67 mg/l to 71 mg/l. Iodide showed variations from 0.01 mg/l to 0.024 mg/l, with high concentrations in surface and bottom layers.

(v) Sulphate in the Arabian Sea: The mean sulphate concentration was found to be 2.8249 ± 0.01863 g/kg in the water samples collected during 88th cruise in Arabian Sea. The $SO_4^{2-}/Cl‰$ ratio was uniformly constant with depth, resulting in an average ratio of 0.1406 ± 0.00208, which is consistent with the average values reported by other workers for different oceanic regions.

(d) Chemical speciation of important metals in the sea

Water samples from the marine and estuarine regions have been analysed for labile and organic fractions of cadmium, lead and copper. The concentration of cadmium was low in the estuarine environment, ranging between 0.05 and 2 µg/l. The organic fraction was found to vary from 0 to 60%. Total lead concentration varied from 0.5 to 13 µg/l with 0-70% present as the organic fraction. Of a total concentration of 0-16 µg/l of copper observed, the organic fraction constituted 0 to 90%. The concentrations of both the forms decreased towards the riverine section. In the surface samples from the Wadge bank these three metals occurred only in labile form. The ranges of concentrations were 0-0.3 µg/l for cadmium; 1-6 µg/l for lead; and 0-6.5 µg/l for copper.

(e) Regeneration of nutrients from plankton and sediments

The distribution of dissolved, exchangeable and fixed ammonium was studied in the sediment. Fixed ammonium nitrogen was found to be the dominant inorganic form of nitrogen, the concentration of which increased with increasing concentrations of dissolved ammonium. The concentrations of fixed ammonium ranged from 54 µg/g dry wt. of the sediments (equivalent to 12% of total nitrogen) to 375 µg/g dry wt. of sediments. The corresponding total N were 450 µg/g and 4780 µg/g respectively.

(f) Studies on organic constituents of sea water

A number of sea water samples were analysed for the dissolved amino acids by TLC; their concentrations were found below detection limits. Amino acids in the particulate matter are also being analysed by hydrolysis followed by the-dansylation. The mixture is being separated by the high performance liquid chromatography.

(g) Dissolved inorganic sulphur system in sea water

A theoretical study on the stability of different sulphur species in sea water has been carried out. It is found that sulphur oxyacids are unstable in an acidic anoxic environment and the intensity of the instability increases with the increasing oxidation state. The reverse is the case in an oxic environment. Metastable species are $S°$, $S_4O_6^{2-}$ and H_2SO_3 in acidic solution and $S_2O_3^{2-}$ in basic solution, for both the environments. In sea water sulphur species showed the same order of stability as they showed in. oxic acidic solution. Apart from $S°$ and $S_4O_6^{2-}$ species $S_2O_3^{2-}$ shows metastability in sea water. Species stability with respect to O_2/H_2O_2

couple is in close agreement with the O_2/H_2O couple. For sea water with a pH of 8.0 and PO_2 of 0.21 atm., HSO_4^{2-} is the next stable species of SO_4^{2-}. H_2S showed high stability in anoxic acidic solution.

(h) Ionic potential as a controller of sea water composition

The role of ionic potential (IP) as a controlling parameter of sea water composition has been assessed. It is found that with IP less than 4, with, the exception of Li and Be in alkali and alkaline earth groups, respectively, residence time has direct relation with IP. But, for all S-block elements, a negative relation is found. Residence time of Lithophilic, Chalcophilic and Siderophilic elements with IP less than 4, decrease, with increase in the IP value. With IP from 4 to 12, elements show direct proportionality between IP and residence time in toto. Elements with IP above 12 show again a negative relation. Significantly elements with ionic charges between 1 and 3 show negative correlation. Lanthanides, with a constant charge of +3 and decreasing ionic radii with increasing atomic number, yielded direct relation. The ionic potential between 4 and 7 is, probably the optimum range for the removal mechanisms in sea water.

(i) Investigation on desalination of sea water

A new design of solar still with top and side walls of glass sheets, was prepared. The still showed an average performance efficiency of about 50%. About 50 litres of fresh water can be obtained per day by setting up 20 stills in a battery fashion. Fabrication cost of each still is estimated to be about Rs. 300/- each.

(j) A new technique for simultaneous sampling of deep sea sediments and near-bottom waters

A new device has been developed for simultaneous collection of deep-sea sediments and near-bottom water samples. The system was tried successfully in the equatorial Indian Ocean at a depth of 4 km. The chemical analysis of the near-bottom samples revealed some interesting features such as an increase in suspended load and lower silicate concentration. The hydrochemical data were comparable with those obtained by the analysis of the sample collected with the hvdrocast earlier in the same area.

(k) Studies in Cochin backwaters

Progress made under this investigation is reported under Regional Centre. Cochin.

3.2.2 Drugs from the sea

(a) Screening of marine organisms

The extracts of the coral **Porites lutea** and the seaweed **Acanthophora specifera** exhibiting antifertility activity have been further fractionated for the confirmation of the observed activity. The antifertility activity of **Acanthophora specifera** has been located in petroleum ether fraction. The highly analgesic activity of **Acanthus illicifolius** was located in chloroform and water-soluble fractions.

(b) Chemical investigations on marine organisms for the isolation of active components

(i) Porites lutea: A tumor lipid butyl alcohol and several steroids have been isolated and characterised from the petroleum ether fraction. The steroids isolated from this coral include cholesterol, dehydrocholesterol, brassicasterol, dihydro-brassicasterol, 4-dimethyl 5 dehydro dinosterol, stigmasterol and fucosterol.

(ii) Stoechospermum marginatum: Two fatty acids besides the novel skeletal diterpenoid (stoechospermol) and fucosterol have been isolated in pure state, the characterisation of which is in progress.

(iii) Chondria armata: Chemical studies of this seaweed exhibiting hypotensive activity resulted in the isolation of several compounds including a new halogenated triterpenoid which has not been reported in the literature so far.

(iv) Acanthophora specifera: Chemical investigation of the petroleum-ether fraction of the crude extract of this seaweed exhibiting antifertility activity has yielded a fatty acid in pure state. This fatty acid which appears to be analogous to prostaglandins is being subjected for further characterisation.

(v) Codium elongatum: Further investigation of the water soluble fraction of this seaweed which showed antiviral activity led to the isolation of sulphated polysaccharides. Since some of the sulphated polysaccharides are known to possess antiviral activity, the isolated sample is being subjected to screening.

(vi) Acanthus illicifolius: The water soluble fraction of this was further separated into carbohydrates, proteinous fraction and residue to locate the observed activity. The chloroform fraction is also being analysed to isolate the active constituent responsible for the activity.

3.2.3 Protection of marine environment and monitoring of pollutants along the Indian coast

During 1981, investigations under this project consisted of a repeat cruise in the Arabian Sea during the same time of the year, along the same cruise track, occupying the same stations, as was done on an earlier cruise in 1977. The objective was to examine the changes if any in the environment in the Arabian Sea. Five cruises were also undertaken in the Bay of Bengal and the Andaman Sea, to study the environmental conditions, particularly off the city of Madras.

Laboratory experiments were conducted to examine the toxic effects of oil and chemical dispersants, both individually and in mixture, on different bottom-dwelling organisms.

(a) Monitoring of petroleum hydrocarbons in the marine environment

Tar ball concentration in the Bay of Bengal was found between 0 and 69.75 mg/m^2 while dissolved/dispersed hydrocarbons ranged from 1.6-42 µg/kg. Similar figures for the two components in the Arabian Sea were 0.3-112.2 mg/m^2 and 55-305 µg/kg respectively. These observations indicated an increase in oil pollution in the Arabian Sea since 1977.

Observations from March 1977 to March 1981 reveals the following:

Oil slicks were sighted on 5582 occasions, about 83.5% of the total observations of 6689. These data were obtained from the Japan Oceanographic Data Centre (JODC) and include the observations carried out by all the ships, both merchant marine and research, plying along the trade and oil tanker routes across the Arabian Sea and the Bay of Bengal.

The concentration of the floating tar balls was 0-0.6 mg/m^2 in the Arabian Sea and 0-69.7 mg/m^2 along the oil tanker route in the southern Bay of Bengal; the total annual occurrence of floating tar balls in these two areas is estimated to be 3700 and 1100 tonnes respectively, with 'residence time' of 33-38 days.

The relative toxicity of five oil-spill dispersants, sent to NIO by Castrol Ltd., was studied using two invertebrate species **Mytilus viridis** and **Macrobrachium idella.** Toxicity of another two oil-spill dispersants, sent by BP of UK was also tested on prawn **Macrobrachium idella.** The LC_{50} values, 95% confidence limit, and the corresponding slope functions were calculated. It was observed that there was a wide range in the relative toxicity of the different dispersants. The ranking order of the emulsions was almost identical for both the species tested, although there was a significant shift in the range of LC_{50} values, indicating that one species is less sensitive than the other. It was observed that the dispersants-oil mixture were less toxic than the dispersants alone.

(b) Toxic and non-toxic heavy metals and metalloids in sea water and marine organisms

During the year analyses of heavy metals in water, particulate matters, zooplankton and fishes, collected from the Andaman Sea, southern Bay of Bengal and Arabian Sea were carried out. Metals examined were Hg, Cd, Pb, Cu, Zn, Fe, Co, Mn and Ni. Detailed examinations of the data have been published.

Studies on the movement and behaviour of pollutants were continued mainly on heavy metals in the marine environment around India. Organisms representing different trophic levels were analysed to examine the degree of contamination in them. The prime interest was centred around commercially important food fishes, though other fishes of less economic importance and some zooplankton samples were also analysed. The levels of concentration of most of the metals in the edible portions (muscles) were much below the minimum limit for contamination.

A report has been prepared to sum up all the observations on toxic and non-toxic heavy metals in analysable forms, which have been carried out under this project since 1977. It is concluded from these studies that the seas around India and the organisms living in them are quite free from all types of heavy metal contamination.

(c) Observations off Madras city

During a cruise of RV **Gaveshani** in 1979, high concentrations of phosphate-phosphorus (0.45-0.50 µg-at/l) were observed at the surface waters off the City of Madras. The cause for this was assumed to be pollution from localized industrial

establishments. To verify this, observations at a number of closely-spaced stations, to a distance of 15 nautical miles along three latitudinal transects, 5 nautical miles apart were carried out during a cruise of **RV Gaveshani** in 1981. The surface concentration of phosphate-phosphorus was 0.24-1.3 μg-at/l decreasing away from the shore. Nitrate-nitrogen was 0-0.55 μg-at/l and silicate-silicon 0.42-5.82 μg-at/l increasing away from the shore.

The thermal power plants at Ennore and Bassein Bridge dispose 2300 tonnes of fly ash per day. The phosphate factory there uses chlorine and phosphates in their cooling waters, 1% of which, goes out from the plant and the badly polluted Buckingham Canal is flushed every year in November during the North-East monsoon. The effect of all these results in the gradual increase of phosphate-phosphorus in the surface waters of the Bay of Bengal off the City of Madras.

(d) Pollution monitoring along Kerala coast

The details of this investigation are given under Regional Centre, Cochin.

3.2.4 Characteristics of estuarine regions of major rivers of India

Two sets of observations were carried out under this project during 1981. During the first set of observations in June, four anchor stations over 12-24 hours were worked off the mouths of the rivers Hooghly, Mahanadi, Godavari and Krishna. Apart from these, latitudinal sections off the mouths of Krishna, Godavari and Mahanadi were worked to examine the influence and extent of the river runoff.

During August-September, eight anchor stations over 12-24 hours were worked. Three of these were at Diamond Harbour. Haldia and Sagar in the river Hooghly, one each at Sandheads Western Channel, off New Moore Island, off Mahanadi, Godavari and Krishna. In addition to these, eight stations were worked along a coastal transect from Mahanadi to Godavari mouths with close observations off the mouth of the Chilka lake.

At each anchor station observations were carried out in tune with the multidisciplinary nature of the project. 3-4 recording current meters were paid out to record the flow at various depths while the surface currents were measured using a direct reading current meter. Wave recording, meteorological observations, hydrographic cast and plankton haul were taken every 3 hours. Water samples were analysed on board for pH, dissolved oxygen and nutrients. A part of the sample was also filtered to examine the variations in suspended matter and their composition every three hours. In addition, one sample, collected at a mid-depth every three hours. were mixed together and filtered to analyse the trace metals with the residual tidal effect. All the plankton samples were preserved for examination in the laboratory. Photosynthetic productivity, both in situ and on deck were run at every anchor station. Snappers and occasionally core samples were also collected for benthic. sedimentological studies and chemical analysis. The observations in physical and biological aspects are given in respective sections while chemical observations are as follows:

During June, at anchor stations off Krishna, Godavari and Mahanadi 24 hr observations on dissolved oxygen, pH and nutrients and at Sandheads Western

Channel, 12 hr observations were carried out. These observations showed that though the pH does not vary much during the 24 hr period, the nutrients in general showed a decrease in concentration during day time and a gradual rise during night. However, off Godavari the nitrate concentration was higher during day time which fell sharply during night.

During Aug-Sept., considerable tidal induced variations in all nutrient concentrations were observed at all anchor stations, excepting the one off Krishna mouth. A seaward decrease in nutrient concentrations (PO_4-P, NO_3-N and SiO_4-Si) observed in the Hooghly estuary indicates the importance of removal mechanisms involved. Though the New Moore anchorage was far from the coast, the influence of Ganges river runoff was significant. Nitrite-nitrogen was present at all depths in the nearshore stations off Chilka Lake which is not so, for the rest of the stations, excepting Godavari anchor station where NO_2-N is found at all depths for all observations. SiO_4-Si significantly decreased within the few metres of the upper layers of the Godavari estuary.

Comparing the fluctuations of phosphate-phosphorus and silicate-silicon with those of salinity at the anchor station off Sagar Island in river Hooghly it has been observed that concentrations were higher during the low-tide and lower during the high tide, which indicates the pre-dominant effect of land runoff and discharges in the rivers. However, nitrate-nitrogen did not show any clear pattern of variation.

Analysis of trace metals like Cu, Cd, Fe, Zn, Pb, Mn, Co and Ni in the dissolved and particulate fraction of samples collected in September 1980, showed a drop in dissolved Fe and Mn concentrations from the riverine region to the estuarine region where mixing occurs (Fe from 273-5 µg/l to 38.5 µg/l and Mn from 7.8 µg/l to 3 µg/l). But the particulate fractions of these two metals were higher in the estuary, which indicates a removal of these metals from solution. Dissolved Cu and Ni showed a linear drop from fresh to more saline water while Zn and Pb showed no particular trend. Dissolved Co concentrations were low throughout. Cd concentration indicated a drop in fresh water and a constant value in saline water. Particulate Cu, Pb, Co and Ni concentrations were low compared to other metals. Particulate Cd concentration was lower in the river than in the region of higher salinity.

3.3

Geological Oceanography

3.3.1 Geological and geophysical surveys to decipher the regional geology and to assess the petroleum and mineral prospects of the continental margins of India

3.3.2 Regional geology and manganese nodule deposits in the Arabian Sea and Central basin of the Indian Ocean

3.3.3 Geochemistry of the sediments of the continental margins of India

3.3.4 Sediments of the western continental margin of India

3.3.5 Paleoclimatic studies on the nature of the summer monsoon over India during the past 10,000 years

3.3.6 Foraminifera as indicators of pollution in the marine environment

33.1 Geological and geophysical surveys to decipher the regional geology and to assess the petroleum and mineral prospects of the continental margins of India

During the period under report, the western continental margin off Mangalore has been surveyed. These surveys included more than 850 lkm of echosounding, 60 lkm of side scan sonar, 1050 lkm of seismic profiling and 1115 lkm of magnetics, followed by seabed sampling. The bathymetric and seismic data from the Direction Bank and marine magnetic data collected off Saurashtra coast have been analysed. Exploration for ilmenite placers off Konkan Coast (between Jaigad and Vijaydurg) and seabed surveys for the development of New Mangalore and Karwar Ports have been completed. Besides, a programme of underwater archaeological exploration off Tamilnadu coast has been initiated. The important findings are given below:

(a) Geomorphology and shallow structure of the continental margin off Mangalore

The topography of the inner shelf is smooth and slopes gently down to a depth of 55 m and is carpeted by 10-12 m thick acoustically transparent clays. The mid shelf is characterised by reef-like features or minor irregularities with 1-2 m relative variations. The outer shelf is fairly smooth, slopes moderate and shows 10 m sub-bottom penetration. The shelf break occurs at about 120 m. The continental slope is undulatory and is marked by 25-30 m subbottom penetration. Beyond the continental slope, the continental margin is dominated by significant topographic variations. At about 50-55 km from the continental slope, a NNW trending 4-5

km wide bank rises from a depth of 2000 m to about 300 km. The bank narrows towards the north. The top reflectors of the bank are possibly due to recent sediments which dip towards the centre and the sub-bottom forms apparently, a low saucer shapped depression. The configuration of the reflectors on the bank suggests that it was possibly a volcanic vent (?) on the ruins of which corals grew and later coverd by recent sediments. Further 30 km west of this bank, a prominent ridge of 5 km wide, trending N-S occurs at about 1450 m which rises to 450-500 m. West of this ridge the seabed is fairly smooth and shows about 50 m sub-bottom penetration. However, the seismic profiles show very low penetration on the Bassas de Pedro bank, presumably due to hard corals. A broad magnetic anomaly of about 200 nt was recorded on the banks.

(b) Surficial geology of the Direction Bank

The seabed on the Direction Bank is marked by uneven topography with relative variations upto 1 m while it is fairly uniform beyond the northern edge of the bank. The sonographs confirm the presence of uneven topography on the top of the bank, resembling sand ribbons/low amplitude sand waves (?) gravel filled depressions. The shallow seismic data indicate a typical penetration of 45 m and a maximum penetration of about 100 m. A prominent subbottom reflector, indicating the thickness of the acoustically transparent layer has been identified in the area; its thickness varies between 5 and 35 m, the maximum being recorded in the southern part of the bank. The thickness decreases towards the east as well as towards the north from the axis of the bank. The records of the southern part of the bank show acoustic masking due to gases which even reach upto 15 m below the seabed. On the other hand, the seismic data of the area beyond the northern edge of the bank show relatively lesser clay thickness but numerous depressions (20-35 m) resembling "Filled basins"/or broad and irregular erosional surfaces.

(c) Magnetic anomalies and basement configuration on the continental margin off Kathiawar

The inner shelf north of Porbandar to a depth of about 50 m is characterised by high frequency short wavelength (HFSW) anomalies whereas, south of Porbandar these anomalies are absent but instead of a well developed WNW-SSE trending high amplitude anomaly is present. The outer shelf and slope (about 50 to 2000 m) north of Porbandar is characterised by either low amplitude anomalies or a magnetically smooth zone while the outer shelf and slope to the south is marked by very broad wavelength, low amplitude anomalies trending WNW-SSE. These two regions of Porbandar are separated by an approximately 25 km wide and 75 km long E-W trending zone bordered by high magnetic gradients and a suspected offset of anomalies on either sides.

The high frequency anomalies on the inner shelf to a depth of about 50 m off Porbandar may be possible due to the occurrence of Deccan Traps at shallow depth. These traps perhaps deepen towards the outer shelf and the thick sedimentary overburden attentuates its magnetic expression. The absence of HF SW anomalies and presence of broad anomalies south of Porbandar probably, indicates the absence of Deccan Traps and deepening of the basement. The E-W trending zone

off Porbandar probably represents a major basement feature and the offset in anomalies may be due to a strike slip fault displacing the Deccan Traps.

(d) Exploration of ilmenite placers off the Konkan coast

Survey along the Konkan Coast from Jaigad to Vijaydurg revealed that the seabed in most of the bays is marked by even topography but in some bays rock outcrops and pinnacles of 2-5 m height have been observed even at a depth of 11 m. The gradient of seabed is steep upto a depth of 8 m beyond which it is gentle. The sand extends to a distance of 2-5 km offshore to a water depth of 9-15 m beyond which it is covered by recent clays. Heavy mineral concentration varied from 1-9% of which ilmenite constituted 51% and magnetite 1-31%. Other minor minerals were augite, zircon, apatite, tourmaline, topaz, kyanite. The ilmenite in these sands contain upto 52% of TiO_2 and minor amount of vandium as V_2O_5 Shallow seismic record has shown maximum penetration of about 45 m. The records revealed three to four reflectors. The top acoustically transparent clay which is underlain by sand of 2-8 m upto depth of 9-48 m was confirmed by piston gravity core resting on uneven basaltic basement.

3.3.2 Regional geology and manganese nodule deposits in the Arabian Sea and Central basin of the Indian Ocean

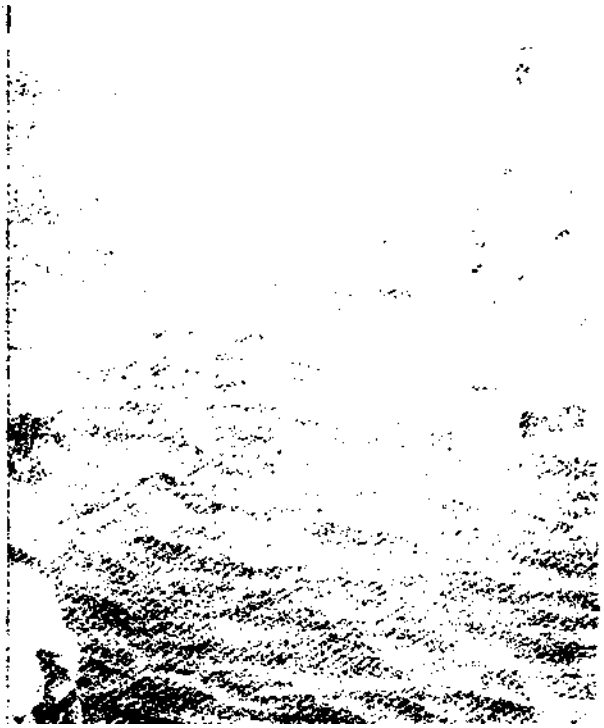
During 86th and 87th cruises over a period of 48 days, **RV Gaveshani** worked in far off areas of the Indian Ocean covering more than 10,000 lkm and carried out detailed surveys for polymetallic nodules. The work included extensive shallow seismic profiling, magnetic surveys and seabed photography by remote controlled camera. Totally 52 sediment samples and nodules from 10 stations were collected using boomerang grabs, dredges and conventional grabs, ranging in depths from 3 to 4.5 km. The diameter of the nodules ranges from 1 to 8 cm and computed concentration varied from 1.1 to 5.8 kg/m^2 which is considered to be very promising for mining. The nodules of different types like k-smooth, k-rough, ellipsoidal, kidney shaped, flat, cannon ball and black burry were noticed. The X-ray diffraction patterns of the nodules show very weak peaks and diffused pattern which is probably due to poor crystallinity and amorphous nature of minerals in nodules which is a common factor specially near and along the active mid-ocean ridges. However, some peaks of distinct type were noticed in the X-ray diffraction patterns which closely resemble to fotorokite and birnessite.

Chemical analysis of the individual layer and core were done taking into account the different shapes of the nodules.

Using Atomic Absorption Spectrophotometer, the analysis were carried out. The averages are as follows:

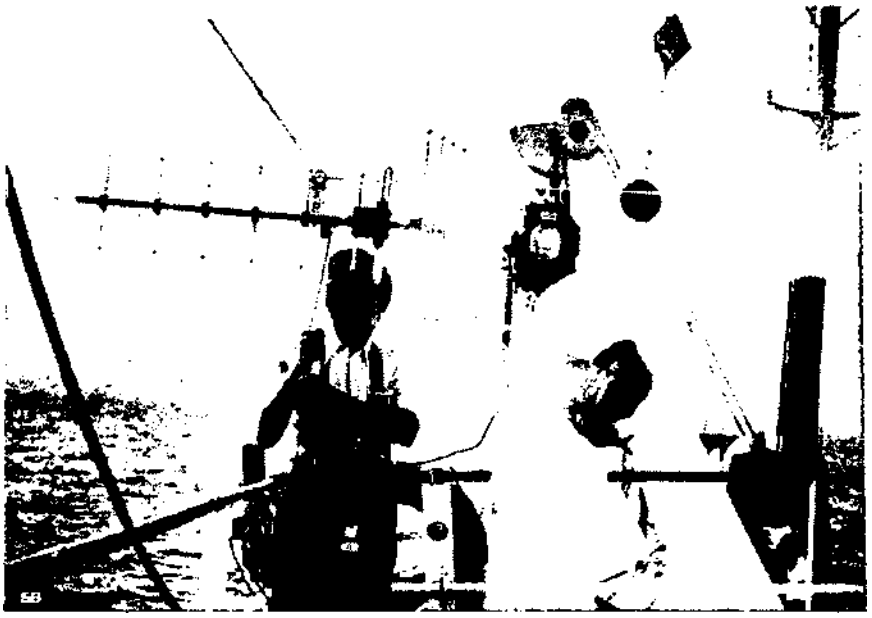
Cu	0.168%	Ni	0.427%	Co	0.106%
Zn	0.089%	Fe	15.433%	Mn	18.166%

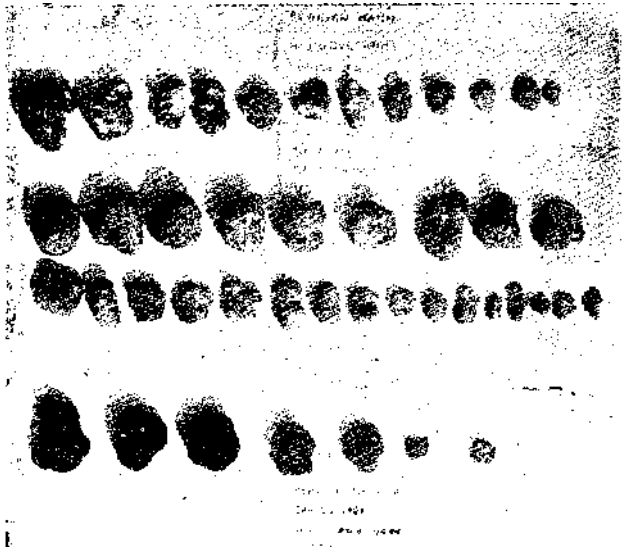
Chemical analysis of nodules is in progress. A collaborative work with Physical Research Laboratory, Ahmedabad on dating of manganese nodules is also in progress.



Lowering of boomerang grab for collection of manganese nodules

Direction under in use to locate the popped-up boomerang grab





Manganese nodules collected by RV Gaveshani.

Bathymetric data collected during the cruises indicated that the eastern flanks of Laccadive ridge are marked by a large unevenness and the intervening area is covered by 50 m thick transparent layered sediments. The echogram showed a monotonous Arabian abyssal plain with flat topography, seamounts and abyssal hills in the Somali Basin.

Scientists who collected the first sample of polymetallic nodule. Chief Scientist, Dr. S. Z. Qasim is 6th from left in the back row.

The magnetic picture in both the basins is marked by a series of highs and with amplitudes of the order of 400 to 600 gammas. Based on the magnetic survey along the cruise track, six divisions were recognized viz. (1) Mascarene basin, (2) Seychelles-Mauritius ridge, (3) Somali basin, (4) Carlsberg ridge, (5) Arabian basin and (6) Chagos-Laccadive ridge.

3.3.3 Geochemistry of the sediments of the continental margins of India

The geochemical investigations were continued on the sediments of western and eastern continental shelf of India. On the western continental shelf, studies were concentrated on the shelf region between Mangalore and Cochin. Bulk sample analyses in respect of several elements were completed and distribution map prepared. On the eastern continental shelf the study of overall distribution patterns of Mn and Ti were completed and data relating to partition of Al, Fe and Ti in acetic acid, acid reducing and in HCl leaches were processed. Further, the suspended particulate matter concentrations in the Hooghly estuary were studied during the period of high river discharge. In addition, with a view to understand the geochemical behaviour of some of the elements like Fe, Mn. Co, Cu from fluvial to estuarine environments, investigations were carried out on the sediments of Vembanad lake. Kerala. The results of the above studies are listed below.

(a) Mangalore to Cochin

The geochemical analysis of Fe, Ti, Ca, Mg, Na. K. Pb, Cr. Sr, Li and calcium carbonate in bulk samples and organic carbon and nitrogen shows that:

(i) calcium carbonate is in lower concentration (5-65%) as compared to the northern part of the shelf.

(ii) most of the trace elements showed higher concentration in the nearshore sediments suggesting their association with detrital phase or with clay minerals in the adsorbed form. These elements also exhibited higher concentration in the slope sediments.

(iii) organic carbon and nitrogen was higher in the nearshore and slope sediments as compared to the sediments of outershelf.

(b) Suspended particulate matter in the Hooghly estuary

Data collected at four anchor stations along the axis of the Hooghly estuary during the period of high river discharge indicates that the highest concentration of suspended particulate matter (SPM) occur in a well mixed region at the head of the estuary and its level decrease seaward as the two layer estuarine circulation becomes prominent. Its concentration is always high near the bottom. In general, the SPM is oscillatory in nature and varies considerably at all depths. Tidal influence on the variation of SPM concentrations decreased seaward. Manifold decrease of SPM concentration levels from bottom to mid-depth thus indicates the significance of resuspension of bottom sediments due to tidal influence. Lateral distribution of SPM exhibits a non-conservative behaviour like many other estuaries. When salinity varies from 20 to 30%o most of the riverine particulate matter is removed from the water column. Relative increase of SPM beyond 30%o salinity indicates a marine source for SPM besides riverine source.

(c) Vembanad lake

Studies on the distribution patterns of Fe, Mn, Ti, Cu, Co, Ni in sediments of Vembanad lake and adjoining river systems have revealed the following:

(i) elemental concentrations closely follow the texture of sediments,

(ii) river sands have low contents of all elements.

(iii) elemental concentrations of lake sediments increase as the grain size decrease.

(iv) sediments in the estuarine region are impoverished in Mn and Co contents and enriched in Ni and Cu, compared to fine sediments of other parts of the lake.

(v) Fe, Mn. Ni, Cu and Co bear significant relationship with organic matter of the sediments.

3.3.4 Sediments of the western continental margin of India

(a) Shelf sediment dynamics: Studies of the sediment dynamics of the Gulf of Kutch, a macrotidal bay and on the neighbouring continental shelf has resulted in the identification of a new phenomenon termed the "dynamic barrier effect of tidal jets". The tidal barrier prevents transport of sediments across the mouth of the gulf to the Saurashtra coast, and also pushes the sediments of the river Indus into the gulf, which becomes therefore, the principal source of the gulf sediments. The tidal barrier also acts as selective filter to allow only the transport of fine grained sediments. When it is recalled that the Gulf is a potential area for the generation of tidal power, these findings become of considerable practical importance. In brief, the result of the study suggest that in comparison to the Gulf of Cambay, the Gulf of Kutch is better suited for tidal power generation.

(b) Clay mineralogy of the shelf sediments: More than seventy sediment samples distributed over a distance of about 1700 km (from Okha to Cochin) on the continental shelf were analysed for clay mineral content by X-ray diffraciometry to evaluate the influence, if any, of the southwest monsoon drift on sediment transport using clay minerals as tracers. It was found that the clay mineral variation does not show any significant influence of the monsoon drift on the inner continental shelf and that the clay mineral composition is to a larger extent determined by the nature of the rock types on the coast. The monsoon drift may therefore, have its core located on the outer shelf or beyond the shelf edge.

(c) Carbonate mineralogy: In continuation of the earlier work on carbonate mineralogy and faunal relationship, studies on shallow water (< 50 m) carbonate sediments indicated that to a first approximation the rapid method of mineral determination by X-ray diffractometer methods are capable of distinguishing deep water from shallow water carbonate sediments. This arises because different depth zones in the ocean have different organisms each with its characteristic carbonate minerals. Secondary aragonite coatings on skeletal fragments in the shelf around Cape Comorin tend to change the bulk mineralogy. These results

are of much significance in studying the depositional environments of ancient carbonate sediments in which petroleum (crude oil) occurs.

(d) Study of nannoplankton

(i) Andaman region: In sixteen sediment samples, from Andaman region, 38 species of nannoplankton were encountered, out of which 14 are modern and remaining 24 reworked fossil flora ranging in age from Eocene to Pleiocene. Majority of the reworked fossils indicated that they are of Miocene age. Modern nannoplankton revealed their affinity to the tropical conditions. It is inferred that the reworked fossils may mainly be the outcrops of Miocene occurring on the Andaman Sea Floor and in part from the turbidites resulting from deposition of the sediment transported by river Irrawaddy.

(ii) Vicinity of Mauritius: Preliminary scanning of the sediment samples have revealed that majority of nannoplankton are not older than Pleistocene. Further investigations are in progress.

3.3.5 Paleoclimatic studies on the nature of the summer monsoon over India during the past 10,000 years

This project was initiated during this year, to determine the nature and extent of climatic fluctuations and to provide a guide to future changes.

About 75 sediment samples selected from the western continental shelf were therefore analysed for felspar content by X-ray diffraction method. The results indicated that the outer continental shelf sediments, which were deposited some 11,000 years ago have a felspar content 5 to 10 limes more than that in the modern sediments. Hot and dry climate in contrast to the present hot and wet climate is the one which led for this enrichment of felspar, typical of monsoon dominated conditions. Since the climate appears to have been arid in the past, the present pattern of rainfall associated with the monsoon must have been absent.

3.3.6 Foraminifera as indicator of pollution in the marine environment

(a) Studies at effluent discharge sites: Due to the loxicity of effluent discharged by a fertilizer factory near Velsao beach, abnormally high number of total foraminifera (7500 in g) were recorded from Velsao and its marine environment to about 5 km distance from the shore. Rotallidae in general and **Ammonia** spp. in particular was found to be negatively affected by pollution whereas, Noniondae was positively affected. Distortion and abnormal growth in the last 4 to 7 chambers in **Ammonia** spp. were observed as an effect of pollution. A total of 27 species of foraminifera were encountered and an interrelation between foraminifera and the organic matter in the sediment was established.

(b) Foraminiferal distribution

(i) A total of 16 living species in the samples from Bombay High region and assemblages indicated a very high and hyposaline environment in this area.

Western side of the eastern bank of a sand bar found parallel to the coast about 7 nautical miles from the coast was marked by the absence of living forms and the concentration of paleogene reworked foraminifera derived by Narmada-Kim-Tapti river complex as suspended load. This condition indicates an unstable substrate. High tidal wave coupled with a high concentration of suspended matter leading to a low penetration of light might be an additional cause for the absence of living individuals in the region.

(ii) Distribution of 78 foraminiferal species from the innershelf off Ratnagiri was somewhat patchy and anomalous at certain stations. To get a meaningful pattern, number of variables were reduced by applying Q-mode factor analysis, which revealed six foraminiferal assemblage within the area. Out of these four assemblages viz. **Ammonia beccarii-Ammonia annectens, Nonionion boueanum-Florilus scaphus** and **Trochammina inflata-Bulimina cxilis** were found important. These assemblages were mapped and correlated with the environmental parameters.

3.4

Biological Oceanography

3.4.1 Survey of biological resources of the seas around India.
3.4.2 Coastal aquaculture.
3.4.3 Biogeographical, ecological and experimental studies on phytoplankton and zooplankton from the Indian Ocean.
3.4.4 Biology of ecosystems under different environmental stresses.
3.4.5 Marine microbiological studies in the seas around India.
3.4.6 Studies on marine fouling, wood preservation and corrosion along the Indian coast.

Primary productivity, planktonology, benthic biology, microbiology, aquaculture and distribution of marine organisms, their interaction with each other and with the environment are some of the major fields of interest in biological oceanography. Yet other major activities include mangrove and seaweed ecology and physiological adaptations in marine organisms.

3.4.1 Survey of biological resources of the seas around India

(a) Primary Production

Investigations on primary production and chl a were made between lat. 11°42.9' & 19°09' N, long, 69°49.8' & 74°31.1' E (18 stations). Studies were also made between lat. 12° 52.5' & 20°16.9' N and long. 80° 30' & 86°51' E. The results are presented in the following table.

Observations were made between lat. 11°42.9' and 19°09' N, long. 69°49.8' and 74° 31.1' E (RV **Gaveshani** cruise 89), where surface Chl a varied from 0.04 to 0.74 mg/m^3; column Chl a from 0.98 to 13.57 mg/m^2; surface primary productivity varied from 1.7 to 55.0 mgC/m^3/day and column values from 115 to 639 mgC/m^2day.

Area	Surface Chl *a* mg/m³		Column Chl *a* mg/m²		Surface Primary Production mgC/m³ /day		Column Primary Production mgC/m² /day	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Krishna River Mouth (24 hours observation)	0.108	0.686	2.170	7 278	14.6	48 0	24S	532
Godavari River Mouth (24 hours observation)	0-112	0.270	0.639	4 295	15 2	15.7	173	283
Mahanadi River Mouth (24 hours observation)	0.088	0.862	2 845	11.127	56.8	159 4	241	293
Sandheads (13 hours observation)	0.147	0.735	6.640	7.950	23.7	53.9	110	201

Trichodesmium blooms were observed at station 1967 during 89th cruise of **RV Gaveshani.** where ^{14}C assimilation value was 23.5 $mgC/m^3/hr$ and chl a 45.1 mg/m^3

Primary production along the Monex track (cruise 91) varied from 0.0002 to 0.16 mgC/m^3 /hr and Chl from 0.009 to 7.15 mg/m^3

(b) Secondary Production

Secondary production data were obtained during the 82, 86, 87 and 91 cruises of **RV Gaveshani.** The zooplankton standing stock values off the south-central West Coast of India varied from 3.2 to 19.2 ml/100 m^3 (Mean 8.7 ml/100 m^3 and 5.0 to 23.5 ml/100 m^3 (Mean 10.3 ml/100 m^3) during the post-monsoon and premonsoon seasons respectively.

Study on the faunal composition, distribution and abundance of common zooplankton species off the south-central West Coast of India revealed marked seasonal variations and high species diversity during premonsoon period. Higher diversity values were also recorded from samples collected around the equatorial region of the Indian Ocean. Biochemical constituents of mixed zooplankton and dominant species were determined. Proximate biochemical analyses indicated protein to be the major component followed by lipid and carbohydrate. Carbon content for the mixed zooplankton was 28.46% and C:N ratio varied from 3.87 to 10.24. Caloric value ranged from 2.117 to 3.317 Kcal/g dry weight. ATP and POC (particulate organic carbon) analyses were done for six dominant species viz. **Euchaeta marina, Undinula vulgaris, Oncaea venusta** (Copepoda); **Euphausia diamedia** (Euphausiacea), **Sagitta enflata** (Chaetognatha) and **Acanthepyra sanguinca** (Decapoda). The ATP values for these species varied from 0.7 to 17.01 mg/individual. The POC values fluctuated from 0.5 to 83.8 mg/individual. Euphausid of decapod species showed higher value of ATP and POC.

(c) Benthic Production

investigations on different aspects of ecology, distribution, abundance, production and trophic relationship of benthos and its relevance to demersal fishery resources were carried out and some of the findings are as follows:

(i) Deep sea benthos of the Central Indian Ocean

Quantitative studies on the abyssal benthos (3500-5500m depth) of the Central Indian Ocean (between Lat. 1°S to 7°N and Long. 57° to 69°E) have revealed the existence of rich fauna and high standing crop. Population density contributed by 3 meiofaunal and 12 macrofaunal taxa was of high magnitude (2175-15233; mean = $644/m^2$). Polychaetes (41.6%), peracarid crustaceans (31.7%) and molluscs (4.8%), besides the agglutinating rhizopod protozoans, formed the macrofauna. Meiofaunal taxa were nematodes (69.4%), harpacticoid copepods (26.6%) and ostracods (4%). Macrofauna and meiofauna were more diverse at higher and lower depths respectively. Macro to meiofauna ratio in the total benthic population was 1 to 31.

The standing crop was uniformly high (0.54-13.75; mean 2.70 gm^{-2}) and many times more than reported for comparable depths in the other oceans. Bio-

mass values rapidly decreased with increasing depth and the contribution of macro to meiofauna in the total standing crop was in the ratio of 31 to 1.

High benthic biomass and population density are relevant to stable environmsntal conditions and to the high organic carbon production in the euphotic zone of the study area. Role of depth and distance from the land on the distribution and abundance of abyssal benthos was observed to be of secondary importance.

Rich fauna and high standing crop were associated with the occurrence of 'manganese' or polymetallic nodules and the probable effects of deep sea mining on the abyssal biota of the Central Indian Ocean have been highlighted.

(ii) Meiofauna of the Bay of Bengal

(a) Estuarins Meiofauna: Quantitative aspects - Distribution and ecology of meiofauna in the mouth region of four major estuaries, viz. Hooghly, Mahanadi. Godavari and Krishna were investigated. Fauna was mainly composed of nematodes. harpacticoids and polychaetes. Abundance varied from 226 to 967 animals per core in the top 10 cm layer of the bottom deposits. Total fauna was contagiously distributed. Biological interactions appear to be predominated factor controlling the distribution of meiofauna in the estuarine environment of the east coast of India.

(b) Sublittoral meiobenthos: Area between 15° 45' to 21° 62' N Lat. and 51° 12'5" to 88° 11'2"E Long, and depths ranging from 18 to 230 m was surveyed. Out of eleven taxonomic groups, nematodes followed by foraminifera and harpacticoida constituted the important taxa. Abundance of fauna was found to be more related to the texture of sediment than the variation in depth. Population density was rather low (mean = 74.66×10^3). Distribution was contagious with diverse fauna in the shallow nearshore region. On the basis of metabolic index, the food requirement of the benthic communities of the Bay of Bengal was found to be lower than in the Arabian Sea and the Andaman Sea.

(iii) Demersal fishery resources of the Indian seas

Quantitative study on the benthos (macro and meio) and its possible relationship with the demersal fishery resources in the 6.2×10^6 km^2 area of the Indian Seas (between Lat. 24°30' to 5° N and Long. 97° to 65° E) showed that the biomass production varied from 0.01 to 601 $g\,m^{-2}$ with mean value of 17.6, 7.3, 5.5 and 0.7 gm^{-2} in the Arabian Sea, the Andaman Sea, the Bay of Bengal and Lakshadweep Sea, respectively.

The shelf produced maximum biomass and the production decreased with the increasing depth. Richness of benthos in the Arabian Sea was related to the upwelling phenomenon while the high biomass values in the northern Bay of Bengal was mainly due to heavy riverine enrichment.

Macrobenthos dominated the shelf whereas the meiobenthos contributed more than 70% in the slope and the deep sea (above 1000 m) region. Overall, the macrofauna accounted for 27%, 28%, 30% and 44% of the total fauna in the Arabian, Andaman, Lakshadweep Seas and the Bay of Bengal respectively.

Annual benthic production was maximum (mean = 3.7 $g\,C\,m^{-2}\,y^{-1}$) along the

southwest (between Lat 12° and 7° N) coast of India. Other areas of high benthic production were the northwest part of Arabian Sea and the northern Bay of Bengal.

The potential yield of demersal fish and crustaceans was found to vary from 28 kg/ha along the shelf of Lakshadweep to 909 kg/ha off the West Bengal shelf. An overall threefold increase in the exploitation of demersal resources is envisaged. The potential resources have been estimated as 1.8 million tonnes, out of which the shelf alone can sustain an annual yield of 1.2 million tonnes. The relevance of benthic standing crop for the estimation of demersal living resources has been observed to be more authentic than the conventional procedures.

(d) Studies on marine algae and mangrove

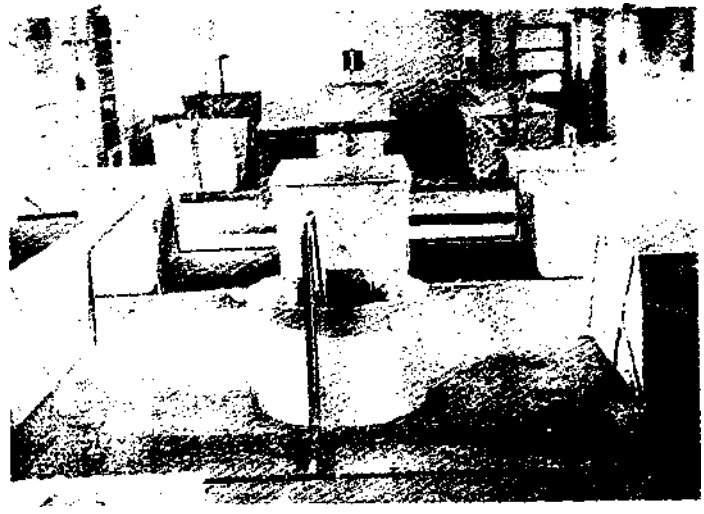
Marine algae studies at Minicoy and Kavaratti atolls in the Lakshadweep region showed a great potential for the large scale cultivation specially in the shallow lagoons.

Phenological observations on the mangrove species of **Rhizophora, Avicennia** and **Kandelia** from Chorao Island (Goa) showed that although there was a tremendous production of floral buds and flowers, the number of mature propagules were few which directly affects the growth.

3.4.2 Coastal Aquaculrure

(a) Aquaculture in waters of Goa

An aquaeulture laboratory with running seawater facility, open circulation system and other research amenities was commissioned in May 1981. The seawater pumped in settling tank is distributed through rigid PVC pipes, which thus avoides any metal contamination.



An inside view of the Aquaculture Laboratory.

(i) Induced breeding in mullets: Work on the stimulated spermiation and ovulation in mullets by gonadotrophic preparations and hyposhyseal extracts, for the mass production of quality fish seeds, has been initiated. Experimental work, on the enhancement of growth in mullets by using indigenous diets, has also been started. Feeding trials are being carried out and the growth rate is being evaluated.

(ii) Studies on genetics and selective breeding of cultivable estuarine and marine species such as mullets and **Penaeus monodon** have been initiated.

In the feeding experiments on the juveniles of **Metapenaeus monoceros,** twelve feeds of zooplankton preserved in 5% formalin, 5% acetic acid were tried after thorough wash in unprocessed and pellet forms. Studies revealed that these feeds were acceptable and consumable but had a low protein, carbohydrate and lipid contents as compared to those unpreserved ones. The former diets were infact more easily digestable. The values of gross growth efficiency and net growth efficiency ranged between 2.40 to 26.94% and 3.05 to 40% respectively.

(iii) Chromosomal studies: Studies were carried out on dominant species of copepods, exposed to the recent total solar eclipse (date 16.2.80). Chromosomal aberrations in the form of unequal homologous pair and a supernumerary chromosome was noticed in species **Paracalanus aculeatus.** The normal karyotype comprised of 6M + 4SM + 2A chromosomes whereas the abnormal karyotype had 6M + 5SM + 2A.

(iv) Mass culture of feed organisms: In order to provide adequately palatable and nutritionally rich feeds to the cultivable species of bivalves, shrimps and finfishes, the mass culture of green algae, rhabdocellid flatworms. harpacticoid copepods and cladocerans has been started.

(v) Commercial culture of mussels: Under the TOKTEN scheme of the United Nations Development Project (UNDP) & CSlR, a feasibility survey on the starting of commercial cultivation of green mussels by raft culture and or long lines, in Goa, was carried out. Site selection, based on environmental requisites, was finalised. The project, proposed to be operated in collaboration with the MYTICULTURE Inc., Ottawa, Canada, besides the production, will also undertake the processing, marketing and extension.

(vi) Unialgal culture: The unialgal cultures such as **Bacillaria paradoxa, Fragilaria oceanica, Rhizosolenia sp., Nitzschia closterium, Pleurosigma** spp. and **Chaetoceros socialis** are maintained for experimental and aquaculture purposes.

(vii) Seaweed cultivation: Standardization of seaweed cultivation techniques at Malvan is in progress. Seaweeds of economic importance such as **Hypnea musciformis, Gracilaria corticata** and **Sargassum** sp. are being cultivated using transplantation and spore settlement techniques.

(b) Aquaculture in waters of Cochin

The work carried out under this investigation is reported under the Regional Centre, Cochin.

(c) Laboratory and field studies on bioenergetics of some marine and estuarine animals

Biochemical changes and energy content of eight species of mangrove foliage **(Rhizophora mucronata, R. apiculata, Avicennia officinalis, Acanthus ilicifolius, Sonneratia alba, Kandclia rheedii, Bruguiera paraviflora** and **Derris trifoliata)** at different stages of life and decay were studied. Increase in the nutritive value of the decomposed mangrove foliage has been attributed to the high microbial flora present in the estuarine waters of Goa. Feeding experiments with **Metapenaeus monoceros** using the partially decomposed mangrove leaves (detritus) of the above mentioned species, showed high food conversion efficiency.

Feeding experiments with the fish, **Etroplus surantensis** using a compounded feed (Acetus 60%, rice bran 20%, Groundnut cake 8%, Tapioca flour 10% and cellulose 2%) at different ration levels were conducted. Maximum growth was recorded at 10% ration level. 175, 450, 650 $cal/kg^{0.8}/week$ represented maintenance, optimum and maximum levels respectively. Utilization of energy at the maintenance level was found to be 33.91% of ths gross energy in the food ration given to **Etroplus** sp. The gross maintenance of protein ration per week amounted to 100 kcal/kg. The utilization of gross protein energy at the maintenance level worked out to be 33.97%. The optimum ratio for effective growth under laboratory condition was found to be 10% live body wt./day.

Food conversion efficiency and biochemical changes of **Metapenaeus Monoceros** (300 — 400 mg wet wt.) have been studied in relation to different daily ration from starvation to 18% of the body wt. under laboratory condition. Shrimps were fed with a compounded diet (Acetus 60%. Rice bran 20%). On theoretical derivations, average daily feeding rates of 29, 100 and 150 mg dry food/prawn/day represented maintenance optimum and maximum feeding levels and reduced moulting. Growth efficiency (k_1 x k_2) increased from 7 to 12% of feeding level. Shrimps fed at 18% of their body weight recorded the lowest conversion efficiency. Water content of starved shrimps was highest (87.49%). Specific dynamic action was found to increase twice at the observed maximum feeding level (18%) than at the optimum feeding level (10%). This showed that the energy cost of converting food into body tissue increases twice at higher feeding levels, therefore it is an important factor in culture operation.

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

The progress made under this project is reported under Regional Centre, Cochin.

3.4.4 Biology of ecosystems under different environmental stresses

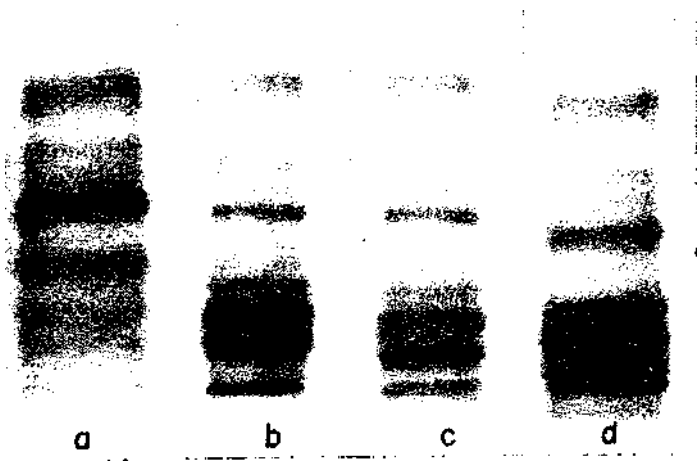
(a) Pollution effects on bottom living communities

(i) Effect of domestic sewage on an estuarine sandy beach fauna: Meiofauna of sewage polluted sandy beach and subtidal regions of Mandovi estuary of Goa were studied. Most of the organisms were restricted to the top 5 cm of the substratum. Nematodes followed by harpacticoids were numerically significant.

A characteristic response gradient in the distribution and abundance of meiofauna in relation to the distance from the source of pollution (sewage) input, was observed. Clear seasonal pattern was observed in the distribution of fauna with significant differences in the mean population density. Differences in the distribution and abundance of fauna could be traced to the organic enrichment, through sewage and heterogeneity of the environment.

(ii) Long term effects on benthos: A critical study for evaluating the long term effects (1973 to 1981) of industrial pollution on the benthic life in the environs of Bombay Harbour was carried out. Bottom fauna in the depth range of 15 to 120 m. comprised of 12 major taxa. It was observed that in the nearshore areas, within 50 km distance from the shoreline, the fauna was very scanty compared to offshore areas, between 50 and 90 km. Most noteworthy observation was that the faunal abundance had declined with the passage of time and at certain places, close to the shore, there was total absence of life on the sea floor. Qualitatively, the fauna became less diversified and dominated mainly by polychaetes.

(b) Electrophoretic studies of fishes: Studies were conducted under controlled conditions on the long-term and short-term effect of low and high concentrations of mercury, a toxic pollutant Electrophoretic patterns of blood serum, haemoglobin and eye lens proteins of fishes **(Tilapia mossambica)**, and tissue uptake of the metal were investigated, along with preliminary studies on the acute toxicity and growth efficiencies. The eye lens protein patterns were quite constant throughout the period of exposure. The electrophoretic patterns of the serum and haemoglobin, however, showed changes in response to mercury, which were more obvious in the serum proteins with respect to number, mobility and intensity of protein fraction. The stress— pattern of **T. mossambica** serum has been determined.



Electrophoretic patterns of serum protein of **Tilapia mossambica** after 72 hrs, exposure in 0.4. 0.6 & 0 8 ppm of mercury respectively. (a) indicates control pattern.

(c) Studies on algal species and mangroves

(i) Studies on the effect of an insecticide (Dimecron) on the photosynthesis and respiration in six marine algal species, revealed that the Chlorophyta members showed least effect of insecticide, whereas, the members of Phaeophyta showed adverse effect on photosynthesis.

Effect of insecticides like Dimecron, Nuvan, Cumann and Nuvacron (Ciba Products) was studied on the seedlings of **Avicennia officinalis** and **Bruguiera gymnorhiza.** High concentrations of these insecticides showed mortality in both the species.

(ii) Investigations on the distribution and uptake of urea by phytoplankton in estuarine, coastal and oceanic water were taken up. Preliminary observations have shown that urea forms substantial source of nitrogen as compared to inorganic sources of nitrogen.

3.4.5 Marine microbiological studies in the seas around India

A comparative study of intertidal microbial ecology from three different areas viz. Banastarim (mangrove), Miramar sandy beach (open) and Dias beach (sheltered) was carried out from September, 1980 to April, 1981. Besides microbiological characteristics, various physico-chemical parameters were also monitored at monthly intervals. The clayey sediments (Banastarim and Dias Beach) always showed higher bacterial population compared to the sandy beach. The increased population is attributed to higher carbon and nitrogen contents. The percentage occurrence of the various physiological groups like the lypolytic, amylolytic and proteolytic were found to be consistently high in clayey and silty sediments throughout the period of investigation. The predominant genera were **Bacillus, Micrococcus** and **Staphylococcus**.

Mixed culture of cellulose degraders have been obtained from the mangrove ecosystem. When mixed cultures were plated, four morphologically different colonies could be recognized, three of which were Gram-negative rods and the other one was Gram-positive non-sporing rods. Preliminary experiments with the crude enzyme (culture filtrate) showed the presence of both endo and exo-glucanase. Further studies on the kinetics of the enzymes and the interation of cellulolytic bacteria with non-cellulolytic bacteria are underway.

During the 86th and 87th cruises of RV Gaveshani manganese nodules were collected from the Indian Ocean area from the grab samples to study the role of bacteria associated with the nodules. A quantitative and qualitative assessment was made from (i) surface of the nodule; (ii) core of the nodule and sediments from nodule and non-nodule areas. Maximum populations were recorded in nutrient agar medium prepared with sea water. Interestingly nitrogen free medium also supported a significant bacterial population, an observation which was not recorded earlier. Actinomycetes, fungi and yeasts were not observed. Core population was relatively very low compared to the surface of the nodule.

Further studies with 120 strains out of 210 strains isolated from the nodule

and sediments, showed that the population was dominated by non-spore forming and spore-forming Gram-Positive bacteria (rods). The isolates were found to tolerate a wide range of salinity (0-32%o) Biochemical tests showed that most of the isolates were proteolytic and able to utilize sucrose and lactose. Acid production was more pronounced with sucrose as the substrate. The isolates have been tested for their ability to oxidize Mn (accretion) and to reduce it (dissolution). Preliminary experiments showed reducers seem to be more common than the oxidizers.

3.4.6 Studies on marine fouling, wood preservation and corrosion along the Indian Coast

Under this project observations have been carried out on (a) Bio-fouling, (b) Wood-destruction and (c) Corrosion.

(a) **Bio-fouling:** The data on bio-fouling — micro as well as macro, were collected from Mandovi-Zuari estuaries and nearshore stations by exposing the panels of different materials such as mild steel, timber (mango wood), electro-plated brass, with cadmium, chromium and aluminium panels at different depths. The extent of monthly and seasonal settlements have been investigated in relation to the environmental parameters such as temperature, salinity, dissolved oxygen and pH.

Considerable bio-fouling on mild steel panels was found during February-March at the estuarine stations, and consisted of sessile barnacles **(Balanus amphitrite),** Hydroides, bryozoans, serpulid worms, tunicates, green mussels, oysters etc. The studies on succession of species showed that in March, sessile barnacles were abundant whereas in August they were replaced by the encrusting bryozoans. At nearshore stations, high values of biomass were replaced by the encrusting bryozoans. At nearshore stations high values of biomass were observed at 1.5 and 6 m depth. The electroplating of brass with cadmium was found to be quite effective in

Bio-fouling on mild steel plate in an estuarine environment of Goa.

resisting the fouling settlement as compared to nickel-chromium plating. The biomass values were found to be 4.220 g and 5.020 g at 5 and 8 m respectively for cadmium plated brass, whereas for the same depths the respective values were 61.350 g and 48.270 g on nickel-chromium plated panels.

From the data on settlement of fouling on moving objects such as ore-carrying barges with an average capacity of 500 tonnes, a biomass of 0.95 tons/ry/barge has been estimated, which causes frictional resistance of about 9204 pounds during operation.

(b) Wood destruction: The data on destruction of timber panels showed that maximum destruction of panels took place at 4.5 m under estuarine conditions. During the pre-monsoon period **M. strata** was found to be the main species of wood-borer responsible for destruction of timber. The pattern of bio-fouling on timber panels was found to be more or less similar as on mild steel panels.

(c) Corrosion: Studies on corrosion were continued during the year. Preliminary observations on the rate of corrosion of mild steel panels under estuarine and nearshore conditions showed a maximum corrosion in surface waters decreasing gradually with the depth. An experimental technnique to quantify the relationship between corrosion and bio-fouling is being developed.

3.5

Ocean Engineering

3.5.1 Ocean engineering studies related to coastal and offshore development

In order to understand the mechanism and to suggest remedial measures for coastal erosion problems, a field programme for the collection of data on waves and currents was carried out during the monsoon season. In this connection, two Aanderaa current meters and wave rider buoy were deployed off Mandovi estuary. The data is being statistically analysed using inhouse TDC 316 Computer.

Considerable amount of work on storm surges and wave hindcasting using numerical models has been carried out during the year. A shorter version of the numerical model on storm surge computation has also been prepared and implemented on TDC-316) computer.

3.5.2 Marine geotechnical studies

Sand samples from different beach stations along Goa coast (Campal, Miramar, Caranzalem) were collected and analysed for grain size distribution.

Fabrication of a piston gravity corer for getting undistructed marine soil sample, is in progress.

3.5.3 Energy from the sea

Status reports on Ocean Thermal Energy Conversion (OTEC), Tidal Power, Wave Energy, Salinity Power and Coastal Aquaculture in India were prepared with up-to-date information about the latest development in these fields.

A laboratory model of an OTEC Plant of 200 watts capacity is under fabrication.

A series of experiments on solar pond on a laboratory scale using a fibre glass tank were conducted. In these studies, the density gradient of the water was about 0.15 g/m. At a depth of 85 cm the temperature rise over the ambient temperature was found to be around 35° C while at surface the temperature increased by about 11°C only. Further, these experiments revealed that a clear plastic sheet floating on the surface of the water collects as much heat as a glass cover. Further studies are in progress to optimise the characteristics of the solar pond and to utilise the heat energy.

3.6

Marine Instrumentation

3.6.1 Development of marine instrumentation system

Electronic digital printers have been specially designed for printing the output ECD data from user's digital instruments/systems. The capacity column can be extended upto 15 digits and a special character also could be printed out to mark any event. The specifications of the unit are as following:

1. Print cycle time	:	400 msec (approx.)
2. Column capacity	:	Upto 15 columns
3. Character positions	:	Upto 13 positions, numerals 0 through 9 and other symbols
4. Data entry	:	Parallel (all columns)
5. Character spacing	:	Column spacing 3.00 mm, line spacing 4.5 mm
6. Print colour	:	Red/Black
7. Paper	:	Ordinary paper Width: 58 + 0 mm Diameter: 70 mm
8. Power	:	+ 17V DC 25 Watts (Approx.)
9. Print command/manual print	:	Logic 1 to 0 transition Logic 0 duration 1 msec minimum
10. Paper feed		Logic 0 produces continuous incremental paper feed at approximately 2.5 lines/sec

Seven Nos. of Rotor current meters are developed and arc in use at the Waltair and Bombay Regional Centres of NIO. User flexibility and digital readouts are incorporated for higher accuracy.

3.6.2 Development of multi-parameter buoy telemetry system

Data buoy system consisting of seven sensors viz., wind speed, wind directio buoy heading, air temperature, sea surface temperature, buoy temperature and relative humidity is designed and developed.

The 6 months' hourly data is recorded and stored on cassettes for onshore play back, on TTY through a reader. The entire electronics for the data acquisition and processing is based on Intel 8085 microprocessor. The power supply is derived from sealed lead acid batteries charged by the solar panels. The mechanical buoy structure comprises of 25 Nos. of HDPE modules capable of providing 1.3 tons of buoyancy. The system is undergoing field trials.

3.6.3 Development of microprocessor based system

(a) Audio cassettee recording method is developed for SDK-86 base data storage and retrieval. Audio cassette recording is very popular and a low cost method for program data storage in microprocessors applications. At the 25 characters/sec, recording rates, the normal C-90 cassette can hold more than 100 K bytes.

(b) An ocean wave digitizer was designed around SDK-86 kit at the request of Physical Oceanographers to provide the digitized data on the paper tape punch in computer compatible format. The system digitizes analog data using ADC-80, 12 bit A-D interfaced to microprocessor kit at every 1/2 sec. and puts it on paper taps punch.

Model of Data buoy developed at NIO.

(c) Data acquisition software for NIO ocean data buoy was developed using MDS236 microprocessor development system and was tested on the general purpose 8085 microprocessor board. An 8085 microcomputer board is switched on for 32 sec. for every hour by the CMOS clock driver. Once the power is on, the microprocessor multiplexes analog channel sequentially. Each channel is repeatedly measured and average value is stored in the RAM and then the data is transferred to the Memodyne digital cassette recorder in the selected format.

3.6.4 Development of underwater acoustic instrumentation system

(a) During the year, a concerted effort was made on the development of a self-recording tidal instrument using a pressure transducer fabricated at the ISRO, Bangalore. A complete prototype system working on lead acid batteries charged by solar panels was demonstrated at the Wisitex International Exhibition held at Bombay. In this system, the user can preprogram the rate at which tidal data is sampled once in 1 to 15 minutes. Analog signals from the underwater unit are brought

to the deck unit, digitised by a twelve bit A to D converter, and stored on RAMS (random access memories). The card containing the data can be unplugged from the main deck unit, and inserted into a read-only unit which displays the data as a tidal trace on a chart recorded.

In the development of this prototype, several aspects such as power consumption of the logic circuits, the choice of a suitable ADC and RAM chips etc., were overlooked.

(b) Software programs for the new micro-based tide gauge using Intels 8086 machine language have been developed and tested successfully on a SDK-86 microboard. Work on the 8085 version of the same programs using the MDS development system is in progress, and would be incorporated in the new tidal gauge.

3.7

Planning and Data

Planning and Data Division continued its activities during the year. The work carried out by each section is as follows:

3.7.1 Planning, Monitoring and Evaluation

Planning, monitoring and evaluation section formulated research projects for 1981-82 in consultation with Project Leaders Periodic Reports and Annual Plan 1982-83 comprising of project budget for 81-82 and 82-83 were prepared. Various other documents such as proposals for establishment of regional centres at Madras and Port Blair, Institute's profile for the next 20 years were prepared.

A close liaison was maintained with Planning Division and Technology Utilization Division of the CSIR and also with collaborating agencies.

3.7.2 Publication and Information

Publication and information section is engaged in catering to the information needs of the user community to bridge the gap between scientists and the public. Activities under Technical Information and Publication Services (TIPS) in oceanography have been enhanced. Various activities undertaken are as follows:

(a) Publications

The following regular publications were brought out in the year 1981 relating to the R & D projects :

1. **Mahasagar:** Publication of this quarterly research journal was continued and the 1981 (Volume 14) issues have been published.

2. **Annual Report 1980:** Information relating to R & D projects on different aspects of oceanography, sponsored projects, cruises and other activities of the Institute for the year 1980 is included. This is the 16th report in the series after the inception of the Institute.

3. **NIO Newsletter:** This gives information on the major activities of the Institute and is continued on quarterly basis. All the four issues of Vol. III were published.

4. Cruise Reports: Soon after the completion of each cruise, a report is published giving the cruise details and preliminary findings. During the year under report 17 cruises were completed and as many number of reports have been brought out.

5. Annual Oceanographic Cruise Report: This publication is a source of Information on the activities of **RV Gaveshani** at the sea. This consolidated report for the year 1980 is under compilation.

(b) Information: Various display charts and models were prepared for the exhibition at India International Trade Fair, New Delhi held from November 14 to December 4. Visiting parties consisting about 3500 students, scientists and research scholars were attended to. The following information products were brought out.

(1) Directories: During the year three directories were brought out viz, (i) Indian National Directory on Marine Research Projects giving almost all the projects under operation in marine based institutes in India, (ii) A third and revised version of Indian National Directory of Marine Scientists has been released. This includes the names of 958 scientists from 75 marine institutions in India in different disciplines of oceanography and (iii) a Directory on Training & Education Facilities in Marine Sciences in India at different levels.

(2) **News items** on R & D activities on the major achievements of the institute are regularly reported to CSIR and to mass media.

(3) **Brochure:** A new brochure on the RV **Gaveshani** was brought out on its completion of 100 cruises.

(c) **Reprographic Services**: This facility has been provided extensively to the staff and also to outside parties.

(d) **News clippings**: All scientific news items about the activities of the Institute appearing in News papers are clipped. Similar news items concerning oceanography in general are also collected and catalogued.

(e) **IOC Depository Centre**: The centre continued to serve as IOC Depository Centre and publications were received from UNESCO, UNEP, WHO and WMO for use at the Institute.

3.7.3 Indian National Oceanographic Data Centre (INODC)

INODCs activities of acquisition, processing, storage and dissemination were continued during the year. This year the following extra facilities were added to upgrade the TDC-316 system.

(a) Programmable Asynchronous Series Communication Interface (PASCI): this enables to hook up any device with output signal compatable to RS 232C with TDC-316 system.

(b) Aanderaa Tape Reader: Tape reader was interfaced with PASCI controller to the TDC-316 for processing of raw data of current meter on quarter inch magnetic tape.

(c) CRT DM10: This has been interfaced to work under DOS-316 working system. This can display Beehive's 80 character per line and a maximum of 24 lines.

Details of some of the important activities are as follows:

(a) **Acquisition:** The data on physical, chemical, meteorological, BT and STD collected by RV **Gaveshani** during thirteen cruises (1978 and 1979) from 239 stations has been acquired. These cruises were undertaken in Bay of Bengal, Arabian Sea and Andaman Sea and also includes cruises undertaken as a part of MONEX-79. The data from BTOS magnetic tapes were transferred through special convert programme to DOS-316 structure magnetic tapes for future use.

(b) **Processing:** Data on R & D and sponsored projects were processed as given below.

(i) Current data off Godavari for vertical and horizontal components were computed.

(ii) Geological and geophysical data of magnetic anomalies in the Bay of Bengal.

(iii) MBT and XBT data of Monex Cruises.

(iv) Physical and Chemical data collected by INS Darshak.

(v) Oceanographic data in EEZ of Kerala, Andhra Pradesh, Tamil Nadu and Andaman and Nicobar Islands.

(vi) Survey data for position fixing.

(c) **Software Services:** The Centre continued to develop software services to assist processing, analysis and dissemination. Two systems on machine language were developed viz. (i) to decode and correct MOEM (Memodyne) tapes containing wave data. This system changes the character codes from Binary to EBCDIC and also converts the MOEM tape to the DOS-316 structure tape and (ii) to convert and transfer the raw data from Aanderaa tape recorder to DOS unlabel magnetic tape in EBCDIC character set. Besides this, the following systems were also developed.

(i) System for wave data editing and correction (SWADEC)

(ii) Computer aided data retrieval system (CADRE)

(iii) Computer aided directory information system (CADIS)

A new format for the current data has been developed for processing and storage on magnetic tapes. For exchange of temperature and salinity data, a new BATHY-TESAC format is being used. Also the centre continued the transfer of oceanographic data into General Format-3 (GF-3) developed by IODE of IOC.

In addition, the following computer programmes were developed in FORTRAN and COBOL for processing and management of oceanographic data and information.

SINGLE : Single linkage cluster analysis, computes similarity matrix and similarity level and prints the cluster members whenever cluster pattern changes.

VARIAN : It computes the analysis of variance and total variance along with error and degree of freedom.

T-TEST : Computes the mean, variances, standard errors and significant tests for both large and small samples.

PROBIT : Does the Probit analysis of the data under which it determines LC50 and 95% confidence limits for LC50 and slope.

MSQPLOT : It generates tables and plots the station locations in the Indian Ocean for different Marsden squares.

TREKAN : Subroutine for printing the grain size samples in a Trekaman Triangle.

DYKE : For elementary processing of geological oceanographic data.

POTEMP : Computes potential temperature from the input hydrographic data.

RSHD : To retrive the selected hydrographic data from INODC data bank as per the users request.

COSPRO : To prepare the estimate of the sponsored projects.

DOFART : To determine the oxygen content at particular salinity with different fertilizers.

(d) Data Dissemination

Request for oceanographic data were received from Indian Navy, universities and many private organizations and the required data were supplied to them. As a part of data dissemination an INODC Newsletter, 1980 was compiled giving mainly the cruise information and data collected by **RV Gaveshani.** Also the Inventory Forms of ROSCOP (Report of Observations/Samples collected by Oceanographic Programmes) and ROMBI (Results of Marine Biological Investigation) were completed for **Gaveshani** cruises undertaken during 1980 and 1981.

(e) Additional Services

Computer facilities were made available to various educational institutions viz. Engineering College, Medical College and Polytechnic for data processing and other technical purposes.

3.8

Regional Centres

3.8.1 REGIONAL CENTRE, COCHIN

A. R & D Projects

During the year the centre continued its research activities on six R & D projects. Details of the work done under each project is as follows.

A.1 Aquaculture in waters of Cochin

(a) Studies on growth dynamics

The experimental studies on the growth of **Penaeus indicus** and **Metapenaeus dobsoni** for three and a half months under different levels of feeding gave a growth pattern different from that of von Bertalanffy as described by some authors. The two distinct growth patterns observed under field and laboratory conditions were therefore evaluated. The growth data were fitted by a linear equation, exponential equation and a second degree polynomial. The latter was found to describe the growth best within the observed range. Retardation of growth was faster in tanks with higher frequency of feeding, suggesting less efficient food conversion compared to prawns under lower frequency of feeding. Laboratory experiments suggest that the length-weight exponent of **P. indicus** and **M. Dobsoni** may be species specific. The length-weight exponents from field samples did not show any significant difference which supports the laboratory findings. Condition factor gave much higher values in nature indicating that the conditions are favourable for their growth in The regions sampled.

(b) Ecological studies

(i) Ecology of certain paddy cum prawn culture fields

The species composition, relative abundance, growth rate and production of the important species of the prawns from 28 stations representing different environment were studied in relation to the physico-chemical characteristics of the environment, the quality and quantity of phyloplankton, zooplankton, benthos, and the nature of the substratum. There was very marked variation between a pond at Thripoonithura towards the south east of Cochin, and another at Ayyampilly to-

Perennial prawn culture ponds in Cochin backwater

wards the north west. At the former station, the values for ammonia, nitrite, nitrate and phosphate were found to be high, probably due to the discharge of effluents in the region from a fertilizer factory.

Areas near the harbour entrance did not show very high variations in nutrient concentrations, but the salinity showed considerable fluctuation (0.5-34‰). Experimental studies have shown that prawns during their intermoulting period are highly voracious and heavily feed on tanaidaceans, amphipods and certain other benthic organisms.

To understand the trends in the fluctuation of prawn production in the filtering fields, data were collected on the annual prawn landings from a number of individual fields to correlate it with the different environmental parameters.

(ii) **High density culture of the shrimps**

Penacus indicus: To study the ecological problems confronted with dense cultures in natural systems, culture experiments were continued using the seeds of the fast growing species **P. indicus**. Culture enclaves were made by fixing Velon netting on raised mud bottom. Each enclave, having an area of 50 m^2 was stocked with 1000 seeds. The feed used was a compound, made from rice bran, groundnut cake, shrimp waste and tapioca.

In one series of experiment, seeds of 20-40 mm having a modal size of 30 mm were used. After 6 weeks, the modal size was 100 mm (weight 6.6 g). After 8 weeks the shrimps were harvested as they began to show the sign of suffocation, especially after midnight. Survival rate was about 62.5%. Harvested shrimps had a modal size of 125 mm weighing about 13.5 g.

In another series, seeds of 45 to 65 mm having a modal size of 55 mm were introduced but harvested after six weeks as the system was found to get polluted. The harvested shrimps measured 125 to 145 mm with a modal size of 135 mm weighing about 18 g.

During the course of experiment ecological parameters such as temperature, salinity, pH, dissolved oxygen, turbidity and organic matter in the substratum were recorded. Plankton and benthos of the culture field as well as those of the feeder canal were sampled at regular intervals. The most important ecological factor affecting the shrimp in the high density culture enclaves were the accumulation of organic wastes and the consequent lowering of the level of dissolved oxygen. Diurnal oxygen pulse of the culture enclaves fluctuated between 6.2 to 1.0 ml/1. The minimum was during the dawn hours when the shrimps, particularly larger ones were found swimming at the surface.

In certain localities in Vypeen island, the colour of the water turned light red due to the bloom of a flagellate.

(iii) Shrimp seed nursery

Shrimp seeds measuring 30-50 mm seems to be ideal for stocking in the production ponds. There is scarcity for seeds of this length group, during the farming season. Since hatchery production has not become a reliable source in our country, farmers depend largely on the natural source. Hence the possibility for organising a seed nursery has been investigated during the year. For this, post-larvae of **P. indicus** measuring 5-20 mm were collected using suitable Velon netting from the Cochin Harbour area and transported to Narakkal farm and stocked in nursery ponds set inside the paddy fields. Supplementary feeding was done using rice bran and groundnut cake. In four weeks the post-larvae attained a size of 40-55 mm with a survival rate of about 60%.

(iv) A survey of bivalves for aquaculturc and ecological studies

A survey was conducted in the Cochin backwaters, to assess the importance of bivalves for aquaculture needs. Monthly samples were collected from four stations fixed for the study. Bivalves were not very abundant and do not occur in all the collections. Data on the environmental parameters and the benthic population is also collected and the study is in progress.

(v) Studies on the clam bed near Ramanthuruth

Near the Ramanthuruth island, in the Cochin backwaters, a clam bed extends to the northern and western part of the island. There is filling activity going on in the western side, with increase in silt content and consequent decrease in the clam population. Hydrographical parameters along with density of the population are observed every month to study this relationship.

A.2 Biogeographical ecological and experimental studies on phytoplankton and zooplankton from the Indian Ocean

(i) Studies on pelagic polychaetes

Work connected with the publication of a monograph on the pelagic polychaetes was continued. Comprehensive survey of the literature on the group from the world ocean was completed. Part two of the monograph would be concerned with the detailed geographic distribution of the Indian Ocean species.

(ii) Copepods

Studies on the calanoid copepods of the family Acartiidae was undertaken and is in progress. **Acartia amboensis, A. negligens** and **A. dana** were observed in the oceanic waters and **A. erythraea** from neritic waters.

Investigations on the Siphonostomae (Copepoda, Cyclopoida) were completed. **Pontoceiella abyssicola** and **Eatania flava,** have been recorded for the first time from the Bay of Bengal and male of the former was the first record from Indian Ocean.

Crycaeidae (Copepoda-cyclopoida) sub genera **Agetus** and **Monocorycaeus** and the species **Cocycaeus (Corycaeus) speciosus** were studied to understand their distribution pattern.

(iii) Fish larva

Distribution and larval characters of 26 species of fish larvae from the Arabian Sea and the Bay of Bengal were studied. General, seasonal and diurnal distribution of fish larvae in the area was investigated in relation to important oceanographic parameters. Relationships between fish larvae and zooplankton biomass, frequency of occurrence and number of larvae etc., were traced.

(iv) Studies on trophodynamics

The data collected during IIOE are being analysed for defining trophodynamic relationships affecting the plankton community.

A.3 Other studies

(a) Studies on distribution of planktonic Foraminifera in the Arabian Sea and their ecological relationships with hydrographical conditions

The above work was initiated by collecting 52 plankton samples, surface (0-10 m) and vertical (0-200 m) from the eastern Arabian Sea, adjoining Konkan coast between 11-15°N and 68-72°E, on board **RV Gaveshani** during the period from 1st October to 15lh November, 1980. Sorting of planktonic Foraminifera from these samples has been completed. 15 species have been identified from these samples, most of which arc characteristic of warm waters. They are grouped into the following assemblages.

(i) Tropical species - Globigerinoides sacculifer, Globoquadrina dutertrei, Globorotalia menardii, G. tumida and Pulleniatina obliquiloculata;

(ii) Subtropical species - Globorotalia Hirsuta and **Hastigerina pelagica.**

(iii) Some species such as **Globigerinella aequilateralia, Globigerinoides ruber** and **Orbulina universa** occur in both tropical and subtropical waters.

(b) Investigation on the foraminifera from Thar desert, India

An interesting study was made by analysing 35 surface sand samples from Thar desert. These have shown the presence of foraminifera of Indian Ocean origin. Studies on distribution, characteristics and species identification of forams is in progress.

(c) Food and feeding habits of hydromedusae

The stomach contents of some common species of hydromedusae from Cochin backwaters were examined to study their food and feeding habits. Examination of **Phialidium brunescens, Eucheilota menoni Black fordia virginica, Eirene ceylonensis, Eutima commensalis** and **Liriope teliaphylla** showed that, the food chiefly consisted of predominant zooplankton during the different months. Fish eggs, small fish larvae, copepods and chaetognaths were found to be the main items of food. Crustacean larvae were also observed occasionally.

(d) Protozoan associates in zooplankton samples

Zooplankton samples from the Cochin backwaters and the shelf and slope areas of south west coast of India were examined for the incidence of protozoan associates. Three species of ciliates were found to be associated with copepods.

(e) Horizontal and vertical distribution of epi- and mesopelagic calanoid copepods in the northern Indian Ocean

Studies on zooplankton samples collected during 7th and 12th cruise of RV Gaveshani revealed a clear vertical zonation in species composition of calanoid copepods. The zones comprised of three depths :- 50-0 m, 150-50 m & 500-150 m, where different species were encountered.

Phytophagus forms like Calanidae, Eucalanidae and parcalanidae dominated the highly productive surface layers, contributing to about 70% in numerical abundance, while in the discontinuity layer. 20% of the population was constituted by omnivores like Centropagidae and Metridiidae, and families Euchaetidae, Aetidiidae, Lucicutidae and Heterorhabdidae which are carnivores formed 40%. the rest being phytophagus forms.

(f) Zooplankton of Gulf of Aden and Gulf of Oman

Zooplankton samples from upper 50 m layers from Gulf of Aden and Oman, collected under a programme between FAO and Norway (Feb. 75 - Nov. 76), were received and analysed at Regional Centre, Cochin.

Copepods formed the dominant component of the premonsoon samples forming 50-80% of the total counts and were fairly uniformly distributed at almost all the stations. Chaetognaths formed the second abundant group. **Sagitta enflata** being the commonest form. Decapod larvae and adults were poorly represented except at a few stations where swarms of stomatopod larvae (Alima) were encoun-

tered. Swarms of the Ostracod **Cypridina dentata** and the Euphausid, **Euphausia distinguenda** were observed at certain stations. Fish eggs and larvae were poor. The study is in progress.

(g) Studies on Wadge Bank

The Centre has undertaken an extensive survey of the Wadge Bank, in view of the uniqueness of the area. During the cruises 92 and 96 of **RV Gaveshani,** a series of zooplankton collections were made and studies are in progress to determine the spawning areas, spawning season and abundance of fish stock.

(h) Study on vertical distribution of zooplankton

The 97th cruise of **RV Gaveshani** covered a track between Cochin and Goa. Along this area, plankton samples were collected to study the vertical distribution of zooplankton.

A new genus and a new species **Hemimysidetes** (Sp. nov.) was recorded from Cochin backwaters. Also two calanoid copepods **Heterorhabdus compactus** from the Bay of Bengal and **H. fistulosus** from the Indian Ocean were recorded for the first time.

(j) International zooplankton collections

The archieves and certain taxa of zooplankton of IIOE are maintained. During the current year many requests for specimen/data were received. Building up of reference specimen is in progress.

(k) Contract sorting of zooplankton

Sorting of zooplankton received from CSIRO, Australia, came to a close by February, 1981. A new species of mysidacea **Petalopthalmus australia** (Sp. Nov.) from samples of west coast of Australia was recorded.

A.4 Oceanography of the waters around Lakshadweep

(a) Zooplankton studies

A survey of abundance and distribution of zooplankton has been carried out in the sea around Lakshadweep group of islands. Abundance of bait fishes depends upon the availability of food, i.e., zooplankton and since tuna fishing is closely Jinked with the availability of bait fishes, the results of the investigation on zooplankton yielded useful information. Zooplankton is more abundant in the waters around Agatti where tuna catch is very high so is the case in the waters around Pitti island. However, at Kavaratti zooplankton is comparatively less and the bait fishes are also less and tuna catch is negligible.

(b) Benthic community of the lagoon

Studies of the benthic community of the lagoon of various islands have been carried out during this year also. The biomass was found to be high at Agatti and Suheli when compared to Kavaratti, Bengaram, Tinnakara and Parli. The biomass

comprises mostly of bivalves, gastropods, polychaetes like **Phyllodoce, Nereis ,** etc., **Amphioxus** sp. and annomuran crab - **Hippaadactyla.**

(c) Reef fauna

A comparative study of the reef of Kavaratti, Agatti and Bengaram islands revealed the diversified and abundant fauna. A random study of the various regions of the reef, revealed the composition to be of crabs, bivalves, gastropods, nudibranchs, echiuroides, holothuroides, etc. The study showed that, functionally similar but unrelated species lived together in the same habitat. Processing of the data is in progress.

(d) Flora

A study of the flora of Lakshadweep has brought out that **Ochrosia oppositifolia** normally seen in upland areas is recorded for the first time from Kavaratti island. A detailed study of its morphological and floral structure is being conducted.

(e) Foraminiferal investigations of the atolls of Laccadive Sea

The atolls at (1) Kavaratti, (2) Agatti and (3) Suheli were chosen for foraminiferal studies. The total population of foraminifera at the stations ranged from 30 to 970 specimen per gram of sediment. Forams belonging to the family Miliolidae have been studied in detail. Thirtysix species and varieties of this family have been identified from the samples of these atolls. Nine genera are represented with **Quinqueloculina** (17 species and varieties) and **Triloculina** (8 species and varieties) as dominant. **Quinqueloculina seminulum, Q. bradyana, Q. parkeri** and **Q. reticulata** have been in highest frequency at most of the stations. Among the eight species of **Triloculina, T. tricarinata, T. trigonula** and **T. affinis** are the widespread miliolids. Other widely distributed members of this family are **Hauerina pacifica, Schlumbergerina alveoliniformis** and **Spiroloculina antillarum.**

A.5 Protection of the marine environment and monitoring of pollutants with special reference to rural areas along the Indian coast

(a) Pollution monitoring along Kerala coast

The condition of beaches along the Kerala coast was thoroughly studied, and based on the data obtained, certain "bacteriological standards" for bathing, are formulated in a general way. Depending on the qualitative and quantitative distribution of **Escherichia coli, Coliform** and **Salmonella** sp., pollution counts (sanitary counts) and the general beach water characteristics, the beaches are classified as follows:

(i) **Highly contaminated beaches,** not suitable for bathing viz. Calicut, Mopla Bay, Neendakara, Vizhingam.

(ii) **Fairly contaminated,** not suitable for bathing during a major part of the year: West Hill, Alleppey, Quilon.

(ii) **Slightly contaminated,** but suitable for bathing: Kovalam, Sankumughom. Payyambalam.

(iv) **Uncontaminated.** suitable for bathing all the year round: Ezhumala. Thappad.

A comprehensive account on the "Health of the Beach" is being prepared.

(b) Estuarine Pollution Studies

(i) Studies on pollution of Cochin backwaters

Detailed investigations in the Cochin backwaters, along the industrial area were continued. High values for nutrients (148 ppm phosphates and 37 ppm ammonia), blooms of planktonic algae and depletion of benthic fauna were recorded at the discharge site, a species of polychaete being the only benthic organism present. The waters of the Chitrapuzha, a river which joins the estuary and which receives effluent from a fertilizer factory, had very high nutrient values with the bottom water almost devoid of dissolved oxygen.

(ii) Studies on certain other estuaries

The Bcypore Kallai, Korauzha, Veli, Ashtamudi and Thottappally estuaries were studied intensively for microbial contamination. Of these, Ashtamudi surface water alone gave a positive record of the Pathogen **Vibro parahaemolyticus.** The year round study of indicator bacteria and general hydrographical features suggests that Veli estuary is a clean area and with considerable potential for tourism. Bacterial counts were maximum at Thottappally estuary.

(iii) Plankton studies in the estuarine system of Kerala

Ecological studies of zooplankton in the major estuaries of Kerala were continued. During the premonsoon period, high salinity conditions prevail in the Cochin, Korapuzha, Mahe, Kallai and Beypore estuaries (34%o in April), while during the same period, in the Veli estuary salinity was only 23%o and at Thottappally. the maximum for the year was 3%o. During monsoon the waters in the estuaries are almost fresh, and a slow trend in increase starts during the post monsoon period. The waters are well mixed and homogeneous in all the estuaries except at Cochin, where during the late monsoon and post monsoon seasons, stratification can be detected. The temperature varies between 20 and 23°C during monsoon and the average temperature was only 31°C during premonsoon. Dissolved oxygen values were generally high in all the estuaries, and did not show much variation between bottom and surface.

Biomass was comparatively high in all the estuaries during premonsoon period, the highest at Cochin, the annual average being 3.25 ml/10 m3, followed by Korapuzha (1.9 ml), Kallai (0.73 ml), Neendakara (0.48 ml), Beypore (0.45 ml) and Mahe (0.35 ml).

A.6 Chemical studies in the coastal and offshore waters in the Arabian Sea and Bay of Bengal

(a) Wadge Bank

During the year studies were conducted in the Wadge Bank region for two different seasons; premonsoon and monsoon. Five sections were worked out from the inshore region towards offshore at an interval of 25 km between the stations. Three nearshore stations were chosen for studies in relation to tide for a period of

24 hours. The chemical parameters studied were pH, dissolved oxygen, inorganic phosphate, ammonia, nitrite, nitrate and silicate.

A preliminary analysis of the data showed that the surface waters were rich in nutrients during both the seasons. Inorganic phosphate values in the surface waters were always higher than 0.5 µg at/1. Nitrate and silicate also showed high concentrations during the period of observation. Another feature observed during this period was the lifting up of the oxygen discontinuity layer to less than 30 m in the nearshore region and to less than 50 m in the offshore region. The temperature of the water was also low. This phenomenon was observed during both the seasons, but with varying intensities. This feature is associated with the upwelling. The waters in the Wadge Bank area is highly fertile probably giving a clue to the rich fishery reported from this area.

(b) Studies on inshore areas and backwaters

Studies on the phosphorus and nitrogen cycles in the coastal shallow environment of Cochin indicated that phosphorus is regenerated actively from the mud to the overlying water. The particulate organic phosphorus formed the major fraction of the total phosphorus available in the water. Various nitrogen fractions were poor in the interstitial water whereas inorganic phosphorus content was high. The main source of nutrients seems to be through the river run off and also partly contributed by fertiliser factory situated upstream.

Primary productivity studies conducted in the shallow coastal environment of the Ramanthuruthu island showed that the island is highly productive. The phytoplankton production was maximum during the months October and November (200 $mgC/m^3/day$) and February and March (100 $mgC/m^3/day$) following the south-west and north-east monsoon respectively. Chlorophyll 'a' concentration was also high throughout the year with peaks coinciding with productivity values.

A.7 Studies on land sea interaction and nearshore circulation with application to coastal zone management

(a) Hydrography and nearshore circulation

During the year the hydrographic survey of the Wadge Bank was carried out from the coast to the southern slope of the bank upto a depth of 2500 m. The survey was conducted during 92nd and 96th cruises of **RV Gaveshani.** The survey covered the premonsoon and the monsoon seasons. Observations were taken from twentyseven stations in each of the cruises. The data collected is being processed.

The preliminary examination of the vertical distribution of the physical parameters showed the presence of cooler and high saline water nearshore as compared to the offshore region indicating the presence of upwelling in the Wadge Bank during the premonsoon season.

Nearshore currents in the Wadge Bank were measured at depths of about 30 m from three locations - off the Neyyar river mouth, off Cape Comorin and off Manapad during both the cruises. The ship was anchored and the Plessey Direct

Reading Current Meter was used in the 92nd cruise and Aanderaa Recording current meter during the 96th cruise. Currents were measured at hourly intervals for a period of 25 hours covering two semi-diurnal tidal cycles. The analysis of the current data to understand the nearshore circulation is in progress.

B. Sponsored Projects

Progress made under each project is given under section 3.9.

3.8.2 REGIONAL CENTRE, BOMBAY

The centre undertook a new multidisciplinary project entitled "Waste assimilation capacity of coastal waters along the west coast of India and the impact of pollution on the marine ecosystem".

Considerable amount of information on various aspects of pollution off Bombay area was collected, besides the work on several projects. The details of work carried out under each project is as follows :

R & D Projects

A. Waste assimiliation capacity of coastal waters along the west coast of India and the impact of pollution on the marine ecosystem

This project was taken up with an objective of studying various physical, chemical and biological aspects of the coastal waters of Bombay and adjacent areas.

(a) Physical characteristics: A comprehensive oceanographic study off Thal (Alibag) revealed that the coastal waters were generally well-mixed and they possess considerable dilution potential. The shoreward component was stronger during flood tide resulting in an overall shoreward drift of the water at the nearshore stations. This phenomenon was presumed to be due to the proximity of the islets viz. Khanderi and Andheri. The float trajectories confirmed these observations and indicated the possibility of the formation of circulation cells near these islets. The complex advective and diffusive processes contributed largely to the high mixing rates of hypothetical pollutants in the area.

(b) Chemical characteristics: Coastal region of Thal will be shortly receiving about 40 to 45 mld (million litres per day) of liquid waste from process plants and residential sectors of a giant fertilizer complex being set up at Thal-Vaishet. The study was undertaken to evaluate the influence of ammonia (50 mg/l). urea (200 mg/1) and BOD (30 mg/1) associated with the waste water on the base-line water quality parameters. Monthly monitoring at 9 stations upto a distance of 8 km from the shoreline was undertaken during spring and neap tides for about a year to evaluate the concentrations of nitrate, nitrite, ammonia, phosphate, dissolved oxygen, biochemical oxygen demand, suspended solids, pH, arsenic, iron, cobalt, nickel, copper and zinc. The base line data were typical of the unpolluted coastal region and there was negligible influence of the waste water discharge in Thana Creek-Bombay Harbour on the water quality of Thal region. Considering the dilution available in the region it has been considered that the release of treated waste water

in the coastal region at a point beyond 2 km from the shoreline will not influence the base-line concentration to any appreciable extent.

(c) Biological characteristics:

(i) Primary production: In Thal area total chlorophyll showed a variation of 1.17 - 59.57 mg/m^3. Maximum values of phytoplankton pigments were recorded during July to September. Rate of primary production showed wide fluctuations (0.69 - 603.21 mg C/m^2/day). Peak in primary production was observed during August. Thirty-two genera of phytoplankton were recorded at Thal and the most common genera were Coscinodiscus, Pleurosigma, Nitzschia, Thalassiothrix and Synedra.

In the coastal waters of Bombay chlorophyll a varied between 0.44 to 66.22 mg/m^3. In general, there was decrease in phytoplankton pigments towards the offshore area. Maximum pigment values were recorded during the premonsoon period, while the minimum was confined to the postmonsoon period. Population maxima of phytoplankton synchronized with the peak of chlorophyll values. Results of carbon assimilation were comparable with chlorophyll. The range of primary production was 10.32 - 2511.30 mg C/m^2/day.

(ii) Zooplankton production: The Thal area sustained a fairly high standing stock of zooplankton. The annual variation in zooplankton biomass was 0.52 - 134.15 ml/100m^3. Zooplankton production was maximum during the postmonsoon period. The coastal waters of Bombay also showed fairly rich standing stock of zooplankton. The mean zooplankton biomass for the period of study was 13.54 ml/100m3. Samples collected during flood conditions showed high biomass towards the nearshore area while the ebb period samples showed the reverse pattern. The polluted regions were characterised by great amount of fluctuations in biomass and lesser diversity of zooplankton than the unpolluted areas.

(iii) Benthic production: The benthic production in Thal area was moderate. The maximum benthos was recorded during premonsoon and the mean population density was 2711/m^2.

Benthic production was moderate in the coastal waters of Bombay. Mean biomass during the period of study was 5.225 g/m^2. Generally high production was recorded during post-monsoon period. The macrobenthic fauna mainly represented by foraminiferans, polychaetes, crustaceans and pelecypods. Meiofauna was relatively more during premonsoon period. Diversity of benthos gradually increased from inshore to offshore stations.

Other studies included the monthly monitoring of profiles of the Versova beach, much affected by seasonal erosion during the year. Refraction pattern of the -waves along this stretch of Bombay coast was also examined.

B. Sponsored Projects

The Centre worked on the following seven sponsored projects:

1. Investigations for the undercreek pipeline at Kasheli, Bombay

2. Disposal of effluents from the Alkali Chemicals and Fertilizers factory at Tuticorin

3. Studies for the location of sites for the disposal of effluents from Pondichery Distilleries Ltd. and Pondichery Paper Ltd., into the coastal waters of Pondichery

4. Underwater current measurements in Bombay Harbour during the southwest monsoon, 1981

5. Selection of site for effluent disposal off Porbandar

6. Selection of site for the disposal of effluents from the chemical factory at Mithapur, Gujarat

7. Studies on waste water disposal in Mahi estuary.

The progress made under each project is reported under section 3.9.

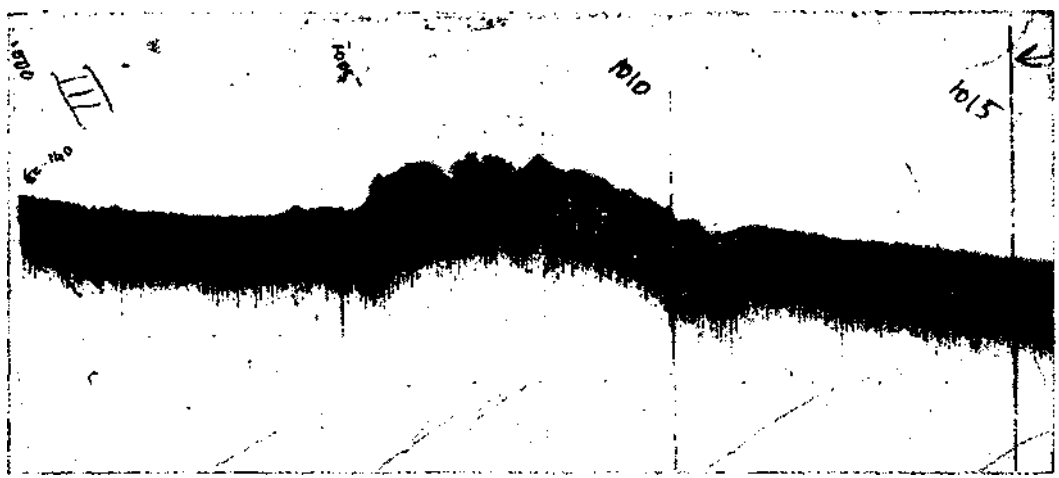
3.8.3 REGIONAL CENTRE, WALTAIR

A. R and D Project

A.1 Geological and geophysical studies

Three anomalous zones have been delineated one each off Waltair, Bhimili and Kutukonda from the earlier magnetic surveys carried out over the continental shelf off Visakhapatnam.

Detailed magnetic and topographic surveys were carried out in. one of the above three anomalous zones upto a depth of 30 metres between Waltair and Uppada. The data were recorded at closer profile interval of 50 metres and sampled



Echogram showing coral reef structure over the continental shelf off Visakhapatnam.

at 5 second interval in order to determine the nature of the high frequency magnetic anomalies associated with black sands. Sediment samples were collected along some profiles in these areas between 5 and 30 m at 5 metres depth interval. Total intensity magnetic map for the area between Waltair and Uppada was prepared. Magnetic anomalies of the order of 1000 gammas were recorded off Kailasa hill. Magnetic anomalies associated with black sand deposits have been identified in some places. Sediment samples are being analysed to estimate the percentages of ilmenite and magnetite concentrations. Sediment distribution maps for the area is being prepared.

Topographic and magnetic surveys were carried out along profiles covering the entire width of the continental shelf. These covered about 50 km along the coast off Visakhapatnam. The ocean bottom revealed several interesting morphological features such as terraces, isolated pinacles and dome shaped karstic structures. No magnetic anomalies were recorded over the dome shaped structure. It is recorded around 70 m water depth and 20 to 30 km in length. The width of the structure varies between 500 and 800 m and its relief is between 8 and 10 m. Sediment samples collected over this feature with the grab and snapper comprise of shell material in high percentage. It thus suggests the presence of reef structures that are formed during the lower sea levels of pleistocene. Detailed sub-bottom seismic profiler surveys and underwater photography are to be carried over these features to elucidate the nature and other environmental conditions that are responsible for the formation of these features and also to assess their economic importance for mining the limestone deposits that are useful in cement industry.

Computer programs like Werner Deconvolution and Modelling for simulating the anomalies caused by placer deposits are being prepared.

A.2 Physical Oceanographic Studies

Monthly observations on beach changes at Yarada have shown that the Yarada beach is in net accretional trend of about 1200 m^3 per year. Weekly observations extending over a year on longshore currents along Visakhapatnam beach have been analysed and they show that the longshore current direction is northeast from April to August and southwest from October to February. The existence of rip currents have been identified on some parts of the coast.

The data on salinity and temperature collected along 3 profiles one each off Bhimilipatnam. Visakhapatnam and Appikonda from April 1979 to February 1981 have been analysed. It shows that upwelling takes place during March-April and sinking, during October and November along the Visakhapatnam coast. The computation of sound velocity from the BT data collected off Visakhapatnam upto 60 m depth is in progress. Studies have been started on the hydrographic characteristics at Visakhapatnam harbour and the beach changes at Visakhapatnam since June, 1981.

A.3 Chemical Oceanographic Studies

Chemical studies were made along the three transects in the nearshore waters off Visakhapatnam covering the area between Bhimilipatnam and Appikonda. The

samples collected at different stations were analysed for the parameters like dissolved oxygen, salinity and nutrients. The seasonal distribution of dissolved oxygen, oxygen saturation associated with the distribution of nutrients indicates the presence of upwelled water during March-April.

With a view to assess the extent of pollution in the Visakhapatnam harbour due to industrial effluents and domestic sewage, studies were carried out with respect to the distribution of nutrients, dissolved oxygen, BOD and salinity in these waters. The data were analysed and the results indicate that the construction of outer harbour retards the tidal flushing resulting in a greater stagnation of these waters. The distribution pattern of phosphate and ammonia indicate the flow of pollutant rich waters at surface towards the sea during low tide. Regular monitoring of pollutants in the harbour waters was also continued during the year. The present work mainly deals with the estimation of heavy metal concentrations in these waters to know the environmental changes made by human activities and industries. The estimation of different fractions of trace metals viz., dissolved, total dissolved and particulate forms revealed that the metals are mostly associated with organic matter.

A.4 Biological Oceanographic Studies

Studies on benthic and zooplankton samples in the Visakhapatnam harbour are in progress in relation to their quantitative and qualitative distribution and the extent of pollution.

B. Sponsored Projects

The Centre worked on the sponsored project entitled "Oceanographic studies for determining the point and mode of discharge of treated effluents from the steel plant into the sea for Visakhapatnam Steel Plant". The progress made under this Project is reported under section 3.9.

3.9

Sponsored Projects

The Institute undertook 12 new sponsored projects of public and private sectors, besides working on other projects which were initiated earlier. A programme of underwater archaeological exploration along the Indian coast in collaboration with Archaeological Department, Tamil Nadu and Indian National Science Academy (INSA) was also started. A brief summary of each project is given below.

A. Pollution control and monitoring

Disposal of effluents from the Alkali Chemicals and Fertilizers Ltd., Madras

This investigation involves the study on the dispersion characteristics of the seas, near the Alkali Chemicals and Fertilizers Factory at Tuticorin. Location of a suitable discharge point for treated effluents is another aspect of the investigation requested by this factory considering the minimum dilution required to avert accidental contamination from the treated effluents from this factory. It was suggested that the discharge point should be located at 500 m away from the shore. A report detailing the findings was submitted to the sponsors in April 1981.

Studies for the location of sites for the disposal of effluents from Pondichery Distilleries Ltd., and Pondichery Paper Ltd., into coastal waters of Pondichery

This project was undertaken at the request of Hydronauts Pvt. Ltd., Bombay. Survey, under this project, for locating effluent discharge points for both the factories was conducted during February and April. Studies on sea bottom characteristics adjacent to the proposed outfall, indicated that the outfall should be located at a distance of 500 m from the shore and the diffusers located near bed at a depth of 8 m and also that the pipeline be burned to avoid the impact of the sea bed topographic changes.

Selection of site for effluent disposal off Porbandar

This project was sponsored by Saurashtra Chemicals, Porbandar. The first phase of this work was undertaken in March to study the general characteristics of the coastal waters adjoining the existing effluent outfall of the factory.

This factory which manufactures soda ash, caustic soda and refined sodium bicarbonate releases industrial waste diluted with sea water, which has high suspended solids and ammonia.

A second phase, involving the detailed study of the characteristics and behaviour of the recipient water body is in progress.

Selection of site for the disposal of effluents from the chemical factory at Mithapur, Gujarat

This project was sponsored by Tata Chemicals Ltd., Mithapur. The first phase of this project involved the study of general oceanographic characteristics of the water bodies adjacent to the sea water intake and waste water outlet of the factory. Field data collection at specific location is in progress.

Studies on wastewater disposal in Mahi estuary

This project was undertaken at the request of Environmental Engineering Consultants, Bombay. Hydrographic data pertaining to the premonsoon, monsoon and post-monsoon period were collected. Biological studies in the estuarine region of the river Mahi, showed a fairly good standing stock of zooplankton, but benthic production was very poor. Sediment textures was sandy at the upper reaches and clayey at the mouth of the estuary. Preliminary report was presented to the company in October.

Hydrobiological survey of the Gurupur river, New Mangalore Harbour and sea off Mangalore (Phase II)

A pre-pollution survey of Gurupur river was requested by Kudremukh Iron Ore Co. Ltd., Bangalore. Study involved investigation on hydro-biological conditions of the area to find out the effects of the pollution on nearshore and intertidal organisms during various stages of their development. A preliminary report was submitted to the sponsors.

Oceanographic studies for determining the point of discharge for treated effluents from the Visakhapatnam Steel Plant into the sea

This project taken up at the request of Steel Authority of India Ltd., Visakhapatnam included monthly collection of oceanographic data on currents, tidal cycles, circulation, etc. The final report incorporating the results of the data analysed was submitted to the sponsors.

Disposal of solid wastes from Gujarat insecticides

The object of this project, sponsored by Gujarat Water Pollution Control Board was to suggest a suitable site for disposal of solid wastes from Gujarat insecticide factory. The work is in progress.

The seabed surveys for the proposed submarine pipeline route for disposal of effluents off Thal, Maharashtra

Rashtriya Chemical & Fertilizers Ltd. (RCF) is setting up fertilizer complex across the Bombay Harbour at Thal (Maharashtra). At their request the discharge point was determined after carrying out comprehensive oceanographic studies. In continuation of the above study the seabed survey of the proposed route from the shore to the discharge point was carried out, which involved echosounding, side scan sonar survey, shallow seismics and core sampling. Report of the study conducted has been prepared.

B. Harbour development

Shallow seismic surveys in New Mangalore port

At the request of New Mangalore Port Trust, shallow seismic echosounding, side scan sonar, ORE & sub-bottom profiling survey was carried out. The data collected is being processed.

Seismic surveys for the development of Karwar port

This project was sponsored by Ports and Inland Water Transport Authority, Karnataka State. The survey involved side scan sonar, ORE & sub-bottom profiling and seabed sampling. The work is in progress.

C. Resources survey

Photorespiration in marine environment

Under this grant-in-aid project sponsored by Department of Science & Technology, New Delhi, studies have been undertaken to understand the living matter in the sea. Study involved the determination of live biomass by various methods. An enzymatic method for determination of glycollate in seawater has been standardised.

Mass culture of brine shrimp, Artemia in salt pans

This project on "Mass culture of **Artemia** in salt pans" was sponsored by M/s. Bharat Salt & Chemicals, Industries (Mundra, Kutch) Ltd., Bombay. The work involved the survey and development of mass culture techniques of **Artemia** in salt pans. Successful techniques have been evolved and the report has been submitted to the sponsors.

Seaweed cultivation at Malvan

Under this grant-in-aid project sponsored by Department of Science & Technology, Govt. of Maharashtra, various experiments on cultivation of seaweeds were carried out using coir rope and settlement nets.

The algal species used for these experiments were **Hypnea musciformis, Gracilaria corticata** and **Sargassum.** Malvan coast is expected to be a good ground for seaweed cultivation.

D. Miscellaneous Projects

Investigations for the undercreek pipelines at Kasheli, Bombay

This project was sponsored by Municipal Corporation of Greater Bombay with a view to gather the baseline data on mechanics of sediment transport in relation to the dredging and maintaining the undercreek channel for laying the freshwater conduit across Bassein creek, Ulhas river at Kasheli. The study has been completed and the report submitted which indicates that the proposed trench across Kasheli may get covered up by sediments very soon.

Underwater current measurements in Bombay Harbour (Middle Ground) during the southwest monsoon, 1981

This project was sponsored by Naval Science and Technological Labora-

tory, Visakhapatnam. Under this project underwater current measurements were made with continuous self-recording current meters which were moored at two locations in Middle Ground Bombay Harbour. The time-series data collected on the near-bottom current velocity during neap and spring phases of the tide, during the south-west monsoon are being analysed.

Shoreline erosion studies at Campal, Miramar and Caranzalem beaches

This project was sponsored by Govt. of Goa, Daman & Diu in July 1981 for shoreline erosion studies at Campal, Miramar and Caranzalem beaches. Regular beach profiles, grain size analysis etc., has been started and the work is in progress.

Hydrographic survey off Cochin

At the request of Naval Physical and Oceanographic Laboratory (NPOL), Cochin this project was taken up. A report on the data collected has been submitted to the laboratory.

The follow-up studies on the beach erosion at Fisherman's Cove, Covelong, Madras

This project sponsored by the Taj Group of Hotels, Bombay was completed and the report has been submitted to the sponsors, suggesting appropriate measures to check erosion and protection of the beach for the suitability of hotel construction.

Marine archaeological studies in the Indian waters

This project was initiated in collaboration with the Department of Archaeology, Govt. of Tamil Nadu and INSA. Project is aimed to provide information on the coastal and maritime history of ancient ports and towns and also on ship wrecks. The first phase of underwater archaeological exploration off Kaveripattanam and Tranquebar in Tamil Nadu has been completed.

The detailed analysis of data is in progress.

Side scan sonar surveys in Mormugao Harbour

This project was sponsored by the Collectorate of Customs and Central Excise, Goa. The data is being processed.

3.10

International Project

Artemia culture: The project on mass culture of **Artemia** sponsored by International Foundation for Science, Stockholm, Sweden has been continued for an extended period from October 1981. Survey to locate the seasonal occurrences along the Indian coast has been completed. Culture experiments are now being made in two hectare area in Tuticorin (Tamil Nadu). Suitable technique for mass culture has been developed and is now available with the Institute.

4

Infrastructure

The infrastructure facilities were continued to be provided to the Institute staff and other agencies. The major facilities are detailed below:

R V Gaveshani: This is the only ocean going research vessel at national level being provided for oceanographic research. This year the research vessel was extensively used for Institute's R & D programme and for sponsored work. Two training cruises were conducted under 'All India Training Programme' in oceanographic surveys. The ship and research facility on board was availed by many research institutes viz. Geological Survey of India, Calcutta; Naval Physical and Oceanographic Laboratory, Cochin; Bhabha Atomic Research Centre, Bombay; Physical Research Laboratory, Ahmedabad.

Computer Centre: The upgrading of TDC-316 computer with Aanderaa Tape Reader, Programmable Asynchronous Series Communication Interface (PASCI) etc. facilitated a better service to the users, both for R & D and sponsored projects. Services such as software development, assistance in processing and analysis was continued. Data services were provided to the Indian Navy, Universities and other Govt. organizations. Various programmes developed and the exact nature of the services offered are given under section 3.7.

Library: The library continued to be expanded and this year saw an addition of 1490 books, raising the holdings to 10,700 books, 210 journals were continued to be subscribed besides about 100 journals which were received under exchange or gifts. The library was not only used by NIO staff but also by students and research scholars from outside organizations. In addition, books were loaned to other Institutes under inter-library loan scheme.

Under library services "New Arrivals" (monthly) and "Aquatitles" (Fortnightly) were continued and two documents 'Estuarine Research in India - a bibliographic study' and 'Catalogue of periodicals' were brought out.

During the year a plain paper copier - Rank Xerox-2300 was added to the library.

Workshop: The workshop is an essential part to carry out the various work satisfactorily. A 600 amp. diesel generator was installed to further improve the capability in various ways. During the year about 300 jobs were handled which include fabrication of spare parts, piston gravity corer, current meter, messenger, maintenance and servicing of equipment, painting, carpentary, mechanical jobs, etc.

The workshop also includes facilities for electroplating and fabrication of printed circuit boards, transformers and other similar items. The electroplating unit undertook copper, nickel, cadmium and chromium anodising and plating work for various instruments and parts.

Administration: Inspite of heavy load of work and shortage of manpower, administrative machinery (Establishment, Purchase, Accounts, Stores, Works) provided a very helpful hand in execution of various projects particularly important projects like deep sea exploration, Antarctic Expedition, etc., where the work was time targeted.

Other services

Services like photography, printing, binding, reprography, drawing and analysis were provided. The personnel handled a large quantity of work which are complementary and equally important to the Institute's R & D work. These facilities, though may be quantified but can only be realised and appreciated.

Composition of various committees of NIO

5.1 CRUISE PLANNING AND PROGRAMME PRIORITIES COMMITTEE FOR RV GAVESHANI

1.	Director-General, SIR CSIR, Rafi Marg New Delhi	Chairman
2.	Capt. M. Sethi Shipping Corporation of India Bombay	Member
3.	Shri S. N. Batra Technical Manager Shipping Corporation of India Bombay	
4.	Shri A. Ananthakrishnan Director (Development) Ministry of Shipping & Transport New Delhi	
5.	Shri V. R. Venkoba Rao Geological Survey of India Calcutta	"
6.	Capt. V. Ravindranath Director (OPS) Coast Guard H.Q. New Delhi	
7.	Shri R. K. Kutkar Assistant Wireless Adviser Ministry of Communication New Delhi	
8.	Shri P. Satyanarayana Naval Hydrographic Office Dehra Dun	"
9.	Shri K. R. G. K. Murty Naval Physical & Oceanographic Laboratory Naval Base Cochin	

"

10.	Dr. V. L. N. Sastry Chief Geophysicist O.N.G.C. Bombay Offshore Project Bombay	Member
11.	Dr. K. L. Kaila Project Coordinator Deep Seismic Survey Project National Geophysical Research Institute Hyderabad	"
12.	Dr. D. K. Rakshit Department of Science & Technology New Delhi	"
13.	Dr. V. V. Bhartiya Principal Scientific Officer Department of Science & Technology New Delhi	"
14.	Shri K. N. Johry Head, International Scientific Collaboration CSlR, Rafi Marg, New Delhi	"
15.	Dr. D. Shankar Narayan Additional Secretary. University Grants Commission New Delhi	"
16.	Prof. D. Lal, FRS Director Physical Research Laboratory Ahmedabad	"
17.	Dr. 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 National Fellow in Environmental Sciences Bhabha Atomic Research Centre Trombay - Bombay	"

20.	Commodore I. K. Puri Adviser, NIO (Ship matters) CSIR, Rafi Marg New Delhi	Member
21.	Dr. S. Z. Qasim Director, National Institute of Oceanography, Dona Paula, Goa	Convenor (upto May 1981) "
22.	Dr. V. V. R. Varadachari Acting Director, National Institute of Oceanography Dona Paula, Goa	(From May 1981)

5.2 RESEARCH ADVISORY COUNCIL

1.	Prof. D. Lal, FRS Director Physical Research Laboratory Ahmedabad	Chairman
2.	Dr. R. Raghu Prasad Assistant Director-General, ICAR New Delhi	Member
3.	Dr. V. V. Sastri Director R & D Institute of Petroleum Exploration Kaulagarh Road Dehra Dun	"
4.	Dr. P. K. Das Director-General of Meteorology Indian Meteorology Department Lodhi Road New Delhi	"
5.	Vice-Admiral O. S. Dawson, AVSM, PVSM Flag Officer Commanding-in-Chief Southern Command, Naval Base. Cochin	"
6.	Dr. A. K. Ganguly National Fellow in Environmental Sciences Bhabha Atomic Research Centre Trombay - Bombay	"
7.	Dr. D. Srinivasan Director Naval Physical & Oceanographic Laboratory Naval Base, Cochin	"

8.	Prof. N. B. Nair Head of the Department of Aquatic Biology & Fisheries University of Kerala, Trivandrum	Member "
9.	Dr. V. K. Iya Director, Isotope Group Bhabha Atomic Research Group Trombay-Bombay	
10.	Dr. S. Z. Qasim Director National Institute of Oceanography Dona Paula, Goa	(Upto May 1981) "
11.	Dr. V. V. R. Varadachari Acting Director National Institute of Oceanography- Dona Paula, Goa	
12.	Dr. T. S. S. Rao Head, Biological Oceanography Division NIO, Dona Paula, Goa	Member Secretary (From May 1981)
12.	Ex-Officio Member	
	i) Director-General, SIR or his nominee &	
	ii) Chairman, Coordination Council of Physical & Earth Sciences Group of Laboratories, CSIR	

5.3 EXECUTIVE COMMITTEE

1.	Dr. S. Z. Qasim Director National Institute of Oceanography Dona Paula, Goa	Chairman (Upto May 1981)
2.	Dr. V. V. R. Varadachari Acting Director, National Institute of Oceanography Dona Paula, Goa	Chairman (From May 1981)
3.	Dr. D. Srinivasan Director Naval Physical & Oceanographic Laboratory Naval Base, Cochin	Member
4.	Prof. N. B. Nair Head of the Department of Aquatic Biology & Fisheries University of Kerala, Trivandrum	

"

5.	Dr. A. K. Ganguly National Fellow in Environmental Sciences Bhabha Atomic Research Centre Trombay - Bombay	Member "
6.	Shri C. V. G. Reddy Head. Chemical Oceanography Division National Institute of Oceanography Dona Paula, Goa	"
7.	Dr. B. N. Desai Scientist-in-Charge Regional Centre of NIO Bombay	
8.	Finance & Accounts Officer National Institute of Oceanography Dona Paula, Goa	
9.	Administrative Officer National Institute of Oceanography Dona Paula. Goa	(Upto Oct. 1981)
10.	Ex-Officio Member	
	i) Director-General, SIR or his nominee &	
	ii) Chairman, Coordination Council of Physical & Earth Sciences Group of Laboratories, CSIR	

5.4 FINANCE & BUILDING COMMITTEE

1.	Dr. V. V. R. Varadachari Deputy Director National Institute of Oceanography Dona Paula, Goa	
2.	Dr. S. P. Deshpande Director, Environmental Planning & Design Consultancy Services Government of Goa, Daman & Diu Panaji, Goa	
3.	Shri H. N. Siddiquie Head. Geological Oceanography Division National Institute of Oceanography Dona Paula, Goa	
4.	Shri R. S. Panesar Head, Engineering Division, CSIR New Delhi	"

5.	Dr. B. N. Desai Scientist-in-Charge Regional Centre of NIO Bombay	Member (upto Oct. 1981)
6.	Administrative Officer National Institute of Oceanography Dona Paula, Goa	"
7.	Finance & Accounts Officer National Institute of Oceanography Dona Paula, Goa	"
8.	Civil Engineer National Institute of Oceanography Dona Paula, Goa	Convenor

5.5 RV GAVESHANI COMMITTEE

1.	Dr. T. S. S. Rao	Chairman
2.	Shri H. N. Siddiquie	Member
3.	Dr. R. Sen Gupta	"
4.	Dr. A. B. Wagh	"
5.	Shri A. Rajachandran	"
6.	Shri S. P. Mittal	"
7.	Shri R. K. Nair	"

5.6 POLICY PLANNING COMMITTEE

1.	Director, NIO	Chairman
2.	Head, Physical Oceanography Division	Member
3.	Head, Chemical Oceanography Division	"
4.	Head, Geological Oceanography Division	"
5.	Head, Biological Oceanography Division	"
6.	Head, Ocean Engineering Division	"
7.	Head, Instrumentation Division	"
8.	Head, Planning & Data Division	"
9.	Scientist-in-Charge, Regional Centre, Cochin	"
10.	Scientist-in-Charge, Regional Centre, Bombay	"
11.	Scientist-in-Charge, Regional Centre, Waltair	"
12.	Administrative Officer	"
13.	Finance & Accounts Officer	"
14.	Section Officer	"
15.	Purchase Officer	"
16.	Stores Officer	"
17.	Civil Engineer	"
18.	Resident Medical Officer	"

19.	Library Incharge	Member
20.	Executive Officer, RV Gaveshani	"
21.	Dr. R. Sen Gupta	"
22.	Dr. T. S. S. Rao	Convenor

5.7 STORES & EQUIPMENT COMMITTEE

1.	Shri H. N. Siddiquie	Chairman
2.	Shri J. S. Sastry	Member
3.	Dr. E. D'Sa	"
4.	Dr. B. U. Nayak	"
5.	Shri C. V. G. Reddy	"
6.	Shri R. M. S. Bhargava	"
7.	Shri P. M. A. Bhattathiri	"
8.	Shri R. R. Nair	"
9.	Shri R. K. Nair	"
10.	Shri S. P. Mittal	"

5.8 GRIEVANCE COMMITTEE

1.	Dr. V. V. R. Varadachari	Convenor Chairman (upto May 1981)
2.	Dr. B. U. Nayak	Member
3.	Shri Lakhbir Singh	"
4.	Shri V. Kesava Das	"
5.	Shri R. M. S. Bhargava	Member-Secretary

5.9 STAFF QUARTERS / HOSTEL ALLOTMENT COMMITTEE

1.	Dr. V. V. R. Varadachari	Chairman (upto May 1981)
2.	Dr. T. S. S. Rao	Member
3.	Shri H. N. Siddiquie	"
4.	Shri Lakhbir Singh	"
5.	Shri A. Rajachandran	"
6.	Shri George Philip	"

5.10 BUDGET

The budget of the Institute for the year 1981-82 is as follows:

(Rs. in lakhs)

	Non-Plan	Plan	Total
Recurring	140.601	103.482	244.083
Capital	4.599	161.356	165.955
Total	145.200	264.838	510.038

5.11 SCIENTIFIC AND TECHNICAL STAFF

The staff (upto a level of JSA/JTA) as on December 31, 1981.

Director

Dr. S. Z. Qasim
(upto 15 May, 1981)

Acting Director

Dr. V. V. R. Varadachari
(from 15 May, 1981)

A. Divisions at the Headquarters

1. Physical Oceanography Division

Head of the Division

Dr. J. S. Sastry

Scientists

Shri L. V. G. Rao
Dr. C. S. Murty
Dr. D. Panakala Rao
Shri M. J. Varkey
Shri P. K. Das
Shri C. K. Gopinathan
Shri V. Ramesh Babu
Shri K. K. Varma (on deputation)
Dr. M. K. Antony
Shri V. Kesava Das

Senior Scientific Assistants

Shri A. F. Anto
Shri A. D. Gouveia
Shri P. V. Sathe
Shri Y. K. Somayajulu
Shri D. V. Rama Raju
Shri Johnson Samuel
Shri R. J. Krishnamacharyulu
Shri V. V. Gopalkrishna

Junior Scientific Assistants

Shri V. S. N. Murty
Shri M. S. S. Sarma
Shri G. Venkata Reddy
Shri A. A. Fernandes

Junior Technical Assistant

Shri G. Nampoothiri

Junior Research Fellow

Shri P. Vethamony

2. Chemical Oceanography Division

Head of the Division

Shri C.V. Reddy

Scientists

Dr. R. Sen Gupta
Shri S. P. Anand
Shri S. Y. S. Singbal
Dr. S. Y. Kamat
Dr. A. Rajendran
Dr. C. G. Naik
Shri M. Manoharan
Shri S. N. De Souza
Mrs. Solimabi Wahidullah
Shri S. P. Fondekar
Shri M. D. George
Shri S. W. A. Naqvi

Senior Scientific Assistants

Shri M. D. Rajagopal
Shri R. S. Topgi (on deputation)
Miss S. S. Naik

Junior Scientific Assistants

Mrs. C. D'Silva
Shri K. Sawkar
Shri T. W. Kureishy
Miss S. M. Sanzgiri
Mrs. L. D'Souza
Mrs. A. Mesquita

Junior Technical Assistants

Mrs. C. F. Dias
Mrs. B. Das

Senior Research Fellow

Shri M. Dilip Kumar

Junior Research Fellow

Miss F. D'Souza

3. Geological Oceanography Division

Head of the Division

Shri H. N. Siddiquie

Scientists

Dr. M. G. Anantha Padmanabha Setty
Shri P. S. N. Murty
Shri R. R. Nair
Shri Ch. Madhusudan Rao
Shri D. Gopala Rao
Dr. M. Veerayya
Shri G. V. Rajamanickam
Shri F. Almeida
Shri G. C. Bhattacharya
Shri A. L. Paropkari
Shri K. H. Vora
Shri R. M. Kidwai
Shri B. G. Wagle
Shri M. V. S. N. Guptha
Shri N. H. Hashimi

Senior Scientific Assistants

Shri A. R. Gujar
Shri R. Nigam
Dr. S. M. Karisiddaiah
Shri A. Mascarenhas
Shri M. V. Ramana (on deputation)
Shri V. Subrahmanyam
Dr. A. B. Valsangkar
Shri L V. Subba Raju

Junior Scientific Assistant

Shri V. Purnachandra Rao

Senior Technical Assistants

Shri K. L. Kotnala
Shri M. C. Pathak
Shri E. Dias
Shri P. Marathe

Junior Technical Assistants

Shri S. K. Nanyasi
Shri H. R. Raghavendran

Junior Mechanical Assistant

Shri A. V. Sonawane

Junior Research Fellow

Shri V. Ramaswamy

4. Biological Oceanography Division

Head of the Division

Dr. T.S.S. Rao

Scientists

Dr. A. H. Parulekar
Shri V. P. Devassy
Dr. A. G. Untawale
Dr. S. C. Goswami
Dr. (Miss) Aditi Pant
Dr. (Mrs.) Sumitra Royan
Dr. D. Chandramohan
Shri P. M. A. Bhattathiri
Dr. (Miss) Loka Bharathi
Shri R. A. Selvakumar
Dr. (Mrs.) Usha Goswami
Dr. Joseph Royan
Dr. M. Madhupratap

Senior Scientific Assistants

Shri C. T. Achuthankutly
Shri S. N. Harkantra
Shri Z. A. Ansari
Shri S. R. Sreekumaran Nair

Junior Scientific Assistants

Mrs. S. Achuthankutty
Shri X. N. Verlencar
Shri T. G. Jagtap

Senior Technical Assistants

Shri V. K. Dhargalkar
Miss Maria R. Menezes

Research Associate

Dr. A. K. Chatterjee

Senior Research Fellow

Shri V. V. Agadi

Junior Research Fellows

Shri C. L. Rodrigues
Shri S. Gouthaman

5. Ocean Engineering Division

Head of the Division

Dr. B. U. Nayak

Scientists

Shri N. M. Anand (on deputation)
Shri S. G. Diwan
Shri T. Balasubramanian

Senior Scientific Assistant

Shri B. A. Ramesh

Junior Research Fellow

Shri D. Sen Gupta

6. Instrumentation Division

Scientist-in-Charge

Dr. E. Desa

Scientists

Shri M. R. Nayak
Dr. E. S. Desa
Shri R. G. Prabhu Desai

Senior Scientific Assistant

Mrs. V. B. Peshwe

Senior Technical Assistants

Shri A. Paneerselvam
Shri Md. Wahidullah
Shri V. M. Date

Senior Mechanical Assistant

Shri S. B. Tengali

Junior Technical Assistants

Shri S. Chellam
Shri O. D'Souza
Shri A. Joseph

Junior Mechanical Assistant

Shri V. N. Chodonkar

7. Planning & Data Division

Scientist-in-Charge

Shri R. M. S. Bhargava

Statistical Officer

Shri S. G. Dalal

Scientists

Dr. R. Mahadevan
Shri J. S. Sarupria

Senior Scientific Assistant

Shri P. V. S. S. R. Sarma

Junior Scientific Assistants

Shri S. R. Bhat
Shri Arvind Ghosh

Proof Reader

Shri S. P. Sharma

Junior Technical Assistants

Mrs. R. Thomas
Shri Andrew Menezes

Junior Research Fellow

Shri G. R. Itigi

8. Library

Jr. Documentation Officer

Shri M. P. Tapaswi

Senior Librarian

Mrs. S. H. Oka

***9.* R. V. Gaveshani**

Advisor

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

Executive Officer

Dr. A. B. Wagh

B. Regional Centres

1. Regional Centre, Cochin

Scientist-in-Charge

Dr. M. Krishnankutty

Scientists

Shri V. S. Rama Raju
Dr. R. V. Unnithan
Dr. P. Sivadas
Shri P. Udaya Varma
Shri U. K. Gopalan
Shri P. Gopala Menon
Dr. V. N. Sankaranarayanan
Shri B. M. Panikkar
Dr. (Mrs.) M. Saraswathy
Shri P. N. Aravindakshan
Dr. George Peter
Shri V. T. Paulinose
Shri T. Balachandran
Mrs. C. B. Lalithambika Devi
Shri K. Kameshwara Rao
Shri P. S. Gore
Shri T. C. Gopalakrishnan
Dr. (Mrs.) V. Santhakumari
Shri K. K. C. Nair

Statistical Officer

Mrs. K. V. Jayalakshmi

Senior Scientific Assistants

Mrs. U. P. Saramma
Mrs. P. P. Meenakshi Kunjamma
Mrs. Rosamma Stephen
Shri P. Haridas

Junior Scientific Assistant

Shri T. Balasubramanian

Senior Technical Assistant

Shri P. Venugopal

Junior Technical Assistants

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

Junior Research Fellow

Shri Domnic Zacharias

2. Regional Centre, Bombay

Scientist-in-Charge

Dr. B. N. Dcsai (on deputation)
Shri S. A. H. Abidi

Scientists

Dr. M. D. Zingde
Shri G. Narayana Swamy
Dr. (Mrs.) Vijayalakshmi R. Nair
Dr. K. Govindan
Shri N. B. Bhosale

Senior Scientific Assistants

Shri M. M. Sabnis
Shri R. V. N. Sarma
Shri S. N. Gajbhiye

Junior Scientific Assistants

Mrs. L. Krishnakumari
Shri A. Suryanarayana
Shri C. V. Vijayakumar

Junior Technical Assistants

Shri P. V. Narvekar
Shri S. K. Bhakta

Junior Research Fellow

Shri P. K. Varshney

3. Regional Centre, Waltair

Scientist-in-Charge

Dr. T. C. S. Rao

Scientist

Dr. K. S. R. Murthy

Senior Scientific Assistants

Shri P. Chandramohan
Shri K. Subrahmanyam
Shri M. M. Malleswara Rao
Dr. V. V. Sarma

Junior Scientific Assistants

Shri T. V. Narasimha Rao
Shri B. Prabhakara Rao
Shri P. Vijayakumar Rathod
Shri K. Mohan Rao
Shri K. V. L. N. S. Rao

Junior Technical Assistants

Shri S. Kannan
Shri M. K. Prema Kumar

Senior Research Fellow

Shri G. R. K. Raju

6

Visitors

6.1 Visitors at Headquarters

Prof. M. G. K. Menon, Secretary. Dept. of Science & Technology and till recently Director General. CSlR. visited the Institute from May 6-8, 1981 and saw the research work being carried out in various Divisions. He was very appreciative of the work done at the Institute and particularly the recent achievement of exploration of manganese nodules in the Indian Ocean. He also held informal discussions with Scientists of the Institute.

Prof. M G. K. Menon looking at the instruments developed at NIO.

Dr. G. S. Sidhu. Director General. Scientific and Industrial Research visited the Institute from October 15-17, 1981. He was taken around the laboratories by the Director and was shown the work in progress in various projects. He evinced keen interest and held discussion with Scientists and appreciated the research work being carried out.

Dr. G S. Sidhu, DG, SIR seen discussing with N.I.O. scientists.

Prof. H. W. Nurnberg, Director, Nuclear Research Centre, Zurich.

Dr. R. C. Misra, Retired Prof. of Geology, Lucknow University, Lucknow.

Prof. Supria Roy, Deptt. of Geology, Calcutta University, Calcutta.

Dr. M. N. Qureshy, Director, Department of Science & Technology, New Delhi

Shri D. N. Bhargava, Controller, Indian Bureau of Mines, Nagpur.

Dr. G. S. Roonwall, Dept. of Geology, Delhi University, Delhi.

Dr. M. N. Bose, Director, Birbal Sahni Institute of Paleobotany, Lucknow.

Shri Joseph Thomas, Managing Director, Travancore Cements Ltd.

Dr. U. Gopalan, EIL, New Delhi.

Shri Edgar E. Noel, Director, USlCA

Shri R. P. Kapoor, Chairman & Managing Director, Hindustan Zinc Ltd., Udaipur.

Prof. E. C. LaFond, California, USA.

Prof. O. Eldholm, Prof. J. Thiede. Shri K. Aubert and Smt. G. Quale of Norway.

Prof. O. G. Houmb, Ship Research Laboratory, Norway.

6.2 Visitors at Regional Centre, Cochin

Shri Mohammad Hussain Bolock, Dy. Minister of Law, Genetics & Fisheries. Gujarat.

Dr. Roland A. Moal, Veterinaire Inspector General, France.

Shri Marcel Raynard. President Director General, Consortium Francain Ponle Development, Paris.

Shri Malhotra, Tata Fisheries Division Cochin.

Dr. G. S. Roonwal, Dept. of Geology, University of Delhi, Delhi.

Prof. S. Dutt, Head. Dept. of Marine Living Resources, Andhra University, Waltair.

6.3 Visitors at Regional Centre, Bombay

Prof. O. G. Houmb, Ship Research Laboratory, Norway.

Prof. Nagabhushanam, Head. Dept. of Zoology. Marathawada Univ., Aurangabad.

Shri D. Edwards, Balfours Consultants Ltd., U. K.

6.4 Visitors at Regional Centre, Waltair

Captain V. K. Singh, Commanding Officer, INS Sandhayak.

Dr. B. N. Bhargava, Director (Retd), Indian Institute of Geo-magnetism, Bombay.

Dr. V. V. Sastri, Director (R & D), ONGC, Dehradun.

Dr. N. L. Ramanathan, Director, Dept. of Environment, New Delhi.

Dr. G. S. Sidhu, DGSIR, CSIR.

Dr. V. K. S. Varadan, Scientific Advisor & Additional Secretary, Ministry of Steel & Mines.

Prof. E. C. La Fond, Secretary General, International Association for Physical Sciences of the Ocean, California, USA.

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Colloquia

Speaker	Subject	Date
Dr. K. S. Yagnik, NAL, Bangalore	Experiments on turbulent boundary layers	8.1.1981
Dr. Dennis Baylow, Dept. of Neurobiology Stanford Univ. School of Medicine, Stanford, California, USA	Physiology of the retina	13.1.1981
Dr. John Nicholls	Nervous system of leech	14.1.1981
Dr. Bruce Wallace,	Development of invertebrate nervous system	15.1.1981
Dr. H. M. Munje, Kanpur	Universal triple education	21.1.1981
Dr. Anand Prakash, Mari-culturc International Inc. Canada	Mussel culture - an overview	16.2.1981
Dr. P. K. Das, Director General. IMD	Storm surges	21.2.1981
Prof. Dr. H. W. Nurnberg institute of Chemistry Kernforschungsanlage Germany	Applications of voltametry in marine chemistry	24.2.1981
Mr. R. Burrows Dept. of Civil Engineering Liverpool Univ.. U.K.	Quasi-static response of offshore structures	23.2.1981
Prof. J. W. R. Griffiths Univ. of Technology Loughborough, Leicestershire, England	High resolution sonar systems including side scan sonars, electronic scanning and the acoustic camera	26.2.1981
Mr. T. P. Higgins Lockheed Space Systems U.S.A.	Ocean Thermal Energy Conversion	3.3.1981
Prof. D. Richards John Hopkins University U.S.A.	Wave power extraction	3.3.1981
Dr. K. N. Kaul NBRI, Lucknow	'We' - in the modern world	7.3.1981

Prof. K. Subba Rao School of Life Sciences Hyderabad	Certain bio-chemical aspects of aging brain	6.6.1981
Dr. G. S. Roonwal Dept. of Geology Delhi University, Delhi	Some aspects of manganese nodules	4.7.1981
Dr. V. V. R. Varadachari NIO, Goa	Highlights of the recent IOC meetings at Tanerefe Cannary Islands	22.7.1981
Dr. P. V. Sane BARC, Bombay	Proton and electron transport during photosynthesis	10.9.1981
Dr. M. J. Swift Queen Mary College London	Decomposition of wood in mangroves of Papua, New Guinea	25.9.1981
Mr. Cheryl M. Jordan United States International Communication Agency. Bombay	Screened VTRs — Energy USA: An update III — Energy from the Day star	28.10.1981
Prof. Eugene C. La Fond, Secretary General International Association for the Physical Sciences of Ocean U.S.A.	Oceanography of the Bay of Bengal and use of submersibles in the sea	12.11.1981

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Awards, honours and membership of various committees

Dr. S. Z. Qasim acted as

— Chairman, Working Committee for the Training, Education and Mutual Assistance (TEMA) of Intergovernmental Oceanographic Commission, UNESCO.

— National Coordinator for the project 'Development of Inland Fisheries under the Rural Technology Programme' of the Commonwealth Science Council, Commonwealth Secretariat, London.

— Member, Indian Commission on Environmental Planning and Coordination of Department of Environment.

— Adviser. Marine Ecology Progresses Series of the Biologische Anstalt Helgoland, Hamburg.

— Chairman, Council of Physical and Earth Sciences Group consisting of 5 laboratories of CSIR.

— Member, Governing Body of CSIR.

Dr. V. V. R. Varadachari was elected as a

— Member of Scientific Review Board of Intergovernmental Oceanographic Commission.

— Fellow of Indian National Science Academy.

— Fellow of the Association of Exploration Geophysicists.

He also continued to serve as

— Member Secretary of the Indian National Committee for SCOR upto Aug. 1981 (Scientific Committee on Ocean Research).

— Member, Board for Ocean Engineering Centre, I.I.T.

— Member, Board of Studies in Physical Oceanography, University of Cochin, Cochin.

— Member, Marine Sciences Advisory Committee for Centre for Earth Sciences Studies, Trivandrum.

Shri H. N. Siddiquie was

— Elected as a member of Editorial Board for the Proceedings of Indian Academy of Science (Earth & Planetary Science)

— Elected as Fellow of the Association of Exploration Geophysicists (AEG)

Dr. J. S. Sastry continued to serve as

— The member of the Joint IOC/WMO Working Committee for IGOSS.

— Member of the Indian Ocean Panel, SCOR Working Group 47.

— Member of the ISI-Thermometers Sub-Committee CDC-33.2.

Dr. B. U. Nayak served as a member of the Indian Geotechnical Society.

Dr. R. Sen Gupta

— Has been recognised as a guide for Ph.D. in Chemistry by Karnataka University.

— Was elected as Member-Secretary, Indian National Committee for Scientific Committee on Ocean Research.

Shri T. C. S. Rao

— Was awarded Ph.D. in Marine Geophysics by Andhra University for his thesis "Some Marine Geophysical Studies in the Bay of Bengal". He worked under the guidance of Prof. V. Bhaskara Rao, Dept. of Geophysics, Andhra University, Waltair.

Dr. R. V. Unnithan

— Continued to serve as Senate Member of the University of Cochin.

Shri L. V. G. Rao continued to serve as alternate member, ISI Thermometers Sub-Committee CDC-33.2 and nominated member of ISI Hydrometers Sub-Committee CDC-33.3.

Dr. E. Desa served as a member for IGOSS, IOC.

Dr. A. H. Parulekar

— Invited member sub-group on Coastal Area Planning for Goa (Task force on Eco-Development Plan for Goa), Planning Commission, Govt. of India & Govt. of Goa, Daman & Diu.

— Member, Regional Advisory Committee (Goa base) Exploratory Fishery Project, Ministry of Agriculture.

— Expert member — Establishment of an aquarium and a Marine Research Station at Digha in West Bengal.

— Member, Task Force on Environmental Protection, Govt. of Goa, Daman & Diu.

— Member, Board of Examiners in Marine Biology and Fisheries, Karnataka Univerity.

— Was also recognised as guide for Ph.D. by Universities of Bombay, Poona, Kolhapur, Karnataka and Jawaharlal Nehru.

Shri R. M. S. Bhargava

— Continued to serve as National Coordinator for International Oceanographic Data Exchange (IODE) of IOC (UNESCO) Paris and as member, Group of Experts on Format Development of IODE & IOC.

— was selected as member of Task Team of IOC on (i) Development of IODE Data Centre Services and (ii) Marine Biological Data.

Dr. A. G. Untawale

— Member Wildlife Board, Govt. of Goa, Daman & Diu.

— Member, subgroup, Coastal Area Planning (Eco-Development Plan for Goa) Planning Commission, New Delhi.

— Member Board of Studies in Botany, Nagpur University, Nagpur.

— Secretary, Seaweed Research Utilization Association of India.

— Member, Biosphere, Forest & Wildlife Theme Committee, Govt. of Gujarat.

— Member, National Mangrove Committee, DST, Govt. of India, New Delhi.

Shri U. K. Gopalan served as

— Member Southern Regional Committee of World Wild Life Fund India.

— Member Board of Studies in the school of Environmental Studies, Dept. of Marine Sciences, University of Cochin, Cochin.

Shri S. C. **Goswami** was awarded Ph.D. by the Punjab University, Chandigarh, on his thesis 'Secondary production in the estuary, inshore and adjacent waters of Goa'. He worked under the guidance of Dr. S. Z. Qasim.

Shri P. S. Joseph was awarded D.Sc. in Geophysics by the University of Sendai, Japan for his thesis "A wave prediction model — combination of single parameterised wind waves with spectrally treated swells". He was guided by Dr. Yoshiaki Toba, Tohoku University.

Shri S. Y. S. Singbal was awarded Ph.D. by Bombay University for his thesis "Some physical and chemical studies on the coastal marine environment of Goa" (West Coast of India). He worked under the guidance of Prof. B. N. Ghosh of the Department of Chemical Technology, University of Bombay, Bombay.

Shri S. A. H. Abidi

— Served as member and Honorary Treasurer for Society for Offshore Engineering and Underwater Technology of India.

— Was awarded Ph.D. by Aligarh Muslim University for his thesis "Studies on organic production of the inshore waters of the Arabian Sea", under the guidance of Dr. S. Z. Qasim.

Dr. D. Chandramohan acted as a member of the sub-committee to prepare a comprehensive proposal in the area of "Marine Biomedical Research" in the proposed Institute for Maritime Management in Tamil Nadu, Govt. of Tamil Nadu.

Shri K. S. R. Murthy was awarded Ph.D. by Andhra University for his thesis 'Airborne and Ground Geophysical Surveys in the Sonrai Copper-belt, Lalitpur District, U.P.' He was guided by Dr. D. C. Mishra, NGRI, Hyderabad and Prof. V. Bhaskara Rao, Dept. of Geophysics, Andhra, University, Waltair.

Shri V. T. Paulinose was awarded Ph.D. by University of Kerala, for his thesis on "The Decapod larvae of the Indian Ocean Penaeinae". He worked under the guidance of Dr. S. Z. Qasim.

Dr. (Mrs) Vijayalaxmi Nair nominated as member of the Editorial Board of the Journal of the Indian Fisheries Association.

Shri M. K. Anthony was awarded the degree of Doctor of Agriculture (Fisheries Oceanography) on his thesis "Wind effect on short term biological accumulation near coastal boundaries as inferred from thermal response to wind forcings", by the University of Tokyo, Japan. He worked under Prof. Toshiyuki Hinano, University of Tokyo, Japan.

Shri S. N. Poi Fondekar was awarded Diploma in Marine Pollution Chemistry by the University of Liverpool.

Shri K. Anthony Joseph was awarded M.Sc. in Physics (Electronics) by the University of Bombay.

Shri E. G. Nampoothiri was awarded M.Sc. in Physics (Electronics) by University of Bombay.

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Deputations

Dr. V. V. R. Varadachari was deputed to

— Tenerife, Canary Islands (Spain) to represent India at the 14th Session of the Executive Council (EC) of IOC and to participate in the First Session of the Ad-hoc Task Team of IOC on the United Nations Conference on ths Law of the Sea (UNCLOS), from 18 to 27 June, 1981.

— Japan, to study the various aspects of developments in ocean sciencs technology in Japan, from 8 to 15 November, 1981.

Shri H. N. Siddiquie was deputed to

— Norway and Canada from 6-10-1981 to 26-10-1981 in connection with discussions regarding the ship.

Dr. R. Sen Gupta was deputed to Norway and Canada from 8 to 26 October in connection with the project "Gangotri".

Shri L. V. G. Rao was deputed to

— Norway from 17 to 23 May, 1981 to attend the Symposium on 'Application of Remote Sensing Data on the Continental Shelf organized by EARSel at Voss during 19-20 May, 1981 and presented a paper prepared jointly with Dr. V. R. Rao, Scientist, ISRO, Bangalore. He also visited the Port & Ocean Engineering Division of the Norwegian Institute of Technology, Trondheim.

Shri R. M. S. Bhargava was deputed to Hamburg (West Germany) to attend the 10th Session of the Working Committee of the International Oceanographic Data Exchange from 3rd to 13th August, 1981.

Shri V. P. Devassy was deputed to France under Bilateral Exchange Programme between CSIR & CNRS from 17th July to 17th September (8 weeks) to acquaint himself with the modern aquaculture practices.

Shri C. K. Gopinathan was deputed to Poland for six weeks during September-October 1981 under the Bilateral Exchange Programme between CSlR and Polish Academy of Sciences. He visited the Institute of Hydro-Engineering of Polish Academy of Sciences, GDANSK and discussed with the Polish Scientists the various problems related to Near-Shore Oceanography and Coastal Engineering.

Dr. S. C. Goswami was deputed to Amsterdam (Netherlands) and Bordeaux (France) from 24th August to 14th September to participate in an Interna-

tional Conference on Copepoda at Amesterdam and International Symposium on 'Coastal Lagoons' in Bordeaux, France.

Shri T. Balasubramanian was deputed to Central Water & Power Research Station, Pune, to attend a 21 day International Course on 'Stratification due to thermal discharges in estuaries, rivers and ponds' from 20 July to 7 August, 1981.

Shri M. V. Ramana was deputed for training to Norway under the NORAD Assistance Programme.

Shri M. V. S. N. Guptha was deputed to Physical Research Laboratory (PRL) Ahmedabad from 9 January to 25 April 1981 under the Collaboration Programme between NIO and PRL.

Shri Y. K. Somayajulu was deputed to attend a short term course on 'Sound Propagation in Layered Media' conducted at the Indian Institute of Science, Bangalore, from 2 to 13 November, 1981.

Shri T. G. Jagtap was deputed to Indian Photo Interpretation Institute (NRSA) Dehradun, for training in Remote Sensing and Forestry Techniques from July 3 to October 6, 1981.

Shri Adolph Mascarenhas was deputed for training in deployment of wave rider buoys and current meters at Norwegian Institute of Technology under the Indo-Norwegian Bilateral Technical Assistance Programme from September, 1981. 1981.

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Meetings, exhibitions, seminars, symposia and special lectures

Dr. T. S. S. Rao, S. C. Goswami, S. R. S. Nair, C. T. Achuthankutty and **M. Madhupratap** presented a paper entitled "Solar eclipse and zooplankton vertical migration" at the International Symposium on "Solar Eclipse", held at New Delhi in January 1981.

Dr. B. U. Nayak delivered lectures

— On "Coastal erosion in India — causes, processes and remedial measures" from 27-30 January at Structural Engineering Research Centre, Madras.

— On "Oceanographic instruments" at Surathkal Engineering College, Surathkal on 13th April, 1981.

— On "Problems of coastal erosion in India" and "Laying of submarine pipeline off Karwar for effluent disposal" at Institution of Engineers, Mangalore on 13th April 1981.

Dr. M. G. A. P. Setty and R. Nigam attended and presented a paper at the "IXth India Colloquia on Micropaleontology and Stratigraphy" held at the Rajasthan University, Udaipur from 2-4 February, 1981.

Dr. M. G. A. P. Setty delivered lectures at Delhi University on 31st July 1981 and at Roorkee University on 1st August, 1981.

Dr. R. Sen Gupta participated in the seminar on "Earth Resources for Goa's Development" organized by GSI at Panaji from 18-21 Sept. 1981 and presented a paper entitled "Water quality of the waters of Mandovi-Zuari estuarine complex (Goa)".

Dr. A. H. Parulekar delivered a series of lectures on "Ecology of fishing grounds and aquaculture" for M.Sc. (Marine Biology) students of Marine Biology Centre, Karnatak University, Karwar in January, 1981.

Dr. A. H. Parulekar, Z. A. Ansari, S. N. Harkantra and **X. N. Verlencar** attended and presented a paper entitled "Solar eclipse - its effect on behavioural activity of some inter-tidal animals" at the International Symposium on "Solar Eclipse" held at New Delhi in January 1981.

Dr. E. Desa, S. B. Tengali and **M. R. Nayak** presented a paper on "Self recording

data buoy" at World Instrumentation Symposium WISITEX-8 at Bombay on April 9. 1981.

Dr. E. Desa and O. D'Souza presented a paper on "Rotor current meter" at WISITEX-81. Bombay on April 9, 1981.

S. P. Anand

— Delivered a key-note address on "Fabrication of a few solar gadgets by the rural youth for their living and utility" at Regional Rural Youth Staff and Leaders Training Workshop for Western Region organized by the Directorate of Extension, Ministry of Agriculture, Govt. of India at Extension Training Centre, Goa from 23 to 28 March. 1981.

— Attended the lndo-FRG Workshop on 'Desalination' held at BARC, Bombay in March 1981 and presented a paper on "Use of threaded wicks in improving the performance efficiency of solar stills".

— Attended the seminar on "Solar energy - Rural and industrial applications" at IIT Kharagpur in March 1981 and presented two papers entitled "On the duration and minimum temperature range for cooking of rice in an improvised solar cooker" and "Multiple uses of marine-cum-farm products solar dryer."

Dr. P. Chandramohan delivered a series of lectures on Marine Microbiology to M.Sc. (Marine Biology) students at Marine Biology Centre, Karnatak University. Karwar in January 1981.

Dr. A. B. Wagh delivered a series of lectures to the P. G. Students of Department of Bioscience, University of Bombay.

B. G. Wagle participated in the seminar on "Earth Resources for Goa's Development" held at Panaji, from 16-19 Sept. 1981.

Dr. R. V. Unnithan presided over the technical session of the Public Health Engineers meeting - one day seminar at Chalakudi on 21st April 1981.

Dr. C. G. Naik presented a paper on "Characterisation of chemical constituents of lipid fraction of **Porites lutea**" at the 1st Annual Conference of Chemists held at Agra in September, 1981.

Dr. (Mrs) V. R. Nair delivered a series of lectures on "Zooplankton and fisheries" at the Central Institute of Fisheries Education, Bombay.

Dr. S. C. Goswami delivered a series of lectures for M.Sc. students of Marine Biology at Marine Biology Centre, Karnatak University, Karwar in March 1981.

Dr. S. Y. Kamat delivered a series of lectures in January 1981 at Marine Biological Centre, Karnatak University, Karwar.

V. P. Devassy delivered lectures on "Red tide formation in tropical seas" and "Some characteristics of plankton production in the Arabian Sea and Bay of Bengal" at Biologique Roscoff & Station Zoologique and Villefranche-sur-Mer, France respectively, in September 1981.

L. V. Gangadhara Rao and **V. R. Rao** presented a paper entitled "Studies in the Indian Continental Shelf - application of remote sensing data" at the symposium on "Application of remote sensing data on the continental shelf" organized by EARSel in cooperation with ESA and NTNF at Voss. Norway during 19-20 May, 1981.

S/ Shri D. Gopala Rao, G. V. Rajamaniekam, G. C. Bhattacharya, M. V. Ramana, V. Subramanyam and **Dr. S. M. Karisiddaiah** participated and presented papers in the 7th Annual Convention of AEG held at NIO, Goa from 15-17 October, 1981.

U. K. Gopalan delivered a lecture

— At SFFCS, Trivandrum on 'Decline of fishery resources' on 25 March, 1981.

— At St. Teresas High School, Ernakulam on 'Biological problems' on 30 April, 1981.

— At K. S. S. P. Guest House. Parur on 'Environmental problems' on 3rd May.

— At Marine Science Dept., Cochin University on 'World Environment Day' on 5th June, 1981.

— At U. P. School, Irimpanam on 'Science popularisation in Kerala' on 19th July, 1981.

— At K. S. S. P., Ernakulam on "Science, Technology, Education and Research in Kerala" on 23rd August, 1981.

C. K. Gopinathan

— Presented a paper entitled "Environmental studies near Mangalore for disposal of industrial effluents" at the First Indian Conference in Ocean Engineering held at IIT, Madras during 18-20 February, 1981.

— Delivered a lecture on "Coastal zone management and ocean engineering studies in India" on September 29, 1981 at the Institute of Hydro Engineering, GDANSK, Poland.

A. F. Anto and **Y. K. Somayajulu** presented a paper entitled "Structure of the oceanic mixed layer of western Bay of Bengal during MONEX" at the symposium on "Environmental Physics and Atmospheric boundary layer" held at IITM, Pune during 24-26 November, 1981.

Dr. S. Y. S. Singbal participated in the seminar on "Earth Resources for Goa's Development" organized by GSI at Panaji from 18 to 21 September 1981 and presented a paper on "Environmental study of the waters of Mandovi-Zuari estuarine complex (Goa)".

Y. K. Somayajulu, and **D. P. Rao** presented a paper entitled "Sound velocity structure of the Bay of Bengal" during Jan-March 1981 at the National Conference on Acoustics and Ultra-Sonics held at the University of Cochin, during 8-10 October. 1981.

G. C. Bhattacharya attended and presented a paper at the "1st Conference in Ocean Engineering" held at IIT, Madras from 18-20 February, 1981.

V. S. Rama Raju, U. K. Gopalan, P. Udaya Varma, P. Venugopal, P. Haridas, T. Balasubramanian, S. Kumaran, C. B. Lalithambika Devi, K. Sarala Devi and **Dr. V. N. Sankaranarayanan** delivered a series of lectures to the Extension Officers of the Orissa State Fisheries, organised by the MPEDA. Cochin from 2 to 21 March, 1981.

V. Ramesh Babu and **J. S. Sastry** presented a paper entitled "Thermal structure of the upper 100 m in the east central Arabian Sea during May-July 1979 and the associated cyclone heat potential" at the symposium on "Early Results of Monsoon Experiments" organized by IMD at New Delhi during 9-11 March 1981.

V. Kesava Das attended the Indo-French Advanced Technology Symposium held at Bangalore during 9-10 December, 1981.

V. S. N. Murthy, D. P. Rao and **J. S. Sastry** presented a paper entitled "Evaporation over the east central Arabian Sea and the lowering of the sea surface temperature during MONEX-79" at the symposium on "Environmental Physics and Atmospheric Boundary Layer", at IITM, Pune during 24-26 November 1981.

V. V. Agadi participated in All India Seminar on "Status of environmental studies in India" held at Trivandrum from 26 to 28 March, 1981 and presented a paper.

A training course in 'Neurobiology'

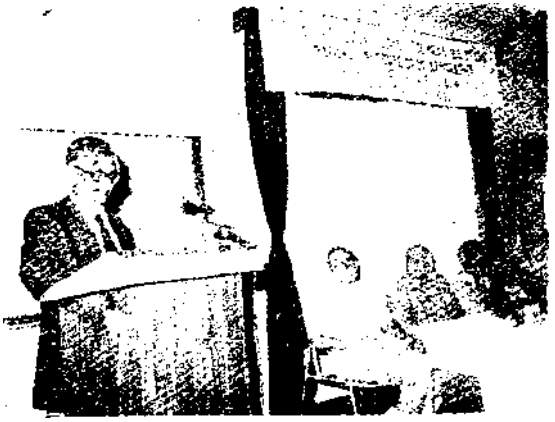
A regional training course on neurobiology cosponsored by the International Brain Research Organisation (UNESCO), Tata Institute of Fundamental Research, Bombay and NIO was held at NIO, Dona Paula from 5-9 January. 1981. The faculty members consisted of Dr. J. G. Nicholls, Dr. D. A. Bayler. Dr. B. G. Wallare from Standford University School of Medicine, California. Dr. J. Jonsen from University of Oslo, Norway and Dr. O. Siddiqui from Tata Institute of Fundamantal Research, Bombay.

This course was aimed to acquaint the participants with recent developments in selected areas of neurobiology of current interest and included tutorials and demonstrations. Fortytwo research students and scientists including five scientists from NIO participated in this program.

Workshop on 'Ocean Futures: The next 25 years'

NIO organised a workshop on 'Ocean Futures - the next 25 years' from March 3-5, 1981. This was sponsored by Department of Science & Technology, Govt. of India, New Delhi.

The workshop was attended by 40 senior scientists, engineers and planners from various organisations such as GSI, BARC, Planning Commission, Remote Sensing Agency, Indian Navy, CSIR, Universities, etc. The workshop had 6 sessions spread over 3 days, viz. (1) General aspects (2) Resources from the sea (3) Ocean Engineering & Technology (4) Ocean, Education & Society (5) Marine Environment and coastal zone management (6) Concluding & Panel discussion. The futuristic



Dr. R. Ramanna inagurating the workshop on Ocean Futures : The next 25 years.'

study identified four priority areas, viz. (1) Living resources (2) Non-living resources (3) New resources of energy (4) Pollution control.

Some of the major recommendations of the workshop were :

1. The limits of territorial waters should be extended and adequate arrangements should be made to protect our Exclusive Economic Zone.
2. Technologies for deep sea mining, extraction of ocean energy and desalination of sea water should be developed in the country as early as possible.
3. Effective measures including legislation should be taken up to check oil pollution in our seas. India should also strive for the ratification of IMCO 1974 convention to fight against pollution hazards.
4. A teaching Institute in Oceanography and Ocean Technology should be established in the country.
5. Marine Policy regarding the use of the sea bed, the use of coastal waters by mechanized and non-mechanized fishing boats should be formulated.
6. Data Centre at NIO should be strengthened and all oecanographic data from marine-based Institutions should be deposited with the Data Centre of NIO.

Seminar under NORAD - Programme

NIO organised a 6-day Seminar on "Geology and Geophysics of Passive Continental Margins" from 23-28 March, 1981, in collaboration with the Norwegian Agency for International Development (NORAD). The seminar reviewed the evolution and sedimentary history of the margins and the occurrence of source rocks for the deposition of hydrocarbons in the oceans. The seminar was attended by 35 senior scientists from ONGC, NGRI, GSI, Indian School of Mines, etc.

Workshop on 'Marine Geosciences in the Eighties'

NIO organised a workshop on Marine Geosciences in the eighties from 10-13 August 1981 which was attended by 36 scientists.

Workshop was intended to evolve a set of scientifically desirable and technically feasible research proposal and to define the scientific objectives and tasks, as well as to co-ordinate arrangements for integrating related projects.

Workshop on Ocean Development

At the instance of the Department of Ocean Development, Government of India, (formed in Aug. 1981) the CSIR with the assistance of the National Institute of Oceanography organised a series of four workshops at different places. These were intended to prepare a detailed profile for the ocean development in the country in the next 20 years. The topics of the vario is workshops were :

1. Educational, Training & Manpower requirement
2. Exploration of Sea-bed Minerals
3. Ocean Engineering
4 Marine Instrumentation
5. Ocean Data Management
6. Ships and Submersibles and
7. Living Resources.

While no proceedings were brought out, the recommendations were forwarded to the Department of Ocean Development.

International Seminar on Estuaries

NIO organised an International seminar on 'Estuaries their physics, chemistry, biology, geology and engineering aspects' from December 7-11, 1981. This was co-sponsorcd by 13 national and international organisations and was inaugurated by Dr. S. Z Qasim, Secretary. Department of Environment. Government of India. New-Delhi.

Dr. S.Z. Qasim, Secrtary, Dep. of Environment inaugurating the seminar on estuaries.

This 5 day seminar in which 115 papers were presented, was attended by 100 scientists from India and abroad.

The seminar made a number of recommendations and in the concluding session it was agreed that inter-disciplinary effects should be made to solve the mysterie of the estuaries.

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Radio Talks

Speaker		Subject
Dr. T. S. S. Rao	—	The Mackerel - a marvel story
Dr. A. B. Wagh	—	Coastal erosion - its causes and prevention (Marathi)
	—	Do we accept scientific attitude and development?
	—	Nodules at the ocean floor - implications of their mining for countries like India
Dr. E. Desa	—	Computer culture: 2001 AD
Dr. A. H. Parulekar	—	Sagar Vidnyan (Oceanography)
Shri R. M. S. Bhargava	—	Sea - a farm
Shri G. V. Rajamanickam	—	Sea - a mine for precious minerals (AIR Ahmedabad)
Dr. S. Y. Kamat	—	Sea - a pharmacy (AIR Ahmedabad)
Shri S. G. Dalal	—	Ocean and the climate

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Publications

12.1 SCIENTIFIC PAPERS

Abidi. S.A.H., B.N. Desai, S.N. Dwivedi and P.K. Varshney. A study on the trend of sports fishery of Mafia Island (Tanzania) along the East African coast from 1961-1982. **Jour. Indian Fish Assoc, 6:** 7-23.

Abidi, S.A.H., S.N. Dwivedi, O.S. Gautam and T.M. Koye. Present status and prospects of future development of aquaculture technology in Andaman. **Shipping & Marine Industries Journal, 6(3):** 121-123.

Achuthankutty, C.T. and S.R. Sreekumaran Nair. A preliminary account on the distribution of decapod larvae in Konkan waters. **Mahasagar — Bull. natn. Inst. Oceanogr., 14:** 211-214.

Achuthankutty, C.T., S.R. Sreekumaran Nair, V. P. Devassy and Vijayalakshimi R. Nair. Plankton composition in two estuaries of the Konkan coast during premonsoon season. **Mahasagar — Bull. natn. last. Oceanogr., 14**: 55-60.

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Ansari, Z.A., A.H. Parulekar and S.G.P. Matondkar. Seasonal changes in meat weight and biochemical composition in the Black Clam **Villorita cyprinoides** (Grey). **Indian J. mar. Sci., 10:** 128-131.

Balasubramaniam, T. and B.U. Nayak. Deep water moorings for oceanographic instruments. **Proc. First Indian Conf. in Ocean Engin., IIT**, Madras, 1 : VIII-14 to 21.

Bhattacharya, G.C, F. Almeida, H.N. Siddiquie and K.H. Vora. Multisensor surveys for offshore constructions off Bombay Island. **Proc. First Indian Conf. in Ocean Engg., IIT**, Madras, 1: VII-29 to 34.

Bhattathiri, P.M.A. and V.P. Devassy. Primary productivity of the Andaman Sea. **Indian J. mar. Sci**., **10:** 243-247.

Bhosle, N.B., C. D'Silva, P. V. Shirodkar and C.V.G. Reddy. Particulate carbohydrate in the euphotic zone of the Bay of Bengal. **Mahasagar — Bull. natn. Inst. Oceanogr., 14:** 251-256.

Chandramohan, P., T.V. Narasimha Rao and D. Panakala Rao. Studies on beach changes at Visakhapatnam. **Mahasagar — Bull. natn. Inst. Oceanogr., 14**: 105-115.

De Souza, S.N., S.W.A. Naqvi and C.V.G. Reddy. Distribution of nutrients in the western Bay of Bengal. **Indian J. mar. Sci, 10:** 327-331.

De Souza, S.N., R. Sen Gupta, S. Sanzgiri and M.D. Rajagopal. Studies on nutrients of Mandovi and Zuari river systems. **Indian J. mar. Sci, 10:** 314-321.

De Souza, F.P. and R. Sen Gupta. On the distribution of bromide and Bromide/ Chlorinity ratios in the waters of the Arabian Sea off Central Indian coast. Mahasagar — **Bull. natn. lnst. Oceanogr., 14:** 309-311.

Devassy, V.P. and P.M.A. Bhattathiri. Distribution of phytoplankton and chlorophyll 'a' around Little Andaman Island. **Indian J. mar. Sci, 10:** 248-252.

Dhargalkar, V.K., V.V. Agadi and A.G. Untawale. Occurrence of **Porphyra vietnamensis** (Bagiales, Rhodophyta) along the Goa coast. **Mahasagar — Bull. natn. Inst. Oceanogr., 14:** 75-77.

Dileep Kumar, M. The oxidation state diagram : stability of dissolved sulphur species in sea water. **Mar. Chem., 10**: 475-486.

Fernandes, A.A., A.D. Gouveia, P.V. Sathe and R. Nagarajan. Wave observations in the Mahanadi basin (Bay of Bengal) during September, 1980. **Mahasagar — Bull. natn. Inst. Oceanogr., 14:** 239-249.

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Harkantra, S.N. and A.H. Parulekar. Ecology of benthic production in the coastal zone of Goa. **Mahasagar — Bull. natn. Inst. Oceanogr., 14:** 135-139.

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