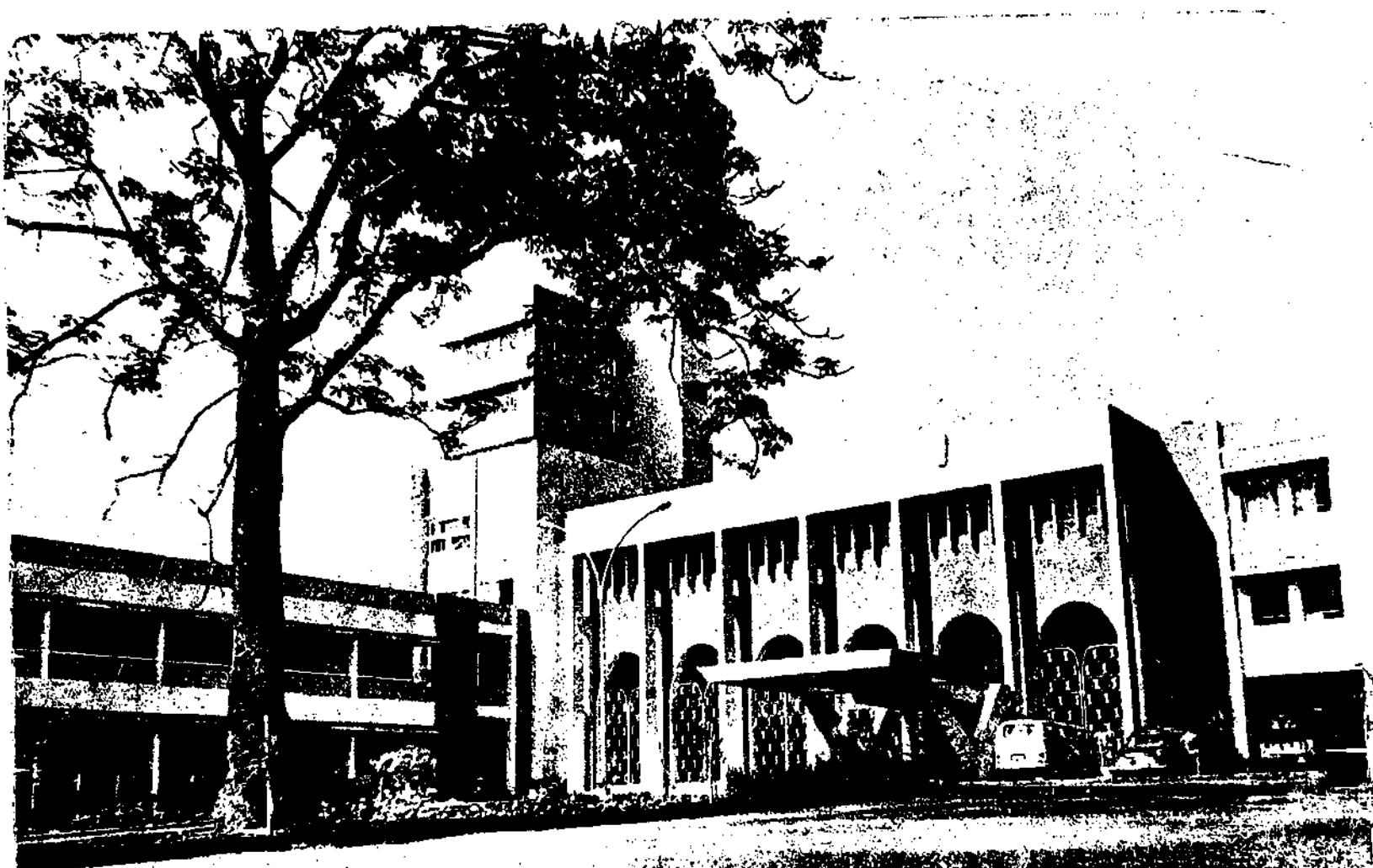
NATIONAL INSTITUTE OF OCEANOGRAPHY GOA- INDIA

ANNUAL REPORT 1975



NIO - Main Building

ANNUAL REPORT

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NATIONAL INSTITUTE OF OCEANOGRAPHY

(Council of Scientific & Industrial Research)
DONA PAULA, GOA

I N D I A

c o n t e n t s

1

general introduction

During the year a high priority was given to applied research in oceanography and the Institute has developed new capabilities to undertake different types of work according to national needs.

In all, 18 projects were undertaken in 1975 and investigations under these projects were carried out at the headquarters in Goa and Regional Centres at Cochin and Bombay. A greater emphasis was given to problems connected with the coastal zone management, physical processes, air-sea interaction, extraction of active compounds from seaweeds, exploration of mineral resources, aquaculture, oceanographic instrumentation, data processing and publication of results.

Moreover, a number of projects sponsored by the industries and public sector undertakings were also carried out. The expertise available at the Institute was fully utilized in providing consultancy services and advica to numerous agencies. Most of the sponsored projects were largely related to protection of the environment from pollution and coastal zone problems. Of the seven sponsored projects at hand, four were completed and reports submitted to sponsoring agencies. These are :

1) Hydrographic survey of Mahi estuary and the Marine environment (sponsored by National Environmental Engineering Research Institute, Nagpur).
2) Studies on the shoreline and adjoining sea at Loliem (sponsored by the Government of Goa, Daman and Diu).
3) Bathymetric and hydrographic survey of the sea off Tarapur (sponsored by Tarapur Atomic Power Authority).
4) Survey for the proposed effluent pipeline route in Cola Bay, Goa Csponsored by Zuari Agro Chemicals Lid.)

The following sponsored projects are underway :

1. Hydrographic Survey of Cochin Harbour area (sponsored by the Cochin Port Trust).
2. Determination of suitable point off Mangalore for the discharge of treated effluents (sponsored by the Mangalore Chemicals & Fertilizers Ltd., Mangalore).

The Institute actively implemented! the following two international projects :

1. First phase of the United Nations Environmental Programme on Marine Pollution Monitoring and Marine Living Resources Assessment for the Indian Ocean Region.
2. Integrated Global Ocean Station System (IGOSS) on monitoring of oil pollution along the Indian coast.

Samples collected during the various cruises of 'INS **Darshak'** during 1974-75 were analysed and data were processed.

At a ceremony held in Calcutta the Institute's first research vessel **GAVESHANI** was commissioned on 31st December, 1975. Shri P. N. Haksar, Vice-President of CSIR and Vice Chairman, Planning Commission, while commissioning the Research Vessel, praised the indigenous shipbuilding technology and said that with the commissioning of **Gaveshani** NIO will enter into a new phase of ocean research.

The first phase of laboratory buildings was completed and the entire accomodation was fully occupied. The first phase of the workshop is also nearing completion.

At the Ninth General Assembly of the Intergovernmental Oceanographic Commission, India was represented by a 3-men delegation and during the election of the Executive Council of IOC, India secured the maximum number of votes.

The Institute was also associated with the Training, Education and Mutual Assistance (TEMA) activities of the IOC.

DIRECTOR

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research activities

2.1

physical oceanography

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

1. Prediction of storm surges at various places along the east coast of India
2. Studies on upwelling in the intertropical Indian Ocean
3. Energy exchange between the sea and the atmosphere
4. Studies on shore protection through utilization of wave energy

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

1. Physical oceanographic studies in the northern Arabian Sea (Darshak programme)
2. Oceanographic studies under the Monsoon Experiment
3. Light penetration in the coastal waters along the Goa coast

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

1. Coastal Oceanography and coastal zone management
2. Hydrodynamic model studies in relation to coastal processes and coastal engineering.
3. Studies on beach drift and circulation along the Kerala coast.

During the year 1975, the research activities in the Physical Oceanography Division were concerned mainly wit'n three different projects.

Investigations carried out under these projects are as follows :

2.11 STUDIES ON OCEAN ATMOSPHERE INTERACTION WITH SPECIAL REFERENCE TO SEAS AROUND INDIA

Under this project four investigations were carried out.

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

During the period under review, hourly sea level data at six major ports along the east coast of India viz., Sagar. Paradeep, Visakhapatnam, Madras, Nagapatnam and Tuticorin

were collected from the Geodetic and Research Branch, Survey of India, Dehra Dun for the periods of seventeen storms that occurred in the Bay of Bengal. Separation of surge from the observed data was carried out for the two storms which occurred in 1970 to formulate the methodology. Meteorological data pertaining to these storms are being analysed.

2. Studies on upwelling in the intertropical Indian Ocean

As part of this investigation, physical oceanographic studies of the Andaman Sea were taken up since the physical oceanography of this region is little known.

Utilizing the oceanographic data collected on board R. V. Serrano during the International Indian Ocean Expedition (IIOE), various vertical and horizontal sections of the distribution of temperature, salinity, density and oxygen were prepared.

To study the geostrophic current pattern, dynamic topographic charts with reference to 500 db surface were prepared for 0, 50, 100 and 200 db pressure surfaces.

The study brings out the following salient features of the region.

The surface waters are relatively warm (>28°C) in the eastern region of the Islands. The surface salinity increases southward. Alternate cells of anticyclonic and cyclonic circulation are observed. The sill depth of the Andaman Basin is about 1300 m. Inside the basin, the water is warmer than the bottom water of the Bay of Bengal by *2*° to 3°C.

A comprehensive study of the oceanographic parameters of the southwest Indian Ocean was undertaken using the Atlantis II (cruise 15) data of the IIOE. Several vertical sections of temperature, salinity, oxygen and thermosteric anomaly were drawn. To determine the transport across the equator, geostrophic currents were evaluated.

To understand the process of mixing of various water masses in the equatorial Indian Ocean, the transequatorial movement of water masses was taken up. Both qualitative and quantitative evaluation of water characteristics were made along 5°N, the equator and 5°S by drawing the scatter diagrams of potential temperature-salinity and potential temperature-density along the three latitudes. The quantitative evaluation was made by computing the volume of water in bivariate classes of potential temperature against salinity in the upper 2,000 m in the three latitudinal belts. The following are the main findings :

a) The admixture of various water masses of the northern and southern hemispheres and the water mass of the Pacific Ocean forms the Equatorial Indian Ocean Water which is vertically homogeneous in the depth range of 100 — 1,000 m

b) Due to the basically zonal flow, the Equatorial Indian Ocean Water checks the free transequatorial movement of water masses at 100 to 1,000 m depth.

c) The influence of the Persian Gulf Water even in the northern region up to 5°N is small.

d) During the southwest monsoon, there is no major cross equatorial flow of the Red Sea Water other than near the African coast.

e) Although the Red Sea and Antarctic intermediate waters have the same density at their sources, the density of the former increases while that of the latter decreases because thermal expansion of sea water decreases with temperature. When these waters come in juxta-position near the African coast, the Antractic Intermediate Water glides over the Red Sea Water.

f) Below 40 cl/t the water in the whole area is of the circumpolar and Atlantic origin.

Utilizing the oceanographic data collected during HOE at 90 stations, the distribution charts of the physical properties at 160, 120, 80 and 60 cl/t potential thermosteric anomaly surfaces have been prepared and the circulation pattern at these surfaces have also been drawn by computing the acceleration potential. In order to have a quantitative estimate of the flow and also the exact depth up to which a particular flow is consistent, zonal components of currents along 84°E have been estimated from geopotential dynamic heights. Some of the important features of this study are as follows :

Low-salinity water from the Pacific Ocean intrudes into the western Indian Ocean along the South Equatorial Current in the layers above 100 cl/t. Below 100 cl/t relatively higher salinity water of the North Indian Ocean appears to penetrate in:o the Eastern Archipelago and ultimately into Pacific Ocean. However, further studies with more data in the Eastern Archipelago region are necessary to confirm the incursion of the North Indian Ocean Water into the Pacific Ocean.

Neither the Antarctic Intermediate Water nor the Sub-tropical subsurface water enter the North Indian Ocean except very near the coasts.

The South Equatorial Countercurrent and the Tropical Countercurrent are found at 12°S — 15°S and 20°S — 24°S respectively. The latitudinal position of these currents vary with longitude.

The Equatorial Jet recently discovered in the Indian Ocean was studied in relation to the variable wind stresses during the two transition periods between the monsoons. The curl of the wind-stress in the equa-

torial Indian Ocean was computed for the four transition months to estimate the mass transport.

3. Energy exchange between the sea and the atmosphere

Under this programme, a study of the heat budget of the Andaman Sea is being worked out. The heat storage calculations in the upper layers of the Andaman Sea were made using bathy thermograms collecied by R. V. **Serrano** during IIOE.

4. Studies on shore protection through utilization of wave energy

Instruments which respond to wave profile and the momentum associated with the breaking waves are being developed. Six field trials were carried out to test the feasibility of the instruments developed in the laboratory.

2.12 STUDIES ON PHYSICAL PROCESSES OCCURRING IN THE SEAS AROUND INDIA

Under this project, the major activities during the period under report were the analyses of the data collected during ISMEX (Indo-Soviet Monsoon Experiment, 1973) and INS **Darshak** Oceanographic Expedition (1973-74). Some studies on the light penetration in the coastal waters and littoral drift and nearshore circulation along the Goa coast were also carried out.

1. Physical oceanographic studies in the northern Arabian Sea (Darshak Programme)

Data collected with STD Recorder in 1974 on board INS **Darshak** during the Oceanographic Expedition in the Arabian Sea were processed and a report incorporating the processed STD data (in digital format) was prepared. Salient features of thermal structure in the north-western Arabian Sea during late winter (February) as evident from the analysis are given below.

The surface temperature varied between 22.3 and 23.5° C, the lower values were encountered in the northern and eastern regions. The thickness of mixed layer, in general, decreased southwards, the decrease being prominent (from about 190 m to about 40 m) in the eastern region as compared to that of the western region (140 m to 90 m). The mixed layer is well marked in the northern and western regions (with the mean temperature gradient less than 0.5°C 100 m) as compared to the southeastern region.The temperature at the upper boundary of the thermocline, varied generally between 22.0°C and 23.0°C, the lower values were., encountered in the northern and western regions. The thickness of the thermocline was less (about 225 m) in the northeastern region as compared to the other regions (where it varied between 250 m and 300 m). Mean temperature gradient in the thermocline varied between 2.3 and 3.4°C/100 m. Maximum temperature gradients in

the thermocline (14 to 16°C/100 m) were observed at 55-65 m depth in the southeastern region. Temperature inversions were often seen between 250 m and 350 m depth levels in association with the presence of Persian Gulf high salinity water.

2. Oceanographic studies under Monsoon experiment

Plotting of T-S diagrams for about 300 stations occupied by USSR Research Vessels was completed.

From May to June, there was no significant change in the surface temperature in the northern Arabian Sea. But in the rest of the Arabian Sea and the northwest Indian Ocean, north of equator, surface temperature-falls by more than 1°C from May to July. The temperature fall was pronounced (more than 2°C) in the western Arabian Sea. Apart from the loss of heat due to the high rate of evaporation, eastward spreading at the surface of cool upwelled water resulting from intense upwelling off Somalia also appeared to contribute to the low temperature of surfacs waters in the Arabian Sea during June and July. Analysis of time sections in respect of buoy stations occupied on the equator indicated significant changes in the temperature and density structures suggesting the influence of internal waves.

Computation of geostrophic currents along 65°E meridional section running across the Arabian Sea into the equatorial Indian Ocean revealed the presence of strong currents with westerly components, extending from the surface to greater depths at 2° to 3° N. Currents with easterly components were found towards north of this region between 5°N and 7°N. Further north, in general, currents with easterly components, were encountered except in a few regions where weak currents with westerly components were located suggesting the presence of eddy circulations.

3. Light penetration in the coastal waters along the Goa coast

Diurnal variations in the optical properties of the waters off Sinquerim (near 12 m line) were studied using submarine photometer and Secchi disc in the months of February, March and April. The extinction coefficient of the waters was found to vary between 0.1 and 0.9. Optical properties and suspended load of the waters along section (near 12 m line) off Baga to Velsao were studied in October, November and December. In this region, significant variations in the extinction coefficient (0.5 to 2.2) and suspended load (1 to 60 mg/|). were observed.

2.13 STUDIES ON LAND-SEA INTERACTION AND NEAR. SHORE CIRCULATION WITH APPLICATION TO COASTAL ZONE MANAGEMENT

The following studies were carried out under this Project during 1975:

1. Coastal oceanography and coastal zone management

(a) The analysis of the data collected during the previous years on the topographic changes at selected stations along the beaches of Goa, viz Calangute, Colva, Baina and Miramar, was completed. The nature and intensity of the changes in the form of cut and fill of the beach sediments with time were examined in relation to the meteorological and oceanographic parameters with a view to understand the circulation of water and sediments in the nearshore regions. The studies revealed that the beaches, by and large, were in static equilibrium. Rhythmic changes in the beach topography occured with low magnitudes and with a periodicity of 45 to 60 days. In addition, a major cycle of changes having a 12 month periodicity was found to be associated with the monsoonal wave and wind activity. The influence of the fluctuations and the rise of ground water table during the rainy season is found to be significant. The beaches tend to recover within two to three months, 60-70% of the sediments which were otherwise lost to the inshore regions during the period of maximum cuts in the monsoon months. Where the beaches experience major cuts, the average recession of the shoreline varies from 35 to 40 metres. The interpretation of the analysed data on the influence of land-sea breeze circulation on the deposition of sediment in the backshore regions of the beaches, specially during the fair weather season, is in progress.

Studies along the sandy beaches of Bombay viz., Chaupaty, Juhu, Versova and the Madh and Manori islands, were continued during the year.

(b) **Studies on wave refraction:**

Wave refraction diagrams were drawn for the 30 km strip of shoreline between Betul point and Velsao. From the refraction diagrams, the wave heights in shallow waters at selected stations along the shoreline were estimated. The results have revealed the following features.

In general, the values of refraction function showed that the amplification of wave heights was reduced considerably for the lower period waves, with a few exceptions. A persistent decrease in wave height at the shoreline was recorded for waves of 6 sec. period approaching from almost all the reference directions. The values of direction function indicate that the alongshore component of wave energy and the associated littoral currents were directed upcoast (indicating northerly component) for deep water waves approaching from southwest and west-southwest directions, while they were directed down coast for those approaching from west and west-northwest directions. The littoral currents were directed generally towards north for waves approaching from west-southwest. However, the direction function along major portion of the shoreline being very low, the wave rays approach the shoreline in a nearly perpendicular

direction which results in greater onshore/offshore components. Similar distribution pattern for the values of the direction function along the shoreline for waves approaching from west also shows the existence of predominent onshore/offshore movements along major portion of the shoreline. There are alternate increase and decrease of wave heights at some points along the shoreline resulting in concentration of wave energy at one place followed by divergence on either sides. As a consequence, flow from zones of higher wave energy to regions of lower wave energy, leading to seaward flows, is noticed. The refraction diagrams for waves approaching from west-northwest show that the refracted wave rays do not reach the shoreline at the extreme northern region indicating that the region is under shadow zone.

c. Littoral drift and nearshore circulation along the Goa coast

Littoral transport along the southern part of Goa coast was studied by (i) calculation of alongshore component of wave energy flux and (ii) repeated surveys of the surf zone (monthly beach profile measurements) at Velsao, Colva and Cavellossim over a period of one year. From these studies, it was inferred that the material transport is offshore during the southwest monsoon season with a northerly component and onshore during the fair weather season with a southerly component.

Nearshore circulation along the Consaulim beach (Goa coast) in the post-monsoon months (October and November) was studied with the help of floats and theodolites. The current velocities at the surface were found to be comparatively higher than those at 4 ft below the surface. The circulation exhibited the influence of rotary type of tidal currents, probably caused by the bay formation north of the region.

(d) **Studies on beach sediments:**

Twelve beach and 26 nearshore sediment samples collected along eleven transects off the coast of Goa were studied for their coarse traction constituents. The sediments on the foreshore of Colva beach are composed entirely of sand size material. It is made up mainly of biogenous components in the coarser size class. Their percentage decreases according to the decrease in the grain size. In contrast to this, the terrigenous constituents increase in the finer size class. The biogenous components are dominated by shell fragments followed by benthic foraminifera. Ostracods as well as echinoids occur in insignificant quantities. A progressive decrease in shell fragment was recorded from coarser to full size class of the coarse fraction. The percentage of foraminifera is highest in the 0.25 mm size class below which a decreasing trend was recorded. A gradual decrease in biogenous components was noticed from north to south of the beach environment.

The sediments are almost in sand size class at about 4 to 5 metres depth in the nearshore region. They are largely made up of terrigenous components with admixture of biogenous constituents. The biogenous components have a good percentage of molluscs in the northern region. It snows a decrease towards south. Among the terrigenous constituents quartz predominates and is followed by darks. Of interest is the occurrence of micaceous minerals and these are recorded in traces. The percentage of coarse fraction in the bulk sample becomes much less at about 10 to 11 m depth. Here it is dominated by terrigenous component. A significant percentage of mica occurs within the coarse fraction. Another component occurring in significant quantity is wood material. Dark minerals which are less significant in the beach environment show appreciably higher percentages in the nearshore environment. A gradual increase in percentage of micaceous minerals is recorded from south to north in the nearshore region.

2. Hydrodynamic model studies in relation to coastal processes and coastal engineering

(a) A scale model of Mandovi showing the detailed bathymetry of the area in and around Aguada bar was prepared, as a preliminary step towards the development of a hydrodynamic model for investigating the problem of formation of bar near the mouth of the river Mandovi.

In connection with the hydrodynamic model studies in relation to coastal engineering, the equipment needed was acquired for the proposed studies on (1) dynamic working models for checking the observed shoaling zones and the circulation cells in the Aguada Bay and (2) the littoral sediment transport and the circulation of water and sediment along the beaches of Goa.

(b) The data on wave climate, analysed for the use in the proposed model studies, indicated the presence of strong velocity gradients parallel to the shoreline for waves of normal incidence, resulting in the irregularly spaced rip current zones. This feature is less conspicuous for waves approaching at an angle. The variations of the wave stresses along with the wind stress in space and time are being examined in detail as they govern the nature and intensity of the circulation prevailing in the littoral and nearshore regions.

3. Studies on beach drift and circulation along the Kerala coast.

This study included the collection of beach profile data at every 1/2 km interval along a part of Kerala coast from Thumboli to Purakkad along with other parameters such as wave period, breaker height and direction of littoral current.

The results obtained are useful in demarcating the areas which are subjected to erosion and accretion and remedial measures are being worked out. A technical report on the beach erosion studies conducted during the period 1969-74 has been prepared.

2.2

chemical oceanography

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

1. Chemical oceanographic studies in the Arabian Sea and Bay of Bengal
2. Carbon-dioxide system in the northern Indian Ocean
3. Diurnal variations in the carbohydrate concentrations in estuarine waters of Goa.
4. Arsenate and arsenite concentration in the coastal and esiuarine waters of Goa
5. Calcium phosphate saturation in sea water
6. Calcium and magnesium concentrations in the waters of Bay of Bengal
7. Vertical distribution of the degree of calcium carbonate saturation in the Indian Ocean
8. Regeneration of nutrients from marine and estuarine environments
9. Interrelationship between nutrients in sea water and plankton
10. Alginic acid content of some brown seaweeds around Goa coast
11. Chemical studies on the extracts of marine plants and animals
12. Pharmacologically active compounds from marine microbes

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

1. Evaporation of water in association with few forms of carbon

Investigations in Chemical Oceanography were undertaken under three projects. Of these, protection of marine environment and monitoring of pollutants forms a part of Task Force No. 101 and has been reported separately.

The studies laid emphasis on (i) Inter-relationships of organic and inorganic constituents of the estuarine and inshore waters around Goa and the coastal, offshore and deep sea regions of the northern Arabian Sea; (ii) Chemistry cf pharmacologically active components of marine plants and animals; (iii) Pollution problems and (iv) On the improvements of efficiency of solar desalination stills.

2.21 CHEMICAL STUDIES IN THE COASTAL AND OFFSHORE WATERS IN THE ARABIAN SEA AND BAY OF BENGAL

1. Chemical oceanographic studies in the Arabian Sea and Bay of Bengal

Chemical oceanographic studies were conducted in the Gulf of Kutch and in the eastern regions of Bay of Bengal during the three cruises of INb **'Darshak'.** On board analysis was carried out for inorganic phosphate, nitrate-nitrogen, nitrite-nitrogen, ammonia-nitrogen, alkalinity and pH. In the shore laboratory salinity, total phosphorus, total nitrogen, fluoride, calcium, magnesium, arsenic, iron, copper, zinc and manganese contents of the samples were estimated. In all 2,500 estimations were carried out on board and in the laboratory.

Processing of data collected during the cruises of INS **Darshak** in 1973-74 and 1975 continued during the year. A comparison of conditions in the Arabian Sea and in the Bay of Bengal showed that the latter is poorer in oxygen as compared to the former. All the three forms of inorganic nitrogen were present in the Arabian Sea while in the Bay of Bengal, only nitrate-nitrogen was estimated which increased progressively with depth. This probably indicates that while denitrification proceeds at intermediate depths of tne Arabian Sea, the process might be absent in the Bay of Bengal. Processing of data for other parameters are in progress.

2. Carbon-dioxide system in the northern Indian Ocean

This study is based on the data collected during the oceanographic expedition of INS **Darshak** (Dec. 1973-May 1974) in the northern Indian Ocean. These included total CO_2, dissolved CO_2 (free CO_2 and un-ionised carbonic acid), bicarbonates and carbonates. The concentrations were computed from the estimated alkalinity, pH, salinity and temperature of the water. Vertical and horizontal distributions of the different components were studied with reference to physical, chemical and biological conditions of the region.

The findings indicate that the regional distribution of the components is not uniform. Relative proportions of the components in the particular region are consistent with the expected equilibrium conditions of the water.

Of all the carbon dioxide components, bicarbonate is most abundant forming 82-95% of total carbon dioxide at all locations irrespective of depth. Carbonate and dissolved carbon dioxide are in extremely low concentrations. Carbonate is about 2-12% and dissolved carbon dioxide is less than 1% of total CO_2. An interesting feature is that despite the low concentrations of dissolved carbon dioxide, the magnitude of its variations with location and depth is quite considerable.

Depthwise distribution of CO_2, HCO_3 and dissolved carbon dioxide showed a general decrease in the upper 100-150 m followed by a sharp rise up to about 500 m. At deeper levels (1000 m), the concentrations are reversed and the magnitude of changes is much less than that of the other components.

Horizontal distribution of total CO_2 and dissolved carbon dioxide in the surface waters showed several cellular structures suggesting marked variations perhaps due to varying nature of biological productivity. The changes are relatively low in deeper layers. High concentrations were observed in the north-eastern part of the region and relatively low concentrations in the southern region.

3. Diurnal variations in the carbohydrate concentrations in estuarine waters of Goa

Diurnal studies conducted on the concentrations of carbohydrates in the estuarine waters indicated significant changes. Soluble carbohydrates were subjected to greater variations than the particulate carbohydrates. It is interasting to note thai the peak values of particulate and soluble carbohydrates were non-synchronous. A time lag was observed between the two peaks. This may perhaps be explained by the fact that during the active phase of production, very little carbohydrates is excreted or released as a result of decomposition or bacterial activity. It is only after attaining the peak growth that the organisms tend to excrete or decompose releasing significant amount of soluble carbohydrates.

4. Arsenate and arsenite concentration in the coastal and estuarine waters of Goa

Arsenic in its inorganic forms mainly occurs as arsenate and in small concentrations as arsenite. In the coastal and estuarine waters, arsenate was found to be the dominant form. In the estuarine waters arsenate varied from 1 µg/l to 22 µg / l (av. 5 µg /l) and arsenite varied from 1 µg/l to 19µg/l. (av. 2.5 µg/l). In the coastal waters the values of arsenate ranged from 1 to 24 µg/l (av. 6 µg/l) and arsenite from 1 to 9 µg/l (av. 1.4 µg/l). Few estimations of total arsenic in the estuarine and coastal sediments also indicated marked accumulation of the element from 4 to 14 ppm. High concentrations in the bottom water suggested active recycling of this element.

5. Calcium phosphate saturation in sea water

The degree of saturation of calcium phosphate was determined in the nearshore waters at Sinquerim, Calangute and Baga beaches and in the inshore waters of Verem, Aguada and Zuari estuary. Later, the studies were extended to other stations along the northern and southern coasts *of* Goa. Analysis of the samples collected from the stations showed that during the pre-monsoon period ionic product of calcium phosphate at Sinquerim varied from 3.16

$x10^{-21}$ to 5.14 x 10^{-20} whereas it ranged from 6.87 x 10^{-21} to 4.2 x 10^{-20} for the sea water at Baga. In the post-monsoon period, the ionic product of sea water from sinque ranged from 3.24 x 10^{-20} to 1.04 x 10^{-20} whereas it varied from 0.96 x 10^{-20} to 8.92 x 10^{-20} for the waters of Baga. Samples collected from a depth of about 20 m from Aguada and Verem were found to be supersaturated in the pre-monsoon season, the ionic product being 7.31 x 10^{-20}. However, the degree of saturation decreased in the post-monsoon period.

Samples were collected in the post-monsoon season from 6 stations (Chapora, Aguada, Calangute, Marmagoa, Velsao and Colva) along the northern and southern coasts of Goa. Surface waters at these stations were found to be undersaturated and at 20 m depth the ionic product increased to a supersaturation value.

Observations were also made on the influence of the other chemical parameters on ionic product. The ionic product varied directly with the salinity. The degree of saturation was found to be dependent more on the concentration of PO_4^{-3} and PH conditions. Calcium concentrations in the water were more or less constant in all the seasons.

6. Calcium and magnesium concentrations in the waters of Bay of Bengal

During the monsoon period samples collected from the Bay of Bengal by INS **Darshak** were analysed for calcium and magnesium concentrations. The concentration of these metals in that area showed significant variation with depth. The calcium concentration varied from 414 mg/kg at the surface to 434 mg/kg at a depth of about 800 m. The magnesium concentration varied from 1.26 g/kg at the surface to about 1.32 g/kg at 800 m. The levels increased with the depth upto about 800 m followed by a gradual decrease in deeper layers.

7. Vertical distribution of the degree of saturation of calcium carbonate in the Indian Ocean

Degree of saturation of calcium carbonate as a function of depth was studied at three locations in the Indian Ocean from alkalinity and pH measurements. The results indicated that the surface waters are four to five fold supersaturated with respect to calcite. The degree of supersaturation is maximum within the first 50 metres. The degree of saturation decreases with the increasing depth and the water becomes either undersaturated or nearly saturated at the depth of about 1,000 metres.

8. Regeneration of nutrients from marine and estuarine environments

Laboratory experiments were conducted on the samples of sediments collected to study the role of micro-

bes on the regeneration of phosphate. Variations in the concentrations of inorganic phosphate in the water layer immediately above and mud-water interface were taken as approximate measures of the regenerative capacity of the mud. The bacteria were plated following the serial dilution method using marine Zobell agar medium.

No significant changes were noticed during the first four days. However from 5th to 10th day the release of phosphate in the water was found to be significant. During this period the phosphate concentration in the water increased from the initial concentration of 1.45 µg - at/l 6.94 µg-at /l with a rate of release of 0.55 µg-at/l/day. During this period the microbial population also showed a drastic increase from 38.1 x 10^4 to 130.2 x 10^4/ g dry soil. The interstitial phosphate decreased from 24.34 µg/g mud to 20.93 µg/g mud with a rate of 0.24 µg/g mud/day. The concentration of adsorbed phosphate also decreased considerably from 36.28 µg/g silt to 34.74 µg / g silt.

After this period a considerable reduction in the concentration of phosphate in the water and a subsequent increase in the concentration of adsorbed and interstitial phosphate were observed in the sediments. Thus the process of adsorption and the released phosphate by the sediment were demonstrated. As the microbial population during this period showed a drastic increase from 130.2 x 10^4 to 365.1 x 10^4 /g dry soil, the decrease in the inorganic phosphate may also be due to the utilization of inorganic phosphate by the microbes.

9. Interrelationship between nutrients in sea water and plankton

To study the interrelationships between nutrients in water and in plankton, analysis of nitrogen and phosphorus was carried out in both seawater and plankton. Estimations were carried out in samples collected from the nearshore waters off Goa and in laboratory cultures. A stoichiometric relationship established from these studies, showed that plankton in the Indian Ocean have almost the same C : N : P ratio as in the other oceans and is similar to the ratio of change of nutrients in water.

10. Alginic acid content of some brown seaweeds around Goa coast

Alginic acid yield in the abundantly occurring brown seaweeds ranged from 8 to 23%. Highest yield was obtained from **Dictyota bartayresii** followed by **Spatoglossum asperum, Colpomania sinucsa, Sargassum tenerrimum** and **Dictyota dutnosa**. Lowest yield was from **Padina tetrastomatica.**

11. Chemical studies on the extracts of marine plants and animals

Extracts of ten seaweeds collected along the central west coast of

India and some marine animals like sea cucumbers, **Zooanthus** etc. were prepared and these were sent to Central Drug Research Institute, Lucknow for pharmacological screening of antibiotic, antibacterial, antivirus, antitumor, antifertility, muscular and CNS activities. The report is awaited for further investigations based on specific activities of the extracts.

Meanwhile, the isolation and identification of two seaweed extracts have been initiated. Petroleum ether extract of **G. corticata** contained long chain aliphatic hydrocarbons and methyl ester of a fatty acid. This was confirmed by spectroscopic data (IR and NMR). In the case of **Chaetomorpha,** the presence of ketones and hydroxy carboxylic acids was noticed. These observations are of interest and reveal the diversity of organic compounds present in seaweeds and this perhaps reflects the biological activity specific to certain seaweeds.

12. Pharmacologically active compounds from marine microbes.

Preliminary survey was made to isolate bacteria, yeast and fungi. The sediments collected from 20 m depth off Aguada, Calangute and Chapora were analysed. The number of bacteria from Aguada was higher than at the other two stations and it was 5 x 10^4/g sediment. The number of yeast cells varied from 3 x 10^4/g sediment to 1 x 10^5/g sediment. Pure cultures of the microbes are being prepared for further studies.

2.22 INVESTIGATION ON DESALINATION OF SEA WATER

1. Evaporation of water in association with few forms of carbon

Experiments were continued on the improvement of rate of evaporation of water by solar radiation. A total of 21 experiments were conducted on the evaporation of water in association with uniformly powdered lamp black, wood charcoal and graphite. A higher percentage of evaporation (15-20%) occurred when lamp black in suspension was used as compared to lined coating of the other forms of carbon. Application of the above results in a modified solar still, which checks the loss of water vapour, has been made and the solar still is under field trials.

2.3

geological oceanography

2.31 Geological and geophysical surveys to assess the petroleum and mineral prospects of t'ne western continental margin of India (Project No. 501)

2.32 Geochemistry of the sediment off the western continental margin (Project No. 502)

2.33 Sediments of the western continental margin of India (Project No. 503)

2.34 Foraminifera as indicators of high organic carbon and pollution in the marine environment (Project No. 504)

Geological Oceanography Division was engaged in the geophysical, geochemical, sedimentological and palaeontological studies of the seas around India. The research activities of the Division were carried out under four projects.

2.31 GEOLOGICAL AND GEOPHYSICAL SURVEYS TO ASSESS THE PETROLEUM AND MINERAL PROSPECTS OF THE WESTERN CONTINENTAL MARGIN OF INDIA

The analyses of the echograms of western continental shelf and slope have revealed many interesting features such as the presence of a sea mount named **'Darshak Seamount** located along 22°N and 66°E and rising to a height of 1050 metres from the bottom to within 450 m. of surface.

Magnetic and gravity data collected by various ships were analysed. Nearshore magnetic anomalies *were* studied in connection with the estimation of ilmenite deposits off Ratnagiri. High positive residual anomalies on the contour map are probably associated with the concentration of magnetic placer deposits. Detailed bathymetric charts at one meter interval have also been prepared for the Kalbadevi, Mirya and Ratnagiri bays as a part of the survey.

400 samples of sediments collected off Ratnagiri at an interval of 100-150 metres in water depths ranging from 0.5 metres to 14 metres have been analysed for their size distribution. The samples are mostly fine sands with some silt and clay.

2.32 GEOCHEMISTRY OF THE SEDIMENT OFF THE WESTERN CONTINENTAL MARGIN

Estimation of manganese, nickel, cobalt, copper and aluminium have been completed in the non-lithogenous fractions of 100 sediments samples. High values of copper have been found and these are being investigated in detail. Analyses of iron, manganese, nickel, cobalt, copper and aluminium in the samples from sites 219 and 220 of the Deep Sea Drilling Project revealed the concentration, source and partition pattern of the element in the different types of sediments as well as through geologic time.

2.33 SEDIMENTS OF THE WESTERN CONTINENTAL MARGIN OF INDIA

The size distribution, light minerology, composition of carbonate components, petrology and radiocarbon age of the limestones from the northern half of the western shelf has been completed. The results indicate that sediments of the Saurashtra Shelf are partially derived from the Indus and that the continental shelf has not undergone significant vertical movement during the Holocene epoch.

2.34 FORAMINIFERA AS INDICATORS OF HIGH ORGANIC CARBON AND POLLUTION IN THE MARINE ENVIRONMENT

Seventy sediment samples were analysed for organic matter and foraminiferal diversity. The organic matter ranged from 0.06% to 0.44% in the unpolluted intertidal region to as much as 6.86 percent in the region of the effluent discharge point of the Zuari Agro-Chemicals Ltd., at a depth of 10.5 metres. A significant finding is that rotalid and miliolid foraminifera dominate in the beach and water-tidal zone whereas in the polluted region Rotalids decreased with the increase in miliolids and species like **Trochamina, Nonionella** and **Bucella**. Due to altered environmental conditions Rotalids and Miliolids show vesicles in their chambers, discolouration due to fillings and decalcification of their ornamentation.

2.4

biological oceanography

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

1. Primary production
2. Extracellular products of planktonic algae
3. Experimental studies on primary production with special reference to the formation of algal blooms
4. Secondary production
5. Benthic production
6. Bio-degradation of organic matter and biochemical investigations
7. Ecology of estuaries
8. Ecology of mangroves
9. Ecology, primary production and related aspects of sandy beaches

2.42 Coastal Aquaculture (Project **No.** 202)

1. Aquaculture in the waters of Goa
2. Aquaculture in the waters of Cochin
3. Laboratory and field studies on the bioenergetics of some marine and estuarine forms
4. Environmental physiology in relation to culture and population dynamics

2.43 Biogeography of the zooplankton of the Indian Ocean (Project No. 203)

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

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

1. Experimental studies of secondary production.

In all, four projects were taken up during the year under report. Each project contained several investigations, the findings of which are given in the following paragraphs.

2.41 STUDIES ON PRIMARY, SECONDARY AND TERTIARY LEVELS OF THE FOOD CHAINS

1. Primary production — The studies on primary production were continued on board INS **Darshak** in the Gulf of Kutch and Bay of Bengal. The earlier studies in north-west Arabian Sea showed that the primary production in the entire euphotic zone varied between 109.06 and 2665.53 mgC $M^{-2}d^{-1}$. The production was high in January and February and declined in the subsequent months. The maximum production was found in February along 21.04°N and 69.45°E.

During these studies it was observed that the Gulf of Cambay acts as an ecological barrier as seen from the distribution of zooplankton and the northern side of the Gulf is highly productive.

In the Gulf of Kutch, the production was comparatively lower than in the other regions of the Arabian Sea. In the sand heads of Bay of Bengal which is very shallow and turbid area, organic production ranged between 117-250 mgC m^{-2} d^{-1} while in deeper regions it ranged between 62.93 and 242.51 mgC $m^{-2}d^{-1}$ with an average production of 159.5 mgC $m^{-2}d^{-1}$.

Studies on the benthic crop in the Gulf of Kutch showed fairly rich values (11.9 to 19.1 g/m^2) in the Dwarka region. Sipunculids dominated the macrofauna and foraminiferans in microfauna.

2. Extracellular products of planktonic algae — During photosynthesis extracellular matter is released from the algal cells. This investigation is aimed at estimating the quantitative release of metabolites and relating this phenomenon with the incidence of bacterial activity in different habitats. In coastal waters of Goa, it was found that the primary production is underestimated by about 5-39% due to the extracellular release during photosynthesis. Fringe mangrove areas of south Goa have yielded anomalous results and a series of diurnal studies are in progress in an attempt to resolve the problems. These studies suggest that estimations of primary production by conventional techniques need a correction in order to obtain the actual rate of production in such environments.

3. Experimental studies on primary production with special reference to the formation of algal blooms — Dynamics of **Trichodesmium erythraeum** was studied during March to June, 1975. Observations were made for about 100 days at an interval of 4-7 days. During the bloom period, **Trichodesmium** counts ranged from 10-38640 filaments per ml. Another abundant organism associated with **Trichodesmium** was **Nitzchia longissima,** the counts of which ranged from 3 to 16900 cells/ml. Primary production at the surface varied from 2.68 to 517.67 $mgC/m^3 7h$.

4. Secondary production — The study was started along Goa coast by sampling five inshore stations at 10 meter depth off Baga, Sinquerim, Cabo, Bogmalo and Velsao. The re-

suit indicate that the mean zooplankton biomass (wet weight) is higher at all the stations (476 g/1000 m^3) during post-monsoon months than during the pre-monsoon period (188 g/1000 m^3). During both the seasons the highest values were obtained off Bogmalo and the lowest oft Sinquerim.

Twenty species of foraminifera were identified from the intertidal collection of Velsao beach. Of these, **Ammonia beccarii** was the most abundant throughout the year.

5. **Benthic production** — Studies conducted in the nearshore and estuarine waters of Goa indicated that the living populations of meiobenthos in the Zuari and Mandovi estuarine systems mainly composed of nematodes, polychaetes and foraminiferans. The biomass was higher in the upper 2 cm of the sediment. The number of animals ranged from 131 to 1687/10 cm^2. The biomass ranged from 0.007 to 2.976 mg/ 10 cm^2).

The observations on the clam bed in Kali estuary showed a seasonal cycle related to environmental factors. At Mashem the biomass production during the pre-monsoon season varied from 0.31 g/m^2 to 129.62 g/m^2 and in the monsoon season, from 0.5 g/m^2 to 48.9 g/m^2.

6 Bio-degradation of organic matter and biochemical investigations — Photosynthetic bacteria were isolated from sand samples collected from a protected beach at Dona Paula (Goa). Using isotope technique, it is seen that the strain is able ío fix CO^2 anaerobically in the presence of light with the maximum efficiency at pH 7. Experimental studies conducted to understand the role of pollutants such as nitrate, nitrite, organophosphate, pesticides and crude oil on the rate of photosynthesis in these bacteria, showed an inhibitory effect which varied from 3 to 90%. While working on soil enzyme, dehydrogenise, it was observed that the enzyme activity at the Velsao beach which is polluted with nitrogenous material, was about 60% less than on an unpolluted beach at Dona Paula. The enzyme activity was found to be positively correlated with the microbial population and organic carbon content The enzyme activity may be used as an index of pollution.

Analysis of mangrove soil from different areas showed the presence of several phenolic acids such as ferulic, syringic, vanillic, phloretic, P-coumaric and p-hydroxy benzoic acids. Of these, phloretic acid is reported for the first time from the mangroves.

Studies on degradation of cellulose and crude oil by bacteria revealed that several strains are able to produce glucose from paper. The enrichment on coal tar resulted in the isolation of a fungal strain identified as **Fusarium** and also some bacteria.

A fungus belonging to genus **Fusarium** was isolated from the beach environment of Cochin and the me-

tabolites produced by it were studied in detail. Paper chromatographic studies revealed that it does not contain any free amino-acids while it is mainly a muco polysaccharide chemically. This substance showed mild antibacterial property against 2 gram positive and 2 gram negative strains tested in the laboratory.

Electrophoretical studies on haemoglobin phenotypes of **Otolithus ruber** using cellulose acetate strips, suggest that there is intra species variation. Denaturation studies in eye lens nucleus and cortex of **Sciena macropterus** revealed that eye lens protein is resistant to denaturation. Electrophoretic mobilities of eye lens and serum proteins of various species of fishes were carried out to construct electrophoretograms of these fishes.

7. **Ecology of estuaries** — The estuarine system of Goa sustain a high organic production having a maximum production of 316 mgC $m^{-2}d^{-1}$ in Cumbarjua Canal followed by Zuari (249 mgC $m^{-2}d^{-1}$ and Mandovi (247 mgC $m^{-2}d^{-1}$ The chlorophyll concentration too, is maximum in Cumbarjua canal. In Zuari, the production was found to increase linearly with the increase in chlorophyll. The transfer co-efficient varied from 1.7 to 39.9% and decreased with an increase in production.

Studies on seasonal distribution of zooplankton with special reference to copepods at two stations in Mandovi and Zuari estuaries indicated higher annual mean production of zooplankton in Zuari (175 g/1000 m^3) than in Mandovi (81 g/I000m^3). In all 43 species of planktonic copepods belonging to 16 families and 20 genera were recorded in Zuari. In Mandovi the total number of species recorded was 33 from 12 families and 16 genera.

During monsoon, the average tertiary production in terms of wet weight worked out to be 19 mg $m^{-2}d^{-1}$ in the Mandovi-Zuari estuarine systems.

8. **Ecology of mangrove** — Mashem mangrove, one of the richest mangroves, located along the Galgibag estuary of Goa was selected for this investigation. Three diurnal studies in three different seasons (May, August and January) were made during the entire tidal cycle. This mangrove is enriched by the decayed mangrove foliage which is carried over by the tides into the entire mangrove swamp. The swamps provide optimum conditions for the growth of larval forms of estuarine animals like prawns, fishes, etc.

Biochemical analysis of fresh leaves of 7 species of mangrove plants was carried out to determine their protein contents. **Derris trifoliata** showed the highest value of total nitrogen. **Avicennia officinalis** had maximum percentage of carbohydrate (40.0-50.0%), while **Sonnertia acida** had maximum percentage of lipids (12.3%). Twelve different free amino acids were recorded from these species. L. Glutamic acid and DL-2-Amino Butyric acid were observed in 4 of the 7 species, while DL-

Threonine was present in 3 species. L-Tyrosine, DL-Valine and Lystine were recorded in only 2 species. DL-Aspartic acids, L-Proline, L-Cysteine, L-Lysine monohydro chloride, Glycine and Serine were found only in a single species. Further studies on the free and bounded amino acids are in progress.

Mangrove foliage forms a major part of detritus production in the swamps and serves as food for estuarine organisms.

9. Ecology, primary production and related aspects of sandy beaches

Ecological studies are being carried out on 4 beaches viz. Colva, Baina, Bawal and Arambol. These beaches represent both clean and polluted environments. Monthly sampling of beach profile, temperature, salinity, oxygen, nutrients, particulate organic carbon and sand grain size were determined. Sediment samples were studied for macrofauna, meiofauna and microbial studies. The results were analysed to develop models for population dynamics and energy flow in these environments.

Experimental studies were earlier started on the effect of pollutants on beach animals. Samples of **Mytilus viridis** and **Emerita holthuisi** and sand from Velsao beach, adjacent to a fertilizer factory (ZAC) were analysed for the arsenic content. Similar samples from a cleaner environment were also collected and analysed. Laboratory experiment was carried out to investigate the rate of uptake of arsenic by **M. viridis** during its exposure for 50 days to sublethal concentrations of arsenic (0.1 and 1.0 PPm of arsenic) and to determine the effects of such exposure on the growth of **M. viridis.** The results showed that during the exposure the arsenic levels in soft tissue increased from 1 ppm to 12.84 ppm and 29.27 ppm for animals exposed to 0.1 and 1.0 ppm respectively. There was no significant accumulation of arsenic in the shells of animals exposed to the experimental pollution regimes. However, during the period of experimentation, there was repeated spawnings of animals both in arsenic solutions and in clean sea water and at the end, the flesh weight per unit length in animals exposed to arsenic was notably lower than in controlled animals.

2.42 COASTAL AQUACULTURE

1. Aquaculture in the waters of Goa — This investigation includes five interdependent programmes which were initiated during 1975.

(i) Phytoplankton culture: Subculturing of **Tetraselmis gracilis, T. chui, Chlorella** sp. and **Synechocystis** sp. was done. The cultures besides being studied for dynamics of growth were also used for feeding the molluscs.

(ii) Seaweed culture: A survey of seaweed resources of Goa was undertaken at the request of Government of Goa, Daman and Diu. An-

nual yield of seaweeds was estimated and economically and nutritionally important species were listed areawise.

Seaweed culture on coir and nylon ropes was started. Species cultivated were **Hypnea musciformis, Gracilaria corticata, Gelidiella** sp. and **Ulva fasciata.** In spite of high silting in the area, rate of growth of seaweeds was satisfactory.

Laboratory trials were conducted on the effect of extracts **of Padina tetrastromatica, Sargassum tenerrimum** and **Ulva fasciata** on the germination and growth of common bean **(Phascolous** sp.) ground nut **(Arachi** sp.) rice **(Oriza** sp.) and white gram. These were used as test seeds. It was found that seaweed extracts in lower concentrations acted as excellent growth stimulant.

Agar and sodium alginate were extracted concurrently from **Geladiella** sp. Other species such as **Hypnea musciformia, Gracilaria corticata, Jenia** sp. and **Acanthophora** sp. were analysed separately as well as in different mixtures for quantitative determination of various chemical constituents. Gelling and melting temperatures, gel strength and heat energy were determined in various seaweeds. Seaweed powder was tried as an item of food for mussels and oysters, grown under laboratory conditions and their ingestion and growth response was found to be encouraging.

(iii) Molluscan culture: Edible oysters (Fig. 1) **(Crassostrea gryphoides),** green mussels (Fig. 2) **(Mytilus viridis)** and window pane oysters (Fig. 3) **(Placenta placenta)** were grown on rafts (Fig. 4) since January, 1975 onwards. Two rafts, each measuring 6.25 m^{-2} and having a displacement area of 2.18 m^3 were floated (Jan. 75) in Dona Paula Bay but later on shifted (February 1975) to Caranzalem Bay, mainly because of excessive silting at the previous site. To start with, the organisms were col. lected from natural beds and transplanted in suitable gears on to the raft.

Spat was collected using spat-collectors made of window pane oyster shells on the raft. The spat thus collected was later transplanted in suitable gear and grown on the raft. Transplanted animals showed good growth rate. Fouling was found to be a major difficulty during culture operations on the raft.

Fig. 1 - Oyster, Craostrea gryphoides growth on the monofilament bags,

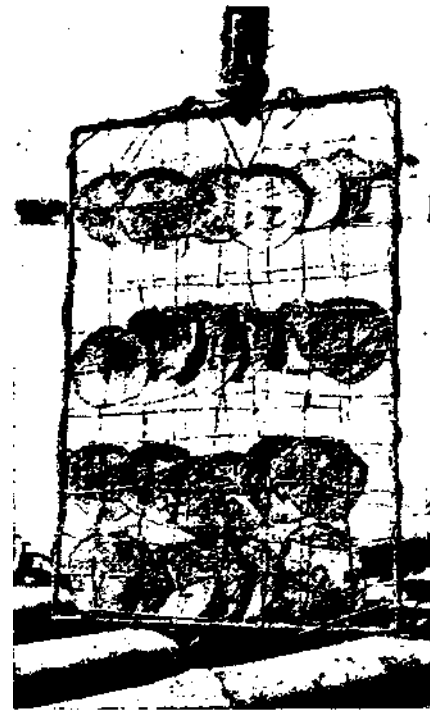


Fig. *2 Windowpane oyster, Placenta placenta growing in sandwich net.*

(iv) Crustacean culture: Baseline information was collected on the breeding behaviour of penaeid, non-penaeid and sergestid prawns in the estuaries and nearshore region of Goa. Investigations on seasonal abundance of prawns, and crab larvae were made. Areas of abundance were demarcated which will be used as collection sites.

Preliminary studies under laboratory conditions on the life history of cultivable species such as **Penaeus Indicus, P. monodon** and **Scylla serrata** are in progress.

Culture of **Macrobrachium** Sp. was initiated in the laboratory. Studies were made on rearing, feeding, length and weight relationship, growth rate and food conversion efficiency. The work was carried out in different phases. In the first phase, emphasis was laid on the rearing of zoea upto post larval stages to be stocked in ponds. Attempts were made to determine cheap and suitable food for the developing stages. Studies were conducted on

the development of eggs upto the different post larval stages. Various food items viz. diatom-cultures, oil-cakes, mashed egg yolk, choped prawn and trash fish were used. The early stages were fed on diatom culture but the later stages accepted only the animal food.

Studies on the effect of environmental parameters on the development of larvae showed that the salinity played an important role during the developmental stages. The optimum salinity for larvae varied from 12%o to 18%o. Higher salinity caused mortality of the larvae. During experiment the water temperature varied from 23° C to 28° C.

Fig. 3 - Rope culture of mussel, Mytilus viridis on the raft at Dona Paula.

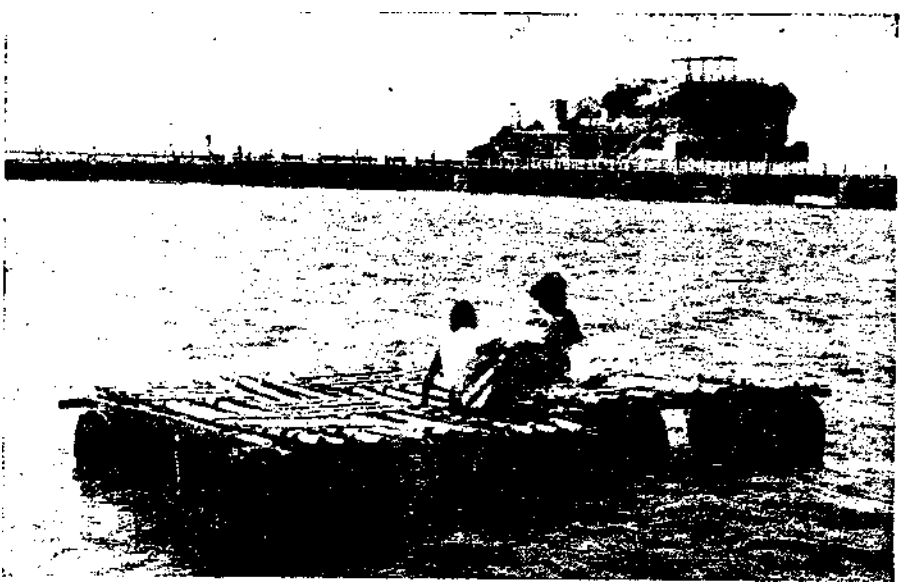


Fig. 4 - A floating raft at Dona Paula used for mussel and oyster culture.

(v) Fish culture: Studies were made on the growth of fingerlings of grey mullet **Mugil cephalus,** and **Etroplus suratensis** collected from the Goa Velha fish farm. The fishes were measured initially and put into large aquarium tanks. Supplementary food (mixture of groundnut oil cake and coconut oil cake in the ratio of 1 : 1 was given to the fish every day as 1% of their total weight. Monthly growth of mullet was about 6 mm in length and 2 g in weight.

2. Aquaculture at Cochin

Culture of food organisms for fish and shrimps: An estuarine amphipod **Corophium triaenonyx** (Fig. 5 & 6), an ideal food for fish and shrimp was cultured in the laboratory. Its life history for two generations during the course of five months was studied. Experimental feeding of this species to juvenile shrimps gave a conversion efficiency between 10 to 20%. In the experimental tanks the population density increased from $200/m^2$ to $10000/m^2$ The population density could be enhanced to 20 times or more if precise information of the ecology of the species is available. The food value of this organism in terms of protein, carbohydrate and fat content was determined. Another gammarid amphipod and a cyclopoid copepod species were also cultured and the mass cultures of a harpacticoid **(Nitocra spinipes)** were continued to be maintained.

Growth studies on oysters. Ecological studies on the edible oyster, **Crassostrea madrasensis** in the Cochin backwater (Fig. 7 & 8) showed that their spawning is seasonal. The spats are obtained from December onwards. The spat growth in the intertidal region at two localities in the Cochin Harbour area showed that those with an average size of 12 mm attained 60.6 mm in 109 days, thus attaining a growth rate of 0.44 mm/day.

Ecological studies on Salvinia: Initial analysis indicated that the presence of moderate quantity of this weed provides a favourable environment for the existence of organisms like polychaetes, amphipods, decapods, copepods and bivalves. Thick beds of decaying weeds with hydrogen sulphide evolving from it were found to be unfavourable for the growth of organisms. Fishes such as sardines and anchovies, shrimps such as **Penaeus indicus, Metapenaeus dobsoni** and **Parapenaeopsis stylifera** collected from the inshore waters showed that they were feeding on weeds.

3. Laboratory and Field studies on the bioenergelics of some marine and estuarine forms — A preliminary survey report was prepared on the energy content and energy distribution of 71 economically important forms belonging to molluscs, crustaceans and fishes. According to the findings, the caloric values ranged from 1904 to 4049 calories per gram dry weight; the fishes contained maximum energy content.

Caloric content of 7 species of economically important seaweeds showed high correlation with their organic matter and organic carbon. Energy budget of the fish, **Amblypharyngodon melettius** fed on the mussel meat showed that the gross.

Fig. 5 - Amphipod culture: Tube dwelling amphipod Corophium triaenonyx emerging from its tube.

Fig. 6 - Amphipod Corophium sp. cultured in the laboratory

Fig. 7 - Oyster fished at Ramanthuruhi island in Cochin backwaters.

Fig. 8 - Cochin harbour urea : An island formed by the oyster shells dredged here

net and assimilation efficiencies were 18.1%, 21.7% and 85.9% respectively. There was little loss of energy through defaecation. 110 mg wet weight of mussel meat yielded 5.1 mg of live fish.

Changes in the biochemical composition, caloric content and energy utilisation during the embryonic development of mole crab **Emerita holthuisi** were studied. The results showed that protein contributed 74% of the total energy available for development. The gross efficiency of the development of **Emerita holthuisi** was 46.2%.

Seasonal variations in the caloric content, organic carbon and lipid were studied in three bivalves — **Donax incarnatus, Mytilus viridis** and **Crassostrea cucullata** for one year. All the three bivalves showed definite seasonal variations in the energy content which was related to the reproductive cycle and lipid content.

4. Environmental physiology in relation to culture and population dynamics — Six initial experiments were conducted under this project mainly to understand the dynamics of growth of prawns and to ascertain whether the growth processes agree with the physiological basis of growth as outlined by von Bertalanffy and to collect information on the growth of prawn that will be helpful for producing faster growing prawns.

(i) Dynamics of growth — Penaeus indicus and **Metapenaeus dobsoni** were kept under different levels of feeding from the juvenile stage for 3 months and their growth was recorded. The growth data suggest that the pattern of growth is not similar to that described by von Bertalanffy. The growth curve appears to have an inflection and an asymptote. Therefore, it may be best described by Brody's equation or by some form of a sigmoid curve.

The regression coefficients in the length-weight relation calculated **for** all the different levels of feeding were not significantly different from 3. In both the species, the regression coefficients varied from 2.946 to 2.953 for **P. indicus** and from 2.905 to 2.918 for **M. dobsoni.** Since the live weight was considered while calculating the length-weight relation, the value close to 3 may be because of this. It also seems to indicate that Bertalanffy's laws of growth have some relevance for prawn although the growth curves do not follow the simple inverse exponential curve of Bertalanffy. This may be because other aspects are also involved in crustacean growth. The equation for oxygen consumption in ml/hour in relation to weight for **Penaeus indicus** is,

$$Y = 0.6414 \; xw^{0.60686}$$

if the regression coefficient in the length-weight relation was three, the exponent in the equation may be expected to be very close to 0.667. The lower value is probably because the total weight which also includes the shell weight was used in estimating the equation. The regression coefficient for the length-weight relation for all the different levels of feeding were found to be less than 3 in both the species. More detailed

analysis of the data and the fitting of the growth curve are in progress.

(ii) Studies on growth in relation to aquaculture — Studies on growth under different levels of feeding showed that the prawns fed 5 times a day grew twice as fast as those on the natural food in the backwaters. As they were fed only on earthworms, a better growth is to be expected if they are fed on a more balanced diet.

Preliminary experiments on the conversion efficiency in relation to asymptotic size suggest that for the same quantity of food consumed, **Penaeus indicus** with a larger asymptotic size show better conversion efficiency, suggesting that for the same quantity of food more prawn flesh could be obtained by rearing **Penaeus indicus** than by rearing **Metapenaeus dobsoni.**

Experiments on the effect of salinity on growth of the juvenile prawn and adults have shown that there is a size specific salinity for optimum growth, the salinity requirement increases as the animal grows.

(iii) Growth studies on Penaeus indicus and Penaeus semisulcatus

Post larvae of **P. indicus** introduced into the rearing tank (salinity 32%o, temperature varying between 17°C to 19°C) moulted between 9-12 days and 7 such moulting stages were observed. The length of the carapace (from the base of the rostrum to the posterior end of the carapace) was used as the index for the rate of growth. The length of the carapace increased by 0.5 cm from one moult to another which was found equal to 0.15 gm of body weight.

Post larvae of **P. semisulcatus** introduced into a rearing tank were observed for more than 2 months (salinity 32%o, temperature 17°C — 19°C). Moulting occurred only twice during this period. The first moult took place after 28 days and the second after 26 days. The animal after the moult was slow and mostly remained at the, bottom of the tank. The rate of feeding was low throughout.

Both **P. indicus** and **P. semisulcatus** were fed once a day with earthworm and bivalve flesh. The excess food particles together with the excreta were removed on the following day before introducing fresh supply of food.

(iv) Growth of prawns in low salinities — Penaeus indicus and **Metapenaeus monoceros** were introduced into rearing tanks having different salinity conditions, and closed sea water circulating system. Animals selected were of similar size and weight and the experiment lasted 35 days. **P. indicus** kept at salinities 5%o and 12%o, moulted rapidly, thrice in the first week and twice in the second weak. Later on, it moulted only once. The animals kept in waters with low salinity (5%o) showed better growth (0.8—1.73 g) unlike those kept at salinity 12%0 (0.79—1.02 g). This shows that postlarval stages of these species prefer low salinities.

(v) Rate of growth of Meritrix sp. Of the three commonly occurring species of **Meritrix casta** is the most abundant in Cochin backwaters; **M. ovam** comes next. They prefer sandy or semi-sandy soil enriched with detritus and are most abundant on the southern side of the Willingdon Island which is a shallow area and is less affected by the tidal flow.

Meritrix casta and **M. ovam** occurred from November onwards with its maximum density during March. The population started depleting with the onset of monsoon and disappeared from July onwards when the water became almost fresh. Under laboratory conditions both the species were found to tolerate vast changes in salinity (10%o — 28%o) and grew 2.61—2.85 g in weight in 20 days at 25%o salinity. They usually preferred detritus and diatoms **(Navicula sp.)** or **Chlorella** sp. The maximum size attained in the laboratory was 3.4 cm and its weight with the shell was 3.65 g.

Biochemical estimations showed protein 12.5%, carbohydrate 2.24% and lipid 4.2% in the animals fed on diatom enriched food **(Navicula sp.)**

The respiratory rates (10^{-3} χ 0.62, 10^{-4} x 0.92, 10^{-4} x 0.13) were estimated during 8, 12 and 24 hours. The differences in the metabolic activity in the fed and starved animals and the ratio between the shell weight, wet weight and dry weight were determined.

(vi) Salinity tolerance of Corophium triaenonyx and Diopatra naeopolitana — Gammarid amphipods and benthic polychaetes are one of the important benthic communities in Cochin backwaters during the saline period. One of the dominant species of amphipods, **Corophium triaenonyx** was used in laboratory experiments. It was observed that the animal mostly preferred salinity around 22%o.

Similar studies were also carried out on polychaetes, specially on **Diopatra naeopolitana.** It was found that they can tolerate salinity from 12%0 to 32%0. Their growth and reproductive rate was maximum when the salinity was around 30%0.

2.43 BIOGEOGRAPHY OF THE ZOOPLANKTON OF THE INDIAN OCEAN

1. Systematics, Zoogeography and Ecology of zooplankton

Preliminary analysis of all the 2000 HOE samples and detailed analysis of a good number of groups were completed. Analysis of 3000 samples collected during the UNDP Pelagic Fishery Project, Cochin is being made for all the major groups. The samples collected by INS **Darshak** from the north and northeastern parts of the Arabian Sea were deposited at Cochin and data on the biomass and studies on animal composition are underway. The highlights of the research work done on the various groups of IIOE and UNDP zooplankton, during 1975 are given below.

(i) Copepoda—Data were collected for studying the ecology of species of **Pleuromamma** and **Gaussia** in the Indian Ocean. Statistical analysis of data to understand the correlation between the swarms of **P. indica** and other factors in certain restricted areas of the Indian Ocean was completed.

The analysis showed that **P. indica** is significantly positively correlated with salinity and phosphate and its relationship with oxygen and temperature is negative and non-significant.

P. indica is the most abundant of the 7 species of **Pleuromamma** recorded from the Indian Ocean and forms over 50% of the total number of specimens belonging to the genus in the upper 200 m of the area; appearing in great concentrations in the northernmost areas of ;he Arabian Sea and Bay of Bengal. The least abundant species **P. quadrangulata,** form only 0.2% of the population and is present only in the equatorial region, between 10°N and S. Considerable variations noticed in the pattern of distribution of the other species, ranging from that of **P. borealis** with maximum occurrence at a station as far south as 34°. but present in scanty numbers along the African coast; **P. gracillis** was obtained from almost all over the entire area excluding the northernmost areas of Arabian Sea and Bay of Bengal.

The calonoid copepod of the genus **Haloptilus** from the IIOE material was analysed and distribution maps for all species were prepared. The main species recorded are **H. longicornis, H. spiniceps, H. ornatus, H. mucronatus, H. acutifrons, H. oxyclphelus** and **H. chierchiae**.

Hitherto unknown males of **H. acutifrons** were recorded from a number of stations in the Indian Ocean. Most species are cosmopolitan in distribution and have already been recorded from the Atlantic, Pacific and Indian Oceans. High population densities are observed off and along the west coast of India; on either side of the equator and central Indian Ocean. They are more abundant off the coasts suggesting that the species of this genus are of oceanic forms.

Calanoid copepods from 116 UNDP samples collected during 1972 from the shelf and slope waters of Cochin were analysed.

50 species of calanoid copepods were identified from the samples. The dominant species are **Undinula vulgaris Cosmocalanus darwinl Centropages furcatus; Euhaeta marina; Eucalanus monachus; Temora turbinata; T. stylifera, T. discaudata; Cardacea discandata;** and **Labidocera acuta.**

Coastal, shelf and slope areas were found to be dominated by distinctly different species. About 24 species of the family Scolecithricidae were identified from the IIOE collections. The analysis of the subgenus **Agetus** (Copepoda, Corycaeidae) is about to be completed and it reveals that **Corycaeus (Agetus) typi-**

cus, Corycaeus (Agetus) flaccus and **Corycaaus (Agetus) limbatus** are represented from the Indian Ocean.

(ii) Resting stages of copepod eggs in the Cochin backwater — It is not known that resting stages for copepods occur in estuaries to escape drastic salinity changes. From mud samples taken from the Cochin backwaters during monsoon, eggs were sorted out and put in high saline water. The eggs hatched within 12 to 14 hours and the naupli were identified to be of copepods.

Further studies conducted on the effect of low saline condition on copepods showed that egg bearing **females of Nitocra spinipes** and **Pseudodiaptomus serricaudatus** release eggs when salinity was reduced from 25%o to 5%o. The eggs of **Nitocra** spinipes hatched almost within one hour whereas the eggs o **Pseudodiaptomus serricaudatus** hatched only when the salinity was restored to about 25%.

(iii) Hyperiid Amphipods— Family Anchylomeridae: This group of Amphipods consists of 3 genera, namely, **Anchylomera, Primo** and **Phrosina** which were present in about 70% of the IIOE plankton collections. Each of the 3 genera are represented by a single species; **Anchylomera blossovelli, Primo macrops** and **Phrosina semilunata** and have wide distribution in the Indian Ocean, notably so towards the north, in most of the samples specially in the night collections juvenile specimens out-numbered the adults. **Primo mzcropa** was found to be the most abundant and uniformly distributed species, especially in northern Arabian Sea. **A. blossovelli** was next in abundance and showed maximum numbers towards southern parts of the Arabian Sea and Bay of Bengal.

(iv) Decapoda — The UNDP plankton samples of the years 1973 and 1974 were analysed. The penaeid prawn larvae were sorted out from 713 samples and these were studied in detail. Most of the larvae were studied up to genera and some up to species level.

During the detailed analysis of over 1500 samples of the penaeid group, Aristaeinae, collected during the IIOE, it was found that the collections were composed of species from three genera only viz. **Aristeus, Gennadus** and **Benthesicymus.**

The genus **Aristeus** is probably represented only by one species. Larval stages of 3rd to 6th zoeal stages were presented and no adult forms were encountered.

Species of the genus **Gennadas** are bathypelagic forms. Both adults and larval forms belonging to five species viz. **G. scutatus, G. propincus, G. sordidus, G. gilchristi** and **G. tanieri** were recorded from the IIOE collections. **G. scutatus** is the most abundant species and both adult males and females were present in good numbers. **G. propincus** comes next in abundance. The hitherto undescribed female of **G. sorditius** is well represented in the collection together with the males.

G. gilchristi and **G. tanieri** were present only in few collections.

The genus **Benthesicymus** is represented only by larval stages. However, two distinct types of larvae were noted and they are still to be identified upto the species level. Larval stages from second zoea to the sixth zoea are available in the collections representing five species of **Gennadas.**

(v) Fish eggs and larvae — Identification of larvae of 8 species of flat fishes, namely **Pseudorhombus elevatus; Arnoglossus tapeinosoma; Bothus ocellatus; Solea heinii Cynoglossus puncticeps; Cynoglossus brevis; Cynoglossus cynoglossus and Cynoglossuslida** were confirmed.

The larvae of **Solea** and **Cynoglossus** sp. appear to be euryhaline, but they cannot tolerate fresh water conditions for longer durations. In the estuarine regions spawning was found to occur in different species in different seasons. In **C. cynoglossus** and **C. brevis** spawning occurs in the premonsoon period, rare during the monsoon and absent in postmonsoon. In the case of **C. lida** maximum spawning occurs in postmonsoon, is rare in the monsoon and absent in premonsoon. **Solea heinii** prefers the postmonsoon period for breeding. **C. puncticeps** breeds during all seasons, with a maximum intensity in the postmonsoon period. **Pseudorhembus elevatus** was **found** only in one collection from Quilon region. **Arnoglossus tapelnosoma** was observed in the waters of salinity ranging between 32.47 to 36.57%o.

2. Studies on the environmental preference, species association, abundance and diversity — The work done on species diversity, species association and abundance during the period under report can be summarised as follows:

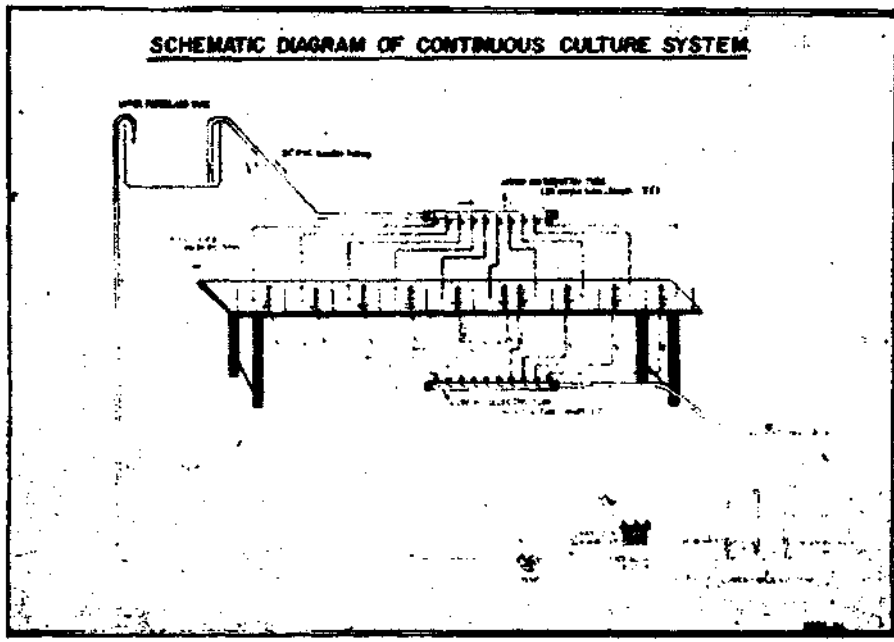
Diversity of species of Euthecosomata in Indian Ocean - Diversity indices were calculated for the species of **Eutheocosmata** in the regions of Somalia Sea, Andaman Sea, North-east Australian Sea and South African Sea using IIOE data. The analysis showed major diversity indites ranging between 1 and 2 in Somalia and Andaman Sea while majority of the stations in the North-east Australian Sea showed diversity values between 0 and 1 and 1 and 2. Thus, of the 4 regions covered, the Somalia Sea has the maximum species diversity as far as Euthecosomes are concerned.

Coexistence and species diversity in Chaetognatha --- Correlation matrix was constructed for studying the co-existence of the species belonging to Chaetognath group in selected regions. Significant positive correlations were observed among the following species :

(1) K. pacifica with **S. hexaptera** and **S. pacifica**

(2) K. subtillis with **S. bedoti** and **S. ferox**

(3) Pt. droco with **S. bipunctata, S. enflata, S. ferox, S. pacifica** and **S. regularis.**



9 - ***Schematic continuous sea water circulating system for culturing planktonic organisms***

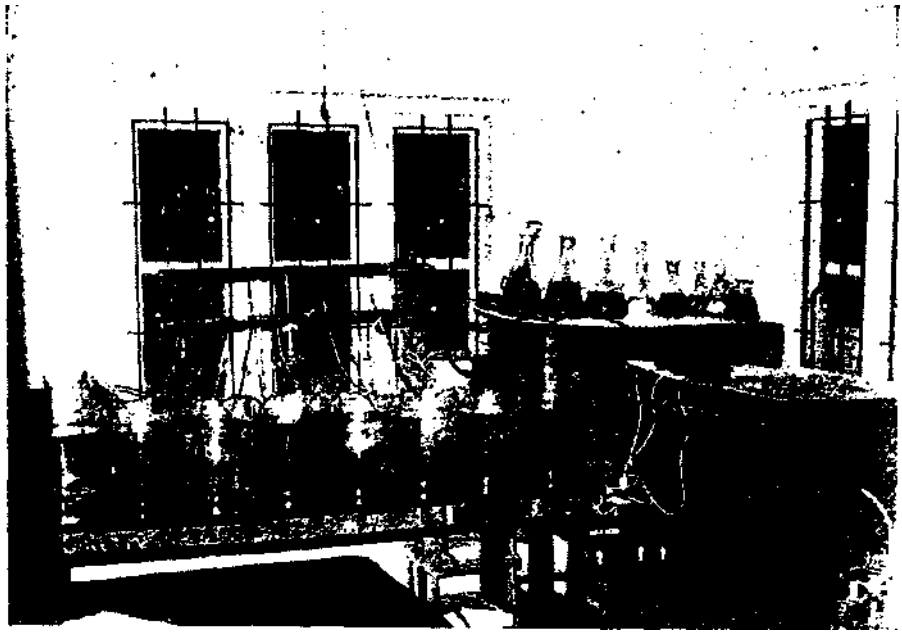


Fig. 10 - Closed seawater circulating system for culturing small benthic and planktonic organisms

(4) **S. bedoti** with **S. hexaptera** and **S. pacifica**

(5) **S. bipunctata** with **S. enflata, S. pacifica** and **S. regularis**

(6) **S. englata** with **S. ferox, S. hexaptera** and **S. regularis**

S. regularis

(7) **S. ferox** with **S. pacifica** and

(8) **S. hexaptera** with **S. pacifica**

(9) **S. minima** with **S. neglecta**

(10) **S. pacifica** with **S. regularis**

S. minima, S. neglecta and **S. pulchra** were found to be negatively correlated with almost all the species, indicating that these species occur always alone.

To study the species diversity of Chaetognatha in the selected regions, diversity indices as defined by Fisher were calculated for each standard haul. It ranged between 1.378 to 0.6233. The low values of the diversity indices indicate that the regions covered were not rich with respect to species.

Effect of salinity and temperature on the abundance — The data were analysed statistically with a view to understand the effect of salinity and temperature on the abundance of the 4 species, viz. **Philadium hemisphaericum, Eutima commensalis, Blackfordia virginica** and **Elrene ceylonensis.** The coefficient of correlation between abundance of the species at each stage with salinity and temperature were calculated. It was observed that salinity was responsible for major changes in the abundance of **P. hemisphaericum.** In the early stages, members of **E. commensalis** were dependent both on salinity and temperature while in the later stages they depended more on salinity than on temperature.

Members of **B. virginica** were found to be significantly negatively correlated with salinity in the young and spent stages. The coefficient of correlation of this species with temperature was insignificant. **E. ceylonensis** also showed more or less similar trend except in spent stages. The individuals having spent staga did not show any significant correlation either with temperature or with salinity.

2.44 ECOLOGICAL, DEVELOPMENTAL AND EXPERIMENTAL STUDIES ON PLANKTON

1. Experimental studies on secondary production — Animals collected from the Cochin backwaters were kept in sea water circulating system of 2000 litre capacity (Fig. 9 & 10) in an air-conditioned room at 17°C in the Laboratory. Some of the findings on the animals are given below:

(i) **Studies on the respiratory rates of tropical zooplankton**—Respiratory rate in the sergestid shrimp **Acetes cochinensis** indicated that the oxygen consumption was maximum (10^{-4} x 0.52) during night (01.00 to 05.00 hrs) and minimum (10^{-4} x 0.41) during day (09.00 to 13.00 hrs). The pattern of oxygen consumption in polychaetes was similar to that of **Acetes,** maximum (10^{-3}x 0.23) during night (01.00 to

05.00 hrs) and minimum (10^{-3} x 0.15) during day (13.00 to 17.00 hours).

(ii) Observation on animal behaviour — The peak hours of feeding in **Acetes cochinensis** were found to be after the dusk and before dawn. Sea water treated with an antibiotic (penicillin), proved to be a good media in which they could be maintained for 15 days. In spite of providing a separate closed sea water circulating system, having separate biological and chemical filters, none of the animals lived beyond 15 days under laboratory conditions.

The tube dwelling polychaetes of the species **Diopatra naeopolitana,** introduced into tanks with sufficient mud at the bottom and connected to a closed sea water circulating system, could be kept alive for more than 3 months. It was observed that the worms build the entire tube within 24 hours and cease to grow in thickness while continuing to grow in length after the completion of the tube. A worm weighing about 0.279 gm needs 3.94 gm of mud for the construction of its tube. Some of the worms build cave like structures to live in them.

The borrowing habits of an alphid, **Alpheus rapax,** were observed in a glass tank containing soft mud. In three days, it made a 'U' shaped burrow having a funnel shaped mouth about 4 cm in diameter. The maximum depth of the burrow was about 10 cm and width 4 cm at the mouth. The average width of the burrow, however, was only 1.5 cm. The animals remained within or at the mouth of the burrow during the day and were found coming out of it during the night to feed on small particles. The animals could be kept alive only for a week.

A 1.1 cm long stomatopod larva, survived in the laboratory for about two months and grew to 2.3 cm. It moulted twice; the first moult was noticed after the 9th day resulting into a juvenile. The second moult was noticed after 22 days. After the 2nd moult the animal survived for another month during which period no moulting occurred. Prior to each moult, the animal remained inactive in crevices or inside the tube provided for sea water circulation and fed very little. After the moulting it was extremely active and fed voraciously on living zooplankton mainly copepods. In the absence of living plankton, coarse powder made out of dried zooplankton was favoured by the animal.

2.5

oceanographic instrumentation

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

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

2.51 DEVELOPMENT OF MARINE INSTRUMENTATION SYSTEMS

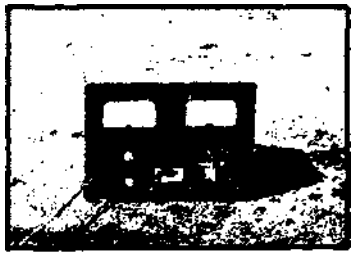
Several new instruments developed in 1975 are summarized as follows :

1) An electronic instrument for recording the tides and counting (Fig. 11) selected waves along the shore was developed. This instrument is useful for studies on coastal engineering and beach erosion problems. The instrument can monitor tidal variations and wave heights. It has provision for counting the selected waves.

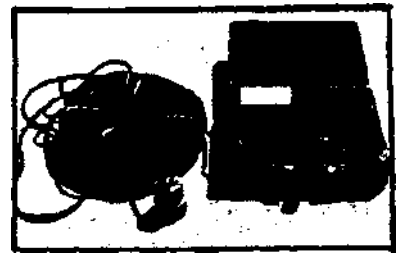
2) Another electronic instrument (Fig. 12) was also developed for the continuous indication of the depth of operation of objects such as instrument platforms, trawl nets, etc. under water.

3) The work on the development of an electronic sedimentation balance for the automatic recording of the rate of sedimentation of sand samples is fast progressing. This instrument is intended to have good accuracy for analysing the sediment samples collected for geological studies.

4) The development of an Inductive Salinometer is nearing completion. The salient features of this instrument are that 1) It employs null-balance principle for the measurement thereby the accuracy of the instrument is increased. 2) Inbuilt temperature compensation is provided and 3) It has digital read-out of the results. It comprises an inductive sensor, a stable oscillator of 14 KHZ frequency at 2 volts (rms) and AC amplifier with a gain of 60 db over a 40 KHZ bandwidth and a detector. A bench model is brought out and has been tested for calibration accuracy with the help of the analog-meter readings. The accuracy is found to be 0.1 without temperature compensation.



Tide and Wave Recorder & Counter



Operational Depth Meter

5) Work has been initiated on the development of a telemetering moored oceanographic buoy for the acquisition of marine environmental data such as (i) air temperature (ii) water temperature, (iii) salinity, (iv) wind velocity, (v) wind direction, (vi) water current, (vii) current direction and (viii) wave height. Of the various circuits and systems required for the measurement and control of this system, the following have been fabricated.

a. Salinity transducer
b. Transducer for air temperature and water temperature
c. Signal conditioner common to all transducers
d. A/D converter common to all signals
e. Modulator and a low power transmitter
f. Command signal identifier
g. Delay line for the command
h. Relay switching circuit for the buoy
i. Low power transmitter for the shore station etc.

6) Another programme to develop an electromagnetic flow meter has been taken up after considering the projected needs of Physical Oceanography over the next 5 years. The specifications of the instrument are, a capability to read from 3 cms/sec to 300 cms/sec, with 1% variation, for water conductivities changing by a factor of 100. The sensor section has been fabricated with graphite electrodes.

7) A simple conductivity type salinometer was fabricated with indigenously available materials. The instrument reads salinity directly and has a range from zero to 38‰ The instrument is good for general use with a sensitivity approx = 0.05‰.

2.52 DEVELOPMENT OF CALIBRATION AND TESTING FACILITY INCLUDING SERVICE, MAINTENANCE AND WORKSHOP

Under this project, the workshop is nearing completion with the inclusion of a carpentry group. During 1975, 409 job orders were completed. These jobs also include the service rendered to outside organizations like University, Post-Graduate

Centre. Government Polytechnic, Goa Medical College, Goa Engineering College, Directorate of Agriculture, Ministry of Labour, Iron ore Mines, etc., in Goa, in repairing and maintaining their instruments.

2.6

planning, publication information and data

The progress of Planning, Publication, Information & Oceanographic Data activities organized under the planning and Data Division of the Institution are as follows:

2.61 PLANNING :

The Division formulated the research projects of the Institute, and compiled them in the form of a booklet "Projects 1975" of NIO. Exercise on Costing, Monitoring and Evaluation of these projects were also carried out by the Division. Periodical reports and project budget for 1975-76 (RE) and 1976-77 (BE) were sent to the Planning Division of the CSIR. These efforts have helped the Institute in exercising the necessary control over the projects and evaluating the progress achieved under each project.

2.62 PUBLICATIONS :

The Division compiled, processed and published the different types of information of the Institute. A new format for Mahasagar — Bulletin of the National Institute of Oceanography was introduced which will include research papers, short notes, news and comments and book reviews. Nos. 1 & 2 of volume 7 of the bulletin were published under the new format.

The Annual Report for the year 1974 was also. published.

2.63 INFORMATION :

The information related to the activities of the Institute was attended to in three different ways.

Firstly, by attending to the visiting parties from different parts of the country. In all, twenty four parties of students/ trainees from professional and academic institutions visited NIO during the year. These were informed about the organisational structure, research activities, findings and their utility, etc. of the Institute. About four hundred and fifty visitors were benifitted with this information service.

The second type of information work was dealt with through postal and telephonic

communications. A large number of letters and phone calls from different organisations raising queries, comments etc. were answered. Thirdly, mass media such as newspapers, scientific periodicals, radio talks etc. were also used to popularize oceanography and to inform people about the activities of the Institute. Six news releases were issued to the news agencies for their coverage through newspapers.

Monthly summaries to the Cabinet, success stories to CSIR and items for the CSIR News were compiled and sent regularly to the Publications and Information Directorate of the CSIR.

The Institute participated in the activities of Joint FAO/ IOC Panel of Experts on Aquatic Sciences and Fisheries Information System (ASFIS) which is evolving as the marine/freshwater, scientific and technical information component of the conceptual world system for all fields of science and technology inherent in the UNISIST concept.

2.64 ACQUISITION, PROCESSING, EVALUATION AND MANAGEMENT OF OCEANOGRAPHIC DATA.

Transferring of station data on to punch cards were continued and during the year data of about 3,900 stations were put on to punch cards. The work on the cataloguing of data for the remaining seasons was also taken up.

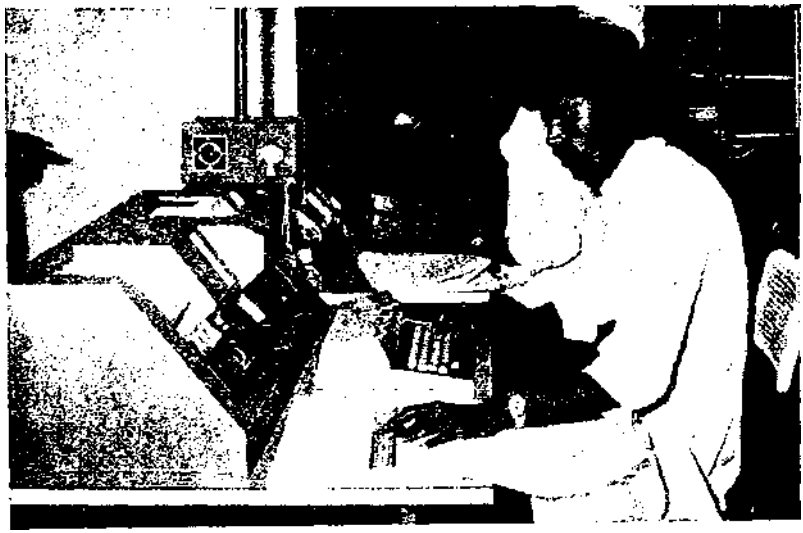
Processing of hydrographic data collected on board 'INS **Darshak'** during 1975 has already been started. T-S curves have been plotted and the data are being subjected to quality check.

The work on the comparative study of Bay of Bengal and Arabian Sea with special reference to the productivity in these two seas is in progress. Work on temperature, salinity, oxygen and PO_4 analyses has been completed. The work on stratification and circulation pattern of the Bay of Bengal is being carried out.

The IIOE (1962-65) and INS Darshak (1973-74) data are being utilized to study the bottom temperature variations in the northern Arabian Sea over a decade.

Attempts are being made to use some of the inventory forms recommended by the VIIIth Session of IOC Working Committee for International Oceanographic Data Exchange (IODE). These inventory forms include Report of Observations/Samples collected by Oceanographic Programmes (ROSCOP), International Geological/Geophysical Cruise Inventory (IG/GCI) and Results of Marine Biological Investigation (ROMBI).

Different types of biological data pertaining to the Indian Ocean available at the World Data Centre — A Washington and US NODC were obtained for the Indian National Oceanographic Data Centre located at NIO. Effort is being made to design



A view of data processing room

a format and transfer these data on to punch cards. A referral catalogue is being prepared for the data available at the Data Centre.

2.7

interdisciplinary task forces

271 Protection of Marine Environment and Monitoring of Pollutants (Task Force No. 101)

2.72 Oceanography of waters Around Lakshadweep (Task Force No. 102)

Scientists from different Divisions were drawn to complete the multi-disciplinary work in these Task Forces. The progress of work is as follows :

2 71 PROTECTION OF MARINE ENVIRONMENT AND MONITORING OF POLLUTANTS

Several investigations were taken up under this project in the waters of Goa, Cochin and Bombay. The purpose of all these studies was to collect baseline data on pollutants and develop an understanding of the effect of man-made changes in the marine environment.

1. Marine Environmental Monitoring in the waters of Cochin

Dissolved oxygen, BOD_5 and total sulphide of the waters indicate localised pollution in the backwaters which is beyond the assimilative capacity and tolerance level of the estuary. Temperature of waters was found to have significant effect on dissolved oxygen and BOD_5 values. During the pre-monsoon period when the water temperature ranged between 31-32.6°C, the depletion of dissolved oxygen was considerably large. Higher BOD_5 values occurred during low tide in the sewage polluted areas. Organic pollution has a significant effect on dissolved oxygen, BOD_5 and sulphide content of the estuarine waters while it has little effect on temperature and salinity.

Polychaeies were found to be the most tolerant group of benthic to pollution of the estuary. Monthly collections of samples of the effluents discharged in Cochin backwaters over a stretch of 5 km near Kalamassery Industrial Complex (Fig. 13 & 14) showed the following characteristics of the effluents; the temperature ranged between 39°C to 42°C; pH between 6.65 to 9.15, sulphate contents from 984 ppm to 1182 ppm.

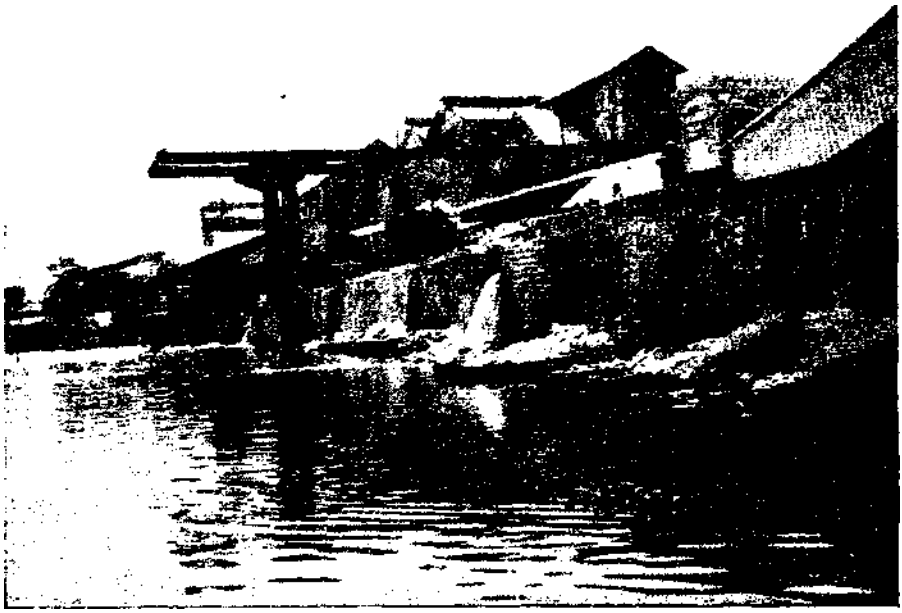


Fig. 14. - A major effluent outfall in Kalamassery Industrial Complex (Kerala)

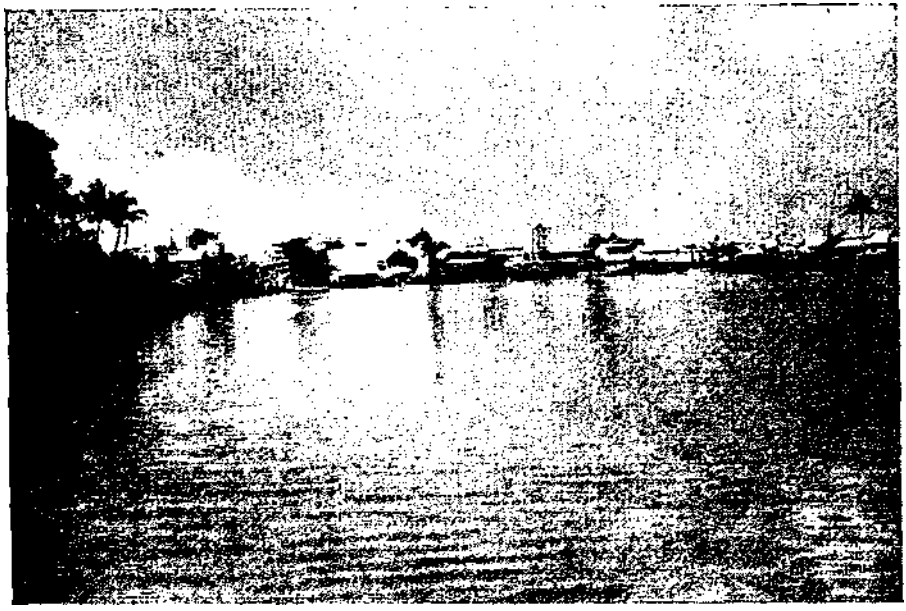


Fig. 15 - A view of the Industrial Complex in Kalamassery

Upstream beyond the complex area at a point the waters showed pH values of 7.25 to 7.55 and sulphate content from 7 to 10 ppm. At a common point of discharge in the industrial complex area, the effluent water showed pH values from 7.35 to 9.15 and sulphate content from 769 to 775 ppm. Downstream, below the complex area at a point, the pH ranged between 7.05 and 7.35 and sulphate content between 497 and 544 ppm.

Bacteriological aspects of pollution in this area are also taken up.

2. Monitoring along Bombay and Saurashtra Coast

Studies under this programme were conducted in the Thana Creek and Bombay harbour area on board INS **Jamuna.** In all 35 stations covering an area of about 340 sq. km were worked. The 16 km long Thana Creek receives effluents from about 80% of the total industries in the Maharashtra State (i.e. more than 30% of the entire country) clustered around this region.

Observations were made on temperature, salinity, dissolved oxygen, light penetration. PO_4-P, NO_3N, pH, total alkalinity, wind speed, etc. Three stations in the region were marked as monitoring stations where intensive observations were made.

The results showed that 90 sq. km area of the Thana Creek is heavily polluted. According to estimations 200 mgd of industrial effluents and 60 mgd of domestic sewage are released in the area. The main factors showing heavy pollution were low dissolved oxygen content (less than 2 ml/l), very high concentration of PO_4-P (5-6 µg at/l) NO_3-N (30-60 µg at/l). The total alkalinity was also high.

The critical condition of the Thana Creek was reported to the Maharashtra Government through the Maharashtra Prevention of Water Pollution Board for remedial measures.

Studies on oil pollution along the Indian coast were taken up under the IGOSS programme and the findings have been dealt with separately.

3. Chemical aspects of marine pollution

Regular monitoring of potential eutrophicators, water quality indicators and toxic heavy metals in Mandovi and Zuari estuaries and in coastal areas off Zuari Agro-Chemicals Ltd. were continued. Analysis of toxic heavy metals, specially mercury by neutron activation analysis was initiated in collaboration with Bhabha Atomic Research Centre, Bombay.

Baseline studies were started on the toxic heavy metals (copper, zinc, arsenic and manganese) accumulated in flora and fauna of the coastal waters of Goa with special reference to commercially important species. Most of the species were found to contain detectable amounts of arsenic (1 to 20 ppm on dry weight basis) but the levels were close to the background concentrations observed by some workers

elsewhere. Crustaceans and molluscs were found to be more tolerant to arsenic. In general, detritus feeders showed higher levels of the metals. Copper content in the algae and fishes was low (3 — 40 ppm) as compared to high levels (upto 900 ppm), observed in the oysters, prawns and crabs. Oysters were found to have the highest ability in concentrating the metal. Higher levels of zinc of the order of 1000 ppm were observed in the oysters.

2.72 OCEANOGRAPHY OF WATERS AROUND LAKSHADWEEP

This project aims at understanding the oceanographic conditions and resources around Lakshadweep group of islands in the coral reef, lagoons and the surrounding waters.

Several algae of economic importance growing in Agatti, Kiltan and Minicoy islands were identified during the survey of living resources of Lakshadweep area. The ecological conditions appear to suit algae farming on a large scale.

Minicoy lagoon appears to be an ideal place for setting up a turtle farming although the eggs and young ones are found more on other islands. A feasibility report on turtle farming is under preparation. The local Directorate of Fisheries is keenly interesting in this project.

2.8

sponsored projects

2.81 Surveys for Zuari Agro-Chemicals proposed effluent pipeline route in the Cola Bay, Goa.

2.82 Model studies of Mandovi Zuari Estuaries and Cumbarjua Canal — Analysis of samples.

2.83 Hydrographic studies in the inner harbour of Cochin Port.

2.84 Determination of suitable points in the sea off Mangalore for the discharge of treated waste material for pollution control off Karwar

2.85 Oceanographic Survey for pollution control.

286 Oceanographic survey of Narara Bet in the Gulf of Kutch.

2.87 Contract sorting of zooplankton.

2.88 Consultancy Services.

During the year the following projects sponsored by private and public sector agencies were taken up:

2.81 SURVEYS FOR ZUARI AGRO-CHEMICALS PROPOSED EFFLUENT PIPELINE ROUTE IN THE COLA BAY, GOA.

Continuous seismic profiling and bathymetric surveys were carried out, surface and sub-surface sediment samples were collected in the Cola Bay, Goa to suggest a route for laying a 2 km long submarine pipeline for effluent discharge. Bathymetric surveys revealed that the north-western part of the bay is deeper and north and north-eastern parts of the bay are shallow. Analyses of surface and sub-surface sediments indicate that the northern and north-western part of the bay is entirely covered by sands of various grain sizes. The reflection records revealed seismic reflectors, i.e. Dharwar Schists with relatively steep apparent dips of 25° to 35° at shallow depths below laterites and also indicates sharp variations of 20-25 meters in basement topography. The areas where the rocks occur at depths less than 5 meters below the ocean bottom were recommended for detailed investigation prior to che laying of pipeline.

2.82 MODEL STUDIES OF MANDOVI ZUARI ESTUARIES AND CUMBARJUA CANAL:
— Analysis of Samples.

On the request of the Captain of Ports, Government of Goa, Daman and Diu, Panaji, the silt charge and salinity were estimated for 71 samples and the size analyses was carried out for 9 samples. The samples were collected by the Captain of Ports during the monsoon and post-monsoon period of 1974 and pre-monsoon period of 1975 and the data were required for medel studies by CWPRS, Poona.

2.83 HYDROGRAPHIC STUDIES ON THE INNER HARBOUR OF COCHIN PORT.

This project was taken up at the request of Cochin Port Trust to conduct some oceanographic studies required for the proposed construction of super Tanker Oil Terminal in the Cochin Harbour. The work was started in May, 1975 and extensive data on currents, salinity, temperature, silt content, specific gravity and bathymetry were collected during spring and neap tides from 30 stations located in the inner harbour region of the Cochin Port from surface to bottom, at depth intervals of 1-2 m.

2.84 DETERMINATION OF SUITABLE POINTS IN THE SEA OFF MANGALORE FOR THE DISCHARGE OF TREATED WASTE MATERIAL FOR POLLUTION CONTROL.

The project was sponsored by the Mangalore Chemicals and Fertilizers Limited to collect necessary oceanographic information concerning the lccation of a suitable point for the discharge of treated effluents into the sea. The investigations, started in December, 1975 and include observations on currents, stability of water column, bathymetry and beach stability.

2.85 OCEANOGRAPHIC SURVEY FOR POLLUTION CONTROL OFF KARWAR —

The Project was sponsored by Ballarpur Industries Pvt. Ltd. for the hydrographic and bathymetric survey in the coastal waters off Karwar and to recommend a suitable point for the discharge of effluents from their Caustic Soda Factory. The one year survey programme was started in October, 1975.

According to the findings the area supports a rich benthic fauna. Good fisheries of mackerel, oil sardine and shrimp occur in these waters.

The current in the nearshore waters are towards the shore and are of about 1 knot velocity. The depth ranges from 5-12 m.

Sampling of 16 stations on 3 different transects is being conducted and data on temperature, salinity, dissolved oxygen, CO_2, pH, conductivity, nutrients etc. are being collected on regular basis.

2.86 OCEANOGRAPHIC SURVEY OF NARARA BET IN THE GULF OF KUTCH.

This project was sponsored by the Engineers India Limited, New Delhi and was started towards the end of 1975. The necessary oceanographic

Fig. 15 - Erosion at Colva beach, Goa caused by a stream joining the sea at Colva (April, 1975)

Fig 16 - Situation at Colva in August, 1975, showing the vertical cuts along the Coast.

information is required in connection with the laying of a pipeline from the proposed oil terminal in the region.

2.87 CONTRACT SORTING OF ZOOPLANKTON

Sorting on zooplankton collected by **R. V. Dr. Fridtjoj Nansen** from the Indian Ocean was undertaken for Fiskeridirektoratete Havfors knings Institut, Bergen, Norway. Sorting of 125 samples has already been made. The work involved estimation of the biomass of the zooplankton by displacement method and subsequently separation of the eggs and larvae from each sample, their preservation and labelling.

2.88 CONSULTANCY SERVICES

Several consultancy services were extended to various public and private agencies on the problems of marine pollution. These are as follows :—

(i) **LUCAS-TVS Limited, Madras.** on the effects of proposed dumping of solid cyanide waste in the offshore waters of Madras.

(ii) **Vishakhapatnam Steel Project Authority,** on problems of discharge of effluents expected to contain phenol and ammonia.

(iii) **Zuari Agro-Chemcal Limited, Goa** — on possible hazards of dumping ammonium sulphate wastes in coastal waters.

(iv) **Oil and Natural Gas Commission** — on the initiation of an UNDP Project for training of personnel and for setting up of an effective organization to control accidental oil spills and blow cuts from offshore rigs and platforms.

(v) **Ministry of Shipping and Transport (Transport Wing) Government of India** — on proposals to deal with matters relating to major oil spill near the coast of India and on setting up of proper facilities at every port to fight such disasters.

(vi) **Travancore Titanium Products Limited, Trivandrum.** — On the disposal of wastes containing mainly ferrous sulphate and sulphuric acid and measures to prevent adverse effects on the environment.

(vii) **Gujarat Water Pollution Control** Board — On the establishment of a safe limit from the shore for the disposal of toxic industrial effluent.

(viii) **Erosion Studies at Colva Beach, Goa** were carried out at the request of Government of Goa, Daman and Diu because a portion of Colva Beach, a major tourist spot was reported to be experiencing erosion (Fig. 15). Studies during April to December, 1975 revealed that it was only confined to a portion where a vertical cut 2 to 3 M (Fig. 16) was formed and this was shifting towards tha shore. This cut resulted because of a stream joining the sea at Colva beach. The cut was predominent when the stream get flooded with freshwater.

The shifting of the stream outlet across and along the beach aggravated the problem even after the monsoon. In this process the variable responsible for the erosion were found to be irreversible leaving no chance for any natural replenishment Remedial measures are being suggested.

2.9

international projects

Implementation of two international projects was initiated at the Institute.

2.91 UNITED NATIONS ENVIRONMENT PROGRAMME.

The first phase of United Nations Environment Programme on "Marine Pollution Monitoring and Marine Living Resources Assessment for the Indian Ocean Region" was initiated and contacts with institutes in 16 countries in the region and several organisation within India were established.

2.92 INTEGRATED GLOBAL OCEAN STATION SYSTEM (IGOSS).

Ten sampling stations along the west coast of India were established for observations on the pilot project on monitoring of oil pollution under the framework of IGOSS. Regular sampling and monitoring of tar ball deposits along the west coast of India are continuing. **Shipping Corporation of India** and **Scindia Steam Navigation Co. Limited,** are helping in this project by carrying out observations on oil spills in the open sea.

3

administrative set-up

3.1 Executive Committee

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

2. Dr. J. S. Sastry — Member
   Scientist 'E' NIO,
   Dona Paula, (Goa)

3. Shri P. E. Sankaranarayanan — "
   Scientist 'E' NIO
   Dona Paula, (Goa)

4. Shri T. C. S. Rao
   Scientist 'C', NIO
   Dona Paula, (Goa)

5. Rear Admiral K. P. Ramnath, A.V.S.M.
   Assistant Chief of Material (Technical)
   Naval Head Quarters
   South Block, New Delhi.

6. Dr. A. K. Ganguly
   Director
   Health Physics Division
   Bhabha Atomic Research Centre,
   Trombay Bombay-28.

7. Shri V. L. N. Sastry
   Chief Geophysicist
   ONGC, Nirmal Building
   10th Floor, Nariman Point,
   Bombay-1.

8. Shri T.S. Bawa
Administrative Officer
NIO, Dona Paula (Goa). Member

9. Shri A. Rajachandran
Accounts Officer
NIO, Dona Paula (Goa). "

3.2 **Budget**

The Budget of the Institute for the year 1974-75 is given below:

Budget	Sanctioned Final Grant Rs in lakhs	Actual Rs. in lakhs
1. Recurring	41.700	41.301
2. Capital	52.630	51.309
Total:	94.330	92.610

3.3 **Scientific and Technical Staff**

Director

Dr. S. Z. Qasim.

A. Divisions at the headquarters

1. PHYSICAL OCEANOGRAPHY DIVISION

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

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

Senior Scientific Assistant
Shri K. K. Varma

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

Senior Research Fellow
Shri M. Veerayya

Junior Research Fellows
Shri Albert D. Gouveia
Miss Shubha Satyendranath
Shri K. Prem Chand
Shri P. V. Sathe
Shri R. Viswanatha Sarma

2. CHEMICAL OCEANOGRAPHY DIVISION

Scientists
Shri C. V. Gangadhara Reddy (Officer-in-Charge)
Dr. R. Sengupta
Shri S. P. Anand
Shri S.Y.S. Singbal

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

Senior Research Fellows.
Shri S. B. Kamat.
Shri S. P. Fondekar
Miss S. S. Naik
Dr. S. Y. Kamat
Dr. A. Rajendran

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

3. GEOLOGICAL OCEANOGRAPHY DIVISION

Head of the Division
Shri H. N. Siddiquie.

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

Senior Scientific Assistants
Shri R. M. Kidwai
Shri B. G. Wagle
Dr. V. Narayanan
Shri F. Almeida
Shri N. H. Hashmi
Shri Victor Rajamanickam
Shri A. Narendranath
Shri D. Gopala Rao

Senior Technical Assistant
Shri B. L. Maitri

Junior Scientific Assistant
Shri G. C. Bhattacharya

4. BIOLOGICAL OCEANOGRAPHY DIVISION

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

Scientists
Dr. K. Radhakrishna (Officer-in-Charge)
Dr. A. H. Parulekar
Shri R.M.S. Bhargava
Dr. A. G. Untawale
Shri V. P. Devassy
Shri S. C. Goswami
Dr. (Miss) Aditi Pant
Dr. (Mrs.) Sumitra Vijayraghavan
Dr. N.G.K. Karanth
Shri P.M.A. Bhattathiri
Dr. M. J. George

Senior Scientific Assistants
Shri S.A.H. Abidi (on deputation to Govt. of Tanzania)
Shri R. A. Selvakumar
Shri K. Kameswara Rao
Shri P. G. Jacob
Dr. (Mrs.) Vijayalakshmi R. Nair
Shri S. Ayyappan Nair

Junior Scientific Assistants
Shri C. T. Achuthan Kutty
Shri N. B. Bhosle
Shri S. N. Harkantra

Pool Officers
Dr. Mrs. Usha Goswami
Dr. Joseph P. Royan

Senior Research Fellow
Mrs. **L.** Krishna Kumari

Junior Research Fellows
Miss P.A. Lokabharathi
Miss R. Shantha Nair
Shri X. N. Verlenkar
Shri Z. A. Ansari
Shri M. V. M. Wafar
Shri T. Bala Subramanian
Mrs. Classy D'Silva

PLANNING AND DATA DIVISION

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

Senior Scientific Assistant
Shri M. K. Antony

Junior Technical Assistants.
Shri P. Venugopal
Shri S. P. Sharma
(proof reader)

6. **INSTRUMENTATION DIVISION**

Shri P. E. Sankaranarayanan

Scientists
Shri T. K. Sivadas
Dr. B. A. E. Desa

Senior Scientific Assistant
Shri K.K.M. Rafique
(on leave)

Senior Technical Assistant
Shri S. Ranganathan

Junior Scientific Assistant
Mrs. Vani B. Peshwe

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

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

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

Scientists
Dr. M. Krishnankutty
Shri V. S. Rama Raju
Shri R. V. Unnithan
Shri V. N. Shankaranarayanan
Shri P. G. Menon
Shri U. K. Gopalan
Shri P. Udayavarma Thirupad
Dr. P. Sivadas
Shri H. K. Iyer
Shri B. M. Panickar
Shri K. J. Peter
Dr. (Mrs.) M. Saraswathy
Dr. C. Sankarankutty
(On Deputation to Govt. of Tanzania)

Senior Scientific Assistants.
Shri Thomas Cherian
Shri Pramod S. Gore
Shri T. Balachandran
Shri P. N. Aravindakshan
Shri V. T. Paulinosa
Dr. George Peter
Shri Jacob George
Shri K. K. Chandrasekharan Nair
Shri Mohd. Rafique
Shri T. C. Gopalakrishnan
Dr. (Mrs.) V. Santhakumari

Junior Scientific Assistants.
Miss Saramma U. P.
Mrs. P. P. M. Kunjamma
Miss Rosamma Stephen
Shri P. Haridas

C. **REGIONAL CENTRE OF NIO, BOMBAY**

Officer-in-Charge
Dr. B. N. Desai

Scientist
Dr. A. B. Wagh

Senior Scientific Assistants
Shri V. Josanto
Shri R. Kashinath
Shri K. Govindan

Junior Scientific Assistants
Shri M. D. George
Shri M. M. Sabnis

4

library

The Library started functioning in the new premises of the library block at the Headquarters at Dona Paula. About 917 items including books and technical reports were added during the year 1975. In all 160 journals were subscribed during the year and 66 journals were received as gift or on exchange basis; 25 microfilms of books and reprints were also procured.

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

Facilities for reference of books and journals were extended to students and research workers from outside institutions.

5

awards, honours & memberships of various committees

1. **Dr. S. Z. Qasim** was awarded the Chandrakala Hora Memorial Medal for the years 1970-1974 by the Indian National Science Academy in May, 1975. The award came in recognition of his contributions to the development of fisheries and marine sciences in India.

Dr. Qasim was also awarded Golden Jubilee Trust Gold Medal by the Institute of Science, Bombay in October 1975.

He served as :

— Chairman, Indian National Committee for SCOR, Indian National Science Academy.

— Member, Board of Directors, Indian Institute of Technology, Powai.

— Member, Indian National Commission for Co-operation with UNESCO.

— Member, Indian National Committee of Environmental Planning and Co-ordination, Department of Science and Technology.

2. **Dr. B. N. Desai** served as :

— Member, ISI, Water Sectional Committee, CDC-26

— Member, ISI, water and effluents subcommittee CDC-26.3

— Member Environmental Protection Advisory Committee, a joint committee set up by the ISI and the National Commission on environment.

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

— Member, study group to identify the service of mercury contamination set up by the Government of Maharashtra.

— Post-graduate Examiner, University of Cochin.

3. **Dr. M. G. Anantha Padmanabha Setty** served as:

— Member, study group No. 2, working group No. 10, International Commission on Geodynamics (1972-1976).

— Member, Executive Council, Indian Society of Earth Scientists (1971-1975).

4. **Dr. V. S. Bhatt** served as :

— Member, Joint FAO/IOC Panel of Experts on Aquatic Sciences and Fisheries Information System (ASFIS).

— National Co-ordinator for International Oceanographic Data Exchange (IODE) and Oceanographic Data Centres.

5. **Dr. A. B. Wagh** served as :

— General Secretary, Symposium on the multi-use of the Coastal Zone, Bombay. 1975.

6

deputations

1. Dr. S. Z. Qasim was deputed to the Fifth Session of the Executive Council of the Inter-governmental Oceanographic Commission in Venice, Italy, in March, 1975.

— was deputed as Leader, Indian Delegation to the Sixth Session of the Executive Council and Ninth Session of the General Assembly of the Intergovernmental Oceanographic Commission in Paris, during October-November, 1975.

2. **Shri H. N. Siddiquie** was deputed to Canada on an invitation through CIDA.

3. **Shri P. E. Sankaranarayanan** was deputed to Canada for getting himself acquainted with the institution, service and maintenance of instruments like Satellite Navigation Systems, Sparker System, Magnetometer System, etc. for the N.I.O. Research Vessel.

4. **Shri T. C. S. Rao** was deputed to U.S.A. on (NSF-CSIR) Exchange Progrmme.

5. **Dr. V. S. Bhatt** participated in the Management Training Programme for Biological Scientists of CSIR laboratories at the Administrative Staff College of India, Hyderabad from 7th to 17th April, 1975.

— participated in the meeting pertaining to Planning, Monitoring, Costing and Evaluation of projects arranged by the Planning Group of the CSIR in August, 1975.

— was deputed to attend the 8th Session of the Working Committee on International Oceanographic Data Exchange (IODE) held in Rome (Italy) from 12th to 17th May, 1975.

— was deputed to attend the First Meeting of the Joint FAO/IOC Panel of experts on Aquatic Sciences and Fisheries Information System (ASFIS) at the United Nations, New York, from 2-5 September, 1975.

— was deputed to West Germany under the CSIR/DAAD Exchange of Scientists Programme from 15th September to 15th December, 1975.

6. **Dr. A. H. Parulekar** was deputed to U.K. in September, 1975 for a period of 6 months under Bilateral-Scientific Exchange Programme between C.S.I.R. (India) and the British Council (U.K.)

7. **Shri T. Balachandran** was deputed for 6 months to work at Department of Oceanography, the University, Southampton, U.K. under UNESCO Training Programme.

8. Dr. (Mrs.) Vijayalakshmi R. Nair left for Scripps Institution of Oceanography, U.S.A. in October, 1975 for 6 months training, under UNESCO Training Programme.

9. **Shri K. K. Varma** attended the training course in computation Programming (Fortran-ll) at the Institute of Tropical Meteorology Poona in March, 1975.

10. Shri A. F. Anto was deputed to Meteorologisches Institut Universitat Hamburg, West Germany under German Academic Exchange Fellowship from 8th June, 1975 to 31st March 1977.

11. **Shri Victor Rajamanickam** was deputed to West Germany on an Indo-German Academic Exchange Fellowship from 8th June 1975 to 25th October 1976.

7

meetings, exhibitions seminars & symposia

1. Dr. V. V. R. Varadachari attended the Geophysical Field Dynamics Workshop organized by the Institute of Science Banagalore in June, 1975.

2. **Dr. J. S. Sastry** attended the 8th National Working Group on GARP at Poona on 30.10.1975.

3. **Shri H. N. Siddique** attended the **R. V. Gaveshani** progress meeting at Garden Reach Workshop, Calcutta on 14th January, 1975.

4. **Sarvashri L. V. G. Rao, P. G. Kurup and K. K. Varma** participated in the symposium on multiuse of coastal zone organized by the Indian Fisheries Association at Bombay during 20-22 November, 1975.

5. Shri T. K. Sivadas attended the get-together organized by National Research Development Corporation with R & D Institutions, industry, entrepreneurs and financial agencies at I.I.T., Bombay, during 19-21 December, 1975. Four instruments developed in N.I.O. were exhibited during the get-together.

6. **Shri R. R. Nair** participated in the ERTS-II (LANDSAT-11) Users meeting at the Space Applications Centre, Ahmedabad 12-13 May, 1975.

7. **Dr. T. S. S. Rao** attended 10th European Symposium on Marine biology held at Ostend, Belgium during September 17-23, 1975 under UNESCO Sponsorship.

8

colloquia and special lectures

8.1 COLLOQUIA (IN GOA),

	Speaker	Subject	Date
1.	Dr. Raja Ramanna	Indian Atomic Energy Programme.	3.2.1975
2.	Dr. P. Koteswaran	Monex Programme.	5.2.1975
3.	Prof. J.E.G. Raymont	Some aspects of biochemistry of zooplankton.	6.2.1975
4.	Dr. J. P. Jillet	General hydrographic Regime of S. E. New Zealand waters and zooplankton distribution.	5.3.1975
5.	-do-	Studies on estuarine zocplankton	6.3.1975
6.	Dr. S. Z. Qasim	Highlighting the advisory activities of IOC	7.4.1975
7.	Dr. B. G. Deshpande	Impact of science on society	22.4.1975
8.	Shri S. P. Anand	Evaporation of water in association with few forms of carbon	2.5.1975
9.	Dr. G. S. Sharma	Upwelling	20.5.1975
10.	Mr. Bruce K. Byers	Dividends from space	26.5.1975
11.	Dr. R. Sen Gupta	The interrelationship between dissolved nutrients and oxygen in the northwestern Indian Ocean.	11.7.1975
12.	Miss Shubha Satyendranath	Incursion of Pacific Ocean water into the Indian Ocean.	22.7.1975

Speakers	Subject	Date
13. Dr. Pulak K. Ray	Zonal Study — a rapid method of studying a large section of coast-line, its application in selected areas of U.S.A.	24.7.1975
14. Mr. S. L. Tierney	Certain aspects of world Meteorology	12.9.1975
15. Dr. Pushkar N. Kaul	Man's need to dive into the sea.	4.10.1975
16. Shri T. K. Sivadas	Instrumentation and telemetry in Ocean measurements (particularly dealing with **In-situ** temperature salinity meter, Freezer alarm and telemetry buoy system).	15.10.1975
17. Dr. St. Jepan Keckes	Pollution in the Mediterranean.	
18. Dr. B. S. Ramakrishna	Data processing by surface acoustic wave transducers	12.11.1975
19. Shri K. Balakrishnan	Diagrammatisation in ocea. nographic data processing	15-12-1975

8.2 SPECIAL LECTURES

Dr. B. N. Desai, Scientist-in-Charge, Regional Centre of NIO, Bombay, delivered a series of lectures to the senior trainees at the Central Institute of Fisheries Education, Bombay.

— delivered special lecture to the participants of the Seminar on Co-operative movement in fisheries, jointly sponsored by the Shri Vaikuntalal Mehta National Institute for Co-operative Management, Poona and the Central Institute of Fisheries Education, Bombay.

— delivered a series of lectures to the post-graduate students of South Gujarat University.

Shri P. E. Sankaranarayanan. Scientist-in-Charge, Instrumentation Division NIO, delivered a series of eight lectures on "Satellite Navigation System" and six lectures on "Hydrosonde System" at the National Institute of Oceanography.

Or. A. B. Wagh, Scientist NIO, Bombay delivered a series of lectures to the Post Graduate students in zoology of Bombay University.

9

radio talks

Speakers	Date	Subject
Dr. S. Z. Qasim	2.4.1975	A review of the work done at NIO during the past 6 months
Dr. S. Z. Qasim Dr. V. V. R. Varadachari Dr. N. G. K. Karanth Dr. (Miss) Aditi Pant Dr. (Miss) Ann Sterling Shri S.Y.S. Singbal and Miss Classy D'Silva	4.4.1975	Pollution — Discussion in English
Dr. S. Z. Qasim	10.4.1975	Oceanography in India
Dr. S. Z. Qasim	2.12.1975	Brief report on the IOC Conference held in Paris

10.1

visit of director general CNEXO

Fig. 17. Mr. M. A. La Prairie D. G. CNEXO with Dr. Qasim Director NIO

Mr. M. A. La Prairie, Director General, Centre National de L'Exploitation des Oceans (CNEXO) France, visited the National Institute of Oceanography, Goa from 1st to 3rd May. 1975. CNEXO, the largest oceanographic institution in France, is devoted to researches on the exploitation of oceans and is a national organization dealing with applied research. The purpose of the visit of Mr. La Prairie was to finalize different aspects of collaboration between the NIO, India and CNEXO, France. He identified some fields for collaboration through discussions with the Director NIO and other scientists.

10.2

visit of director general CSIR

Fig. 18 Prof. Nayudamma visiting Instrumention Laboratory

Prof. Y. Nayudamma, Director General Scientific & Industrial Research, visited the National Institute of Oceanography on 18th and 19th June 1975 He addressed the scientists and other staff of the Institute. Talking on the strength and weakness of the CSIR, he stressed on the need for collaboration between the common branches of science to form a task force with a view to solving problems of national importance.

11

publications

11.1 PUBLICATIONS OF THE INSTITUTE

1. Annual Report 1974

2. Quarterly bulletin of the Institute: **Mahasagar,** Vol. 7, Nos. 1-4

11.2 PAPERS PUBLISHED BY STAFF

Achuthan Kutty, C.T.	1975	Occurrence of **Acetes australis** colefax and **Acetes vulgaris** Hansen in coastal waters of India. **Curr. Sci.** 44(31) : 469-470
Al Hasan, R., Cougblan, S., Pant, A. and G.E. Fogg.	1975	Seasonal variation in phytoplankton and giycollate concentration in the Menal Strait. Angelessey, J. **Mar.** bio!. **Ass.** (U.K.) 55: 557-565
Balasubramanian, T. and M.V.M. Wafar.	1975	Primary Productivity of some sea grass beds in the Gulf of Mannar, **Mahasagar, Bull. natn. Inst. Oceanogr., 8** (1 and 2) : 87-91
Bhosle, N. B.	1975	Variation in Haemoglobin in **Otollhus rubber** (Cuv. and Val.), **Mahasagar. Bull. natn. Inst. Oceanogr., 8** (3 and 4).
Bhosle, N. B.,Untawale A.G. and V. K. Dhargalkar.	1975	Effect of Seaweed Extract on the Growth of **Phaseolus vulgaris. L. Indian J. Mar. Sci.** 4(2) 208-209.
Cherian, T., Rao, L. V. G. and K. K. Varma.	1975	Variation in physical characteristics of the waters of Zuari estuary, **Indian J. Mar. Sci. 4(1) : 5-10**

Dwivedi, S.N., Bhargava. R.M.S. and A.G. Untawale	1975	Marine living resources and ecosystems along the West Coast of India. **Proc. 3rd International Ocean Dev. Conf., Tokyo, 3** : 31 -41.
Dwivedi, S.N. and N. B. Bhosle,	1975	Haemoglobin polymorphism in a catfish **Tachysurus cealatus** (Val.) **Geobios. 2:** 77-78.
Dwivedi, S.N., Parulekar, A.H. and V.P. Devassy	1975	Oil Pollution of Goa beaches, **Proc. 3rd International Ocean Dev. Conf.** Tokyo, 3: 139-149.
Dwivedi, S.N., Lokabharathi, P.A. and V.M.A. Hakkim.	1975	Benthic studies in the environs of a sewage outfall, Panjim, Goa. **Shipping and Marine Industries Journal, 8** : 663-64.
Dwivedi, S.N. and M. R. Menezes.	1975	Serum Protein differences in **Mugil cephalus L** and **M. parsia** Ham-Buch. Fam. Mugildae. **Geobios 2:** 8-9.
Fondekar, S. P. and C. V. G. Reddy.	1975	Arsenate and arsenite level in the coastal and estuarine water of Goa. **Mahasagar, Bull. natn. Inst. Oceanogr. 8** (3 & 4).
George, Jacob, Purushan, K.S., and M. Madhupratap.	1975	Distribution of planktonic ostrapods along the southwest coast of India, **Indian J. Mar. Sci, 4** (2) : 201
George Peter.	1975	On the seasonal distribution of some polychaetes in the Indian Ocean area along 110 Meridian. **Mahasagar, Bull. natn. Inst. Oceanogr. 8** (1 & 2) : 45-52
George, M J.	1975	On the penaeid prawn, **Parapenaeopsis stylifera** and a new variety of the species from Cochin. **J. Mar. biol. Ass. India. 15** (1) : 420-423.
George, M . J .		On a rare brachyuran crab zoea from the southwest coast of India. **Curr. Sci.** 44 (5) : 162-163.
Gopalan, U.K.	1975	Incidence of shell disease in shrimp in New York Bight. **Mar. Pollut. Bull; 6** (149-153).
Goswami, S.C.	1975	Metamorphosis of two species of genus **Oithone** beird (copepoda) **Indian J. Mar. Sci.** 4(1) : 60-67.

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