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NATIONAL INSTITUTE OF OCEANOGRAPHY

(Council of Scientific & Industrial Research)

PANAJI, GOA

INDIA

CONTENTS

1

Introduction

The sixth report of the National Institute of Oceanography gives an account of the scientific projects carried out in the various divisions and units of the Institute along with a picture of the administrative set up, facilities, activities and the list of scientific contributions from the Institute during 1970-71.

All the projects under investigation during the year 1970-71 are briefly dealt with. The Physical Oceanography Division made important contributions to our understanding of physical processes such as coastal erosion, sediment transport on the west coast, and also started hydrographical studies in the Bombay area.

Under Chemical Oceanography, further studies on the phosphate distribution of the southern Bay of Bengal were made based on IIOE data. An interesting feature discovered was the high phosphate value off Madras, especially in the western Bay and the shelf extending upto about Long. 84° 30′E. Maximum concentration was found in the slope water around 900 m.

The Geological Oceanography Division continued its studies on sediment cores of the Arabian Sea, beaches around Goa and estuarine sediments, particularly those of the Vembanad lake. Foraminiferal studies of the sediments have brought out some interesting results. The occurrence of *Globigerina pachyderma,* a typical polar cold water form has been recorded in these warm waters.

Under Biological Oceanography, the Indian Ocean Biological Centre made a significant contribution to our knowledge of the plankton in the Indian Ocean, by publishing 2 fascicles of atlases in 1970. The IIOE Plankton Atlas Vol. II Fasc. 1 has 11 maps showing the distribution of copepods and decapod larvae in the Indian Ocean. The Vol. II Fasc. 2 has 10 maps showing the distribution of fish eggs and larvae in the Indian Ocean. The western Arabian Sea, the west coast of India and the northern Bay of Bengal are all found to be extremely rich in plankton production.

Work on the productivity, phytoplankton and zooplankton in the estuarine and

coastal water systems of Cochin, Goa and Bombay have revealed a wealth of information of great importance for further intensive studies and exploitation of these waters.

A new dimension in research was added to the Institute's work when it took up pollution problems at Bombay at the request of the Bombay Municipal Corporation. This work is in progress.

The Indian National Oceanographic Data Centre continued to receive further data from the World Data Centres and are being codified.

As regards administration and construction activities at the headquarters, rapid progress has been maintained in the construction of the staff quarters, hostel and main laboratory buildings. Further centralization of work at Cochin was achieved among the 3 units existing there and Cochin has been given the status of a regional centre of the Institute.

31 research papers, excluding the publications of the Institute were published by the scientists of the Institute in various journals.

N. K. PANIKKAR
DIRECTOR

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national institute of oceanography its divisions and units

As already reported last year, the National Institute of Oceanography is comprised of five divisions and three units which are given below. Cochin has been given the status of a regional centre of the Institute and includes two divisions and one unit which are functioning over there.

	Divisions	*Telephone number*	*Telegraphic Address*
1.	Indian National Oceanographic Data Centre (Planning and Data Division) NIO, Miramar, Panaji, Goa.	2923 extn.	OCEANOLOGY PANAJI
2.	Physical Oceanography Division, NIO, Miramar, Panaji, Goa	2923 extn.	—do—
3.	Geological Oceanography Division, NIO, Miramar, Panaji, Goa	2923 extn.	—do—
4.	Biological Oceanography Division. NIO, Karikkamuri Cross Road, Cochin-11	31814	GEOPHYSICS COCHIN
5.	Indian Ocean Biological Centre P. B No. 1913, Pullepady Cross Road, Cochin-18	33306	OCEANOLOGY COCHIN
	Field Units		
1.	Biological Oceanography Unit, NIO, Miramar, Panaji, Goa	2923	OCEANOLOGY PANAJI
2.	NIO, Field Unit, 169-170, BPT Buildings, Sassoon Docks, Colaba, Bombay-5	213597	OCEANOLOGY BOMBAY
3.	Physical Oceanography Unit Karikkamuri Cross Road, Cochin-11	33538	GEOPHYSICS COCHIN

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oceanographic research and activities

3.1

physical oceanography

3.10 General

1. Hydrographic Survey off Greater Bombay

Work under this Project was started in August, 1970. Since then, eight series of observations at the rate of one every month, each consisting of hydrographic survey and current measurements over four selected sections in the coastal waters off Greater Bombay confined to 6 fathoms contour were completed. Drift studies using surface drogues were also carried out from November onwards. Preliminary analysis of the data collected so far indicated the following features:

(i) Thermal gradients were not found except during September and October

(ii) Sharp density gradients were also not noticed.

(iii) The waters were found to be more or less highly turbid excepting off Malabar Hill and occasionally off Mahim Bay.

(iv) The speed of current was found to be lower near the bottom than at the surface, the direction being the same.

(v) From the drift trajectories the surface velocities were found to vary from 0.3 to 2.5 kts. with the maximum values occurring off Colaba in association with the flow from the creek at the harbour entrance.

Apart from the hydrographic survey, twelve tracks of echosounding were made during February-March for studying the nature of bottom in the four selected zones (off Monori, Bandra, Worli, and Malabar Hill), where the sewage pipes would be laid. From this bathymetric survey the sea bottom was found to be having irregular slopes up to about one and a half miles from the shore. From there up to 6 fathom-contour uniform slopes prevailed all along the tracks surveyed.

3.11 Oceanic Properties

1. Oceanographic Studies at Mormugao and Cochin Harbours:

Investigations on the wave conditions and sediment transport in the Mormugao Harbour were continued. Under the programme of studies on the diurnal and seasonal variation of hydrographic and meteorological parameters at the harbour, two sets of observations were taken near the end of harbour break water in the summer season covering high and low tidal ranges. During the monsoon months (June-Sept.) as the harbour pier was not approachable, the observations were carried out from the end of Dona Paula Jetty at the times of high and low water tidal ranges in each month. Hourly observations were taken on a typical monsoon day (20-7-70) over 12 hour tidal cycle (6 A.M. to 6 P. M.) covering the situation of maximum tidal range (about 2.4 m) for the whole season. Preliminary analysis of the data for the monsoon months indicated the following features:

1. Surface water temperatures as low as 25.3°C and as high as 29.6°C were encountered during this season.

2. The surface salinity decreased to around 26-20%**o** in June and dropped to minimum (16%**o**) in July-August and rose gradually to more than 30%**o** towards the end of September. However, in July and August, surface salinity values less than 2%**o** and as high as 8-16%**o** were encountered during the consecutive low and high water periods associated with tidal currents.

3. Dissolved oxygen of surface waters generally varied between 5.40 ml/1 and 3.60 ml/l, the values associated with the ebb waters of low salinity being high compared to the low values associated with the flood waters of relatively high salinity.

Field investigations aimed at a comprehensive study of temperature, salinity, dissolved oxygen, suspended load etc. of the surface, and near bottom waters in the Mormugao Bay in relation to tidal currents were started in the month of October. During the post-monsoon season (Oct-Nov.), 6 cruises were carried out on board TARINI and data for the general survey of hydrographical features during flood and ebb currents and also 12 hour tidal cycles at the mouth and at the rear portion of the Bay were collected. Processing of the data collected so far has been taken up.

Investigations on the texture, coefficient of sorting and skewness of the sediments for 78 stations in and around the Cochin bar mouth were completed. The median diameter of the samples was found to vary between 0.0034 mm and 0.34 mm. The general nature of the sorting of the sediments was poor.

3.12 Physical Processes

1. Studies on Sediment Transport at Moplah Bay, Cannanore

Under this programme, surface currents in and around Moplah Bay were evaluated using floats and theodolites, and maps depicting the surface flow during the north-east monsoon season were prepared. Simultaneous observations on tide, wave angle, breaker height and wave periods were carried out.

A possible solution to the problem of accretion in the harbour was found in constructing a breakwater in the SSE direction, with more gentle sea-ward slope, taking into consideration the wave run up and the constructional feasibility. Wave, forces assuming different slopes of the sea wall were calculated to determine the size of the armour stones.

2. Beach Erosion Studies along Goa and Kerala Coasts

During the period under report, in all

220 beach profile measurements together with the observations on related oceanographic and meteorological parameters, were made at the twelve selected stations along the three main beaches of Goa as per the number indicated against each of them.

Calangute — Candolim	80
Miramar — Caranzalem	60
Colva — Banaulim	80

These studies indicated building up of beach material, in general, from October through April, excepting in the month of February during which cuts in the beaches were noticed all along the coast. The beaches were found to be under erosion from May onwards coinciding with the onset of the monsoon. Vertical cuts varying from 1.5 m to 2.75 m were noticed especially in the foreshore region during the monsoon months.

To investigate the micro-scale change in the beach sediment processes, hourly observations on beach profile and the related oceanographic and meteorological parameters were made over complete tidal cycles at different places along the Calangute and Miramar beaches.

As a first step to study the distribution of wave energy along the Goa coast in relation to erosion and sediment transport, wave refraction diagrams were constructed for the waves of periods 6 secs. and 8 secs, and deep water wave direction of SW, W and WNW.

Beach profile studies at the seven selected stations along the Kerala coast were continued. In all, 65 beach profile measurements were made during the period under report, as mentioned below:

Narakkal	17
Saudi	8
Thumboli	6
Purakkad	6
Elankunnapuzha	17
Manassery	6
Punnapra	5

In the monsoon months, vertical cuts of beaches varying from 0.75 m to 3.0 m were noticed.

3. Rheological Studies on Mud-water Mixtures

Under this programme, an experiment was conducted to determine the frictional resistance on a model boat under different concentrations of mud-water mixtures. The static friction showed a sharp inflex point at about 15 volume percentage of mud and the rate of change of friction above this value shot up very rapidly. Following the suggestion of Hamilton that above 23 per cent concentration the suspension starts getting elastic property, it was inferred that a relation between the static friction and elasticity is possible.

4. Physical and Dynamical Studies of the Estuaries of Goa and Kerala Region

Detailed study of the data collected previously revealed that the Comburjua Canal, which connects the Zuari and Mandovi estuaries, forms a channel of dynamic exchanges, the flow of the canal being primarily determined by the tidal conditions. The general flow pattern was found to be from Zuari to Mandovi causing the more saline and denser waters of Zuari to flow into the less saline and loss dense waters of Mandovi. Observations taken at two stations situated on either side of the Canal during November 1970 indicated that (i) on the Mandovi side of the canal the ebb current (103.5 cm/sec.) dominates flood current (17.0 cm/sec.) while on the Zuari side more or less equal flood (109.5 cm/sec.) and ebb (108.5 cm/sec.) currents prevail; (ii) the near-bottom waters are more saline than the surface waters; (iii) the suspended sediment load varies from 0.01 to 0.06 gm/l on the Mandovi side and from 0.03 to 0.09 gm/l on the Zuari side.

Observations on the hydrographic parameters at fixed stations in the Cochin back waters, started earlier, were continued.

3.13 Waves

1. Wave hindcasting for Alleppey and Goa coasts

Under this programme, which aims at making wave hindcasts for Alleppey and Goa coasts to understand the erosion problem there, geostrophic wind speeds were calculated for the months May to August for the years 1965 to 1959, for the areas around Alleppey and Goa from the data available from the typical weather charts. Calculation of the surface wind based on the air-sea temperature difference and the curvature of isobars was started.

2. Wave Refraction Studies in Relation to Sediment Transport along the West Coast of India

As part of this programme, wave refraction diagrams for the region between Cape Comorin and Goa were constructed for the waves of periods, 14 secs., 12 secs., 10 secs., and 6 secs., for deep water wave directions of SW, WSW, W and WNW as these were found to be the predominant wave periods and probable wave directions. From the refraction diagrams, refraction and direction functions for 68 stations along this part of the coast were calculated. Detailed refraction diagrams were also constructed, on five enlarged maps along this coast viz., Cape Comorin to Anjengo, Anjengo to Alleppey, Alleppey to Cannanore, Cannanore to Bhatkal and Bhatkal to Goa, for waves of WSW direction and 10 secs, period, as they are more important for a study of regional variations in the direction of sediment transport. Study of the convergence and divergence in the sediment transport along this coast in relation to the special features like mud banks etc., was started.

3. Wave Energy Computations

The monthly and seasonal values of wave power at 10 fathom line for the average of the significant wave height and the maximum of the highest ten percent waves were computed for every two degree latitude along the coastline extending from West Pakistan to Malaya. This coastline experiences higher waves for a greater period of time during the months of June and July. The high energy waves occur off Bombay and Saurashtra, around Ceylon and off Circars coast. The highest wave energy (2160 Mega Watts Hour) in the area under study was found off Saurashtra in the month of July.

3.2

chemical oceanography

3.20 General

1. Fabrication of Shallow Water Sampler

A project on estuarine and nearshore oceanographic studies off Goa was undertaken to study and compare the pre-pollution and pollution conditions in the estuaries. In this connection an apparatus 'shallow water sampler' to collect samples from very shallow areas for physico-chemical studies was fabricated. It is a modified version of Hale's water sampler coupled with a Secchi disc. It is specially used for the collection of samples for the estimation of dissolved gases like oxygen and hydrogen sulphide. A note on this sampler has been sent for publication.

3.21 Composition of Sea Water

1. Distribution of Nutrients in the North Indian Ocean

Processing and analysis of the IIOE data on the nutrient salts (phosphates, nitrates and silicates) of the Arabian Sea and Bay of Bengal were continued.

Analysis of the phosphate distribution in the Southern Bay of Bengal based on the data collected during the XXII cruise of INS Kistna in the month of February, covering the region between Lat. 17°N and 6° N and Long. 80° E and 85°E was completed. A significant feature noted is the presence of marked convergence of the surface waters in the shelf region extending down to the depth of 75 m, along the coast between Lat. 17°N and 11°N, characterised by very low phosphate concentrations of less than 0.4 µg at /L. This feature is in contrast to the beginning of upwelling noted in the northern region in January itself. The hydrographical factors also lend support to the strong mixing in the region during February. The depth-wise distribution of phosphates shows a rather sharp gradient of increasing concentration, coinciding with the rapid fall in the oxygen levels. The depth of phosphate maximum appeared to be generally varying between 500-900 m.

Another feature of interest is that off Madras the phosphate levels were very high (>1 µg at/L), especially in the waters beyond the shelf extending up to about Long. 84° 30'E. In this region over the entire water column down to 1000 m, the concentrations varied between 1 and 6 µg at/L. Maximum concentration was found in the slope waters around 900 m. From long. 85°E, the phosphate levels once again tend to become very low towards east,

suggesting boundary conditions. These observations suggest the possible effects of the incursion of Persian Gulf and Red Sea waters (200-500 m).

Along Long. 83°E, between Lat. 8°N and 11N, a tongue of high phosphate (>2 µg at/ L) waters at depth 200-400m was found, oriented towards north associated with the salinity maximum corresponding to the Persian Gulf waters.

3.22 Organic Compounds

1. Studies on the Determination of Dissolved Organic Matter in the Sea Water off Cochin

Studies on the analytical aspects of the estimation of dissolved organic carbon in sea water around Cochin by direct ultra-violet absorption spectrophotometry are in progress. The concentration of dissolved organic matter (DOM) in sea water being extremely low offers considerable difficulty in the detection. The complicated analysis by wet oxidation followed by the detection of CO_2 evolved using infrared analyser and high precision conductivity meter etc. require elaborate fabrication of the apparatus and also depend on the availability of the highly sensitive detectors. Therefore the U-V absorption maximum characteristic of DOM in sea water around 250-260 mu is being utilised for the estimation of dissolved organic carbon in sea water. Instead of using any specific component of DOM for calibration purposes, the standard stock DOM is prepared from the fresh plankton material. Calibration tests with standard DOM in all glass re-distilled water show good linearity between optical density and DOM at 260 mu. However, the same tests with aged sea water (initially almost free of DOM) showed deviations. The factors responsible for this deviation are being examined and further tests are in progress.

3.23 Oceanic Properties

1. Oxygen Studies

The analysis for the depths of occurrence of oxygen maxima and minima in the north-east Indian Ocean (Bay of Bengal and Andaman Sea, between 0° and 26°N latitude 80-100° E longitude) indicates that the oxygen poor waters in the upper layers are not uncommon in the Bay of Bengal especially along the east coast of India, during the south west monsoon period. The seasonal upwelling observed along the east coast of India might be responsible for bringing up the oxygen poor waters from the subsurface layers.

In the northern Bay of Bengal the oxygen content of the surface and subsurface layers is found to be higher, probably due to the influence of freshwater discharge from the rivers. Similarly in the north equatorial current region also the waters are found to be rich in oxygen due to the influence of the north equatorial current.

Attempts have been made to correlate the depth of mixed layer and the amount of inorganic phosphate available in the mixed layer and in the upper 100 m. column of the N.W. Indian Ocean. Analysis indicates that a good correlation exists between the depth of the mixed layer and the amount of phosphate available in the layer, while there seems to be no correlation between the depth of mixed layer and the amount of available phosphorus in the upper 100 m column.

3.3

geological oceanography

3.31 STRATIGRAPHY AND SEDIMENTOLOGY

1. Sediment Cores from the Arabian Sea
2. Sediment Studies of the Beach Around Goa
3. Beach Rock Studies of the Goa Coast
4. Estuarine Sediments

3.32 MICROPALEONTOLOGY

1. Foraminiferal Biostratigraphy of the Cores from the Arabian Sea
2. Foraminiferal Studies of the Shelf Sediments

3.33 MINERALOGY AND GEOCHEMISTRY

1. Geochemical Studies of the Cores
2. Mineralogical and Geochemical Studies of Shelf and Estuarine Sediments

3.31 Stratigraphy and Sedimentology

1. Sediment Cores from the Arabian Sea

The long cores were studied in detail at 2.5 cm. interval. The distribution and occurrence of characteristic lithofacies and biofacies variations are indicated in schematic stratigraphic column for each core. Further lithological and faunal facets are described which reveal such features as unconformities, turbidity flows, organic content and variations in the number and variety of fossil assemblages.

The sedimentological aspect emphasizes the sediment content, colour, texture, composition, mega and micro-fauna, presence or absence of oolites, oolitic lenses, detrital grains, mineral composition and faunal essociation. There are considerable variations of these factors region-wise and depth-wise. Studies are in progress to understand these variations which would provide the necessary basic data for mineral exploration.

2. Sediment Studies of Beaches Around Goa

Monthly collections of beach sands is in progress along with profile study of the Morjim-Arambol beach of northern Goa, both detailed sedimentological and mineralogical studies. Transport of mineral grains and sand is exhibited by the amount of roundness as a result of wear and tear and this is being investigated on the sands of Miramar beach also. The black sands of Miramar beach constitute nearly 40% sand and contain minerals like Ti, Fe and Al.

About 600 samples collected from the different parts of the Calangute beach during different months were analysed for their grain size distribution. This analysis has revealed that there is marked seasonal variation in the grain size of the sediments. Accross the beach the mean grain size (Mz) was found to vary between 0.023 phi and 2.58 phi in the foreshore with an increasing trend towards the step during the period, June-August. In the breaker zone, the Mz varied from 0.78 phi to 1.68 phi. For the foreshore region, the average Mz values were in the fine sand grade from October to March and there after in the medium to coarse sand range. Along the beach the Mz values of the foreshore showed an increasing trend from

north to south during all the months except in August when a reversal was noticed.

For the foreshore, the distribution of the values was 67.5% in sorted class, 21% in well sorted class, 5.5% in very well sorted class and 5.8% in poorly sorted class. The sorting values increased from berm to seaward and from north to south in association with increase in mean grain size. The sediments from the backshore and dunes were moderately sorted, while those from the interior dunes were well sorted.

All the samples from foreshore were negatively skewed, while those from the backshore and dunes were either positively skewed or nearly symmetrical, and those from the breaker zone were in a very negatively skewed to nearly symmetrical distribution. There was a seasonal variation in skewness values from negatively skewed to nearly symmetrical during monsoon season.

Analysis of 400 sediment samples for carbonate content indicated that it decreases from north to south on the foreshore and increases slightly from upper foreshore to low water line, exhibiting seasonal variations.

3. Beach Rock Studies of the Goa Coast

Beach rock or beach sand stone is a consolidated and hardened loose beach sand which occurs in thin bands, often in patches along the Goa coast. Similar beach rock exposures are noticed on the east and west coasts of India. It is formed as a result of percolation of water, movement of underground wastes, optimum temperature conditions (around 29°C) and surf action in the intertidal areas. The presence of beach rocks suggests eustatic movements of the coastline. With a view to understanding the characteristics of beach rock formation detailed studies have been undertaken during the year.

In addition to the study of beach rock formations, granulometric studies of precambrian conglomerates and quartzites exposed along the northern coast of Goa have been undertaken, with a view to understanding paleo-environmental conditions of deposition and to compare the results with the Recent. The work is in progress.

In order to compare the sediment distribution pattern on the shelf with the source area, a survey and study of the rock types found along the Goa coast has been undertaken. Mapping of the northern sector has been completed and it is found that the rock types are chiefly quartzites, schists and dykes and these compare well with Dharwar system rather than Cuddappah age. Forty-three different dykes are noticed and these can be classified into two broad categories.

4. Estuarine Sediments

Sediment transport and mineral content of the material brought in by the Mandovi and Zuari rivers and the discharge of the sediment material into the estuary has been under investigation. The formation of a sand bar at the mouth of Mandovi just at the onset of the monsoon is an annual feature and the factors favouring the formation of this sand bar are being studied. The sediment samples collected are being analysed to determine the marine characteristics of brackish water sediment types.

3.32 Micropaleontology

1. Foraminiferal Biostratigraphy of the Cores from the Arabian Sea

Both mega- and micro-faunal contents of the cores have been studied. The cores from the shelf with a great variety of foraminifera and other fossils indicate low energy and reducing environment; cores from the slope were rich in organic matter. Cores from the basin contained mainly pelagic oozes. Heavy concentration of organic matter and the presence of indicator

foraminifera may provide the clue for the occurrence of petroleum hydrocarbons.

2. Foraminiferal Studies of the Shelf Sediments

The planktonic foraminifera in the shelf sediments of the Arabian Sea and the Bay of Bengal were studied. The sectors from which the collections were made are: Karwar-Mangalore; Bombay; off Cochin and Visakhapatnam-Masulipatam. *Globigerina pachyderma* which is a typical bipolar cold water fauna has been recorded in an otherwise warm water environment. Twenty-five species of planktonic foraminiferans have been identified which include abundant forms like *Globigerina bulloides, Globigerinoides ruber, G. succulifer, Globoquadriva dutertrei, Globorotalia menardis* and *Pulleniatina obliqueloculata.* Further it is observed that foraminiferal population decreases shorewards but increases progressively slopeward where much of the sediment is composed of skeletal and non-skeletal calcium carbonate. 120 species of benthic fauna have been identified from these sediments and their ecology is being worked out.

3.33 Mineralogy and Geochemistry

1. Geochemical Studies of the Cores

Detailed geochemical investigations are being carried out on the core samples collected from the Arabian Sea. The cores from the shelf showed great similarity in composition, mineral content, while those from the slope were fine-grained, calcareous clay material rich in organic matter. The geochemical studies involve determination of constituents which are not only in traces but also in abundance. The trace elements that are being studied are cobalt, nickel, lead and zinc. Among the elements and constituents present in great abundance, studies are being carried out on carbonates of calcium, magnesium, manganese, phosphate and organic matter. The salient features of distribution will be reported later.

2. Mineralogical and Geochemical Studies of Shelf and Estuarine Sediments:

(i) As part of the investigations of the shelf sediments of the Arabian Sea, the Ca/Mg ratio in the sediments off Bombay is being studied to gain an insight into the depositional environment in a terrigenous-carbonate province. Secondly, the organic content in 21 shelf sediment samples collected off Bombay were analysed and the analysis showed that organic content is high in the inner shelf and slope and low in the outer shelf region.

(ii) Sediment samples collected from the shelf and slope regions along four sections normal to the coast off Bombay, Karwar, Mangalore and Cochin have been analysed for iron and cobalt contents and their distribution studied. Iron was found to be present in higher concentration in the sediment samples collected off Cochin in comparison with those from other places.

(iii) Studies on the distribution of titanium in the shelf sediments off the West Coast were completed. Higher content of titanium was found in the sediments in southern part of the west coast. Inner shelf sediments have been found to have higher content of titanium as compared with those of the slope region. Major part of the titanium is concentrated in silt-clay fraction of the sediment. Concentrations range between 100 and 8500 ppm.

(iv) The sediment samples collected from the different parts of the Vembanad lake between Cochin and Alleppey have been studied

for their organic content in relation to the distribution pattern of the sediments and hydrographical features of the lake. The organic matter content of the sediments varies from 0.1% to 6.0% with an average of 2.55%. It follows broadly the distribution pattern of the sediments in that the finer sediments (silty clays and clayey silt) have a higher organic matter content than silty sand and sands.

(v) Studies on the samples collected from the Cauvery basin with the object of understanding the coastal development of the Coromandal coast have shown that beach sands contain heavy minerals like Garnet, Hornblende, Zircon, Epidote, and some amount of monazite, Rutile. Tourmaline, Kyanite etc. indicating multi-cycle deposits. Work on the radio activity of these to determine the monazite content is in progress.

3.4

biological oceanography

3.40 GENERAL

1. Studies on Cochin Backwaters
2. Hydrology of Gulf of Cambay

3.41 ZOOPLANKTON

1. Systematic and Distributional Studies of HOE Collections
2. Post-monsoon Zooplankton Ecology of Mandovi Estuary in Relation to Tides
3. Studies on Planktonic Foraminifera from the Eastern Part of the Arabian Sea

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1. Experimental Studies on Phytoplankton Culture

3.43 PRODUCTIVITY

1. Some Problems Related to Measurement of Primary Production
2. Primary Productivity of Mandovi and Zuari Estuaries of Goa
3. Secondary Production in waters Around Goa
4. Hydrography and Productivity of Coastal Waters along the Konkan Coast between Panaji and Bombay

3.44 MARINE ECOLOGY

1. Ecology and Food-chain Studies on Beaches and Inshore Regions of Cochin

3.45 MARINE POLLUTION

1. Marine Pollution and Disposal of Sewage in Bombay City

3.46 MARINE FOULING

1. Studies on the Settlement of Fouling Organism on Fiberglass Coated Wooden Hull

3.47 FISH AND FISHERIES

1. Studies on the Development of *Tylosurus crocodilus* (Le Sueur)
2. Yield Studies on Fish
3. Studies on the Age and Growth of Silver Pomfret, *Pampus argenteus*

3.40 General

1. Studies on Cochin Backwaters

(i) *Distribution of Suspended Material in Cochin Backwaters:* Investigations on the distribution of suspended material in Cochin Backwater and its possible effect on the silting in Cochin Channels were continued during year under report.

Analysis of the data shows a definite seasonal pattern of the suspended material, superimposed by the tidal effects. The suspended material was minimum during pre-monsoon months (Jan-May), maximum during monsoon months (May-Sept.) and was in between during post-monsoon months (Sept-Jan).

Though the tidal effects on the distribution are noticeable in all the seasons, the variations during pre-monsoon months are very significant. During this

period, strong flood currents transport considerable quantity of suspended material into the backwaters. It settles there rather than flow out during the ebb.

(ii) *Studies on Distribution of Phytoplankton in Cochin Backwaters:* Marked seasonal fluctuations were observed. During the pre-monsoon months high phytoplankton concentrations were recorded. Significant features were the blooms of *Nitzschia sigma* (1506400 cells/liter) in May 1970 and total absence of dinoflagellates during the monsoon months.

(iii) *Bacteriological Studies:* A highly divergent group of bacteria viz. Sulphur bacteria were isolated from the mud of Cochin backwaters. Two types of Sulphur bacteria viz, 'Purple Sulphur bacteria' and 'Green Sulphur bacteria' were isolated and cultured in the laboratory for morphological studies. Further work is in progress.

2. Hydrology of the Gulf of Cambay

The preliminary analysis of the samples collected during the cruises of INS *Darshak* was completed and a report prepared for publication. This analysis showed that the water mass under investigation was both isothermal and isohaline throughout the Gulf. The stations nearer the mouths of rivers had estuarine conditions whereas the stations located at the mouth of the Gulf were found influenced by the open sea. The Gulf waters were highly turbid due to the presence of large quantities of mud brought down by the major rivers Narbada and Tapti. The plankton was found to be rich towards the mouth of the Gulf and very poor in the interior region. A study of benthos of the Gulf revealed almost total absence of macrofauna. The microfauna was mainly represented by Foraminifera. Ninetytwo species belonging to 40 genera of the Foraminifera from the mud samples were identified and described.

The following species were recorded for the first time in the Indian waters.

1. *Textularia pseudocarinata* Cushman
2. *Virgulina concave* Hoglund
3. *Virgulina panciloculata* Brady
4. *Loxortoma vostum* Cushman
5. *Lagena sulcata* (Walkar and Jacob) var. *Spicuta* Cushman and Medulloch
6. *Lagena costata* (Williamson) *var. amphora* Reuss
7. *Elplidium oceanicum* Cushman
8. *Globigerina calida* Parker

The foraminiferal fauna of the Gulf was found to be more or less similar to that known from the tropical Pacific and Philippines.

3.41 Zooplankton

1. Systematics and Distribution Studies of IIOE Collections

(i) *Systematic Study of Various Sub-sorted Groups:* Systematic studies of the sub-sorted groups such, as, fish eggs and larvae, copepoda, decapod larvae, chaetognatha, Ostracoda, Heteropoda, Polychaeta and Anthozoa were carried out. The results are given in the following paragraphs.

Fish eggs and Larvae: Of the 1927 zooplankton samples collected and sent to the IOBC during the International Indian Ocean Expedition, the fish larvae were represented in about 87% of the samples. The Arabian Sea was covered by about 690 collections. These

collections have been analysed. A report on the distribution of fish eggs and larvae has been submitted to the UNESCO.

An estimate of abundance of fish larvae has been made on the basis of actual number of larvae in each station. It has been noticed that the highest concentration of fish larvae was along the Arabian Coast, Somali Coast, Red Sea and West Coast of South India and Ceylon. The lowest grade in the density was located in the central part of the Arabian Sea, particularly towards the southern region.

The total fish larvae collected were sub-sorted into 55 groups (up to the family level) and the distribution charts for the various families prepared. The results show that the oceanic zone is dominated by larvae of deep sea and bathypelagic fishes such as Gonostomids, Stomiatids, Paralepids, Scopelarchids and Myctophids. The coastal zone includes larvae of strictly coastal fishes such as Anchovies, Sardines, Lizard fishes, Flat fishes, Gobies and Scorpaenid fishes. The intermediate zone consists of a mixture of larvae of bathypelagic and coastal species. This is found to be the richest zone in kinds of fish larvae. Most of the larvae of economically important fishes of the families Thunnidae, Scomberomoridae, Carangidae and Gobiidae are collected from this zone. Even larvae of certain fishes such as Engraulids and Synodontids are represented here. A number of eel larvae are also recorded from this zone.

Investigations on the quantitative distribution of the flat fish larvae indicate that compared to other planktonic taxa, the larvae of Heterosomata are represented only in very small numbers and that too only in about 11 per cent of the IIOE samples. In general, the flat fish larvae are more abundant in the collections from the Bay of Bengal than from the Arabian Sea or from any other part of the Indian Ocean. The larvae are concentrated in the neritic region. The flat fish larvae were not found in the central and southern Indian Ocean (about 52°E to 100°E and 10°S to 45°S). They were seen more in the northern half of the Bay of Bengal. As the salinity in this region is comparatively low, it appears that the larvae prefer low salinity. The presence of 65 per cent of the larvae in the collections taken during night may indicate their preference to low light intensity and vertical migration from deeper layers.

Copepoda : A study of the distribution of Copepoda in the Indian Ocean indicates that the areas of highest density are located along the Somali Coast, extending northwards to the Arabian Coast. Other noteworthy areas of high values occur at the tip of the Indian peninsula, the northern end of the Bay of Bengal and to the south of Java. Low values occur all over the southern Indian Ocean, south of 10°S latitude. The lowest range of abundance is widely spread over the southern part of Indian Ocean for the day stations only; it is replaced by the next higher range (3000-8999) in the night stations. A low-value area

occurs in the middle of the Arabian Sea. Whereas this low-value area is larger and extends up to the west coast of India in April to October, it is less extensive and more westwardly located in October to April. The environmental factors which might be responsible for bringing about these patterns are being studied.

Preliminary analyses of the 1927 plankton samples received at the IOBC during the IIOE, revealed presence of the large deep sea species *Gaussia princeps* (Scott) at only 19 stations. All these collections were approximately from the upper 200 m. of water with only one exception. All the stations were located in the northern hemisphere; 13 in the Bay of Bengal and 5 in the Arabian Sea; and with only two exceptions all were night collections. The 66 specimens collected, include males, females and copepodites V, IV, III and II. Twenty per cent of the total specimens were obtained from the single station in the southern hemisphere. The hydrographical conditions at the lowest level of the water column sampled, indicated that the salinity and the temperature were slightly higher (33.6%**o** and 195°C) and oxygen content much higher (4.5 ml/1) at the single southern hemisphere station than at the other stations from where the remaining 80% of the specimens were collected. In these areas, salinity had a range of 34.9 - 35.3%**o**; temperature 12.0 - 13.6°C and oxygen 0.1 - 0.8 ml/1.

The previous records of this characteristic bathypelagic species in the Indian Ocean were only in the region north of the equator. In both the Arabian Sea and the Bay of Bengal the sub-surface waters which extend from below 100 or 150 metres have an admixture of deep water and intermediate water having a low temperature. Thus, in the Bay of Bengal, sub-surface water has 5-15°C temperature and sub-surface water in the Arabian Sea has 10-19°C temperature. Mixing of Indian Ocean South Tropical Surface Water with Indian Ocean Central Water was evident at the southern station. These environmental conditions may explain the presence of a bathypelagic species in depths only as low as 200 meters.

Decapod Larvae: Out of the 1548 IIOE samples, 1518 samples contained decapod larvae. Seasonwise and day and night analysis of the samples have been made and it indicates a higher abundance of these larvae in the night collections.

Very high concentrations of the larvae are met with at one station each in western and eastern Indian Ocean, off Port Elizabeth and south of Java respectively and 3 stations off the west coast of Indian peninsula, the latter constituted mostly by brachyuran larvae. In the central Indian Ocean south of 10°S latitude there is very little representation of these larvae in the plankton. A stretch of this area of low abundance of decapod larvae extends from the middle of the Arabian Sea northwards to the Makran Coast. In Bay of Bengal also in the central region there are areas with very little representation of decapod larvae.

The trends in distribution of the

larvae of the major groups of decapods are also delineated. The larvae of penaeid prawns show a maximum concentration around the southern extremity of Indian peninsula and off the Somali Coast. The larvae of mostly Paguridae and Callianassidae, also have a similar pattern of occurrence. However they are equally abundant in the Gulf of Cambay region. In the case of Brachyuran larvae the greatest numbers occur in the region surrounding the Indian peninsula, northern part of Somali coast, Andaman Sea and off the western Australian coast. Caridean larvae are abundant near South African coast and also south of Java in the eastern Indian Ocean.

The data on the distribution of the larval and juvenile stages of *Funchalia* sp. (Penaeidae; Crustacea, Decapoda) from the material obtained from IIOE collections have been analysed. Juvenile stages of both *Funchalia woodwardi* Johnson and *Funchalia balboae* (Faxon) were recorded by Ramadan (1938) from the central part of the Arabian Sea from station No. 96 of John Murray Expedition. The only record of mysis stage assigned to the genus *Fnnchalia* is from the New Zealand region by Gurney (1924). The present records of the mysis stage as well as juvenile is made for the first time from the Bay of Bengal, off Madras Coast and from the Arabian Sea. The collection of the mysis from the same stations as that of the juveniles makes it easier to assign the larvae to the particular species.

Chaetognatha: A total of 19 species belonging to four genera were present in these collections. The species were *Eukrohnia fowleri, Krohnitta pacifica, K. subtilis, Pterosagitta draco, Sagitta bedoti, S. bipunctata, S. bombayensis, S. decipiens S. enflata, S. ferox, S. hexaptera, S. lyra, S. minima, S. neglecta, S. pacifica, S. pulchra, S. regularis, S. robusta. and S. zetesios.*

S. enflata was the most common chaetognath in the area, constituting the major part of the total Chaetognatha. *Pt. draco, S. bipunctata, S. bedoti, S. ferox, S. pacifica* and *S. regularis* were next in numerical abundance. *K. pacifica, S. neglecta* and *S. robusta* were moderately common while *K. subtilts, S. hexaptera, S. minima* and *S. pulchra* were occasionally represented. *S. bombayensis* was recorded only in the collection from Gulf of Cambay. The occurrence of mesoplanktonic species like *S decipiens, S. lyra* and *S. zetesios* and the bathypelagic form *E. fowleri* was also noticed.

The area near Somalia sustains high density populations of the epiplanktonic species. Based on the distribution pattern, the various species can be grouped by their regional dominance as follows :

1. Widely distributed:
   S. enflata and *S. pacifica*
2. Coastal : *S. bedoti, S. neglecta* and *S. robusta*
3. Equatorial : *S. ferox*
4. Western Arabian sea (West of 60°E) :
   K. subtilis, S. hexaptera and *S. pulchra*

5. Near Somalia, Southern Arabian Sea and western coast of India and Ceylon:
   Pt. draco and *S. regularis*
6. Scattered distribution:
   K. pacifica and *S. bipunctata*
7. Rare : *S. bombayensis*

The distribution of certain species during the southwest (April 15 - November 14) and northeast (November 15-April 14) monsoon periods showed differences in their abundance. *K. subtilis, S. enflata, S. ferox, S. neglecta, S. pacifica* and *S. regularis* had higher population density during the southwest monsoon while *S. pulchra* alone showed comparatively higher concentration of the species during the northeast monsoon. The remaining epiplanktonic species maintained a more or less uniform pattern of distribution for the two seasons.

Ostracoda: Species of *Bathyconchoecia* live at considerable depths, on or just above the bottom and not easily sampled with plankton nets. During the IIOE it was collected at a station where sonic depth was only 210m, and that may be the reason for collecting this bathypelagic organism with a plankton net. *B. deeveyae* is a new record in the Indian Ocean.

Amphipoda: Major portions of almost all the collections are contributed by Gammaridea and Hyperiidae. All the adult forms as well as juvenile stages were counted, tabulated and plotted. Throughout the year amphipods showed a greater abundance along the coast of Oman, Somalia, and off the south coast of Java. However, greater abundance was noted along the southwest coast of Ceylon, off the coast of Burma and off the coast of East Bengal during the southwest monsoon period, and in the Gulf of Aden, south and southeast coast of India and off the northwestern coast of Australia during the northeast monsoon period. In general it can be stated that amphipods show greater abundance towards the northern part of the Indian Ocean and within Lat. 10°—30° S and Long. 105°—115°E.

Heteropoda: Pterotrachea coronata was present only in 49 samples out of the 1927 that were examined from the epipelagic zone of the Indian Ocean, with a total of only 63 specimens. It was found to have a wide range of distribution from 23°19'N to 32°04'S. However, it was absent in the eastern Arabian Sea, in the northern and western parts of the Bay of Bengal and in the central zone of the southern Indian Ocean. It was found to be common around the mouth of the Gulf of Aden, in the eastern part of the Andaman Sea and the northwestern seas off Australia. It is found that the sucker is undoubtedly confined to the male. Females were 2.5 times as numerous as males.

The principal food of the species includes copepods and chaetognaths, and was found in almost all the water masses of the upper layers of the Indian Ocean, at different seasons of the year. Comparing the data of the stations where the net sampled a single water mass, it may be seen that the species must be euryhaline and eurythermal. It was taken at stations where the highest temperature in the water column was 16°C

and at others where the lowest temperature was not below 20°C and up to 26°C. Likewise it was found in water columns where the highest salinity was about 33%**o** and in others where the lowest was about 35%**o**. It seems likely that this species requires relatively high oxygen content since it was not taken in waters with less than 2.0 ml/1 dissolved oxygen. Most specimens come from stations where the net fished through different layers whether the boundary between the two water masses was shallow or deep, whether a thermocline was present or not. About 75% of the specimens were taken in night hauls. Thus, although *P. coronata* has been described as a warm water epipelagic species, the present data suggest that it is a warm water widely tolerant species that performs vertical migrations following the copepods on which it feeds. For this reason it is common in some upwelling areas although only very few specimens were found in the centre of the upwelling. The scattered and wide distribution of this species and its greater abundance in enriched areas may be explained by its eurytopic capacity and its feeding habits.

Pelagic polychaeta : Two new species and a new variety of pelagic polychaetes, belonging to the families *Lopadorhynchidae* and *Alciopidae,* have been recorded from the IIOE samples. Of this *Lopadorhynchus henseni var. indica* is found to be abundant and widely distributed in the Indian ocean. 420 specimens of this species have been recorded from the various parts of Indian Ocean. *Lopadorhynchus panikkarii* is a rare species and only 18 specimens have so far been obtained, 2 from Arabian Sea, 4 from Bay of Bengal and 12 from Southern Indian Ocean. *Plotohelmis sumatraensis* also is very rare, practically absent in the Arabian Sea and Bay of Bengal, only 14 specimens being collected, all from Southern Indian Ocean.

6 species of pelagic polychaetes, out of the total 34, have been found to be new records for Arabian Sea and Bay of Bengal.

Anthozoa: Of the 1927 IIOE zooplankton samples, 35% are devoid of Anthozoa. Numerical abundance of anthozoan larvae varied from 1 to 200/haul. Neritic forms are rare over great depths and more frequent in the proximity of the bottom. They occur in larger numbers in the northern hemisphere where extensive coast line and wide shelves offer suitable habitats for the adults. Larvae also occur in large numbers along Somali coast and Gulf of Aden. In the Bay of Bengal the distribution is uniform as compared to the Arabian Sea area. The overall abundance was greater in the April to October period. Larval distribution for every 10° increment of latitude has been studied, peaks and falls are noted. In the west east distribution a trend is noticed in the October to April period in shifting of the peak period to eastern longitudes. Absence of larvae in the south central Indian Ocean at the tropical convergence zone is noted. As the Indian Ocean islands offer suitable settling substratum, the larvae are in abundance in their vicinity.

Despatch of IIOE material

The sorted material from IIOE collections have been sent to the following specialists

Specialist	*Group*	*Date of despatch*
1. Dr. T. S. Park	Heterorhabdidae	8.4.1970
2. Dr. Lanna Chang	Halobates	27.4.1970
3. Dt. Dechance	Paguridae	4.8.1970
4. Dr. Pampapathi Rao	Tornaria larvae	24.10.1970
5. Dr. George Grice	Candaciidae	24.10.1970
6. Dr. C. T. Shih	Lycaopsidae, Lycaedae, Pronoidae	26.10.1970
7. Dr. Berry	Aliquots of Laccadive and Kavaratti collections	11.11.1970
8. Dr. Schmeleva	*Calocalanus*	21.12.1970
9. Mr. M. Sakthivel	Pteropods	1.1.1971
10. Dr. Wear	Porcellanidae	21.1.1971
11. Dr. Haq	Temoridae, *Calanopia*	21.1.1971

(ii) *Subsorting of Copepods :* Subsorting of copepods into different groups was continued during the year under report and 60 samples were subsorted. For completing the preliminary phase of copepods subsorting with atleast one sample each 5° square, a selection of stations was made and the samples at present are being sorted out accordingly.

(iii) *Preparation of Plankton Atlas:* Following the publications of IIOE Plankton Atlas Volume II Fascicle 2 showing the distribution of fish eggs and larvae in the Indian Ocean in March, 1970, work on the distribution of Copepoda and decapod larvae in the Indian Ocean was completed and published in June, 1970. This fascicle contained 11 maps, namely distribution of Copepoda (total), Copepoda during April 16- October 15, during October 16 - April 15, during day and night, decapod larvae (total) decapod larvae (excluding Brachyura), decapod larvae during April 16- October 15, during October 16- April 15, during day and night. The preparation and contouring of 20 maps to form the next fascicle has been completed and its publication work is in press.

(iv) *Preparation of Handbooks to the International Zooplankton Collections:* Preparation of the handbook volume II showing the salinity, temperature dissolved oxygen and other parameters at the various stations of the IIOE was completed and is in the process of printing. Volume III on the proceedings of the Plankton. Workshop held in February 1969 was also completed and is in press.

2. Post Monsoon Zooplankton Ecology of Mandovi Estuary in Relation to Tides

Fortnightly zooplankton samples were collected during high and low tides from September to December 1969 in order to study the post monsoon zooplankton fluctuations in Mandovi Estuary. A total of 15 samples have been collected and basic sorting of all major groups have been completed. The data regarding displacement volume is given in the following table. The

volume of zooplankton is more in high tides during postmonsoon period upto October and represents marine forms. This is reversed during November-December months when the volume of zooplankton is dominated by estuarine forms.

TABLE I

Displacement Volume of Plankton near Mandovi Bridge

Date	Volume (ml)	
	High tide	Low tide
27-8-1969	43.0	6
30-8-1969	35.1	21.0
12-9-1969	5.0	7.0
25-9-1969	24.0	18.0
13-9-1969	2.0	1.0
24-10-1969	25.0	2.0
24-11-1969	2.0	9.0
10-12-1969	5.0	10.0

Preliminary results bring out significant differences in the qualitative composition of the dominant plankton groups.

During high tide the following groups were dominant. *Pleurobrachia* sp., chaetognaths, pteropods, polychaete larvae, hydromadusac and cladocerans and during low tide the groups such as zoea, mysids, *Acetes* sp., amphipods, cirriped nauplii, and stomatopod larvae were found to be dominant in the samples.

Copepods, decapod larvae, fish eggs, fish larvae and *Lucifer* sp., were common in both the samples however varying in numbers.

3. Studies on Planktonic Foraminifera from the Eastern Part of the Arabian Sea

Twenty-two species of planktonic foraminifera have been identified from the bottom sediments of the Arabian Sea off Bombay and quantitative documentation of individual species has been made. Species composition has shown that the sediments of the continental slope region off Bombay are represented by larger number of species and genera than the shelf sediments and forms which are dominant in the eastern part of the Arabian Sea are *Globigerina bulloides, Globigerinoides ruber, Globigerinoides succulifer, Globiferinita glutinata, Globiferinella aequilateralis, Orbulina universa, Pulleniatina obliquiloculata* and *Globorotalia tumida.*

From the quantitative distribution of this group it has been found that the concentration of planktonic foraminifera decreases towards the coast.

Further studies on this group of foraminifera in relation to oceanographic conditions of the Arabian Sea are in progress.

3.42 Phytoplankton

1. Experimental Studies on Phytoplankton Cultures

Unialgal cultures of 12 phytoplankton organisms were grown in enriched sea water, and the effect of their environmental factors viz., salinity, light and nutrients were investigated on their growth and rate of photosynthesis.

When cultures were transferred to seawater of salinity range 5 to 35‰ different organisms showed wide tolerance, but the maximum photosynthesis of a large number of organisms was within the salinity range 10-25‰. Ecological observations on their distribution and abundance in the estuary and nearshore regions showed their maximum abundance when the salinity is low.

In order to understand the adaptability to different salinity the organisms were actually grown in the sea water medium of different salinities. Maximum photosynthesis was found to be within the salinity range of 5-15‰.

Studies on the organic carbon lost as extracellular products during the photosynthesis showed that 8-25% of the carbon fixed was excreted out.

Studies were also commenced on the relation of different productivity parameters such as direct cell counts, C^{14} production, chlorophyll and particulate organic carbon for phytoplankton organisms grown at different environmental conditions. Simultaneously the changes in the concentration of extracellular products are being followed and the work is in progress.

3.43 Productivity

1. Some Problems Related to the Measurement of Primary Production by Using C^{14} Technique

i) *Effects of Bottle Size on Primary Production:* By making use of bodies of different capacities and same concentrations of phytoplankton, a series of experiments were conducted for estimating production. The results indicate that within the volume range (50-250 ml) used there was no noticeable influence on primary production.

(ii) *Effects of Different Amounts of Inert Material on the Self-absorption of* C^{14}: All experiments were conducted by using different phytoplankton cultures. Bottom mud collected from Cochin Backwaters was autoclaved and dried and was the source of inert material. Primary production measurements in turbid water by using C^{14} technique, necessitates a correction for self-absorption. In view of this it has been found that even when the thickness of deposit on the filter was 0.4 mg/cm^2, the true production value was about 16% more than the observed value.

(iii) *Effects of Organic Pollulants on Light and Dark Bottles:* Investigations were done using (a) protein, (b) carbohydrate and (c) bacteria. Varying amounts of protein (hydrolysed casein) and carbohydrate (glucose) were used with constant volume of cultures. Under the experimental conditions investigated protein and carbohydrate were found to have no detectable effect on primary production values. The concentrations of protein and carbohydrates used, varied from 0 to 10 mg/1 and 0 to 20 mg/1 respectively.

In the next series, different concentrations of bacteria *(Pseudomonas, Archromonas* and *Vibrio)* which are commonly found in polluted estuaries and inshore waters were used with constant volumes of cultures. The concentrations of bacteria used were:

(a) 2×10^3 —2×10^5 counts/1

(b) 10^7 — 10^8 counts/1

In the former case there was no effect on light and dark bottle while in the latter case the values obtained were very erratic and dark bottle uptake was found even to exceed the light bottle uptake.

2. Primary Productivity of Mandovi and Zuari Estuaries

The work on this scheme was started in January 1970 and continued till September 1970.

In continuation of the earlier work further studies were made on the seasonal organic production in the waters of Goa region. Two different patterns of seasonal changes in the environmental features in relation to high and low tides in the Mandovi and Zuari estuaries were noted.

In both the estuaries during high tide, maximum temperature was noted in the month of May and a second smaller peak was noted in July while during low tide the peak occurred in April with moderate monthly variation. The two estuaries were colder during low tide in January and February and during southwest monsoon, whereas warm during high tides in May.

The waters of the two estuaries are more saline from January to May while the salinity in Mandovi estuary is slightly lower as compared to Zuari. In Mandovi estuary the waters were nearly fresh (salinity 0.4%**o**.) in August while in Zuari estuary the lowest value of salinity was 5%**o**.

The distribution of dissolved oxygen presented two peaks in both the estuaries, one during January-February (Northeast monsoon) and the other during June-July (Southwest monsoon). The drop in oxygen during March-April is related to high temperature and high salinity of the waters of two estuaries. In June-August, marked difference in oxygen values was noted in the two estuaries. During low tide the dissolved oxygen was higher in Mandovi than in Zuari estuary.

Organic production was calculated by the rate of photosynthesis, C^{14} assimilation and chlorophyll *a* content. The production rate was influenced by tidal conditions. The production rate during low tide (270-350 $mgC/m^3/day$) was lower than that of production rate during high tide conditions (550 $mgC/m^3/day$). The fluctuations in production rate from January-August exceeds 10-11 times during high tide conditions whereas it is only eight fold during low tide conditions in both the estuaries.

As regards the production in terms of C^{14} assimilation, it was higher in Mandovi estuary during January-April than in Zuari. This difference is more evident during high tide conditions. But the condition reverses with the onset of Southwest monsoon due to more freshets in the Mandovi estuary. The rate of production was found to be directly related with the temperature in both the estuaries.

The initial chlorophyll α in the high tide waters of the two estuaries was more than that during the low tide. The increase in the chlorophyll *a* after 4 hrs. of incubation was found higher in January and May during low tide conditions and in March and June during high tide conditions in the two estuaries which revealed two separate peaks of production rate in estuarine and neritic waters.

3. Secondary Production in Waters Around Goa

The following four stations have been selected for the above study.

1. Caranzalem Bay
2. Off Dona Paula (Cabo head) - 10 fathoms
3. Mormugao Harbour
4. Near Grand Islands, Off Baina - 10 fathoms

In view of the limited facilities only second and fourth stations were selected and regular weekly samples were collected during the post-monsoon period from 15th September, 1970 to 15th February, 1971. This will lead to the study of the post-monsoon conditions and their relationship with the local fisheries. A total of about 20 samples have been collected from both the stations and these studies will be continued through the next year during post monsoon period.

4. Hydrography and Productivity of Coastal Waters along the Konkan Coast between Panaji and Bombay

The project was started in November 1969 and was continued through March

1970. (As also reported last year in the Annual Report, 1969-1970). Regular monthly cruises were continued after monsoon from September 1970 to March 1971. In all, seven stations namely Vengurla, Malwan, Deogad, Vijaydurg, Harnai, Sriwardhan and Janjira, were fixed for undertaking monthly observations.

The environmental features and productivity values on the Konkan Coast show great variations in different regions which are probably caused by the presence or absence of drainage through the various river systems in the region.

Estimations of chlorophyll *a, b, c* and carotenoids indicate the abundance of diatoms at all the seven stations which is also supported by the numerical counts of phytoplankton elements as well. Pattern of increase or decrease of chlorophyll pigments and phytoplankton abundance showed direct relationship with temperature, salinity and oxygen. The data are being analysed and processed in order to draw final conclusions on the characterisation of the waters of Konkan Coast.

Studies on the seasonal variation and distribution of zooplankton in relation to oceanographic parameters along the central west coast of India is being carried out every month since November, 1969. About 113 zooplankton samples have been collected so far. Marked fluctuations have been observed in the biomass at all the places during the period from April 1970 to March 1971. The characteristic features of zooplankton distribution as revealed in the present studies are enumerated below.

I. The pattern is similar to that of last year when two peaks were clearly seen respectively during November and April. Very low concentrations were observed during December-January.

II. Ratnagiri, Sriwardhan, Harnai, Janjira, Malwan and Vengurla showed fairly high production of zooplankton. As usual, copepods dominated in almost all the samples. Decapod larvae were fairly in good number in the places influenced by the river system.

III. It has been observed that the general prawn fishery was fairly good during this year especially around Ratnagiri. In our samples cladocerans were fairly rich, upto Ratnagiri, a zone where heavy mackerel landings were reported. This corroborates our earlier finding that mackerel fishery is related with the abundance of cladocerans and that the cladocerans can be taken as indicator sp. of the mackerel.

IV. Mackerel fishing season is prolonged this year and bumper catch from Karwar and Panaji have been reported. Plankton samples collected during this season are being processed.

V. A few specimens probably of *Gossea brachymera* (Hydromedusae) were collected from Vengurla. This is a new record for the Indian Ocean. Another hydromedusa, *Podocoryne ocellata* has also been recorded from Vengurla.

3.44 Marine Ecology

1. Ecology and Food Chain Studies on Beaches and Inshore Regions of Cochin

(i) *Energetics of Flat Fish Populations Occurring on Sandy Beaches:* The metabolic rate of some of the flat fishes was determined in the laboratory by measuring their oxygen consumption during starvation and when the fish was actively feeding. In addition to the metabolic rates some feeding experiments were also carried out to determine the food-intake in relation to growth

and increase in body weight. This gave the index of efficiency.

Standard oxygen consumption of two tropical fish, *Cynoglossus* and *Halophryne*, and two temperate counter - parts *Pleuronectes* and *Cottus* was measured within temperature tolerance ranges of 15.0 - 37.5° C and 2.5 - 25.0° C respectively.

At 28°C, the standard oxygen consumption of *Cynoglossus* was 1.2 times that of *Pleuronectes* at 10°C, and of *Halophryne* was 1.45 times that of *Cottus*. Substantial temperature compensation is thus indicated in fish which have evolved in temperate and tropical regions.

Growth increments of samples of *Cynoglossus* taken at regular intervals from the sea varied between 0.9 and 2.0 mm per week. From samples taken through out a 24 hour period in the sea, evidence was produced for a diurnal rhythm in feeding, with the greatest feeding activity occurring at night. Measurements of standard oxygen consumption of *Cynoglossus* at 28°C suggested a relationship of oxygen consumption to live weight of

$$Q = 0.372\ W^{0.734}$$

mg oxygen per hr. live weight (g)

For *Brachirus* & *Synaptura* this was

$$Q = 0.362\ W^{0.682}$$

mg oxygen per hr. live weight (g)

The standard oxygen consumption of *Cynoglossus* was temperature dependent between 15 and 30°C, but independent of temperature between 30 and 37.5°C. A feeding experiment was conducted in which *Cynoglossus* were fed with the polychaete, *Diopatra neopolitana* at 28°C. A maintenance food intake of 25% of the body weight per week was indicated. The metabolic level of the fish was related to food intake, being highest at the highest feeding levels. Efficiencies of conversion of assimilated food into growth of 11 to 12% were observed.

(ii) *Food Conversion in Prawn:* Laboratory feeding experiments of the penaeid prawn *Metapenaeus dobsoni* were conducted using different types of aquatic food of plant and animal origin, using algae, Salvenia weed, polychaetes, oligochaetes, amphipods, and detritus. Efficiency of conversion was found to be lower in the case of plant and detritus diet when compared with animal diet. The cannibalistic tendency was more dominant among the batches of prawn fed on detritus and plants. This indicates the preference of the species to feed on animal diet, and can also sustain on other items of food in the absence of animal diet.

An interesting feature noted was that the intestine of prawn which is normally straight was found to distend when fed on algae and fermented Salvenia weed.

(iii) *Ecology and Food Chain Studies of Beaches :* Recently in collaboration with British scientists from Marine Laboratory, Aberdeen under IBP, investigations of ecology of different beaches and inshore waters were made. A series of biological samples were collected using cores, grabs, D-nets and beam-trawl from various

locations of different transects of the beach, from supralittoral down to 10 meters. A detailed survey of the physical factors affecting the quantitative and qualitative distribution of intertidal animals were carried out with particular interest on the crab fauna, sublittoral work pertains to the quantitative assessment of benthic organisms using grab, D-net and beam-trawl and skin diving. Laboratory and field experiments on the temperature regulation of the Ocypod crabs were conducted. The data are being analysed.

(iv) *Distribution of Interstitial Fauna of Cochin Beach and Shertallai Beach:* Vertical distribution of the interstitial fauna from surface to permanent water level beneath the soil was investigated at the two beaches at different tidal levels.

At Shertallai the shollow sloping beach has the fauna distributed from 0-10 cm depth at low tide level and 0-40 cm at mid tide region and upto 110 cm at high tide level. Ciliates were more prominent at low tide and mid tide levels. At high tide region nematodes were more abundant. Nematodes were found in abundance next to ciliates at mid tide and low tide regions. This was followed by turbellarians, harpacticoids, archiannelids, gastrotriches, polychaetes, etc. In certain samples archiannelids were found in large numbers at mid tide and low tide larvels. Large fluctuations of the fauna was observed in the mid tide region due to frequent sand shifting.

(v) *Bacterial Flora of the Beach Sand and Beach Sea Water:* Fifty-four strains of bacteria, 28 from the beach sea water at Cochin were isolated and their morphological and biochemical features were studied. Enterobacteriaceae (Coliforms) were very dominant botli in sand and sea water. These were followed by the general *Vibrio, Pseudomans, Achromobacter Flavobacterium, Bacillus* and *Photobacterium.* Most of the strains were gram-negative and motile rods. Only five strains from the flora of the Cochin beach could be recognised as marine and the rest appeared to be of terrestrial origin.

Recently, studies on the vertical distribution of bacterial flora of the beach sand in high, mid and low tide levels at Cochin beach were commenced and the work is in progress.

3.45 Marine Pollution

1. Marine Pollution and Disposal of Sewege in Bombay City

During the period under review the National Institute of Oceanography was approached by the Bombay Municipal Corporation to assist them in preparing a report for the disposal of sewage and effluents into the sea surrounding the Bombay City. The Bombay Municipal Corporation appointed Binnie & Parterns, London as their consultants along with CPHERI, Bombay; the National Institute of Oceanography was appointed co-consultant for this programme. The project on marine pollution and disposal of waste was thus taken up by the scientists of the Bombay Unit and the Physical Oceanography Division. At present the sewage and effluents are disposed off right into the shore and has created serious health hazards in Bombay city. A survey of the present status of the disposal system was made and

the work on extending the present disposal lines to greater depth and distance was initiated. Six to seven points on the east coast of Bombay Harbour and Thana creek were chosen for the studies. Various parameters such as temperature, salinity, dissolved oxygen, productivity (planktonic and benthic) were investigated along with the measurements of currents, direction of currents, drift studies, float test etc. After analysing the data and studying the bottom profile by means of echo-sounder, four outfalls on the west coast of Manori, Bandra, Worli and Malabar points were suggested. It was also observed that there was no temperature or salinity gradient in the waters under investigation since the depth only extended up to seven fathoms as far as to the extent of seven miles from the shore. The bottom was uniformly covered by a thick layer of silt and clay. Silting appears to be almost a continuous process which is indicated by almost total absence of benthic organisms. Plankton appears to be comparatively rich in cleaner areas like Manori and Malabar point.

The Thana creek appeared to be highly polluted as a result of discharge of industrial wastes from a large complex of industries around it. The dissolved oxygen content of water is very low, 1.5 c.c per litre and therefore unsuitable for life.

3.46 Marine Fouling

1. Studies on the Settlement of Fouling Organisms on Fibreglass Coated Wooden Hull

In recent years the fishing and navigation in Goa has increased with the use of considerable number of boats of various size made of different material. In the recent technology on boat material, one of the developments is covering of wooden hull with fibre glass, which is supposed to resist rapid fouling and boring. Observations were carried out on the settlement of fouling organisms on the fibreglass coated hull of the research vessel MLV *'Tarini'* of NIO. The 45-footer boat having 595 sq. ft of submerged portion of the hull, was used for oceanographic work for nine months from June to February, 1971, except for three monsoon months when dry docking was necessitated due to the settlement of foulers. The material was collected from the different sides of the hull from an area of 1 sq. ft. each.

The highest settlement was found on the starboard side (540.72 gm/sq. ft) and the lowest at bow side with 170.45 gm/sq.ft. The portside and sternside showed an average of 395.72 and 225.94 gm/sq.ft. respectively. The estimated settlement on the complete hull was of the order of 1984 kg.

All the major fouling organisms viz. cirripedes, molluscs, annelids, bryozoans, coelenterates as well as their associates were encountered in the samples. Barnacles (cirripedia) were most abundant varying from 48.28 to 59.93% at different parts of the hull. They formed 3 tiers of settlement showing the intensity of their abundance. *Balanus tintinnabulum tintinnabulum* was present only on the sternside and completely absent on other sides.

Molluscs were next in abuundance by percentage and ranged from 12.4% to 23.91%. Their settlement was highest on sternside which was exposed always and thus easily accessible, Oysters and mussels were prominent molluscan foulers.

The percentage of annelids and bryozoans ranged between 0.78% - 3.6% and 0.8%-1.67% respectively. Another important group of fouling organisms were hydrozoans. The hydrozoan settlement was largely on bow and stern sides (14.5% and 70% respectively). Maximum turbulence at stern side due to propeller action and the action of the current due to cutting of water

at bow area appear to be conducive factors for such predominant settlement on specific sites. Though hydrozoans are known to cause considerable damage to protective coating, the fibreglass sheathing did not show any deterioration during this period.

Miscellaneous components included amphipods, isopods, decapods and algal matters scattered all over the hull with maximum on port side.

3.47 Fish and Fisheries

1. Studies on the Development of *Tylosurus crocodilus* (Le Sueur)

In the month of October 1970 a large number of fish eggs washed ashore in bunches were collected from the Miramar Beach.

In order to ascertain the species, the eggs were brought and reared under laboratory conditions. They hatched in about 8-10 days. The larvae could be kept alive for 12 days. On identification they were found to be of *Tylosurus corcodilus* (Le Sueur).

Detailed studies were made with regard to the growth of the embryo, the development with special reference to the circulatory system, pigmentation and coloration, larval behaviour, larval growth etc.

As the fish is highly carnivorous, and its large number in estuaries may cause damage to the estuarine fauna, studies on its larval growth and larval behaviour may find some use in their eradication if estuaries were to be cultivated in the near future.

2. Yield Studies on Fish

The work on fish population model was continued during the year. The concept of eumetric fishing developed by Beverton and Holt was reexamined to facilitate a better understanding of catch-per-unit-effort. An attempt was also made for an easier estimation of the condition of optimum exploitation of fish.

3. Studies on the Age and Growth of Silver Pomfret, *Pampus argentenus:*

Age and rate of growth of silver pomfret was studied using the scales and otoliths collected from the commercial landings at Cochin. The von-Bertalanffy growth equation fitted to the data is

$$Pt = 37.003 \left\{ 1 - e^{-0.319 (+ - 2969)} \right\}$$

3.5

data, documentation, information & publication

1. Data Exchange, Preparation of Catalogues

Work on indexing and cataloguing of the data available in the Indian National Oceanographic Data Centre (Planning and Data Division) is in progress. Information regarding the station position and physical and other oceanographic parameters for 1° square in the Indian ocean have been entered on monthly basis, on the catalogue cards.

During the period under review, the Centre acquired more data for the Indian Ocean from the World Data Centre 'A' Washington, USA and 'B' - Moscow, U. S. S. R.

i. *Data Received from world data Centre 'A' Washington, USA*

Country	*Ship*	*Particulars of Data*	*No. of stns.*
USA	R/V *Argo*	Physical & Chemical	109
USA	R/V *Atlantis*	-do-	229
West Germany	R/V *Meteor*	-do-	265

ii. ***Data received from World Data Centre 'B', Moscow, USSR***

USSR	R/V *Vorobyey*	Physical & Chemical	147
USSR	R/V *Orlek*	-do-	395

2. Documentation

The documentation programme expanded to a considerable extent during the year under report. The programme incorporated original survey work on documentation and the documentation extension service to the scientific staff of the Institute, the details are given in the following paragraphs

I. *Documentation Work:* In regard to a proposal to start a journal entitled, *'Indian Journal of Marine Sciences'* with a view to facilitate the publication of scientific papers on marine sciences, the Indian National Committee on Oceanic Research in its 13th Meeting, strongly recommended that the proposed journal may be started by the Publications & Information Directorate of the CSIR. In its first meeting, the Executive Council of the NIO approved the proposal in principle and suggested that detailed survey may be made on the number of papers published by the Indian scientists in the Indian and foreign journals in various disciplines of marine sciences, in order to assess the quantum of material so as to start a new journal. A detailed survey of such papers published during past 13 years from 1957 to 1969 was made. The results of the survey indicated that -

i) The average number of papers published in the field of marine sciences was in the order of 44 prior to 1966.
ii) There has been a constant increase in the flow of papers after 1966 to an average of 62 papers per year.

The report was submitted to the Chief Editor of Publications and Information Directorate, enabling him to consider the possibilities of starting the journal and fixing up its periodicity. The report resulted approval in principle by the Executive Council of the Publications & Information Directorate.

Compilation of Mailing List: An upto date mailing list was compiled countrywise in the alphabetical order for the year and includes around 500 institutions and organisations in India and abroad to whom all the publications of the Institute are regularly mailed.

II. *Documentation Service:* The nature of documentation service extended to the scientific staff of the Institute is given in the following paragraphs:

(i) *Current Awareness Service:* A monthly service relating to distribution of a documentation list of current scientific papers on various disciplines of oceanography was continued during the year. The scientific papers were arranged in the documentation list in accordance with the subject classification adopted in the *Oceanic Index* and *Deep Sea Research*

(ii) *Acquisition, Processing and Retrieval of Scientific papers:* In all 500 reprints of scientific papers have been received so far from various sources in India and abroad. These were classified and indexed. A subjectwise list was compiled for circulation among the staff of the Institute for their information.

(iii) *Compilation of Bibliographies :* A selected bibliography of scientific papers published during 1970 in various disciplines of marine sciences related to the Indian Ocean was compiled for publication in the quarterly bulletin, *Mahasagar,* Dec. 1970.

A few bibliographies on specific subjects such as estuarine system, phosphate distribution in the Indian Ocean and dikes and basic rock were compiled on the specific request from the scientists.

(iv) *Abstracting:* The material suitable for publication in the *Mahasagar* in respect of sections, information from abroad, Scientific and Technical Notes etc., was abstracted.

(v) *Collected Reprints of the Institute :* The reprints of the papers published by the scientific staff of the NIO were classified, arranged authorwise in the serial order of the contribution number, and were compiled in the form of collected reprints.

(vi) *Translation and Reprography:* As the facility of translation of scientific papers and reprography service has so far not been provided at the Institute, the service of Indian National Scientific Documentation Centre was availed for this job. A few papers were translated and photocopies of a dozen papers and microfilms were obtained from INSDOC.

3. Information and Publication

The Information and Publication Section which at present forms a part of Planning & Data Division started functioning only last year. The work carried out in this division is given in the following paragraphs :

(i) *Information*: The object is to highlight the activities of the Institute and its various divisions and units in popular form in the news papers and periodicals. It is aimed at keeping lay public abreast with the activities in the field of oceanography. The incentive for this kind of work was specially provided

by a letter received last year from Dr. V. K. R. V. Rao, the then Minister of Education (Govt. of India) wherein he specifically emphasized that the activities of the laboratories of the CSIR should be brought to the notice of the common man through various media of mass communication such as, news papers, periodicals, radio, television, etc.

(ii) *News Release & Popular Articles :* During the year under report there has been constant flow of material to the daily news papers, a glimpse of which can be had from the production of some important news items sent to the press (Fig.)

Of several popular articles sent for publication, mention can be made of the following:

Bhatt, V. S. 1970. Systematic Oceanographic Studies in India *Navhind Times*, May 3, Sunday Magazine.

Bhatt, V. S. 1970. The Atlas that may Revolutionise Fisheries Research In India. *Mahasagar* 3(2).

Bhatt, V. S. 1970. IIOE Atlas on Copepoda and Decapod Larvae. *Mahasagar* 3 (3).

Dehadrai, P. V. 1970. Estuarine Heritage of Goa. *Goa Today* 6.

(iii) *Radio talks & News Broadcasts :* A series of radio talks on 'Studies in Oceanography', by scientists of the Institute was arranged on popular topics related to physical, chemical, geological and biological oceanography. The talks were broadcast from All India Radio, Panaji which are given below:

Studies in Oceanography

Sr. No.	Speaker	Subject	Date of broadcast
1.	Dr. N. K. Panikkar	Ocean Research In India	16-7-70
2.	Shri R. Jayaraman	Raw Material from the Sea	13-8-70
3.	Dr. S. Z. Qasim	Production of Living Matter in the Sea	17-9-70
4.	Dr. T. S. S. Rao	Marine Plankton	15-10-70
5.	Dr.V.V.R. Varadachari	Monsoon & Ocean Currents	19-11-70
6.	Dr. M.G.A.P. Setty	The Shelf and Sea Floor	17-12-70

Besides these broadcasts, oceanographic news items emerged from the participation of the Director, National Institute of Oceanography in some of the major International Oceanographic Conferences and meetings. A list of these is given below:

अरबी समुद्रातील बेटांलगत
सागर-संपत्तीचे संशोधन
प्रा. पणिक्कर यांची घोषणा

(आमच्या प्रतिनिधीकडून)

पणजी, दि. २१— भारत सरकारच्या अनुदानाने स्थापन झालेल्या इंडियन नॅशनल सायन्स अॅकॅडेमीकडून अरबी समुद्र किनाऱ्यावरील लक्षद्वीप मिनिकॉय व कोचीन किनाऱ्यावरील बेटांचे सागर संपत्तीच्या दृष्टीने संशोधन केले जाणार अ... ची माहिती या अॅकॅडेमीचे चिटणीस व ... नॅशनल प्रा. एन. के. पणिक्कर ... आहे.

O edificio em D. Paula do Instituto Nacional de Oceanografia ficara' pronto em 1972

(Do Nosso Reporter)

PANGIM, 21 — O edifício de três andares do Instituto Naciona! de Oceanografia, ora em construção, em Dona Paula, deverá ficar pronto em 1972, segundo declarou hoje o Dr. N.K. Panikkar, director do dito Instituto.

A planta do edifício ... rá a área de 30 ... da pelo ...

Vaz, que trabalha para a Bombaim, Gregso... King.

Indian team for 'ocean world'

Express News Service

PANJIM, Sept. 18 ... Panikkar, Director, National Institute of Oceanography ...

Marine scientists visit Goa

PANJIM, May 14— At the invitation of Dr N. K. Panikkar, Director of the National Institute of Oceanography, Director of the Indian Ocean Biological Centre (IOBC) and secretary of the Consultative Committee (IOBC) ... visited the Institute here ...

Dr Panikkar on farm panel

PANJIM, Oct. 7—Dr. N. K. Panikkar, Director, National Institute of Oceanography, has been appointed as a part-time member of the newly-constituted National Commission on Agriculture of the Union Government. The object of the Commission is to enquire into the progress, problems and potential of Indian agriculture (including fisheries and forestry). The Commission is headed by Mr C. Subramaniam.

Oceanographic trawler

PANJIM, May 18—A 45-foot oceanographic trawler having 41 ft. ... undertaking a journey from Bombay ... vessel of the National Institute of Oceanography ...

Low sea fish yield due to outmoded methods

Hindustan Times Correspondent

New Delhi, April 24—India's seas abound in fish. But the fish yield is low. Dr N. K. Panikkar, Director of the National Institute of Oceanography, said here today the low yield—about 1.4 million tonnes—was because of the outmoded equipment and boats that fishermen used. He advocated the use of synthetic ... driven boats ... deep-fish ...

... the Arabian Sea, Dr Panikkar said the fish came to the bay to spawn as the water there was relatively calm, and when the larvae ... they swam back to the sea.

THE NATIONAL TIMES, FRIDAY, JULY 3, 1970, PAGE THREE

Bay of Bengal ideal nursery for fish larvae

By A Staff Reporter

NEW DELHI, April 24.

THREE-QUARTERS of the total annual catch of 1.4 million tons of fish is accounted for by the Arabian Sea region off the West Coast, but for breeding the fish show a preference for the quieter waters of the Bay of Bengal.

Dr. N. K. Panikkar, Director of the National Institute of Oceanography, Panjim, Goa, said today that the Bay of Bengal seemed to provide an ideal nursery for fish larvae since its waters were less turbulent. The Bay of Bengal was almost land-locked, like a gulf.

Though the breeding took place up to 200 metres below the ocean surface, the sunlight could penetrate to this depth—the fish and larvae were not disturbed by the movement of ships and boats.

Dr. Panikkar has also ... atlas on fish eggs and ... Indian Ocean, which ... by Dr. ... Council of ... Research ...

Ocean study centre is getting ready

NEW DELHI, July 2—On a ... tongue of ... between the estuaries of the Zuari and Mandovi in Goa ... buildings of the National Institute of Oceanography ...

Plankton atlas released

By A Staff Reporter

PANJIM, ... the International Indian Ocean Expedition produced by the Indian Ocean ... under the auspices of ... National Institute of Oceanography was released ...

Role of Chemical Oceanography

... to instrumentation, chemists, particularly ... analyses ...

Problems of ownership of oceans discussed

PANJIM, February 9— The National Institute of Oceanography will be arranging regular colloquia from time to time on subjects pertaining to marine science.

The inaugural talk of the series was given today by Dr N. K. Panikkar who dealt with ... of ownership of the ... Dr. Panikkar ... history ... colonial ... the oceans and the ... also lead to the discovery of areas of prospective oil deposits.

Marine Biology includes all the problems pertaining to the animal and plant life in the sea. Mention can be made of the systematic and taxonomical studies of the living ...

... Members ... has been ...

What is Oceanography?

Oceanography (also known as oceanology) is the scientific study of oceans, its contents and boundaries. It is a composite science where basic scientists are drawn to work on the Physical, Chemical, Geological and Biological aspects of the ocean and also the problems ...

डॉ. एन. के. पणिक्कर

ഇന്ത്യാസമുദ്രം സമഗ്ര പഠനവിഷയമാകും

—ഡോ. എൻ. കെ. പണിക്കർ

No.	Speaker	Subject	Date of broadcast
1.	Dr. N. K. Panikkar	AIR Interview. Dr. N. K. Panikkar, Dr. J. E. Smith and several members of the IOBC Consultative Committee.	15-3-70
2.	„	Bird Watching in Goa	18-6-70
3.	„	AIR Interview on 'The Ocean World' the Joint Oceanographic Assembly held at Tokyo	11-10-70
4.	„	Indian Ocean Part I	8-1-71
5.	„	Indian Ocean Part II	12-1-71

(iv) *Information Disseminated:* Requests from various sources for the activitie of the Institute were received and the information supplied. Mention can be made of the meterial about the Institute supplied for the following.

1. CSIR Annual Report, 1970.
2. CSIR Handbook, 1971.
3. Report on 'Science & Technology, of the COST
4. UNESCO survey on 'Research Facilities on Science and Technology in Asia'.

3.6

cruise conducted during the year

1. Blue Fin Cruise (combined NIO-CIFO Project)

1. Blue Fin Cruise (combined NIO - CIFO Project)

Under this project two cruises were undertaken this year, following the same cruise pattern and making collections at the fixed stations. Investigations on the various groups of the plankton are being carried out. The decapod larvae from these samples have been sorted out and are being studied. A paper on the decapod larvae found in these collections is under preparation. Preliminary report of the 2nd cruise is attached. Collections could not be made during cruise III because of the rough weather.

Second Cruise of 'Blue Fin'

Cruise No.	:	2
Cruise period & itinerary	:	8-4-1970 to 11-4-1970 Dep. Cochin 8-4-70, 1600 hrs. Arr. Cochin 11-4-70, 1130 hrs.
Area of operation	:	Off Kerala coast; between Cochin & Quilon
Ship details	:	Blue Fin - Over all length 28.45 M. Displacement light ship 192 tons; 600-650 H. P.
Skipper	:	Shri U. Balan
Project personnel	:	Shri M. Sakthivel (Leader) IOBC Shri T. Balachandran, IOBC Shri Rajendran, CIFO Shri S. V. M. Abdul Rahim, IOBC Shri K. S. Purushan, IOBC plus 8 trainees of CIFO
Object	:	1. To study the vertical distribution of zooplankton in relation to the depth of thermocline 2. To study the seasonal changes of zooplankton in relation to hydrographical changes 3. To study the faunal composition and distribution of bathypelagic plankton 4. To train operative trainees of CIFO in handling oceanographic equipment and collection of environmental data

Study area : Three tracks were covered off Cochin, Alleppey and Quilon with 5 stations each

Weather : Clear and cloudy

Interesting observations

1. There is a distinct rise in the surface temperatures by about l°C to l.5°C when compared to the first cruise in February.
2. The depth of thermocline is slightly pushed upwards from the depth of 100 m to 75 m.
3. There is a slight decrease in the biomass of zooplankton than the 1st cruise. However, Quilon track still stands for higher biomass than the Alleppey and Cochin tracks.
4. A large swarm of amphipods was noticed in the area off Cochin. A considerable number of Tornaria larvae were also found to occur in the inshore stations off Cochin.
5. Swarms of euphausids were found in the area off Quilon.

BLUF FIN CRUISE 11

8—4—1970 to 11—4—1970

Station	Date	Lat.	Long.	Sonic Depth (m)	Temp. C°	Surface Salinity ‰	Oxygen ml/l	Type of haul	Duration from	Duration to	Flow meter TSK	Wire out (m)	Coll. Val. (ml.)	Remarks.
14	8-4-70	09°56'N	76°04'E	28.3	30.6	35.08	5.67	Vertical	19.04	19.10	490	37	1.6	
15	,,	09°53'N	75°55'E	41.2	30.0	34.72	5.67	,,	20.30	20.35	530	45	3.0	
16	,,	09°51'N	75°47'E	66.8	30.5	34.29	4.82	,,	21.45	21.50	745	75	3.6	
17A	9-4-70	09°48'N	75°39'E	164.6	30.4	34.65	4.54	,,	00.55	01.05	810	75	6.5	Thermocline Depth 75 m
17B	,,	09°48'N	75°39'E	164.6	30.4	34.65	4.54	,,	01.08	01.15	2910	180	3.2	
18A	,,	09°46'N	75°28'E	1005.8	30.1	34.65	4.82	,,	03.05	03.10	825	80	3.8	Thermocline Depth 75 m
18B	,,	,,	,,	,,	,,	,,	,,	,,	03.35	04.10	10220	1100	12.0	
19A	,,	09°19'N	75°33'E	914.4	29.9	34.29	,,	,,	08.20	08.30	890	75	12.0	Thermocline Depth 75 m
19B	,,	,,	,,	,,	,,	,,	,,	,,	07.52	08.15	7628	1000	90.0	(mud)
20A	,,	09°23'N	75°50'E	182.9	30.1	34.72	5.67	,,	11.10	11.15	150	75	4.5	Thermocline Depth 75 m
20B	,,	,,	,,	,,	,,	,,	,,	,,	11.00	11.08	2480	200	7.0	
21	,,	09°25'N	75°58'E	69.5	29.9	34.72	5.67	,,	12.43	12.50	1040	75	3.5	
22	,,	09°26'N	76°05'E	54.0	30.6	34.29	5.67	,,	14.10	14.16	800	60	5.0	
23	,,	09°28'N	76°11'E	29.3	30.5	34.65	5.95	,,	15.15	15.20	400	30	1.8	
24	,,	08°55'N	76°29'E	28.3	30.2	34.65	5.95	,,	21.43	21.50	490	30	5.2	
25	,,	08°53'N	76°21'E	53.0	30.4	34.47	6.81	,,	22.50	22.57	771	60	4.0	
26	10-4-70	08°51'N	76°13'E	62.2	30.0	34.47	6.52	,,	00.35	00.43	925	70	4.5	
27A	,,	08°49'N	76°05'E	201.2	30.0	34.81	6.24	,,	02.25	02.33	1250	100	3.8	Thermocline Depth 85 m
27B	,,	,,	,,	,,	,,	,,	,,	,,	02.35	02.49	3075	220	8.0	
28A	,,	08°34'N	76°00'E	1051.6	30.2	34.81	6.10	,,	06.26	06.32	1120	90	5.0	
28B	,,	,,	,,	,,	,,	,,	,,	,,	05.40	06.25	26550	1100	18.0	

4

administrative set-up

4.1 Executive Council

1.	Dr. P. Koteswaram Director General of Observatories India Meteorological Department Lodi Road, New Delhi-3	—	Member
2.	Dr. A. N. Bose Head of the Dept. of Food Technology & Biochemical Engineering, Jadavpur University, Jadavpur, Calcutta-32.	—	,,
3.	Cdre. K. R. Ram Nath, I. N., Director Naval Science & Technology R & D Organisation Ministry of Defence New Delhi	—	,,
4.	Prof. S. P. Chatterjee Advisor National Atlas Organisation 50/A Gariahat Road Calcutta-19	—	,,
5.	Shri C. V. Gole Director Central Water & Power Research Station, Govt. of India Khadakvasla Poona-24	—	,,
6.	Prof. R. Ramanadham Professor of Meteorology and Oceanography Andhra University Waltair	—	,,

7. Shri S. K. Ranganathan — ,,
Director, Gr. II
Naval Science & Technology
R & D Organisation
Ministry of Defence
New Delhi

8. Director-General — ,,
Scientific & Industrial Research
Rafi Marg, New Delhi

9. F. A. to C. S. I. R. — ,,

10. Director — ,,
National Institute of Oceanography
Panaji, Goa

The Chairman of the Executive Council is yet to be nominated

4.2 Sub-committees of the Executive Council

I. *Scientific Sub-committee*

A. *Physical & Chemical*

1. Prof. A. N. Bose
2. Prof. R. Ramanadham
3. Shri C. V. Gole
4. Dr. P. Koteswaram
5. Prof. D. Lal
6. Dr. A. K. Ganguly
7. Director, Naval Physical and Oceanographic Laboratory, Cochin
8. Prof. D. B. Wagh
9. Director, NIO - Convener

B. *Biological*

1. Dr. C. V. Kulkarni
2. Dr. R. Raghu Prasad
3. Shri G. N. Mitra
4. Prof. S. Krishnaswami
5. Director, Naval Chemical & Metallurgical Laboratory, Bombay
6. Director, NIO - Convener

C. *Geological*

1. Prof. M. S. Krishnan
2. Shri K. K. Dar (Atomic Minerals Division)
3. Representative from Geological Survey of India
4. Prof. A. G. Jhingran, Delhi University
5. Director, Naval Science & Technology
6. Director, NIO - Convener

II. *Building & Finance Sub-committee*

1. Chairman, Executive Council, NIO
2. Secretary, CSlR
3. FA to CSIR
4. Principal Engineer, PWD, Govt. of Goa, Daman & Diu
5. Director, NIO - Convener

III. *Ship Facilities Sub-committee*

1. Chief Hydrographer to the Govt. of India
2. Commodore I. K. Puri, I. N. (Retd.)
3. Shri M. C. Perumal, Director, Central Inst. of Fisheries Operatives. Cochin.

4. Shri M. Devidas Menon, Director, Indo-Norwegian Project, Cochin
5. Director, NIO - Convenor

4.3 Budget

The Budget of the Institute for the year 1970-71 is as given below: .

Budget item	*Sanctioned* (Final grant Rs. in lakhs)	*Actual* (Rs. in lakhs)
1. Recurring	13.352	13.285
2. Capital	4.169	4.006
Total	17.521	17.291

4.4 Scientific and Technical staff of the National Institute of Oceanography

Director

Dr. N. K. Panikkar

1. *Divisions at the Headquarters*

I. Physical Oceanography
II. Geological Oceanography
III. Biological Oceanography
IV. Planning & Data

2. *Regional Centre, Cochin*

I. Indian Ocean Biological Centre
II. Physical Oceanography
III. Biological Oceanography

3. *NIO Unit, Bombay*

1. I. Physical Oceanography

Scientist- in-charge
Dr. V. V. R. Varadachari

Scientist
Shri L. V. Gangadhara Rao
Shri C. S. Murty

Senior Scientific Assistant
Shri V. Hariharan
Shri P. K. Das

Junior Scientific Assistant
Shri M. K. Antony

Mechanical Assistant
Shri Mohammed Rafique

Pool Officer
Dr. M. P. M. Reddy

1. II. Geological Oceanography

Scientist- in - charge
Dr. M. G. Anantha Padmanabha Setty

Scientist
Shri R. R. Nair
Shri P. S. N. Murty

Junior Scientific Assistant
Shri R. M. Kidwai
Shri F. I. Almeida

Senior Research Fellow
Shri Victor Rajamanickam

Junior Research Fellow
Shri M. V. Shankaranarayana Guptha
Shri M. Veerayya
Shri B. G. Wagle
Shri R. S. Murali

1. III. Biological Oceanography

Scientist-in-charge

Scientist
Dr. S. N. Dwivedi
Dr. M. S. Prabhu
Dr. P. V. Dehadrai
Shri R M. Dhawan

Senior Scientific Assistant
Shri S. A. H. Abidi (on deputation to Tanzania)
Shri R. A. Selvakumar

Senior Technical Assistant
Shri R. M. S. Bhargava

Junior Scientific Assistant
Shri S. V. M. Rahim

Junior Research Fellow
Shri S. Ayyappan Nair

1. IV. Planning & Data

Scientist-in-charge
Shri R. Jayaraman

Scientists
Shri S. P. Anand
Shri V. N. Shankaranarayanan
Dr. V. S. Bhatt

Senior Scientific Assistant
Shri D. Panakala Rao

Junior Scientific Assistant
Shri S. Y. S. Singbal

Senior Documentation Assistant
Shri S. K. Kumar

Senior Librarian
Shri P. V. Dixit

Junior Research Fellow
Shri S. B. Kamat

2. I. Indian Ocean Biological Centre

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

Scientists
Dr. M. J. George
Dr. R. V. Unnithan

Senior Scientific Assistants
Shri P. Gopala Menon
Shri M. Sakthivel
Shri K. J. Peter
Dr. (Smt) M. Saraswathy

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

Research Fellows
Shri S. C. Goswami
Dr. (Smt) Saramma Abraham
Shri S. Subramanian
Miss V. Chandrika
Miss U. P. Saramma
Shri P. Haridas

2. II. Physical Oceanography

Scientist-in-charge
Shri P. S. Srivastava

Scientist
Shri V. S. Rama Raju

Senior Scientific Assistants
Shri P. Udaya Varma Thirupad
Shri P. G. Kurup
Shri Ch. Madhusudana Rao

Senior Research Fellows
Shri V. Narayana Pillai
Shri Thomas Cherian

Junior Research Fellow
Shri A. Balachandran

2. III. Biological Oceanography

Scientist-in-charge
Dr. S. Z. Qasim (at present on deputation to ICAR as Director, Central Marine Fisheries Research Institute, Cochin)

Scientists
Dr. M. Krishnan Kutty
Shri C. V. Gangadhara Reddy
Dr. C. Sankarankutty (on deputation to Tanzania)

Senior Scientific Assistants
Shri B. M. Panikkar
Shri P. M. A. Bhattathiri
Shri V. P. Devassy

Senior Technical Assistant
Shri U. K. Gopalan

3. NIO Unit, Bombay

Scientist-in-charge
Dr. B. N. Desai

Scientist
Dr. A. B. Wagh

Junior Scientific Assistant
Shri K. Kameswara Rao

5. Library

The library facilities are available at the Headquarters and the Regional Centre, Cochin. Total collection of books and back volumes of periodicals on various disciplines of marine sciences is 5200. Books are being classified according to colon classification (6th revised edition). An upto-date catalogue satisfying all the approaches is also being prepared. Library is subscribing to 105 (Indian and Foreign) journals and periodicals of which 15 journals are being received on exchange. The library receives and issues books and periodicals on inter-library loan basis with the libraries of various institutions in the country. The copies of the acquisition list (consisting of latest additions of books and periodicals) are periodically distributed among the scientific staff to keep them informed of the new books received at the library.

6. Awards, Honours, Memberships of Various Committees

Dr. N. K. Panikkar was appointed as a part time member of the National Commission on Agriculture of the Government of India.

Shri M. J. George was awarded Ph. D. degree by the University of Madras for the thesis on 'Studies on Penaeidae (Crustacea, Decapoda)'. Dr. M. J. George was also elected as a Fellow of the International Academy of Fishery Scientists.

7. Deputations

Dr. N. K. Panikkar, Director attended World Food Congress at the Hague as a special invitee of the FAO. As a delegate of the Govt. of India he also attended 'Pacem In Maribus', an International Convocation held at Malta to explore peaceful uses of the high seas and the sea-bed beyond the limits of National jurisdiction.

Dr. N. K. Panikkar, participated in 'The Ocean World', the Joint Oceanographic Assembly held at Tokyo from 13 to 25 September 1970. Other participants from the NIO were Shri P. S. N. Murthy Scientist of the Geological Oceanography Division and Shri K. J. Peter, Senior Scientific Assistant of the Indian Ocean Biological Centre, Cochin.

As Chairman of the Indian National Committee on Oceanic Research, Dr. Panikkar participated in the meeting of the Scientific Committe on Oceanic Research (SCOR) of the International Council of Scientific Unions.

Dr. N. K. Panikkar, attended the 12th meeting of the Bureau and Consultative Council of the Intergovernmental Oceanographic Commission held at Bordeaux (France) from 1st to 6th March 1971 as the Government of India's representative on the IOC Bureau and Consultative Council of which India is a member.

Dr. Panikkar also attended the International Coloquium and Exhibition on the Exploitation of the Oceans, held in Bordeaux from March 9 to 14, 1971 in the capacity of a member of the Committee of

Honour. He also chaired the technical session on the Exploitation of Ocean Great Deep.

Dr. S. Z. Qasim, Scientist-in-charge, Biological Oceanography Division of the NIO was appointed as the Director of the Central Marine Fisheries Research Institute, Mandapam Camp.

Dr. T. S. S. Rao, Scientist-in-charge, Indian Ocean Biological Centre went on deputation to Smithsonian and other Institutions in USA and Japan for two months from April to May, 1970.

Dr. S. N. Dwivedi, Scientist who was on deputation as a Professor of Natural Sciences in Vientiane (Laos) for about 3 years came back to the headquarters and resumed his office in the Biological Oceanography Division.

Dr. C. Sankarankutty of the Biological Oceanography Division left for Tanzania on deputation for 3 years as Fisheries Officer in the Government of Tanzania.

Shri M. Sakthivel, Senior Scientific Assistant went on deputation for one year to West Germany under exchange programme scholarship.

Shri S. A. H. Abidi, Senior Scientific Assistant of the Biological Oceanography Division left for Tanzania on deputation for 3 years as Fisheries Officer in the Government of Tanzania.

Shri P. K. Das, Senior Scientific Assistant went on deputation for a Refresher Course in *"Beach Erosion and Coastal Engineering"* conducted by the Central Water and Power Research Station in June 1970 at Poona.

Shri V. T. Paulinose, Junior Scientific Assistant went on deputation to Denmark for a special course in Marine Biology and to Paris for special training at Natural History Museum, on UNESCO Fellowship from April to September, 1970

8. Meetings, Exhibitions, Seminars and Symposia

Shri R. Jayaraman, Scientist-in-charge of the Planning & Data Division attended the Conference of the Directors of the CSIR Laboratories at New Delhi as Dr. N. K. Panikkar, Director, NIO was out in Europe to attend the 2nd World Food Congress at the Hague, Netherlands.

Shri R. Jayaraman and Dr. M. G. Anantha Padmanabha Setty, Scientists attended the meeting on 'Offshore Mineral Exploration' at the Geological Survey of Indian Calcutta in August, 1970.

Shri R. Jayaraman participated in a seminar on "Pollution and Human Environment" organised by the Bhabha Atomic Research Centre at Bombay in August, 1970 and presented a paper on "An Oceanographic Approach to the Problem of Pollution in the Marine Environment".

A function was arranged at the time of the release of the International Indian Ocean Expedition Plankton Atlas Vol. 2 Fascicle 1 on the distribution of Copepoda and decapod larvae in the Indian Ocean at the premises of the National Institute of Oceanography, Miramar, Panaji, which was witnessed by various State Government officials, heads of various institutes, the staff of NIO and the press. Shri Nahul Sen, the Lt. Governor of Goa officially released the Atlas. An exhibition was also organised on this occasion by all the divisions of the Institute at the headquarters.

Dr. B. N. Desai and Dr. A. B. Wagh, scientists of the Bombay Unit of NIO participated in the Survey on Environmental

Pollution arranged by the Indian Association of Occupational Health, and presented a paper on the Marine Pollution and Disposal of Sewage in Bombay.

The staff members of IOBC actively participated in the International Symposium on Indian Ocean and Adjacent Seas held at Cochin from 12 to 18 January 1971. In all six papers were presented by the staff members of the IOBC and Dr. T. S. S. Rao, Dr. M. J. George and Dr. Martha Vannucci chaired the sessions respectively on Marine Ecology, Crustacea and Zooplankton. In this symposium Shri R. Jayaraman presided over the session on 'Chemical Oceanography'. Dr. V. V. R. Varadachari and Shri P. S. Srivastava presented their papers in the session on "Physical Oceanography'.

Seminars held at IOBC

	Speaker	*Date*	*Subject*
1.	Dr. T. S. S. Rao	10-7-70	Remarks on a recent visit to Oceanographic Laboratories in USA and Japan
2.	Dr. T. S. S. Rao & M. Sakthivel	18-7-70	IIOE Stations - Observation on Zooplankton collections
3.	Dr. V. R. Meenakshi	14-8-70	Organic composition of some molluscan shell structures
4.	C. B. Lalithambika Devi & S. V. M. Abdul Rahim	28-8-70	Distribution of plankton in relation to fishery resoures
5.	T. Balachandran	5-9-70	Methods adopted for preservation of plankton
6.	P. S. Srivastava	26-9-70	The problem of sedimentation in the Mopla Bay harbour, Cannanore
7.	Dr. M. J. George	8-10-70	Prawn fisheries of India
8.	Dr. M. Vannucci	17-10-70	Exchange of Oceanographic Data
9.	Dr. M. Vannucci	24-10-70	Water masses in the Indian Ocean
10.	U. K. Gopalan	7-11-70	Energy in animal ecology
11.	L. R. Kasturirangan	16-1-71	Distribution of Copepoda in the Indian Ocean
12.	Dr. M. Saraswathy	16-1-71	Distribution of *Gaussia* (Copepoda Metridiidae) in the Indian Ocean
13.	Jacob George	23-1-71	On the occurrence of *Bathyconchoecia deeveyae* Kornicker (Halocyprididae : Ostracoda) in the Indian Ocean

14.	Dr. M. J. George	23-1-71	On the zoogeographic distribution of Indian Penaeidae
15.	P. Venugopal	30-1-71	On Diversity Index
16.	Mrs. Vijayalakshmi R. Nair	6-2-71	Chaetognatha from the Laccadives, with a note on the new record of *Spadella angulata* & distribution of Chaetognaths in the Arabian Sea
17.	P. G. Kurup	12-2-71	Physics of mud banks
18.	V. Chandrika & Saramma, U. P.	20-2-71	Plankton distribution of South Africa between 20°E and 22°E
19.	Rosamma Stephen & K. Sarala Devi	20-2-71	*Haloptilus acutifrons* (Copepoda: Calanoida) in the Indian Ocean with a description of the hitherto unknown male
20.	P. N. Aravindakshan	27-2-71	On the distribution and ecology of *Pterotrachea coronata* Forskal 1775 (Heteropoda) in the Indian Ocean
21.	K.J. Peter	6-3-71	Distribution and abundance of the various families of fish larvae in the Arabian Sea
22.	K. K. C. Nair	6-3-71	A preliminary report on the general distribution and variation in abundance of the Amphipods in the Indian Oceans

Lectures delivered at Cochin

	Speaker	*Date*	*Subject*
1.	Prof. H. Steinitz Hebrew University Jerusalem, Israel	5-10-70	The Suez Canal as a link between Indian and Atlantic Oceans
2.	Dr. D. D. Kuehlmann Museum of Natural History Berlin, G. D. R.	19-1-71	The valuation of functional ecological units of little water bodies as ecosystems and the consequences with regard to the ecological terminology
3.	Dr. N. Delia Croce Institute of Zoology University of Genoa Via., Balbis, Genoa, Italy	20-3-71	*Penilia avirostris* Dana in the Indian Ocean
4.	Dr. R. Ralph Dept. of Agriculture & Fisheries for Scotland, Marine Laboratory Aberdeen, Scotland, U. K.	24-3-71	The biology of the Antarctic Ocean

9. Colloquia and Special Lectures

Dr. N. K. Panikkar gave a special lecture on 'Scientific Problems which have emerged from the International Indian Ocean Expedition' at the Symposium on 'Indian Ocean and Adjacent Seas', held from 12 to 18 January 1971, at Cochin.

Dr. N. K. Panikkar gave a talk on the 'Problems of the ownership of the Oceans' on 9th February, 1971 and on 'Oceanographic Meeting' held at Bordeaux, France from 1st to 6th March 1971, on 20th March 1971.

Dr. M. G. A. P. Setty, Scientist, as invited honourary guest speaker delivered three special lectures on 'Marine Geology and Oceanography' at the Summer Institute, Bangalore University in the month of May, 1970.

Dr. Robert Ralph and Dr. Eleftheriou of U. K. the two visiting scientists from U. K. under the collaboration programme between the Marine Laboratory, Aberdeen and the NIO gave talks respectively on the 'Biological Problems of the Antarctic' and 'Benthic Studies'.

10. Distinguished Visitors

Dr. Paul L. Illg	Department of Zoology, University of Washington, Seattle, USA.
Dr. John C. Marr	F.A.O., Rome, Italy
Dr. H. G. Kewalramani	Senior Scientist, Department of Fisheries, Bombay-2
Dr. P. M. Narang	Taraporewala Acquarium, Bombay-2
F. A. Boraey A. A. Alsayes	Institute of Oceanography & Fisheries Alexandria, Cairo, Egypt, UAR.
Prof. K. Pampapathi Rao	Dept. of Zoology, Bangalore University, Bangalore
Dr. A. N. Sastry	Graduate School of Oceanography, Rhode Island. Kingston, R. I., USA.
Dr. H. Steinitz	Dept. of Zoology, Hebrew University, Jerusalem, Israel
Dr. B. N. Ghosh	University of Bombay, Panjim Centre, Panjim, Goa
Dr. Howard A. Bern	University of California, Berkeley, USA.
Dr. S. Jones	Retired Director, Central Marine Fisheries Research Institute and President, Marine Biological Association of India, Mandapam
Dr. & Mrs. E. C. LaFond	Naval Undersea Center, San Diego, California, USA.
Prof. G. P. Wells	Zoology Department, University College, London
Prof. D. Lal	Tata Institute of Fundamental Research. Bombay-5
Dr. Fern Moore	Ocean Floor Anlaysis Division, US Naval Oceanographic Office, USA.
Dr. Hugh F. I. Elliott	173, Woodstock Road, Oxford.
Mr. M. S. Narayanan	Naval Physical & Oceanographic Laboratory, Cochin-4
Dr. Michel Pichon	Station Marine d 'Endoume & Centre d' Oceanograph ie, 13, Marseille, 7. France.
Dr. V. G. Neiman	Institute of Oceanology, Academy of Sciences of USSR., Moscow.
Dr. Alain Sournia	Museum Hist. Naturelle, Paris, France

Dr. Robert Fenaux	Station Zoologique, France
Dr. D. Spencer Davies	Zoology Dept., Glasgow University, UK.
Dr. Paul Willis	Smithsonian Institution, Washington, USA.
Dr. H. A. Felhmann	
Dr. J. A. Gueredrat	Ostrom Centre, New Caledonia, B. P. 4
Dr. D. H. H. Kuhlmann	Museum of Natural History, Berlin, GDR.
Dr. Ronald L. Wigley	N. M. F. S. Biological Laboratory. Woods Hole, Mass., USA.
Dr. Rama	Tata Institute of Fundamental Research, Bombay-5
Dr. R. Ananthakrishnan	Institute of Tropical Meteorology, Poona-5
Dr. P. Koteswaram	Director General of Observatories, New Delhi-3
Dr. V. Sethuraman	Professor. Indian Institute of Technology, Madras-36
Dr. R. Ralph	Dept. of Agriculture & Fisheries for Scotland, Marine Laboratory, P. O. Box 101, Victoria Aberdeen, UK.
Dr. A. Eleftheriou	-do-
Dr. N. Della Croce	Institute of Zoology, University of Genoa, Via Balbis, Genoa, Italy

VISITING SCIENTISTS

Dr. Bui thi Lang, University of Saigon, S. Vietnam visited the Indian Ocean Biological Centre, Cochin-18 from 27-5-1970 to 12-6-1970 under Unesco Fellowship. She studied the identification and analysis of Eucalanidae from selected stations of the IIOE collections.

Dr. K. Pampapathi Rao, Head of the Department of Zoology, Bangalore University, Bangalore visited the Indian Ocean Biological Centre to study the Tornaria larvae of the IIOE collections, in September, 1970.

Prof. N. Della Croce, Universita Di Genoa, Instituto Di Zoologia, Genoa, Italy visited the Indian Ocean Biological Centre, Cochin-18 from February to April, 1971 under a Unesco grant for studying the Cladocera of the IIOE collections.

Dr. Robert Ralph and Dr. A. Eleftheriou, Department of Agriculture and Fisheries for Scotland, Marine Laboratory, Aberdeen, U. K. visited the Biological Oceanography Division of N.I.O., Cochin under the International Biological Programme and worked from February to April, 1971 on the ecology of intertidal fauna. Both these scientists also visited the headquarters at Panjim and gave lectures on their fields of specialisation.

11.

publications

11.1 Publications of the Institute

1. Annual Report 1969-1670
2. Bulletin of the Institute,'Mahasagar' Vol.3, Nos. 1-4
3. International Indian Ocean Expedition Plankton Atlas. Vol. 2, Fascicles 1 & 2

11.2 Papers Published by Staff Members

94 Dehadrai, P. V. 1970. Observations on certain environmental features at the Dona Paula point in Mormugao Bay, Goa. *Proc. Indian Acad. Sci.* 72(2)B: 56-57.

95 Dehadrai, P. V. 1970. Changes in the environmental features of the Zuari and Mandovi estuaries in relation to tides. *Proc. Indian Acad. Sci.* 72(2)B: 68-80.

96 Desai, B. N. & Wagh, A. B. 1971. Marine pollution and disposal of sewage in Bombay (Abstract) Symposium on environmental pollution. XXI All India Annual Conference of Occupational Health Congress (Bombay).

97 Devassy, V. P. & Gopinathan C. K. 1970. Hydrobiological features of the Kerala backwaters during pre-monsoon and monsoon months. *Fish. Technol.* 7: 190-194.

98 Edwards, R. R. C; , J. H. S; Gopalan, U. K; Mathew, C. V. & Finlayson, D. M. 1970. Feeding, metabolism and growth of tropical flat fish. *J. Exp. mar. Biol. Ecol.* 6: 274 - 297.

99 Edwards, R. R. C; Blaxter, J. H. S; Gopalan, U. K. & Mathew, C. V. 1970. A comparison of standard oxygen consumption of temperate and tropical bottom living marine fish. *Comp. Bio. Chem. Physiol* 34: 491 - 495.

100 George, M. J. 1971. Systematics and distribution of Penaeidae of Indian region. *Symposium on Indian Ocean & Adjacent Seas. Mar. biol. Ass. India, Cochin:* 28 (Abstract)

101 Gopalan, U. K. 1970. Further observations on a newly located prawn fishery off Saurashtra coast. *Fish. Technol.* 7: 180-185.

102 Jayaraman, R. 1970. An oceanographic approach to the problem of pollution in the marine environment. *Proc. Seminar. Pollu. Human Environ.* (COST working group on human environment. Bombay): 527-535.

103 Krishnan Kutty, M. 1970. The estimation of optimum condition for regulating a fishery when growth and mortality rates are known. *Proc. Nat. Inst. Sci. India.* 36 B: 21-32.

104 Murty, P. S. N; Rao, Ch. M. & Reddy, C.V.G. 1970. Distribution of nickel in the marine sediments off the west coast of India. *Curr. Sci.* 39(2): 30-32.

105 Nair, R. R. 1970. Beach rock and associated carbonate sediments on the fifty fathom flat, a submarine terrace on the outer continental shelf off Bombay. *Proc. Indian Acad. Sci.* 73(3) B: 148-154.

106 Nair, R. Vijayalakshmi. 1971 Distribution of chaetognaths along the salinity gradient in Cochin backwaters, an estuary connected to the Arabian Sea. *Symposium on Indian Ocean and Adjacent Seas. Mar. biol. Ass. India. Cochin:* 98 (Abstract)

107 Panikkar, B. M. & Rajan, S. 1970. Observations on the ecology of some sandy beaches of the southwest coast of India. *Proc. Indian Acad. Sci.* 71B: 247-260.

108 Panikkar, N. K. 1970. Marine fisheries development. National Food Congress Resource papers. Indian Freedom from Hunger Campaign Society. Ministry of Food Agriculture, CD and Cooperation, Government of India. Commission II Contr. No. 40 pages 1-3.

109 Panikkar, N. K. 1970. The need for integrated studies and training in Oceanography in India. *J. Souvenir, 10th World Met. Day. Ind. Met. Soc. Visakhapatnam Branch:* 21-22.

110 Pylee, Abraham. 1970. A horizontal water sampling bottle. *Mahasagar.* 3(1): 22-24.

111 Qasim, S. Z. 1970. Some characteristics of a *Trichodesmium* bloom, in the Laccadives. *Deep-Sea Res.* 17: 655-660.

112 Qasim, S. Z and Sankaranarayanan, V. N. 1970. Production of particulate organic matter by the reef on Kavaratti Atoll (Laccadives). *Limnol. Oceanogr.* 15: 574-578.

113 Rao, K. Kameswara. 1970. On a little known milliolid Foraminifera from north-eastern part of the Arabian Sea. *Curr. Sci.* 39(4): 87-88.

114 Rao, K. Kameswara. 1971. On some Foraminifera from the north eastern part of the Arabian Sea. *Proc. Indian Acad. Sci.* 72(4): 155-178.

115 Rao. D. P. & Jayaraman, R. 1970. On the occurrence of oxygen maxima and minima in the upper 500 meters of the north western Indian Ocean. *Proc. Indian Acad. Sci.* 71 (6) B: 230-246.

116 Rao, V. Chalapati & Rao, T. S. Satyanarayana. 1971. Distribution of particulate organic matter in the Bay of Bengal. *Symposium on Indian Ocean and Adjacent Seas. Mar. Biol. Ass. India, Cochin:* 21 (Abstract).

117 Rao, V. Chalapati & Rao, T. S. Satyanarayana. 1971. Distribution of dissolved organic phosphorus and nitrogen in the Bay of Bengal. *Symposium on Indian Ocean and Adjacent Seas. Mar. Biol. Ass. India, Cochin:* 22 (Abstract)

118 Rao, V. Chalapati & Rao, T. S. Satyanarayana. 1971. Distribution of trace elements (iron, copper, manganese & cobalt) in the Bay of Bengal. *Symposium on Indian Ocean and Adjacent Seas. Mar. biol. Ass. India, Cochin:* 56 (Abstsact)

119 Reddy, M. P. M. 1970. A systematic study of wave conditions and sediment transport near Mormugao Harbour. *Supplement to Mahasagar.* 3: (1): 27-44.

120 Santhakumari, V. 1970. The life cycle of *Eutima comensalis* sp. nov. (Eutimidae, Hydromedusae). *Mar. Biol.* 5(2): 113-118.

121 Sankaranarayanan, V. N. & Reddy, C. V. G. 1970. Total phosphorus content in the waters of the Arabian Sea along the west coast of India. *Proc. Nat. Inst. Sci. India.* 36 B: 71 - 79.

122 Selvakumar, R. A. 1970. Cladoceran swarms in relation to mackerel fishery along the west coast of India. *Curr. Sci.* 39 (21): 481 - 482.

123 Trevallion, A; Ansell, A. D: Sivadas. P. and Narayanan, B. 1970. A preliminary account of two sandy beaches in south west India. *Mar. Biol.* 6. 268-279.

124 Wagh, A. B. & Bal. D. V. 1970. Various associates of sessile barnacles in Bombay waters. *J. Bomb. nat. Hist. Soc.* 67(2): 351-353.

125 Wagh, A. B. & Bal, D. V. 1970. Diametrically opposite result of human activity on barnacle populations *J. Bomb. nat. Hist. Soc.* 67(3): 589-591.