national institute of oceanography, india

1969-70

council of
scientific and industrial research
india

ANNUAL REPORT

5

1969-70

NATIONAL INSTITUTE OF OCEANOGRAPHY

(Council of Scientific & Industrial Research)

PANAJI, GOA,

INDIA

OBITUARY

Darashaw Noshirwan W'adia, F. R. S., National Professor of Geology, Geological Adviser to the Government of India. Department of Atomic Energy, and Chairman, Indian National Committee on Oceanic Research and Executive Council of the National Institute of Oceanography, died on 15th June, 1969, at the Willingdon Nursing Home, New Delhi, after a brief illness.

Prof. D. N. Wadia (1883-1969)

Born on 23rd October. 1883, in Surat, Wadia had his early education in the place of his birth and later in Baroda. where he took his degree in Natural Science. Geology attracted him most. But in his days, geology was taught as a special subject only in the University of Calcutta and Madras and so Wadia had to study geology all by himself, thereby becoming a self-taught geologist. After graduating from Baroda. he joined the Prince of Wales College, Jammu, in 1907, where he taught geology for 14 years. He joined the Geological Survey of India in 1921 and served that organization till his retirement in 1938. As an officer of the Geological Survey of India, Wadia worked mostly in the Kashmir Hazara area of the North-Western Himalayas and his paper on Syntaxis of the North-Western Himalayan region published in 1931 is considered as a monumental work and the most fundamental contribution to our knowledge of Himalayan tectonics.

To an active scientific worker like Wadia. the term retirement had no meaning and in fact, retirement from service in the year 1938 marked the beginning of a really active career for him. Since that date, his contributions to the subject of geology and allied branches of knowledge are to be considered most invaluable. Wadia was successively Government Mineralogist in Ceylon, the first Director of the Indian Bureau of Mines. Geological Adviser to the Government of India, Department of Atomic Energy, a position which he held till his death. In the latter position, Wadia was the Head of the Atomic Minerals Division.

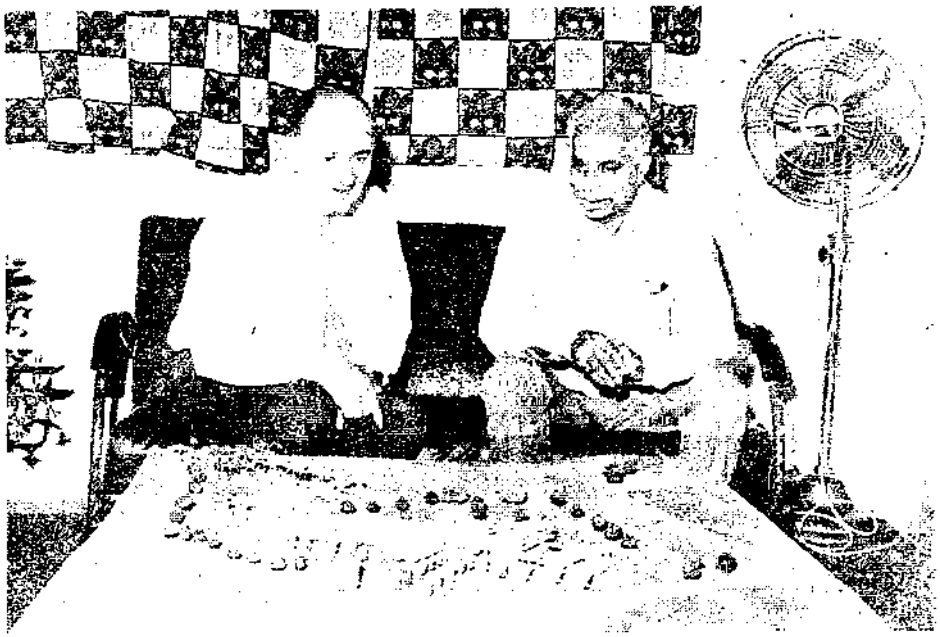
Wadia held several high and distinguished positions in Indian science, such as President. Indian Science Congress. President of the National Institute of Sciences of India and President of the Geological, Mining and Metallurgical Society of India. He presided over the Twelfth Session of the International Geological Congress held in New Delhi in December 1964 and was the Leader of the Indian Delegation to the Thirteenth Session of the International Geological Congress held in Prague in August-September, 1968. He was also a Member of the Board of Scientific and Industrial Research and the Governing Body of the Council of Scientific and Industrial Research for several years.

A Fellow of the Royal Society, London, Wadia was also recipient of Back Award of the Royal Geographical Society in 1834 and the Lyall Medal from the Geological Society, London, in 1943, all in recognition of his contributions to Indian geology. The Government of India honoured him with the award of Padma Bhushan in 1958 and in the year 1963, he was made a National Professor. He has published several scientific papers in Mineralogy and Structural Geology and was the author of the widely read book "Geology of India", first published in 1916.

As Chairman of the Indian National Committee on Oceanic Research, Professor Wadia was indeed, the most effective sustaining force behind the Indian participation in the International Indian Ocean Expedition. which led to organized scientific activities in the field of ocean research in India and which laid the foundation to the setting up of the National Institute of Oceanography as one of the National Laboratories under the Council of Scientific and Industrial Research. He spared no pains to secure recognition for this new scientific venture in the country. His great zeal and enthusiasm for the 'young, fascinating science' as he used to call oceanography, was almost infective and his eagerness to see that oceanography finds its proper place :in the scientific map of India will always be remembered. In official and non-official bodies concerned with decisions on Indian scientific policy. Dr. Wadia exerted his influence to support Indian programmes of oceanic exploration. This was particularly so in efforts to secure ship facilities with the Navy and other organizations. His dream to have a full-fledged institute established was fulfilled but not the completion of the laboratories and an ocean-going research ship. Even a few days before his death, he was planning a visit to Goa and discuss the future set-up of the Institute. In his death, India has lost a great son and a dedicated scientist but, more than that, Indian oceanography has lost its great benefactor and patron during its formative years.

- N. K. PANIKKAR

CONTENTS



Prof. J. E. Smith, F. R. S., Chairman. UNESCO Consultative Committee for the Indian Ocean Biological Centre. Director, Marine Biological Laboratory, Plymouth, U. K. and Dr. N. K. Panikkar, Director, National Institute of Oceanography, with the model of the proposed NIO buildings at Panaji, Goa.

1

Introduction

The fifth 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 1969—70.

All the projects under investigation during the year 1969—70 are briefly dealt with. The Indian National Oceanographic Data Centre, besides acquiring, processing and retrieving the data pertaining to the Indian Ocean, also took up the work of analysis of the depths of occurrence of oxygen maxima and minima in the upper 500 meters of the North Western Indian Ocean and on the phosphate distribution in the 100 meter column below one square meter in the whole of the Arabian Sea.

The Division of Physical Oceanography which began to function at the headquarters of the Institute in Panaji took up a few new projects in the Goa region. Among those, the one on studies relating to the problems of bar formation at the mouth of the Mandovi river deserves special mention. Other new projects highlighted in the report are: the sediment transport studies at the Mopla Bay harbour, Cannanore; oceanographic studies of the Mormugao and the Cochin harbours and the physical conditions of the estuarine environments in the Goa and Kerala regions.

The Geological Oceanography Division has been mostly concerned with projects started during previous year. Studies on sediments of the Vembanad lake in Kerala is one of the major projects undertaken by this Division.

The Division of Biological Oceanography at Cochin extended its programme of work on the waters around the Laccadives which has brought to light some interesting findings. A new project on the energetics of the local flat fish populations of the inshore area of Cochin was also taken up. Experimental studies on the culture of algae and the influence of environmental factors on the growth of tropical phytoplankton organisms have shown interesting results.

In Goa the work on the productivity of Mormugao Bay and the comparative studies on environmental features of the Mandovi and Zuari estuaries along with seasonal abundance of the phytoplankton and zooplankton formed essential basic studies to enable further researches on these estuaries.

The Indian Ocean Biological Centre at Cochin is now engaged on the systematic, taxonomic and distributional studies on the various groups of planktonic organisms, from the collection of the International Indian Ocean Expedition. Atlases relating to the total Plankton Biomass were issued and draft charts for many other groups are under active preparation.

The year marked the organization of the headquarters of the Institute at Panaji (Goa) and re-organization of various divisions and units at the Headquarters. Construction of scientists' hostel, senior scientists' quarters along with the Director's bungalow has been started during the year.

N. K. PANIKKAR
DIRECTOR

2

national institute of oceanography, its divisions and units

With the shifting of the Headquarters and the Data Division of the Institute from New Delhi, and of the Physical Oceanography Division from Cochin to Panaji, the National Institute of Oceanography was reorganised in the following manner:

	Divisions & Centres	*Telephone Number*	*Telegraphic Address*
1.	Indian National Oceanographic Data Centre (Planning and Data Division) NIO, Miramar, Panaji, Goa.	2923 extn. 2	Oceanology Panaji
2.	Physical Oceanography Division NIO, Miramar, Panaji, Goa	2923 extn. 2	do
3.	Geological Oceanography Division, Miramar, Panaji, Goa.	2923 extn. 2	do
4.	Biological Oceanography Division, 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

2.1

indian national oceanographic data centre (inodac), panaji

A. Data Exchange, Preparation of Data Catalogues

B. Oxygen Studies

C. Phosphate Studies

A. Data Exchange, Preparation of Catalogues

The physical and chemical oceanographic data collected during the International Indian Ocean Expedition period on board INS KlSTNA for the cruises 15-28 have been exchanged with the World Data Centre 'A' Washington, USA and 'B' Moscow, USSR.

Regarding the preparation of the Data Catalogue, the work on the grouping up of all the available data for the Indian Ocean collected by various ships during the IIOE has been completed on the monthly basis for each latitude and longitude grid.

B. Oxygen Studies

The analysis of the depths of occurrence of oxygen maxima and minima in the north west Indian Ocean have been completed and a paper entitled "On the Occurrence of oxygen maxima and minima in the upper 500 meters of the northwest Indian Ocean" was presented at the Annual Session of the Indian Academy of Sciences at Aurangabad in December, 1969 and since then sent for publication. This study reveals that there are considerable seasonal and regional variations in the distribution of oxygen in the upper 500 m. in north western Indian Ocean. All along the Arabian Coast, the oxygen maxima are observed at about 50 m. depth while along the west coast of India, the waters are found to be more turbid towards the surface thereby reducing the photic zone. Thus very often in this area, the oxygen maxima are seen in the surface layers. The oxygen maximum is seen in deeper layers towards the open sea, perhaps because of the greater transparency of the waters. During the southwest monsoon season, the oxygen rich equatorial Indian Ocean waters spread towards the northern part of Arabian Sea. During the north east monsoon, on the other hand, near stagnation condition prevails in the central and northern parts of the Arabian Sea and there is not much change in the oxygen content of these waters. The sub-surface waters reflect the characteristics of the Red Sea and Persian Gulf waters to some extent. The southern Arabian Sea waters reflect the characteristic of the Bay of Bengal and eastern Indian Ocean. Similar work is being extended to the northeast Indian Ocean viz. Bay of Bengal. Andaman Sea etc. The data for the area are being collected.

C. Phosphate Studies

Studies on phosphate distribution in the 100 meter column below 1 sq. meter in the whole of Arabian Sea have been made on the data collected by various ships which had participated in the IIOE. During the period of the report, the analysis of data collected by R. V. Vityaz has been completed. The analysis was done in 1 degree squares. Although the ultimate aim is to pool all the data, work out the averages and plot the average value of phosphate concentration below 1 square meter, in view of the

fact that the amount of data is very vast and the analysis would take a considerable amount of time it was considered worth while to present the data of Vityaz in this report. So far, data relating to pre-south-west monsoon (March-May) and post monsoon (September-November) have been completed.

The analysis of Vityaz data has revealed that during the pre-southwest monsoon (March-May) nearer to west coast of India between Goa and Bombay the phosphate concentration in a 100 meter column varies between 4.4 and 4.7 mg. per square meter. The range is larger off Somali coast and the Gulf of Aden, the extreme values being 3.7 and 7.6 mg. In the central part of the Arabian Sea the concentrations range between 2.9 and 5.9 mg. A region of moderately high phosphate is observed in a transect from Bombay to Socotra (west south-west direction from Bombay). The highest recorded concentration (20.5 mg.) has been observed near the equator between 55-60°E.

In general, it is found that the concentration during the post monsoon months (September-November) are much higher in the whole of the northern Arabian Sea. The concentrations are above 7 mg. nearer the coast off Gulf of Cambay where values of the order 10.8 mg. are seen. Off the Arabian Coast, Gulf of Oman and Pakistan coast values range between 10 and 14 mg. while in the Gulf of Aden the values lie between 7 and 11 mg. It is also seen that much higher concentrations are found in the central part of the Arabian Sea as compared with the pre-southwest monsoon months. Along the equator, however, the values are much lower than in pre-monsoon months. Higher concentrations during the post monsoon months appear to indicate the spread of upwelled waters in the Arabian Sea having high concentrations of nutrients. Further work along these lines is being continued.

2.2

physical oceanography division (pod) , panaji

A. Coastal and Nearshore Oceanographic Studies

B. Estuarine Studies

C. Trace Element Distribution Studies in Shelf Sediments

D. Physical Factors Governing Sediment Transport in Moplah Bay, Cannanore

During the year under report, the Physical Oceanography Division at Goa began to be organised with a small team of physical oceanographers. The existing projects in coastal oceanography along the Kerala coast were continued at Ernakulam. while new projects in coastal studies were started along the Goa coast by the team working at Headquarters. Some of the projects which were started during the year in collaboration with the other departments are:

i) The sediment transport studies at Moplah Bay harbour, Cannanore, undertaken at the request of the Indo-Norwegian Project. Ernakulam.

ii) Studies on the Aguada bar formation undertaken at the request of Government of Goa.

iii) Cochin harbour and Marmugao harbour studies initiated at the request of the respective harbour authorities.

A survey of the Vembanad Lake, in Kerala including studies on its bathymetry the physical and chemical aspects is in progress.

A. Coastal and Nearshore Oceanographic Studies

(a) Beach Studies

(i) Goa Coast

To understand the nature of the beach changes and the factors and processes responsible for these changes, studies on the beach profiles and oceanographic parameters such as waves, nearshore and littoral currents, were undertaken from August 1969 at twelve selected stations along three beaches of Goa, namely Calangute-Candolim. Miramar-Caranzalem and Colva-Banaulim. The details of stations at each of these beaches and the profiles so far taken are as follows :

Location	*No. of Stations*	*No. of Beach Profiles measured*
Miramar-Caranzalem	4	52
Calangute-Candolim	5	65
Colva-Banaulim	3	15

On the Miramar-Caranzalem beach, very good building up was noticed followed by removal of material from Caranzalem and Campal sides. The beach material was found to be more or less fine grained at Caranzalem and line to medium at Miramar throughout the observation period. Calangute-Candolim beaches experienced erosion from September to December months and since then build up of material was observed. The Colva-Banaulim beach did not show any major change.

(ii) Kerala Coast

The beach profile studies at the seven selected stations along the coast of Kerala were continued. In all, 132 beach profiles were taken during the year. The loss of considerable amount of material was noticed near Thottapally region. Vertical cuts in the beach foreshore of the order of three metres were also recorded. The observed variations in the beach widths, vertical variations etc. for the different stations are given below :

Location	No. of Profiles Taken	Range of width of the Beach (in meters)	Stable portion of the Beach from the Preference point (in meters)	Maximum Vertical Variations in the Beach (in meters)
Narakkal	26	45-60	5	0.75
Elankunnapuzha	30	60-80	43	1.00
Saudi	14	40-60	5	0.75
Manassery	14	20-50	6	1.25
Thumboli	19	70-85	40	1.50
Punnapra	16	35-74	15	2.50
Purakkad	13	0-40	0	2-3

(b) Studies on the Aguada Bar Formation

In order to understand the factors responsible for the formation of Aguada bar, preliminary surveys were made twice in the month of March 1970. Observations on currents were made over complete tidal cycles along with the suspended sediment load. This study revealed that flood and ebb current maxima were 4.1 kts. and 3.5 kts. respectively. The suspended sediment load was found to be 750 mg. per 5 liters Work is being continued.

(c) Oceanographic Studies at

(i) Marmagao Harbour and

(ii) Cochin Harbour

(i) Marmagao Harbour

Wave refraction diagrams were constructed for predominant wave directions and periods of waves approaching the harbour and the maximum heights of the waves affecting the harbour as well as the littoral movements in the harbour area were evaluated from the characteristics of the deep water waves obtained from a study of the data of Indian Daily Weather Reports for 1968 and 1969. The wave heights in shallow water (20'depth contour) were computed from the refraction diagrams. During the south-west monsoon high waves of 8 second periods from WSW were found to occur in the port area. The heights were found to be minimum slightly north of the harbour breakwater and maximum on the Dona Paula side. (The maximum and minimum values as obtained from these studies are 15.2' and 10.4'). The littoral drift was found to be directed into the Bay from either side of the harbour.

General hydrographic studies such as temperature, salinity, oxygen, light penetration, suspended sediment load, surface drift etc., of the waters near the end of the harbour breakwater were made regularly at monthly intervals over complete tidal cycles and under different tidal ranges for about nine months during the year. Preliminary analysis of the data indicated the following features for the harbour waters for the summer months (April and May).

1. The temperature of the surface waters generally varied between 30.4°C and 31.4°C, the diurnal range being less on the days of high tidal range as compared to low tidal range.

2. the surface salinity varied between 35.2%**o** and 37.00%**o**, the mean value being generally high during high tidal range as compared to low tidal range.

3. the dissolved oxygen varied from 3.10 ml/L. to 4.80 ml/L. The flood waters during the night time were found to contain low oxygen as compared to the ebb waters during the day time.

ii) Cochin Harbour

Regular observations at fixed stations near the Cochin Barmouth were carried out to study the variation of the concentration of silt at the surface and sub-surface depths. Simultaneously, current patterns were also observed to study the effect of currents and water movements on the silt content.

(d) Mudbanks of Kerala

The bottom sediments from the Narakkal and the Purakkad mudbanks indicated very high concentration of phosphates as compared to the adjoining shelf sediments. The values for the phosphate, iron and calcium carbonate for the two mudbank regions are given below:

	Narakkal	*Purakkad*
Phosphate (micro gms./gm.)	325-2500	700-3400
Iron (milli gms/gm)	62-154	95-115
Calcium Carbonate (percentage by weight)	5-8.4	8-15

The wave refraction studies conducted for the region Purakkad indicated converging long-shore currents leading to possible offshore flows. It is felt that this offshore flow might be opposing the onshore transport of the fine sediments being carried by the premonsoon waves resulting in localisation of sediments at the rip heads. This has been put forward as a possible explanation for the formation of mudbanks.

B. Studies on the Physical Conditions of the Estuarine Waters of the Goa and Kerala Regions representing Central and Southern parts of the West Coast of India

(i) Goa Region

Preliminary studies on the currents, temperature and salinity at different depths of four selected stations in the Mandovi and Zuari rivers and the Cumbarjua Canal connecting these two rivers, were made during November '69 and January and March '70 over complete tidal cycles. In addition to general hydrographic studies, determination of suspended sediment load was also made at a few places during the course of the surveys. The preliminary results obtained from the observations made on the currents are as follows :

In the river Zuari, at a station occupied near Borim bridge in January '70, the observations indicated that the flood velocities at the surface varied from 42 cm/sec, to 70 cm sec. and the ebb velocities from 70 cm/sec to 150 cm/sec. The surface salinity varied from 17.2%**o** to 23.5%**o**. In the river Mandovi at a station occupied three miles from the entrance in March '70, the studies show that the speed of the flood maximum is 150 cm/sec and that of the ebb 120 cm/sec. In the Cumbarjua Canal, the observations on current carried out during November '69 and March 1970 under different tidal range indicated the predominance of flood over the ebb on the Mandovi river

side of the canal while on the Zuari side of the canal the predominance of ebb was noticed. On the Mandovi side of the canal the flood and the ebb maxima for surface currents were 90 cm/sec and 60 cm/sec respectively. On the Zuari side of the canal the corresponding values for the flood and the ebb were 70 cm/sec and 150 cm/sec. Very little change in the current velocities was noticed from the surface to one metre above the bottom in the canal.

ii) Kerala Region

The observational programme commenced during the previous year at three stations in the Cochin backwaters was continued. Study on the seasonal variations of the hydrographical parameters of the backwaters revealed well mixed, stratified and partially mixed conditions during January to August, September to November and December to January respectively. The salinity of the backwaters was found to have an inverse relation with the fresh water discharge from the rivers. Studies on the hydrographic parameters over complete tidal cycles, the circulation pattern and the factors responsible for the siltation in and around the backwaters and the harbour as well as the rate of sedimentation are being continued.

C. Trace Element Distribution Studies in Shelf Sediments

The estimation of trace elements in the shelf sediments off the coasts of India was completed. Boron was estimated in the clay fraction of the estuarine sediments off Krishna delta. The boron content in the sediments was found to vary from 66 ppm to 130 ppm. The analysis for similar sediment samples from the west coast of India is in progress.

D. Physical Factors Governing Sediment Transport in Moplah Bay, Cannanore

Survey of the Moplah Bay (Cannanore) was taken up in collaboration with the Indo-Norwegian Project in September 1969. The studies included bathymetry, tides and tidal currents and sediment transport, the last one using fluorescent tracers. The following were the main findings:

(i) Bathymetric studies revealed accretion in the Moplah Bay harbour region in three locations, and these are (a) the region of the harbour immediately adjacent to the breakwater, (b) near the seawall in the NW side of the bay and (c) near the rivulet in the northern side of the harbour.

(ii) Tracer studies revealed net movement of sand into the bay from each of the three injection points, located (a) outside the breakwater tip on its western side, (b) on the seaward side of the breakwater and (c) between groins on the NNE corner of the Moplah bay harbour.

2.3

geological oceanography division (god) , panaji

A. Geochemical studies on Shelf Sediments off the coasts of India

B. Sediments of the Gulf of Cambay and the Gulf of Kutch

C. Sand Movement Studies

D. Sediments of Vembanad Lake

E. Characteristics of the Beach Material of Goa

F. Micropalaeontological Studies

A. Geochemical Studies on the Shelf Sediments off the Coasts of India

Two aspects of the west coast shelf sediments namely (i) Distribution pattern of Nickel and (ii) Clay mineralogy, have been studied in the shelf and slope sediments collected between Bombay and Cochin. The results obtained are given below.

Studies on Nickel distribution: Nickel content was estimated in twenty four samples spread over four sections, namely off Bombay, Karwar, Mangalore and Cochin. The sections covered were normal to the coast and the sediments collected were from the shelf and slope regions. The maximum and minimum concentrations of Nickel obtained in each of the sections are given below:

Name of the Section	*Nickel concentration in ppm*	
	Maximum	*Minimum*
Off Bombay	45	24
Off Karwar	53	19
Off Mangalore	31	16
Off Cochin	38	12

An analysis of the values obtained has revealed that the fine grained sediments in the inner shelf and the slope sediment contain relatively higher amount of Niekcl than the sediments in the region in between. Even among the fine-grained sediments, the sediments off Bombay, Karwar and Cochin have relatively higher concentration of Nickel than the sediments off Mangalore. An examination of the distribution of Nickel with other elements like Manganese and Iron shows that there is a better correlation with Manganese than with Iron. The organic content of sediments and the concentration of Nickel do not appear to be related to each other unlike in the case of other constituents.

Clay Mineral Studies: Clay fractions separated from a few of the samples taken from the different sections mentioned above have been subjected to X-Ray analysis. The analysis has revealed that the clay minerals in these sediments exhibit certain regional variations in that (i) the sediments off Bombay and Karwar are characterised by the presence of predominantly mixed layers of montmorillonite and illite with subordinate amounts of kaolinite group of minerals, (ii) the sediments off Mangalore by the presence of approximately equal proportions of mixed layers of montmorillonite and illite and (iii) the sediments off Kerala coast having predominantly kaolinite group of minerals with subordinate amounts

of montmorillonite. This regional variation in the clay mineral content may perhaps be attributed to the difference in the source rocks present along the different parts of the west coast.

B. Studies on the Sediments of the Gulf of Cambay and the Gulf of Kutch

During the 4th, 5th and 6th cruises of I.N.S. "DARSHAK" about twenty five sediment samples were collected using gravity corer. La Fond-Dietz snapper and dredge. The samples collected have been studied for their physical characteristics. From the results obtained from these studies and from the notations of the bottom given in the Admirality Chart No. 2736, a sediment distribution map has been prepared for the area known as "FIFTY FATHOM FLAT". Broadly, from the coast to the shelf edge four zones of sediments have been delineated. They are (i) silty clays, (ii) oolitics, and (iii) coral fragments and sand, and (iv) rock (limestone-beach rock). The occurrence of beach rock in the outer continental shelf is indicative of the fact that the outer continental shelf has been influenced by the Pleistocene low stands of sea-level. Radiocarbon dating of a few of the samples collected from this region is in progress and perhaps this data may help in unravelling the evolutionary history of this part of the shelf.

Continuous echo sounding was done during the cruises, and 300 miles of echogram was obtained for topographic studies. An examination of the echograms has revealed that the Fifty Fathom Flat has a very rugged topography. A comparison of this echogram with one obtained in the vicinity of Androth Island, a typical coral atoll, has shown great similarity between the two.

C. Sand Movement Studies in Selected Areas (In collaboration with POD)

Sand movement studies have been initiated at two places namely (i) Moplah Bay in Cannanore, and (ii) Mandovi Estuary in Goa. In Moplah Bay at Cannanore, the studies are being made in connection with the development of a minor harbour while at the second place the studies are taken up in view of the navigational hazard created by the formation of a bar at the mouth of the estuary.

Studies on the bar formation in Mandovi estuary were started in February 1970. A preliminary survey was made and sediment samples were collected with a view to understand the nature of sediments in the region. The material collected are being studied for their physical characteristics.

D. Studies on the waters and Sediments of the Vembanad Lake and the Associated River Systems (in collaboration with POD)

Work was started on this project in November 1969. Field work was carried out during November-December '69 and 250 bottom sediment samples were collected from different parts of the lake between Ernakulam and Alleppey. Studies on the different aspects of these sediments have been undertaken at the request of the Kerala Slate Government.

E. Studies on the seasonal variations in the characteristics of the Beach Material of Goa

As a part of the comprehensive programme aimed at understanding the short term and long term changes taking place in the beaches of Goa. Studies on the seasonal variations in the characteristics of the beach material have been taken up in this division. To start with, Miramar and Calangute beaches have been taken up for study. Work on Miramar beach was started in September 1967 while the work on the Calangute beach started in Augest 1969. Details of the work done so far are given below:

Miramar Beach: Six stations at one Kilometer interval were fixed between Campal and Caranzalem. Sediment samples were collected across the beach at each of these six stations at monthly intervals. In all 350 samples were collected and analysed for their grain size and mineralogy. Granulometric studies have revealed that the beach can be divided into two segments: (i) between Miramar and Gasper Dias composed of medium of fine sand and (ii) Gasper Dias to Caranzalem composed of fine to very fine sand. There is no marked change in the size of the beach material from season to season except for accumulation of shells during the fair weather season. The sediments are well sorted and slightly positively skewed.

Mineralogically, the sediments arc composed of Pyroxenes, amphiboles, epidote, tourmaline, zircon, spinel and opaques with minor amounts of rutile, staurolite and biotite.

Calangute Beach: This beach which is situated between two promontories namely Aguada in the south and Bagha in the north is about 7.5 kilometers long. Five stations have been fixed on this beach from north to south and sediment samples are being collected across the beach from these five stations at fortnightly intervals for the study of grain size characteristics, mineralogy, calcium carbonate content and iron content. So far nearly seven hundred samples have been collected of which 250 samples have been analysed for their grain size and the statistical parameters like median diameter, sorting etc., computed. Carbonate content has been determined in 120 samples by the loss in weight method. The studies on this beach are being done in collaboration with the Physical Oceanography Division.

F. Micropalacontological Studies of the Marine Sediments off the Coasts of India

A study of the distribution and ecology of the Foraminifera in the shelf sediments off the west coast of India between Bombay and Alleppey has been undertaken. Foraminifera have been separated from the samples collected from 33 stations and their identification is in progress.

Stratigraphic and micropalaeontological studies of the sediment cores obtained from a few localities in the Arabian Sea have been completed.

2.4

biological oceanography division (bod) , cochin

A. Oceanography of the Waters Around Laccadives

B. Energetics of Local Flat-Fish

C. Studies on the Cochin Backwaters

D. Yield Studies of Fish

E. Environmental Factors and Growth of Phytoplankton

F. Some Problems of C^{14} Measurements

A. Oceanography of the Waters Around Laccadives

Cruises were undertaken on board the passenger-ship M.V. *"Laccadives"* to Kavaratti and other atolls of the Laccadives. The Oceanographic Studies carried out during these cruises have brought to light some interesting findings which are summarised below:

(i) Characteristics of a 'Trichodesmium' Bloom in the Laccadives

In April 1968 a bloom of *Trichodesmium erythraeum* occurred in great profusion in the Laccadives and largely occupied the upper few metres of the water. The chief characteristics of the environment during the bloom were the minimum nitrate-N and a sparse population of other phytoplankton and zooplankton. The ability of *Trichodesmium* to fix molecular Nitrogen provides an important source of nitrogen enrichment which may make a substantial contribution to the nitrogen budget of tropical seas.

(ii) Primary Production of an Atoll in Laccadives

In the midst of oceanic conditions, Kavaratti Atoll with a ring-shaped coral reef and a rich growth of attached algae and macrophytes in its shallow lagoon, constitutes a highly productive environment. The transparency of water near the coral reef is fairly high and the phytoplankton production in the surrounding sea is low. The lagoon seems to sustain a higher standing crop of phytoplankton than does the adjacent sea.

Estimates of gross production and community respiration made from diurnal changes in oxygen at two stations in the lagoon and from oxygen changes in water during its transport over the reef, showed that lagoon and reef communities are both autotrophic. Experiments conducted on the oxygen exchange of several species of plants and corals confirmed that their rates of photosynthesis for 12 hours were greater than their rates of respiration for 24 hours. The conclusion that Kavaratti is among the most productive environments was drawn by a comparison of estimates made at Kavaratti with those of other marine areas.

The highly variable nature of zooplankton abundance in the surrounding sea and in the lagoon makes it apparent that in some seasons oceanic source of nutrition to corals in the form of zooplankton may be important, but

zooplankton alone cannot meet the total energy needed by the reef community.

(iii) Production of Particulate Organic Matter by the Reef on Kavaratti Atoll (Laccadives)

The concentration of particulate organic carbon in the vicinity of Kavaratti Atoll is much greater than that of the surrounding sea. The particulate organic matter, which is largely produced by the coral reef, amounts to about 20% of the total gross production of the reef community. In the absence of an adequate standing crop of phytoplankton, it is possible that paniculate matter may form an important source of energy to zooplankton in coral reef waters.

(iv) Primary Production of a Sea-grass-bed on Kavaratti Atoll (Laccadives)

Along the intertidal zone of Kavaratti Lagoon, a sea-grass-bed, largely consisting of *Thalassia* and *Cymodocea*, grows on a substratum of loose coral sand and coral debris. Primary production of this grass bed was estimated from a study of diurnal changes in dissolved oxygen over the bed and conducting experiments on some isolated plants determining their rates of oxygen production and consumption. Both these studies showed that photosynthesis of the community during the hours of daylight is greater than its respiration during day and night. The presence of this autotrophic plant community near the reef seems to be useful for it offers protection to animals and is consumed by the herbivorous animals of the reef.

B. Investigations on the Energetics of Local Flat-fish Populations Occurring on Beaches and in Near-shore Areas

a. Respiratory Measurement

i) Standard Oxygen Consumption

Laboratory experiments were conducted on the oxygen consumption of flat-fishes using a closed circuit respirometer (Beckmann). Results of oxygen consumption were analysed according to widely accepted relationship.

$$Q = a\ W^{b}$$

Where Q is the oxygen consumption in mg/h, W is the live weight of fish and a and b are the two constants to be determined. The mean 'a' and 'b' values for four species of *Cynoglossus* were: a = 0.3722 and b = 0.7342.

ii) Standard Oxygen Consumption in Relation to Temperature

Cynoglossus could tolerate a temperature range of 15.0 to 37.5°C. In the range 30 to 37.5°C, the standard oxygen consumption was temperature-independent, and did not change in this range. Below 30°C, oxygen consumption was temperature-dependent, being almost linear on a longarithmic scale, with a Q_{10} = 2.4.

iii) Active Oxygen Consumption

Cynoglossus is provided with exceptional adhesive powers on flat surfaces, and therefore, it is difficult to force the fish to swim in a current or water. But in a few cases where it did swim, values of about 100% increase in oxygen consumption, over standard, were observed at 28°C (room temperature).

The scope for activity was thus low as compared to flatfish from the temperate region where increases of 4 or 5 times in the oxygen consumption have been reported to occur.

iv) Experimental Starvation

Individuals of all flatfish were kept without food at 27-29°C and weighed under anaesthetic at intervals of about one week to measure their loss inweight. The present loss in wet weight in a total of 43 individuals were of 12 to 2% per week.

v) Experimental Feeding

After trials with different sorts of dead and live foods, tubiculous polychaetes were used after their removal from the tubes. There appeared to be direct relationship between increase or decrease of body weight to the food actually consumed by the fish over a period of a week. The food intake was expressed in terms of percentage of the body weight and maintenance level of food intake was shown to be of the order of 25% of body weight.

vi) Day-Night Experiment on Feeding Rates

In the inshore area, 30-minutes hauls were taken by a beam trawl to cover the 24-hour period. Analysis of the wet weight of the stomach contents in relation to the wet weight of the fish were used to investigate any diurnal rhythm in feeding and to gain some information on the average quantities of food taken. The quantity of food consumed was found to be much greater at night than during the day time. Thus it seems that feeding is largely controlled by chemical or mechanical stimuli rather than the visual ones.

C. Studies on the Cochin Backwaters

Continuous collections of detritus by an apparatus made locally, were made from the Cochin backwater throughout the year. The collected material was centrifuged, washed, dried and weighed. This gave an index of the rate of sedimentation of the suspended material in the estuary. The detritus was further analysed for total phosphorus, organic carbon, protein, carbohydrates and lipids. From this analysis it become clear that the organic detritus forms a large proportion of the suspended material and plays an important role in the food chain of the estuary. Many filter feeders and omnivores in the estuary are dependent upon detritus for food. The calorific value of detritus calculated from protein carbohydrate and lipid fractions was found to be fairly high, indicating that detritus can form an imporant source of energy to animals

D. Yield Studies on Fish

Work on fish population models and yield studies were continued during the period under review. The concept of eumetric fishing developed by Beverton and Holt was once again re-examined using the table of yield functions given by these authors. This was done to facilitate a better understanding of some of the eumetric fishing/yield curves and the changes in the catch-per-unit-effort with increased fishing pressure. An attempt was also made for an easier estimation of the conditions of optimum exploitation. These methods could be applied when growth in weight was allometric or when the natural mortality varied with age. Some of the common methods of interpolation have also been suggested for evaluating the fishing levels for which a given mesh size maximises the catch-per-unit-effort or for finding the changes in the fishing intensity needed to bring the yield and catch-per-unit-effort to any desired level.

The suitability of the Beverton-Holt model and the Schaefer model for making yield assessments with a view to maximising the profit has also been examined together with the usefulness and drawbacks of the two models. Although the profit maximisation depends on both biological and economic conditions, regulatory measures based on eumetric value-cost curves are not expected to be very far from the maximum profit level. Very often, due to the limitations in the data one is forced to rely upon the eumetrie fishing/yield curves alone.

E. The Influence of some Environmental Factors on the growth of Tropical Phytoplankton Organisms

Unialgal cultures of 12 phytoplankton organisms, isolated from a typically marine environment (inshore waters off Cochin), were grown in an enriched seawater medium (Erdschriber). These clones were kept at room temperature and were allowed to grow under fluorescent illumination. When the cultures become sufficiently dense, the effects of three environmental factors (a) salinity, (b) light, and (c) nutrients were investigated on their rates of photosynthesis.

(a) **Salinity:** The cultures were exposed to a salinity range 5 to 35‰ and their rates of photosynthesis at each salinity was measured by the C^{14} method. Different organisms showed a wide adaptability to changes in salinity and in almost all organisms a maximum photosynthesis was obtained at a salinity range 10-25‰. Ecological observations on their distributions were also made in the Cochin backwater during a period when typically brackish water occupied the top-most layers and the salinity was low. Maximum abundance corresponded with their salinity requirements studied in the laboratory. In conclusion, it may be said that maximum phytoplankton abundance in the shelf waters of the Arabian Sea, as is commonly seen during the monsoon period, is due to the fact that their photosynthetic maximum is adjusted to low salinity.

(b) **Light:** Photosynthetic rates of several species of phytoplankton organisms were investigated at different wave-lengths of light, by using sharp cut-off filters obtained from Corning Glass Works, New York, U. S. A. In most of the species, maximum light saturated photosynthesis was obtained at 430 to 455 mμ and minimum between 600-650mμ. When these data were plotted against the amount of energy transmitted through these filters, the curves obtained in different species were similar to that of a typical photosynthetic curve in sunlight. These results indicate the photosynthesis, in some organisms at least, is directly related to the amount of energy transmitted through them at a particular wave length.

(c) **Nutrients:** The effects of changing concentrations of two nutrients, phosphate-P and nitrate-N were investigated on the rates of photosynthesis of *Ceratium* and *Biddulphia*. The range in phosphorus and nitrogen concentrations was from 0.5 to 10 μg at/1. The experiments with *Ceratium* lasted 12 days and with *Biddulphia* 30 days. The phosphorus requirement of *Ceratium* was found to be above 2-5 μg—at/1. The rate of photosynthesis at these concentrations increased continuously throughout the experiment. Concentrations higher than 5.0 μg-at/l accelerated photosynthesis for 9 days, followed by a sharp decline thereafter. The nitrogen requirement of *Ceratium* was found to be about 0.5/μg-at/l. Concentrations of nitrogen higher than 0.5/μg-at/1 brought about a decrease in photosynthesis. Similar results were obtained when nitrogen was used in conjunction with phosphorus.

In the other series of experiments with *Biddulphia* entirely different results were obtained. While the phosphorus requirement

of this organisms for maximum photosynthesis was about the same as in *Ceratium* i. e. 5/µg-at/l, its nitrogen requirement was much greater and maximum photosynthesis was obtained when nitrate-N was increased to 5.0/µg-at/1. When these two nutrients were used in combination, maximum photosynthesis continued to occur at all concentrations from 1 to 10 µg-at/l. Peak values, however, were obtained on the 8th day which was followed by a progressive decline thereafter.

F. Some Problems Related to the Measurement of Primary Production by using C_{14} Technique

The SCOR/IBP Working Group-24 on "The estimation of primary production under special conditions", during its meeting held in Southampton, in U. K. July/August, 1968 and in its report submitted to the SCOR (Ref: Proceedings SCOR, Vol. 5 No. 1,1969) entrusted the Biological Oceanography Division of the National Institute of Oceanography, the following work related to C^{14} methodology. This was considered an important investigation as the information available in the literature on these aspects are neither enough nor accurate:

a) Size of bottles used for C^{14} incubations during experiments.

b) Effects of different proportions of inert material on the self-absorptian of C^{14}.

c) Amount of material to be filtered to avoid appreciable self-absorption and to give a satisfactory filtering time.

d) Chemical oxidation by using organic pollutants in the light and dark bottles during the C^{14} incubations.

A series of experiments were carried out to resolve some of these problems. The results obtained in these studies are in the process of compilation and analysis.

2.5

Indian ocean biological centre (iobc), cochin

A. Sorting and Subsorting of the International Collections

i. Amphipoda
ii. Copepoda
iii. Fish-eggs and Larvae

B. Specialised Studies of the IIOE Collections

I. Anthozoan Larvae
II. Pelagic Polychaetes
III. Chaetognatha
IV. Amphipoda
V. Ostracoda
VI. Copepoda
VII. Heteropoda
VIII. Fish-eggs and Larvae (Heterosomata)
IX. Atlas Preparations
X. Medusae (Local Collections)

C. Zooplankton Fixation and Preservation, SCOR-UNESCO Working Group 23 Programme

A. Sorting and Sub-sorting of the International Collections

(i) Amphipoda

Dr. H. E. Gruner, Chief Specialist for Amhipods was at IOBC during October-November 1968 and together with Dr. T. B. Bowman and Shri K. K. C. Nair, prepared a scheme for subsorting the Amphipods of the International Collections. Dr. Gruner's report was approved by the 7th Meeting of the Consultative Committee.

Subsorting of the group was started by Shri K. K. C. Nair in August 1968 and subsequently Shri P. G. Jacob joined him and together they have completed 1200 sub samples. This leaves behind approximately 2000 sub samples to be completed. At the present rate of subsorting it is expected that the job would be completed within a year.

Allocations and Consignment

To speed up the subsorting, it was decided to divide the Amphipoda into the following 12 groups which with a little experience could be separated easily.

1. Gammaridea
2. Lanceolidae
3. Scinidae
4. Vibiliidae
5. Phronimidae
6. Paraphronimidae
7. Hyperiidae
8. Anchylomeridae
9. Lycaeopsidae
10. Pronoidae & Lycaeidae
11. Oxycephalidae
12. Thyropodidae & Platyscelidae

The subsorted material was alloted to the following specialists.

Dr. T. E. Bowman, Washington	—	Hyperiidae
Dr. H. E. Gruner, Berlin	—	Thyropodidae, Platyscelidae
Mr. K. K. C. Nair, IOBC, Cochin	—	Vibiliidae, Paraphronimidae, Phronimidae, Anchylomeridae, Oxycephalidae
Dr. S. T. Shih, Ottowa	—	Lycaeopsidae, Pronoidae, Lycaeidae
Dr. M. E. Vinogradov, Moscow	—	Gammaridae, Lanceolidae, Scinidae

(ii) Copepoda

Subsorting procedures for Copepods were formulated in May 1968 and the work of subsorting commenced soon after. Samples for subsorting were selected from the 1548 standard collections, in such a way so as to give seasonal and geographical coverage, and in this way 1050 representative samples were selected for studies. Two hundred samples have already been subsorted by now; work has been speeded up recently by varying the size of the sub-sample according to to the numerical abundance of Copepods in the sample. During the first phase of the work, one sample from each five degree square was taken to ensure uniform geographical coverage. The sub-sorting of the total of 1050 selected stations would be completed in the next three years.

Allocations and Consignments

Material has been despatched to the following specialists who have agreed to undertake the related work of the subsorting of the material.

1)	Fleminger	:	Labidocera, Pontellina, Centropagidae (Oceanic)
	Grice	:	Candaciidae
	Haq	:	Temoridae, Calanopia
	Matthews	:	Undinula, Augaptilidae (excepting Haloptilus)
	Minoda	:	Lucicutia
	Park	:	Heterorhabdidae
	Pillai	:	Pontella, Pontellopsis
	Tanaka	:	Euchaetidae
	Vervoort	:	Aetidiidae, Phaennidae
2)	Krishnaswamy	:	Sapphirinidae and Copilia

The following are IOBC Staff working on IIOE Meterial

Kasturirangan	:	Harpacticoida
Goswami	:	Oithona
Rosamma & Sarla Devi	:	Haloptilus
Saramma Abraham	:	Acartia, Centropagidae (nearshore)
Saraswathy	:	Gaussia, Pleuromamma, Siphonostomes (as approved by Senior Specialist)

(iii) Fish Eggs and Larvae

When the IIOE plankton samples were sorted at the IOBC, a large number of fish eggs and larvae were separated. Even as early as 1965 it was suggested by Dr. Hansen that further subsorting of the group may be taken up without any delay and this task was assigned to K. J. Peter. A scheme for the subsorting of fish larvae was prepared and work was started. Later this was presented to the Consultative Committee in 1967 and was approved. Certain minor modifications were made afterwards in consultation with Prof. T. S. Rass, Chief specialist for fish eggs and larvae. As more and more fish larvae fraction became available out of the regular sorting, three additional staff members also devoted part of their time to the subsorting of fish larvae. At present the following people are engaged in the subsorting programme.

K. J. Peter
C. B. Lalithambika Devi
V. Santhakumari
S. V. M. Abdul Rahim

The fish larvae have been sub-sorted into 55 groups mainly upto the family level. Out of the 1927 IIOE samples collected, 1685 have been subsorted. The remaining 242 samples are expected to be completed within three months. The data processing of the sub-sorted groups has been carried out simultaneously and logged under a separate scheme mentioned above.

Allocation and Consignment

In response to the letter from the Chief Specialist and the UNESCO Curator regarding the allocation of various groups of fish larvae, the following expressed their willingness to start the work immediately and the material was despatched to them.

Castle	—	Anguilliformes
Jones	—	Scomberomoridae, Thunnidae Holocentridae and Dactylopteridae
Silas	—	Synodontidae and Bregmacerotidae
Peter	—	Clupeidae, Engraulidae and Scombridae
Lalithambika Devi	—	Pleuronectiformes.

The material alloted to the following specialists are almost ready for despatch. These will be sent as the subsorting is completed.

Rass	—	Argentinoidei
Bertelsen	—	Ceratioidei
Bapat	—	Carangidae
Ostroumova	—	Myctophidae
Novikova	—	Stomiatoidei
Gorbunova Belianina	—	Gempylidae
Kovalevskia	—	Beloniformes
Mukhacheva	—	Coryphaenidae
Rofen	—	Paralepididae
Ueyanagi	—	Xiphiidae and Histiophoridae

Visitors at the proposed site for the NIO buildings, Panaji, Goa.

B. Specialised Studies of the IIOE Collections

(i) Anthozoan Larvae

The pelagic anthozoan larvae of the IIOE collections were sorted out as one taxon and this was taken for special studies, with reference to their systematics, distribution and abundance. The entire taxon belonged to one subclass *Zoantharia.* 1560 samples have been subsorted to three different orders namely *Actiniaria, Zoanthidea* and *Ceriantharia, Ceriantharians* were further subsorted to 3 families viz., *Acontioidiferidae, Botrucnidiferidae* and *Cerianthidae* based on the presence of either Acontia or Botrucnids or absence of both respectively. Ceriantharia of the above 3 families were further classified into 31 genera and 80 species, based on the internal anatomy by sectioning.

Semper's larvae of Zoanthidea were classified into two groups of long and round type viz., *Zoanthella* and *Zoanthina* respectively. Actiniarian classification was based on the number of sarcosepta present.

Camera Lucida sketches of these larvae and their sections are being drawn for description. The identification upto the species level is to be confirmed by the senior specialist. The classification followed is that of Carlgren (1924) and Leloup (1964).

Though holoplanktonic forms belonging to the families *Minyadidae, Metridiidae, Sagartiidae* and *Actiniidae* are reported to occur in plankton collection, these 1560 samples consist only of meroplanktonic forms. Though in general meroplanktonic forms are neritic in occurrence, a fair proportion of oceanic forms also have been collected.

Anthozoan larvae collected from local collections are being reared in the laboratory and observations are being made on the reproduction by pedal laceration.

(ii) Pelagic Polychaetes

The pelagic polychaetes of the IIOE Collections were sorted out into two major groups during general sorting. "Tomopterids" and '"other polychaetes", which belong to families of pelagic polychaetes other than Tomopterids. Out of these, the latter group was taken up for special study since the general sorting was over. Now about 1200 samples have been subsorted to the different species belonging mainly to four families. *Alciopidae, Typhloscolecidae, Phyllodocidae* and *Aphroditidae.* Alciopids and Typhloscolecids are all purely pelagic while Phyllodocids include only one subfamily of holopelagic species: there are only a few species of holopelagic froms under *Aphroditidae,* the others that are found in the collections under this family are only larval or post larval stages of benthonic groups.

So far 29 species of pelagic polychaetes have been found to occur in the IIOE samples. All these have been sketched under camera lucida and described. Out of the 29 species, 3 are new and a few have been recorded for the first time from Indian waters.

The larval polychaetes preserved separately, have not been taken so far for detailed study. For identification of the species, "the key for identifications" (Dales, 1957) was mainly used. The keys for identification by Tebble (1962) and Stop-Bowitz (1948) were also used from time to time. All the identifications made so far up to species level, have been confirmed by Dr. R. Philip Dales, the senior specialist of this group.

(iii) Chaetognatha

Plankton samples collected during the International Indian Ocean Expedition from the Arabian Sea area north of 10°S were analysed. Chaetognaths from 614 standard samples were identified upto species level. Each species was again subsorted into five maturity stages taking into consideration the growth of the testis and the ovary. Ninteen species belonging to four genera were encountered in these collections. The species were *Eukrohnia fowleri, Krohnitta pacifica, Krohnitta subtilis, Pterosagitta drace, Sagitta bedoti, Sagitta bipunctata, Sagitta bombayensis, Sagitta decipiens, Sagitta enflata, Sagitta ferox, Sagitta hexaptera, Sagitta lyra, Sagitta minima, Sagitta neglecta, Sagitta pacifica, Sagitta pulchera, Sagitta regularis, Sagitta robusta* and *Sagitta zetesios.*

S. enflata, S. pacifica, S. bedoti and *P. draco* were the commonest forms in these waters. As these samples are from 200-Om depth, mesoplanktonic chaetognaths do not comprise a significant part of the material. *E fowleri* and *S. decipiens* alone are the deep water species in the present collections.

Charts on the distribution of chaetognaths for whole of the Indian Ocean were prepared based on the numerical data available at the Indian Ocean Biological Centre.

Total Distribution

Maximum abundance was observed off the Somali Coast, near the southern coast of Arabia and the southern part of the Nicobar Islands. The western

part of the Arabian Sea and the Bay of Bengal, showed uniformly high density of population. There was gradual decrease in numerical representation of chaetognaths from the north to the southern part of the Indian Ocean.

Seasonal Distribution

The period of mid-April to mid-Octocbr (southwest monsoon period) showed a comparatively higher density of chaetognaths. Maximum density was observed off Somali coast and near Nicobar Islands. During mid-October to mid-April (north east monsoon period) maximum population was near the southern coast of Arabia

Day and Night Variations

There was no significant difference between day and night collections except that the lower density areas extended further north in the night collections. In both the day and night charts there was uniform abundance on the Somali coast, southern Arabian coast and Bay of Bengal.

(iv) Amphipoda

The Amphipods of the IIOE were sorted out during the general sorting and subsorting of the group was started by Shri K. K. Chandrasekharan Nair towards the end of June 1968. In consultation with the chief specialist of the group, Dr. H. E. Grunner it was decided to subsort the groups under the major heads, viz. suborder: *Gammaroidea* and suborder *Hyperiidea* which are represented by the families. *Hyperiidae, Oxycephalidae, Vibiliidae, Paraphronimidae, Phronimidae, Anchylomeridae, Platysclidae, Thyropodidae, Pronoidae, Lycaeidae, Lycaeopsidae* and *Scindae.* So far 1200 samples have been subsorted.

Out of the families mentioned above, five families viz. *Oxycephalidae, Vibiliidae, Paraphornimidae, Phronimidae, Anchylomeridae,* which were alloted to Shri Chandrasekharan Nair have been taken for special studies. Collections from 68 stations have already been examined and identified up to species level.

The species identified so far are listed below:

Family: Oxycephalidae

Species- *Oxycephalus clausi*
Oxycephalus piscator
Oxycephalus latirostris
Leptocotis tenuirostris
Streetsia challengeri
Symorphynchotus antennarius
Rhabdosoma whiteni
Rhabdosoma armatum
Rhabdosoma minor

Family Phronimidae

Species- *Phronima sedentaria*
Phronima stebbingi
Phronima collettee
Phronima atlantica
Phronima pacifica

Family : Anchylomeridae

Species- *Phrosina semilunata*
Anchylomero blosso villi
Primno macropa

Family Vibillidae

Species- *Vibilia vivatrix*
Vibilia stebbingi
Vibilia pyripus
Vibilia armatum
Vibilia robusta

Family Paraphronimidae

Species- *Paraphonima gracilis*
Paraphronima crassipes

Besides the adult forms juvenile stages have also been recorded. Since little attempt has been made to study the early stages of Hyperiids in the past, much difficulty in identifying the juvenile stages was felt especially in the case of forms belonging to the family *Vibillidae* and *Phronimidae.*

(v) Ostracoda

Since the ostracods are very abundant in most of the IIOE samples and since it would take some time to complete the entire Indian Ocean collections, the samples from the Arabian Sea were separated from the collections and sub-sorted. All species were preserved separately after careful examination.

Charts showing the distribution of the ostracods with day and night and seasonal variation were also prepared.

Species observed in the Arabian Sea samples

Bathyconchoecia lacunosa (Muller)
B. deeveyae Kronicker
Archiconchoecia striata Muller
A. ventricosa Muller
Halocypria brivirostris (Dana)
Halocypria globosa (Dana)
Conchoecia oblonga (Claus)
C. echinata Muller
C. discophora Muller
C. procera Muller
C. elegens Sars
C. decipiens Muller
C. acuminata (Claus)
C. parthenoda Muller
C. skogsbergi Iles
C. curta Lubbock
C. striola Muller
C. atlantica Lubbock
C. magna Claus
C. porrecta Claus
C. spinirostris Claus
C. imbricata Muller
C. prosadene Muller
C. alata Muller
C. concentrica Muller

(vi) Copepoda

Genus: Haloptilus

Studies on the copepod genus *Haloptilus* collected during the IIOE have been undertaken. 160 samples were analysed for species studies. The following species were indentified

Haloptilus longicornis

H. spinciceps *H. Oxycephalus*
H. oranakis *H. longiceps*
H. validus *H. mucronatus*
H. acutifrons *H. plumosus*

H. longicornis and *H. spiniceps* are the dominat species in the samples examined. *H. longiceps* which was recorded (single female specimen) from Sagami Bay of the Pacific Coast of Middle Japan was obtained from a number of stations in the Indian Ocean.

Genus Gaussia and other Copepods

Copepods belonging to the genus *Gaussia* had been separted during the basic sorting of Zooplankton at the IOBC. This interesting bathypelagic genus is monospecific and the single species *G. princeps* has been obtained

from 18 localities in the Indian Ocean. Adult males, females, and copepodites 5, 4 and 3 were obtained from the collections. An interesting point noticed about the presence of this species in the water column from the upper 200 meters, is that all the stations are located towards the north of the equator. (Northern Hemisphere)

Analysis of Copepod samples so far completed showed presence of six species of *Pleuromamma,* viz. *P. xiphias P. quadrungulata, P. abdominalis, P. gracilis, P. indica* and *P. piseki.*

Scattered incidences of a fauna of Sphenostoma (Copepoda-Cyclopoida) has been brought to light. Siphonostomous copepods are very rare in the plankton, represented by only a few genera. Representatives of the two genera *Ratania* and *Pontoeciella* have been identified from the IIOE collections.

Studies on Acartiidae

The family Acartiiade comprises nearly 60 species of planktonic forms most of which are neritic and abundant in inshore waters of the Indian Ocean.

Only three species, namely *Acartia danae, Acartia negligens* and *Acartia amboinensis* were found to occur in typically marine region. Of these *A. amboinensis* was found only near the Laccadive Islands and the other two in the open ocean.

Eleven species of the family Acartiiade, nine species of the genus *Acartia* and two species of the genus *Acartiella* were recorded from the Cochin Backwaters during the present study. Of these, one was new and the other was a new record for the west coast of India.

Seasonal variation in the distribution of species and in the size of the specimens were observed. Mostly larger specimens were obtained during the premonsoon period. No single species of this family was found to dominate throughout the year and in no part of the year were all the species found to occur. The maximum number of species was present from March to June. In certain months the family Acartiidae was represented in the collections by only one species, for example, *Acartiella gravelyi* in September and *Acartia plumosa* in October and November.

Certain species preferred a specific range of salinity *A. bilobata, A. centrura, A. erythraea,* and *A. spinicauda* were absent during the monsoon months while *Acartiella keralensis* occurred abundantly in June and July.

Salinity gradient appears to have a remarkable effect on certain species in the fact that they show variations in primary and secondary morphological characters from their counterparts in marine area.

(vii) Heteropoda

Identifications of gelatinous heteropods is almost complete. The gelatinous heteropoda include two families: *Carinariidae* and *Pterrotracheidae. Carinariidae* includes 3 genera: *Carinaria, Pterosoma* and *Cardiapoda. Pterotracheidae* includes two genera, namely *Pterotrachea* and *Firoloida.*

Detailed study of the following species is in progress.

Carinaria lamarcki	*Cardiapoda richardi*
Carinaria cithara	*Pterotrachea coronata*
Carinaria gales	*Pterotrachea hippacompus*

Carinaria cristata	*Pterotrachea sultata*
Pterosoma Planum	*Pterotrachea minuta*
Cardiapoda placenta	*Firoloida desmaresti*

The distribution charts prepared for the groups Heteropoda and Cephalopoda are ready for publication.

(viii) Fish Eggs & Larvae (Heterosomata)

Although the distribution of the adult flat-fishes has been described in detail, very little has been published on the larvae. The larvae of Heterosomata were subsorted from the sorted fish larvae of the IIOE collections for detailed study of the group. The meristic characteristics of the flat-fish larvae were compared with those of the adults for considering the specific status of the individual specimens. The work of J. R. Norman (1928 and 1934) was mainly consulted for comparison. Projection drawings were made to elucidate specific characteristics. Adult specimens were collected as far as possible and comparison was made with the alizarin preparations of larvae. Studies on the development and distribution of the larvae were also done. Most of the larvae available in Indian Ocean were studied in detail as they are still undescribed. The following species contained in 8Sl samples of the 1109 collections have been provisionally identified.

Pseudorhombus elevatus, Ogilby: *Arnoglossus tapeinosoma* (Bleeker): *A. aspilos* (Bleeker): *A. elongatus Weber: A. intermedius* (Bleeker): *Engyprosopon cocosensis* (Bleeker): *Bothus mancus* (Broussonet); *B. panterinus* (Ruppell) and *Cynoglossus brevirostris* Day.

To identify the eggs and larvae satisfactorily to the species level, it is desirable to rear the eggs and larvae up to a stage until the specific characters are apparent in the larval forms. This will also help to link the different stages of larvae occurring in the plankton. In view of this, weekly plankton collections were made from the Cochin Harbour area after dusk and the eggs were sorted out and reared in the laboratory.

(ix) Atlas Preparation

The IOBC has published last year two fascicles of maps showing the distribution of biomass in the Indian Ocean. A set of ten maps showing the distribution of fish eggs and larvae is under publication and will be released in April 1970. A further set of 11 maps showing the distribution of Copepods and Decapod larvae is in the press and is expected to be ready for release by the end of July, 1970. A detailed report on the significance of these maps is under preparation. Besides, about 120 charts showing the distribution of principal zooplankton groups in the Indian ocean are ready for publication.

(x) Medusae (Local Collections)

While a vast amount of information has accumulated in the past on the taxonomy of the medusae, very little is known about their ecology in Indian waters. Hence a detailed study of these organisms has been undertaken from the ecological point of view.

Medusae were sorted out from the local plankton collections and were identified up to species level under the guidance of Dr. Vannucci, Specialist of this group. The development stages and sexes were noted.

So far thirtythree species listed below were identified of which *Eutima commensalis* is a new species. The species are the follwing.

Euphysore abaxialis, Zanclea costata. Podocoryne carnea, Ectopleura sp., *Halocordyle disticha, Cytaeis tetrastyla. Bougainvillia fulva, Pandea rubra, Tiaropsidium japonicum, Obelia* spp., *Phialidium brunescens, P. rangorae, P. hemisphericum, Blackfordis virginica, Eucheilota menoni, Phialucium carolinae P. taeniogonia, Eirene ceylonensis, E. menoni, Eutima hartlaubi, E. browne, E. neucaledonia, E. japonica, E. commensalis, Acquorea acquorea, A. conica, A. macrodactyla, Aglaura hemistoma, Aglantha elata, Liriope tetraphylla, Geryonia proboscidectylis, Cunina peregrine,* and *Solmundella bitentaculata.*

A few of them are new records to the Indian waters. All the developmental stages of *Eutima commensalis* were gathered from the plankton and so it was possible to describe the life cycle of the species in full.

C. Zooplankton Fixation and Preservation SCOR-UNESCO Working Group 23 Programme

Experimental investigations on fixation and preservation of zooplankton samples were carried out at IOBC for working out a corrective procedure for the deterioration noticed. The past experience has shown that one particular preservative was not apt to preserve all groups of organisms.

The observational part includes two aspects - one of the qualitative and other of quantitative. The quantitative aspect includes transfer of specimens into different types of preservatives and measuring shrinkage due to weight and volume loss or gain.

The other aspect is concerned with the qualitative observation of stuctures of taxonomic value of the organisms. Quality of fixation and preservation is observed by noting the morphological features.

The fixation series include (1) use of volatile *ethanol* and *isopropanol* in addition to formaldehyde at varying strengths as fixatives of plankton. (2) use of different buffers - $Na_2 B_4 O_7$, Hexamethylene tetraamine, $NaHCO_3$ $CaCO_3$. Tris HCl. Potassium Sodium tartrate, NaOH, CH_3OH at varying strength during fixation and use of sodium acetate and sodium ascorbate for colour retention, (3) effect of temperature in the formation of gas bubbles in organisms and (4) time factor for microbial invasion during fixation.

Preservation series include use of Phenoxetol, Ethylene glycol and formaldehyde in various strengths in combination with various buffers as preservatives. The points under investigation are (1) the relation between pH and solubility of shells of planktonic organisms (2) pH and per cent loss in weight, and volume of organisms (3) histochemical reaction of preservatives with animal protein (4) effect of light and temperature on pigment loss, etc.

Formaldehyde acetate and formaldehyde ascorbate fixatives are found better than formaldehyde alone in preserving the pigments of organisms. Addition of acetate and ascorbate helps in maintaining an optimum pH. The time factor for microbial invasion is found directly proportinal to the delay caused before fixation. In order to avoid formation of gas bubbles in organisms, during fixation, use of cold water is being tested. The results are quite satisfactory especially in the case of Saphirinids.

The UNESCO programme includes 22 series of experiments each with around 40 separate variations to cover buffering

methods, preservation of calcium, oil globules, etc. These experiments are being replicated at IOBC to increase the reliability of the final assessment of the best fluids, besides work at other centres like SOSC. Bath University, U. K., etc. These series include examination in detail of the known and used techniques of fixation and preservation using such fluids as formaldehyde and alcohol. In addition possible use of new reagents such as MDMH and DOWICIL 100 are being investigated.

Most of the series are in operation now. In all experiments pH measurements and formaldehyde assay, where needed, are carried on along with observation on specimen condition. These experiments are carried on board *'Blue Fin'* and *'Neendakara'*. Preservation experiments are carried on at the laboratory. Whole mount staining for observing the effects of the fluids on the whole animal and histological sectioning and staining to reveal tissue character have to be started in near future.

Participants and invitees at the meeting of the Consultative Committee at Panaji, Goa

2.6

biological oceanography unit panaji

A. Hydrography and Productivity of Mormagao Bay

B. Environmental Features of Mandovi and Zuari Estuaries

C. Phytoplankton and Zooplankton in the Estuaries

2.6 Biological Oceanography Unit, Panaji

Studies have been undertaken on primary production and its seasonal and diurnal variations in the waters of Goa region as an initial step to understand the Biological productivity of the area in relation to environment conditions.

A. Hydrography and Productivity of Mormagao Bay

The Mormagao Bay which is an estuary of the river Zuari has somewhat pronounced diurnal tides which influence the various physical and chemical conditions of the waters.

The annual surface temperature variation was of the order of 5°C, the limits being 26°C and 31°C. There are two peaks during October-December and April-May. The salinity showed much greater variations ranging between 13.4% and 35.5%. In general marine conditions prevailed almost throughout the year except for the period of the south west monsoon. Diurnal picture of salinity variations during the south west monsoon was quite interesting in that, there was a fluctuation of the order of about 12.6% during spring tide as compared with 3.6% during neap tide. Turbidity and Extinction coefficient were high from May to August and low from October to April. During the south west monsoon because of high trubidity due to excessive suspended matter, light peneration is considerably reduced up to 10 p p m of turbidity, the variation of extinction coefficient with turbidity follows exponential pattern. At higher values of turbidity this relationship is considerably disturbed.

The primary productivity along with the other oceanographic parameters showed a marked seasonal pattern which is largely induced by the south west monsoon. Increase of the primary productivity by about two or three times during premonsoon and postmonsoon period as observed by oxygen evolution method, was related to the cycle of phytoplankton abundance.

The period of greater difference between gross and net primary productivity coincides with the period of higher temperature value in the area which probably affects the respiration rate of the organisms.

Short term changes in the parameters induced by the tide and light and dark conditions of the days were also well marked.

B. Environmental Features of Mandovi and Zuari Estuaries

A comparative study of certain oceanographic and Biological aspect of the two estuaries at spring and neap tides were conducted from August to February to assess the seasonal influence on the ecosystems. Temperature, salinity, pH, dissolved oxygen, nutrients, chlorophyll pigment,

biological productivity and plankton showed marked tidal influence which varied during monsoon and postmonsoon periods.

The two estuaries were somewhat warmer in August than in early February. During southwest monsoon the temperature showed tide controlled rhythm in Zuari estuary while in Mandovi estuary the temperature was apparently related closely to the variations in the atmospheric temperature. But during postmonsoon the effect of tide was noticeable both in Mandovi and Zuari estuaries as the temperature decreased with the flood and increased at the ebb.

In the Zuari estuary almost marine conditions prevail during the postmonsoon months with little freshwater discharge. In the Mandovi estuary on the other hand appreciable changes in the salinity continue to occur during the postmonsoon months also as a result of considerable fresh water discharge by the tributaries feeding the Mandovi river.

High and low values of dissolved oxygen were obtained with the flood and ebb tides in the two estuaries and in the postmonsoon months and fluctuation were smaller than those during the monsoon months. Moreover, during the monsoon months the dissolved oxygen values in the two estuaries showed a marked inverse relationship with the salinity in the area. In the postmonsoon months also a similar inverse relationship between oxgyen and salinity was observed in the Zuari estuary but in the Mandovi estuary the dissolved oxygen appeared to be influenced more by the temperature.

The two estuaries are rich in the inorganic phostphate-P the source of which in the Zuari estuary appears to be largely from neritic waters, whereas in regard to the phosphate-P in the Mandovi estuary land drainage influences are apparent. The in situ fluctuations of chlorophyll *a* in relation to flood and ebb were well marked, in both the estuaries. As compared to the Zuari estuary the pigment concentration in the Mandovi estuary was high but the magnitude of variation in the quantity of chlorophyll *a* was considerable in both the estuaries during the monsoon period.

It is interesting to note that the concertration of chlorophyll *a* was inversely related to the salinity in the estuaries as the latter changed with the flood and ebb tides. Probably the flora associated with lower salinity dominates the crop of phytoplankton in the Zuari and Mandovi estuaries.

Diurnal changes in the chlorophyll content of natural phytoplankton populations due to endogenous rhythm have been well known. Also the photoperiod is supposed to be the causative factor of such diurnal rhythm. However, in dynamic estuarine ecosystems such as the Zuari and Mondovi estuaries, the effect of day and night conditions seem to be overshadowed by the tidal changes and thus the quantity of the pigment is probably influenced by different stock of phytoplankton which is introduced by the flood and ebb tides.

Primary production in the Zuari and Mandovi estuaries during monsoon and postmonsoon periods which was studied by the rate of photosynthesis (C^{14} uptake) in the incubator exposed to constant illumination was found to be closely related to changes in the organic phosphate & chlorophyll *a* which in turn varied markedly with the flood and ebb tides.

Experiments on C^{14} assimilation of the natural phytoplankton in the laboratory under constant illumination indicated that in natural environments the south-west monsoon causing excessive turbulence, high turbidity and insufficient light penetration probably affects the photsoynthetic activity of phytoplankton even in the presence of high concentration of nutrients.

C. Phytoplankton and Zooplankton in the Estuaries

Studies on the biological productivity of Goa waters would be incomplete without information on the seasonal abundance of plankton and the succession of various species forming the total crop in relation to time, tide and space.

Diatoms showed only one maximum in a year i. e. the summer peak from February to April inclusive with a secondary rise in December which, however almost merged with the general maximum.

On the west coast, the phytoplankton production period in Bombay harbour is from September to February while off Calicut the primary maximum of plankton bloom is from May to September. According to the present observations, waters of Goa coast appear to be intermediate by having its plankton maximum from February to April.

It is interesting to note that the summer peak and the secondary December rise of phytoplankton coincides with that of zooplankton in the region. This contradicts the classical relationship as phytoplankton peak should be followed by the zooplankton peaks, since the former serves as food for the latter. Probably tidal currents and vertical turbulance might also be partly responsible for the negative correlation of the phyto and zooplankton in the estuaries.

Rare occurrence of phytoplankton and complete disappearance of zooplankton during peak south west monsoon period in July-August has been recorded in relation to high rainfall, low surface salinity, low pH, high turbidity and insufficient light penetration. Numerical abundance of diatoms at the surface in the Zuari and Mandovi changed with the flood and the ebb. These changes were well marked during the post monsoon period. During the monsoon month the diatoms were more abundant in the Zuari estuary than in the Mandovi estuary whereas during the post-monsoon period the diatoms counts in the Zuari estuary were similar in relation to high waters. However, the pattern of variations in the number of diatoms in the two estuaries in relation to tides during monsoon and postmonsoon months corresponded with that of chlorophyll *a* and the rate of photosynthesis (C^{14} uptake). Thus the pigment quantity and the rate of production in the two estuaries were closely related with natural phytoplankton populations.

Inspite of the negative correlation of the phytoplankton with zooplankton succession, there appears to be a definite pattern of the succession of certain species of phytoplankton forming the major constituents of the existing crop in relation to various seasons.

Out of major diatoms, *Coscinodiscus* and *Thallasiosira* occur throughout the year whereas *Chaetoceros* and *Aulacodiscus* occur during October to April. *Thallasiothryx* appears only during the secondary bloom of diatoms from October to December whereas *Pleurosigma* is noticeable only from December to June. Fish larvae were collected only during October.

2.7

nio field unit bombay

Gulf of Cambay Investigations

Gulf of Cambay Investigations

Studies on hydrography and biology of the waters of the Gulf of Cambay and around Bombay were continued during the period under review.

Studies on the plankton and benthic fauna along with hydrographic data collected during the cruises 1, 2, 3 on board I. N. S. 'Darshak' undertaken during the previous year were completed and a paper entitled 'Studies on hydrobiological features of the Gulf of Cambay, Part I. Preliminary Account' by the scientists of Bombay unit has been prepared. Hydrographical parameters investigated were salinity and temperature. The results showed that the Gulf is both isothermal and isohaline. There was a complete absence of microfauna in the interior of the Gulf but predominance of Foraminifera was very evident. The plankton was rich towards the mouth of the gulf but decreased towards the interior region.

Sediment core samples collected from the northeastern part of the Arabian Sea during cruise-2 on board I. N. S. 'Darshak' in January to February, 1967 have been analysed for study of the nature and distribution of Foraminifera. A paper entitled 'On some Foraminifera from northeastern part of the Arabian Sea' by K. Kameswara Rao has been sent for publication in the *Proceedings of Indian Academy of Sciences* (1970). This paper described ninety two species of Foraminifera belonging to 40 genera of 16 families. Foraminiferal species recorded for the first time in Indian waters are *Textularia pseudocarinata* Cushman, 2) *Virgulina concava* Hoglund, 3) *Virgulina paucilocula*ta H. B. Brady, 4) *Loxostoma rostrum* Cushman, 5) *Lagena sulcata* (Walker and Jacob) *var. spicata* Cushman and Mc Culloch, 6) *Lagena costata* (Williamson) *var. amphora* Reuss, 7) *Elphidium oceanicum* Cushman and 9) *Globigerina calida* Parker.

The foraminiferal fauna of the continental shelf waters of the northwestern part of India is similar to that of Gulf of Cambay and most of the species reported in this paper are also known from the tropical Pacific and Philippines.

During Feb.-March 1970, a cruise was undertaken in the Gulf of Cambay on board I. N. S. 'Darshak' in which hydrographical and biological data were collected. Also a continuous echo-sounding was made and an echogram of the cruise track for about 300 miles was obtained for the study of the nature of bottom profile. The echogram shows that the inner shelf is gently sloping and smooth with little topographic reef. The outer shelf in sharp contrast is highly irregular all the way to the shelf edge (140 meters) being composed of pinnacles, knolls with intervening depressions and is very similar to the topography commonly found in areas of reefs.

The area under investigation consists of two very distinct sediment types. From the shore to a depth of 60 meters, designated as the inner shelf, the sediments are dominantly olive green silty clays with little calcareous matter. From 60 meters to a depth of 140 meters, designated as the out shelf, carbonate rocks and sediments, the latter being composed of corals, oolites and shells of gastropods, Foraminifera are dominant.

2.8

cruises conducted during the year

1. On board Steamers of the M/s Chowgule Steam-ship Co.
2. First cruise of Blue-Fin.
3. Cruise number 6 on board INS Darshak.

(1) On board steamers of M/s Chowgule Steamship Co.

During the year 7 cruises were made on board the passenger ship plying between Panaji and Bombay belonging to M/s Chowgule Steamship Co. Facilities were provided for making observations at the at the various ports of call by the ship. Thus nearshore oceanographic studies have been undertaken at the stations off the following ports:

1. Vengurla
2. Malvan
3. Deogad
4. Vijayadurg
5. Musakhasi
6. Ratnagiri
7. Jaigad
8. Harnai
9. Shrivardhan, and
10. Jangira

At these stations, in addition to routine hydrographic observations, primary production measurements and also plankton collections were made. As most of these stations were shallow having depths of not more than 5 metres, all collections were made from surface to 3 metres. Collections were made both during day time and night time. The hydrographic data are being analysed.

In regard to the measurement of phytoplankton surface samples were filtered and the plankton abundance was estimated by measurement of Chlorophyll. Preliminary observations indicate that the maximum value of Chlorophyll was recorded in the month of May. The values were of the order of 9.5 mg. per cubic metre. In the course of these observations the influence of the land drainage on the plankton production in the nearshore environment was also studied. The study of the zooplankton collected during these cruises indicate the pattern of distribution and seasonal variations along the Konkan coast.

Marked fluctuations have been observed in all the places during this observation period from November, 1969 to May, 1970. Based on the displacement volume of Zooplankton two peaks in the biomass were clearly seen in all the places, one during November/December and another during April/May. Ratnagiri, Sriwardhan, Harnai and Jangira seem to be fairly good places for the high production of Zooplankton. Night samples, as usual, are rich in their concentration. The highest value was observed at Jangira during April in a night sample. The minimum values were obtained at different places from December-February at different times. As usual copepods dominated in almost all the samples. Decapod larvae were fairly abundant in all the places where there is an influence of river system. January samples showed a peak for this group. Cladocerans were fairly good in November upto Ratnagiri, a zone where heavy mackerel landings were reported. Number of mackerel shoals were also observed in this zone. Chaetognaths representation was also fairly good followed by Medusae, Polychaete larvae, *Oikopleura* sp.

Pteropods, Amphipods, Ostracods, fish-eggs and larvae. Few specimens of *Gossea* sp. (hydro-medusae) were collected on 18.5.70 from Vengurla (day sample). *Gossea* is a new record for the Indian Ocean, if it will prove to be *G. brachymera* as our specimens have a close relationship to that. Otherwise it will be a new species.

Again from Vengurala in a night sample on 24.5.70 another hydromedusae, *Podocoryne ocellata* was recorded which is also probably a new record for the Indian Ocean. Further investigations on the validity of these two hydromedusae and other qualitative and quantitative aspects of zooplankton are in progress.

2) First Cruise of Blue-Fin

Report on the 1st cruise of 'Blue Fin'

Cruise No.	:	1
Cruise period & itinerary	:	24-2-70 to 26-2-70 Dep: Cochin 24-2-70 1640 hrs.
		Arr: Cochin 27-2-70 0700 hrs.
Area of operation	:	Off Kerala Coast; between Cochin and Quilon.
Ship Details	:	BLUE FIN (Overall length 28.45 m.; Displacement lightship 192 tons; 600-650 H. P.: Skipper: Shri K. Balan)
Participating organisations	:	i) National Institute of Oceanography
		ii) Central Institute of Fisheries Operatives.
Project personnel	:	Dr. T. S. Satyanarayana Rao, IOBC (Leader) Mr. M. Sakthivel, IOBC. Mr. P. Udayavarma Tirupad, POD. Mr. Ch. Madhusudana Rao, POD. Mr. T. Balachandran, IOBC Mr. K. K. Chandrasekharan Nair, IOBC. Mr. S. V. M. Abdul Rahim, IOBC. Mr. K. V. S. Murthy, CIFO. Mr. A. Subramanyam CIFO + 8 trainees of CIFO.
Object	:	1) To make a detailed study on the vertical distribution of zooplankton in relation to the thermocline depth; 2) To study the seasonal changes of zooplankton in relation to hydrographical changes; 3) To relate zooplankton distribution with DSL and fish abundance; and 4. Training of operative trainees of CIFO in handling of oceanographic equipment and collection of environmental data.

Study area : Three tracks were covered off Cochin, Alleppey and Quilon each with 4 stations and a deep sea station at 1000 m. off Quilon.

Weather : Clear throughout and slow moving swell.

Station List and observations : List attached.

Nansen bottles were operated at depths(rn) 10, 20, 30, 50, 75, 100, 150, 200 wherever possible for oxygen, salinity, temperature and phytoplankton samples. BT was operated to find out the depth of thermocline. The thermocline depth varied between 75 and 100 m. in the offshore area.

BT net was used to collect zooplankton samples by vertical hauls from bottom to surface; and from the depth of thermocline to surface. It was interesting to observe that the volume of zooplankton was rather high across the Quilon section rather than Alleppey and Cochin sections.

3) Cruise No. 6 of INS DARSHAK

Cruise period : February 3-11-1970

Area of operation : Bombay to Gulf of Cambay, India.

Itinerary : January 4 Depart Bombay
January 7-8 Occupy stations in the Arabian Sea off north-western part of India.
January 11 Return to Bombay.

Personnel : Dr. B. N. Desai, Scientist, NIO, Bombay (Leader)
Shri R. R. Nair. Scientist, NIO, Goa.
Shri K. Kameswara Rao, Junior Scientific Assistant, NIO. Bombay.

Object : To investigate hydrographical features. Biology and Geology of the Gulf of Cambay in the northwestern part of India.

Weather/Currents : Weather was clear during this cruise and there were no clouds. Sky was blue and the visibility very good. There were no strong currents.

Hydrographical studies : Measurements of surface and bottom temperatures, salinity and oxygen. The temperatures of surface waters at different stations had been observed to vary from 25 to 26°C and those of bottom waters at varying depths from 18.9 to 25.3°C. Similarly surface salinities ranged from 35.9 to 36.8%$_{O}$, those

of bottom waters from 36.1 to 36.6%**o**, oxygen from 4.8 to 5.8 ml/1 (surface) and that of bottom waters from 1.5 to 5.5 ml/1. The depth of water varied from 49 to 219 maters.

A continuous echosounding was made and an echogram of the cruise track for about 300 miles was obtained for the study of the nature of bottom profile. The echogram showed that the inner shelf was gently sloping and smooth with little topographic relief. The outer shelf in sharp contrast was highly irregular all the way to the shelf edge (140 meters) being composed of pinnacles, knolls with intervening depressions and was very similar to the topography commonly found in areas of reefs.

Sediments:

Area under investigation consisted of two very distinct sediment types. From the shore to a depth of 60 meters, designated as the inner shelf, the sediments were dominantly olive green silty clays with little calcareous matter. From 60 meters to a depth of 140 meters, designated as the outer shelf, carbonate rocks and sediments, the latter being composed of corals, oolites and shells of gastropods, Foraminifera were dominant.

Plankton

As in the previous cruise, it had been observed that some samples were rich in medusae and others were dominated by Copepods and Chaetognaths

BLUE FIN CRUISE

24-2-1970 to 26-2-1970

LOG

Station	Date	Lat.	Long	Sonic depth (metres)	Temp (°C)	Salinity	Oxygen	Zoopl. (HT Net)	Phyto-pl.	Type of haul	DURATION From	DURATION To	FLOW METER (TSK)	WIRE OUT (m)	COLL. Vol. Ml.	Remarks
1	24-2-70	09°56'N	76°04'E	27.4	+	+	+	+	+	Vertical	1943	1945	20	38	7.5	
2.	,,	09°53'N	75°55'E	41.2	,,	,,	,,	,,	,,	,,	2137	2141	140	50	1.5	
3.	,,	09°51'N	75°47'E	66.8	,,	,,	,,	,,	,,	,,	2255	2303	500	90	4.0	
4A.	25-2-70	09°48'N	75°39'E	182.9	,,	,,	,,	,,	,,	,,	0255	0315	1500	200	4.5	Thermocline
4B.	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	0330	0340	380	100	3.0	depth 100m.
5A.	,,	09°23'N	75°50'E	,,	,,	,,	,,	,,	,,	,,	0808	0828	2028	210	12.0	Thermocline depth 100m.
5B.	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	0834	0842	222	110	10.0	
6.	,,	09°25'N	75°58'E	64.1	,,	,,	,,	,,	,,	,,	1000	1005	213	75	3.0	
7.	,,	09°26'N	76°05'E	54.0	,,	,,	,,	,,	,,	,,	1105	1108	55	55	4.0	
8.	,,	09°28'N	76°11'E	29.3	,,	,,	,,	,,	,,	,,	1207	1209	35	30	6.0	
9.	,,	08°55'N	76°28.5'E	27.4	,,	,,	,,	,,	,,	,,	1609	1611	375	30	14.0	
10.	,,	08°53'N	76°20.5'E	53.4	,,	,,	,,	,,	,,	,,	1744	1747	520	60	8.0	
11.	,,	08°51'N	76°12.5'E	62.2	,,	,,	,,	,,	,,	,,	1918	1921	390	70	8.0	
12A.	,,	08°48.5'N	76°04.5'E	182.9	,,	,,	,,	,,	,,	,,	2118	2122	2035	220	12.0	
12B.	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	2140	2143	250	70	5.0	
13.	26-2-70	08°34'N	76°00'E	1006.5	nil	nil	nil	,,	,,	,,	1235	0120	7405	1105(30)	32.0	

Cruise No. 6

7th and 8th February, 1970

OCEANOGRAPHIC LOG SHEET

BOMBAY TO GULF OF CAMBAY

Station No.	Date & time	Geographic position		Depth water (m)	Wind Direction	Wind Force (in knots)	Pressure (Mbs)	Air tem. Dry °C	Air tem. Wet °C	Visibility	Waves	Seawater Temp. °C		Salinity ‰		Oxygen	
		Latitude (N)	Longitude (E)									surface	bottom	surface	bottom	surface	bottom
	February																
58(A)	1041/7th	18°55′.7	72° 22′.8	49	NNE	8	1012.0	27.7	23.3	b7	calm	26.3	25.0	35.9	36.1	5.0	4.9
59(B)	1350/7th	19°07′.0	71° 51′.9	77	NNE	8	1013.0	25.4	23.3	b5	calm	25.8	25.0	35.9	36.1	5.3	5.0
60(C)	1725/7th	19°19′.3	71° 22′.3	82	NNW	7	1013.0	25.4	23.2	b5	calm	25.3	24.7	36 2	36.1	5.3	5.0
61(D)	2035/7th	19°32′.2	70° 52′.3	85	NNW	9	1013.0	25.0	22.5	b5	calm	25.3	24.3	36.3	36.2	5.2	5.0
62(E)	0001/8th	19°07′.0	70° 22′.1	86	NNW	7	1013.0	24.2	21.1	b5	calm	24.7	24.0	36.6	36.3	5.5	5.3
63(F)	0300/8th	19°54′.5	69° 55′.6	86	NE	6	1014.0	24.4	22.7	b6	calm	25.6	25.3	36.6	36.4	5.8	5.5
64(G)	0605/8th	20°05′.4	69° 28′.7	219	NE	11	1015 0	26.1	21.1	b7	2 ft.	25.6	21.7	36.3	36.2	5.4	1.5
65(H)	0910/8th	20°30′.6	69° 18′.7	183	NNE	6	1013.0	25.3	21.4	b7	1 ft.	25.0	18.9	36.7	36.5	5.6	1.5
66(J)	1248/8th	20°36′.9	69° 44′.5	82	SW	6	1013.0	25.6	22.5	bc6	2 ft.	25.3	24 9	36.8	36.6	5.0	4.4
67(K)	1545,8th	20°14′.9	69° 52′.0	73	NNW	7	1015.0	25·8	23.1	b5	2 ft.	25.0	24.4	36.5	36.2	5.5	5.3
69(L)	1825/8th	20°22′.2	70° 18′.2	73	NW	6	1015.0	24.4	22.5	b5	2 ft.	24.7	24.2	36.3	36.2	4.8	4.8

3.

administrative set up

3.1 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 Department 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 Director National Atlas Organization 1, Acharya Jagadish Bose Road Calcutta - 20	—	,,
5. Shri C. V. Gole Director Central Water and Power Research Station Govt. of India 20, Bombay Poona Road, Poona-3	—	,,
6. Prof. R. Ramanadham Professor of Meteorology and Oceanography Andhra University Waltair (A. P.)	—	,,

7. Shri S. K. Ranganathan — Member
Deputy Director
Naval Science & Technology
R & D Organization
Ministry of Defence
New Delhi

8. Director-General — Ex-Officio-Member
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.

3.2 SUB-COMMITTEES OF THE EXECUTIVE COUNCIL*

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 and 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 & Technolngy
6. Director, NIO - Convener

II. *Building & Finance Sub-Committee*

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

III. *Ship Facilities Sub-committee*

L Chief Hydrographer to the Govt. of India
2. Commodore I. K. Puri, I. N. (Retd)
3. Shri M. C. Perumal, Director, Central Instt. of Fisheries Operatives
4. Shri M. Devidas Menon, Director, Indo-Norwegian Project.
5. Director, NIO - Convener

3.3 BUDGET

The Budget of the Institute for the year 1969-70, is as given below :

Budget Item	Sanctioned (Rs. in lakhs)	Actual (Rs. in lakhs)
1. Recurring	12 048.	11.775
2. Capital	6.344	6.276
Total	18.392	18.051

3.4 SCIENTIFIC & TECHNICAL STAFF

NIO Headquarters, Biological Oceanography Unit, Panaji, (Goa)

Director
Dr. N. K. Panikkar

Scientist
Dr. P. V. Dehadrai

Senior Scientific Assistant
Shri S. A. H. Abidi

Senior Technical Assistant
Shri R. M. S. Bhargava

Research Fellow
Shri R. A. Selvakumar

Pool Officer
Dr. A. B. Wagh

Indian National Oceanographic Data Centre, Panaji

Scientist-in-charge
Sri R. Jayaraman

Scientists
Dr. S. N. Dwivedi (on deputation to Laos)
Shri S. P. Anand
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

Senior Draftsman
Shri D. R. Mongia

Physical Oceanographic Division, Panaji

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

Scientists
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

Unit of Physical Oceanography Division, Cochin.

Scientist-in-chargc
Shri P. S. Srivastava

Scientists
Shri V. S. Rama Raju

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

Senior Research Fellow
Shri V. Narayana Pillai

Junior Research Fellows
Shri Thomas Cherian
Shri A. Balachandran

Geological Oceanography Division, Panaji, Goa

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

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

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

Junior Research Fellows
Shri M. V. Shankaranarayana Gupta
Shri M. Veeraya
Shri B. G. Wagle

Shri R. S. Murali

Biological Oceanography Division, Cochin

Scientist- in-charge
Dr. S. Z. Qasim

Scientists
Dr. M. Krishnan Kutty
Shri C. V. G. Reddy
Dr. C. Sankarankutty

Senior Scientific Assistant
1. Shri B. M. Panikkar
2. Shri P. M. A. Bhattathiri
3. Shri V. P. Devassy

Senior Technical Assistant
1. Shri U. K. Gopalan

Research Fellows
Shri V. N. Sankaranarayanan
Shri P. Sivadas

Indian Ocean Biological Centre, Cochin

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

Scientists
Shri L. R. Kasturirangan
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
., Jacob George
„ George Peter
„ V. T. Paulinose
Shrimati Vijayalakshmi R. Nair
Shri T. Balachandran
Shrimati C. B. Lalithambika Devi
Shri T. C. Gopalakrishnan
„ K. K. Chandrasekharan Nair
Shrimati V. Santhakumari
Shri Pramodkumar S. Gore

Research Fellows

Dr. N. Ravindranatha Menon
Shri S. C. Goswami
„ S. Subramanian

4. Library & Documentation

The library facilities are available at all the divisions of the Institute. There is a common library for all the divisions at Ernakulam. In all, the library of the institute is having 4000 books on various disciplines of Marine Science and it is receiving 85 journals and periodicals from all over the world.

The library receives and issues books and periodicals on inter-library loan basis with the libraries of the various institutions in the country. The copies of acquisition list (consisting of newly purchased books) are periodically distributed among scientific staff to keep them informed of the additions to the library.

Documentation work has been in progress on the following lines:

1. Survey of the papers and articles published on various disciplines of Marine Sciences by Indian authors from 1957-1969, was made to explore the possibilities of starting a *'Journal of Marine Sciences'*. The findings were sent to the Chief Editor, Publication & Information Director, New Delhi for assessment.
2. The bibliographical details of papers & articles on Indian Ocean by Indian and foreign authors for the year 1969-70 were obtained and a *'Selected Bibliography'* on the Indian Ocean, 1969 was completed and published in Deceber 1969 issue of "MAHASAGAR", the quarterly bulletin of the Institute Vol. 5 No. 4,1969.
3. Documentation service was started in the form of Documentation list of current scientific papers and cyclostyled copies of the same were periodically distributed among the Scientific Staff. The work is being continued.

5. AWARDS, HONOURS, MEMBERSHIP OF VARIOUS COMMITTEES

Dr. S. Z. Quasim, Scientist has been awarded a Commonwealth Visiting Professorship in the United Kingdom for the academic year 1970-71.

6. DEPUTATIONS

Dr. N. K. Panikkar. Director went on deputation to France on 2nd September 1969, to participate in Session IV of the Intergovernmental Oceanographic Commission held in Paris. He was elected as Chairman of Working Group on Mutual Assistance. He was also elected Vice-Chairman of the Committee which dealt with problems relating to long term and expanded programme of oceanographic research' and the International Decade of Ocean Exploration.

Shri V. S. Ram Raju, Scientist was deputed to West Germany for three months from November 1969 to January 1970 for advanced training in Physical Oceanography under Exchange Programme between CSIR and German Academic Exchange Service.

Shri C. V. Gangadhara Reddy, Seientist went on deputation to the United Kingdom from May to August, 1969, for studying the latest techniques in Chemical Oceanography under the CSIR — British Council (U.K.) Exchange Programme.

Shri P. Gopala Menon, Scientific Assistant went on deputation to work with the Senior specialist for Decapod larvae, Dr. D. I. Williamson, Marine Biological Laboratory, Port Erin, Isle of Man, U. K. under UNESCO Travel Grant in January 1970.

Shri George Peter, Scientific Assistant, was deputed for practical training in specialised plankton study in British Museum under UNESCO fellowship, Jan-May 1969.

Shri Jacob George, Scientific Assistant, went on deputation for the special course in Marine Biology, Denmark, training at British Museum and at Manchester University under UNESCO Fellowship, April-July 1969.

7. MEETINGS, EXHIBITIONS, SEMINARS, SYMPOSIA ETC.

Meetings:

The 8th Annual meeting of Consultative Committee for Indian Ocean Biological Centre was held from 16th to 21st March, 1970 at IOBC. Dr. J. E. Smith, F. R. S, Director, Marine Biological Laboratory, Plymouth, (U. K.) and Chairman of the Committee presided.

Exhibition

Although the Institute did not organise any exhibition during the year under report,

the IOBC participted in the exhibition conducted during the symposium on 'Deep Sea Fishing' held at the Central Institute of Fisheries Operatives, Ernakulam by putting up some charts depicting the distribution of fish eggs and larvae in the Indian Ocean.

Seminar

A seminar on Monsoonal changes in the Zooplankton of the Cochin backwaters was held in July !969. The details of the participants are given as under.

Sl. No.	*Names of Participants*	*Subject*
1.	Dr. S. Z. Qasim	Survey of the work at BOD
2.	Dr. T. S. S. Rao	Survey of the work done in all the other coastal areas of India.
3.	Mr. P. S. Srivastava	A few oceanographic equipment used in estuarine studies
4.	Dr. N. R. Menon & Mr. S. C. Goswami	Fortnightly changes at two fixed stations.
5.	Mr. P. Venugopal & Dr. N. R. Menon	Tintinnids
6.	Dr. (Mrs) Saramma Abraham	Systematics of *Acartia*
7.	Mr. D. J. Tranter	Ecology of *Acartia*
8.	Mr. K. C. Nair & Mr. D. J. Tranter	Biomass and faunistic changes along the salinity gradient in the two seasons.
9.	Mrs. Vijayalakshmi R. Nair & Dr. T. S. S. Rao	Chaetognaths
10.	Mrs. V. Shantakumari	On Hydromedusae
11.	Mr. V. P. Devassy	Faunal studies in the backwaters
12.	Mr. K. J. Peter & Mr. T. O. Chandrabhanu	Fish eggs and larvae
13.	Mr. Abraham Pylee	An Instrument for use in backwaters
14.	Mr. V. N. Pillai	Origin of backwaters and salinity gradients Vembanad
15.	Dr. T. S. S. Rao & Mr. D. J. Tranter	Future programme of research at IOBC

Symposia

First all India Symposium on Estuarine Biology held at Tambaram, Madras on December 27-30, 1969 was attended by several scientists. The list of participants from the Institute and papers read by them is given below.

Sl. No.	*NIO Participants*	*Papers contributed*
I.	Padmakar V. Dehadri	Changes in the environmental features of Zuari and Mandovi esturies in relation to tides.

2.	Saramma Abraham	A preliminary systematic survey of the family Acartiidae with special reference to Cochin backwater.
3.	N. Ravindranatha Menon P. Venugopal & S. C. Goswami	Tidal biomass and faunistic composition of the zooplankton in the Cochin backwaters.
4.	V. Santhakumari & M. Vannucci	Monsoonal fluctuations in the distribution of the Hydromedusae in Cochin backwaters 1968-69.
5.	K. K. C. Nair & D. J. Tranter	Zooplankton distribution along salinity gradient in the Cochin backwaters before and after the monsoon.
6.	M. Saraswathy	The period and nature of settlement of shipworms in Cochin backwaters, a tropical estuary on the South West coast of India.
7.	N. Ravindranatha Menon	Vertical and horizontal distribution of fouling bryozoans in Cochin backwaters.
8.	Vijayalakshmi R. Nair	Seasonal fluctuations of Chaetognaths in the Cochin backwaters.

8. COLLOQUIA AND SPECIAL LECTURES

The following lectures were delivered by distinguished visitors to the IOBC.

Sl. No.	*Names*	*Subject of Lectures*
1.	Dr. Erik Hagmeier	On Research Activities in Indonesia and Helgoland
2.	Dr. Robert G. Wear	(i) Current marine research activities and fisheries development in New Zealand (ii) Decapod larvae and related research work at the Victoria University, New Zealand.
3.	Prof. G. E. Fogg	Antarctic Productivity
4.	Dr. Allen Munro	Some aspects of the Biology of sandy shores.
5.	Dr. John Wells	
6.	Dr. J. E. Smith	Some problems of marine pollution
7.	Dr. M. Seyaert	Research on the phytoplankton ecosystem in the subtropical zones.
8.	Dr. M. Omori	A commercially important Sergestid Shrimp *Sergestes lucens* Hansen, its biology and forecasting for fisheries.
9.	Prof. B. Kimor	Some aspects of plankton associations in the eastern Mediterranean.
10.	Prof. T. S. Rass	Geographical examples in world fisheries
11.	Dr. A. Fleminger	Maintenance of distribution and range among boundary current Copepods.

9. DISTINGUISHED VISITORS

Dr. John D. Issacs,	Scripps Institution of Oceanography La Jolla, California, USA.
Mary Carol Issacs,	Scripps Institution of Oceanography La Jolla, California, USA.
Prof. G. Krishnan.	Director, Zoology Laboratory University of Madras. Madras
Mr. Willian B. Cox,	Geographic Attache, American Embassy, New Delhi
Dr. Erik Hagmeier,	Biologische Anstalt. Helgoland, W. Germany
Prof. V. J. Mathew,	Professor of Zoology, St. Philomena's College Mysore.
Dr. K. J. Joseph,	Professor of Zoology, University of Calicut, Calicut.
Prof. G. E. Fogg,	Westfield College, London. NW. 3.
Prof. S. Dutt,	Department of Zoology, Andhra University, Post graduate Centre, Guntur—5
Prof. T. S. Rass	Institution of Oceanography. Academy of Sciences. Moscow, USSR.
Dr. A. Fleminger,	Scripps Institution of Oceanography. La Jolla, Calif, USA
Dr. M. Steyaert	UNESCO Office of Oceanography, Paris. France
Prof. B. Kimor	Sea Fisheries Research Station, Haifa, Israel
Mr. J. M. Howe	UNESCO Liaison Officer, New Delhi—3
Dr. M. Omori.	Ocean Research Institute, University of Tokyo, Japan
Dr. J. E. Smith	Director. The Laboratory of the Marine Biological Association, Citadel Hill. Plymouth.

At the Annual Day Celebrations of the Regional Centres of NIO, Cochin - Dr. M. Vannucci distributing prizes to winners.

10

publications

10.1 PUBLICATIONS OF THE INSTITUTE

1. Annual Report 1968-69

2. Quarterly Bulletin of the Institute. "MAHASAGAR" Vol. 2 No. 1 to 4.

10.2 PAPERS PUBLISHED BY STAFF MEMBERS

ARAVINDAKSHAN P. N. 1969
Preliminary report on the geographical distribution of the species of *Carinariidae* and *Pterotracheidae* (Heteropoda. Mollusca) from the International Indian Ocean Expedition. *Bull. natn. lnst. Sci. India.* 38 Pt. II : 575-584

DESAI. B. N. AND M. KRISHNANKUTTY, 1969
Comparison of the marine and estuarine benthic fauna of the nearshore regions of the Arabian Sea. *Bull. natn. lnst. Sci. India.* 38 pt. 11: 677-683

GEORGE, M. J. 1969.
Systematics-Taxonomic considerations and general distribution. In 'Prawn Fisheries of India'. *Bull Cent. Mar. Fish. Res. Inst.* 14: 5-48

GEORGE, M J. 1969.
Genus *Metapenaes* Wood Manson and Alcock 1891 *Bull Cent Mar. Fish. Res. Inst.* 14: 77-126

GEORGE, M. J. 1969.
Genus *Microbrachium* Bate 1868 *Bull. Cent. Mar. Fish. Res. Inst. 14:* 179-216

GEORGE, M. J. 1969.
Two new records of scyllarid lobsters from the Arabian Sea *J. mar. biol. Ass. India.* 9(2) : 433-435

GOPALAN, U. K. 1969
Studies on the maturity and spawning of Silver pomfret, *Pampus argenteus* in the Arabian Sea *Bull. natn. Inst. Sci. India.* No. 38, pt. II: 785 796

KAMESWARA RAO, K. 1970.
On a little known miliolid foraminifera from northeastern part of the Arabian Sea. *Curr. Sci.* 39 (4) : 87

KRlSHNAN KUTTY, M. AND S. Z. QASIM 1969.
Theoretical yield studies on the large scale tongue sole. *Cynoglossus macrolepidotus* from the Arabian Sea. Bull. natn. *Inst. Sci. India* 38 pt. II: 864-875

MENON, N. RAVINDRANATHA AND NAIR, N. BALAKRISHNAN. 196S.
Rediscovery of Bugulella *clvata Hincks* (Ectoprocta) *curr. Sci.* 38: 439-440

MENON, N. RAVINDRANATHA AND NAIR, N. BALAKRISHNAN. 1969.
Notes on *Alcyonidium erectum* Silen (Ectoprocta) from the Indian Oecan *Curr.* 38 116—117

MURTY, P. S N.. CH M. RAO, AND C. V. G. REDDY. 1969.
Distribution of nickel in the marine sediments of the west coast of India. *Curr. Sci.* 39 (2): 30-32

MURTY, P. S. N . REDDY, C. V. G. AND V. V. R. VARADACHARI 1969
Distribution of organic matter in the marine sediments off the west coast of India. *Proc. natn. Inst. Sci. India* 35 (5) B. 377—384

PANIKKAR, N. K. 1969
Developments in Indian Marine Fisheries. Fisheries of Western Indian Ocean. Science and Industry International year book 1968 U. S. S. R. : 92—101

PANIKKAR, N. K. 1969
Fishery resources of the Indian Ocean *Bull. natn. Inst. Sci India.* 38 pt II : 667—673

QASIM, S. Z. AND
C. K. GOPINATHAN, 1969
Tidal cycle and the environmental features of Cochin backwater (a tropical estuary). *Proc. Indian. Acad. Sci.* 69 : 336—348

QASIM, S.Z., S. WELLERSHAUS,
P. M. A. BHATTATHIRI,
AND S. A. H. ABIDI, 1969.
Organic production in a tropical estuary. *Proc. Indian Acad. Sci.* 69 : 51—94

RAO, M. SUBBA AND
Ch. M. RAO, 1969
A preliminary note on sedimentation during a single tidal cycle on the Waltair beach. *Geological review of India.* 31 (3): 41—45

SAKTHIVEL, M. 1969
A preliminary report on the distribution and relative abundance of Euthecosomata with a note on the seasonal variations of *Limacina* species in the Indian ocean. *Bull. natn. Inst. Sci. India.* 38 pt II: 700—717

SANKARANARAYANAN,
V. N. AND S. Z. QASIM, 1969.
The influence of some hydrographical factors on the fisheries of Cochin area. *Bull, natn. Inst. Sci. India* No. 38 pt. II: 846—853

SANKARANARAYANAN,
V. N., AND S. Z. QASIM, 1969.
Nutrients of the Cochin Backwaters in relation to environmental characteristics *Mar. Biol.* 2 (3) : 236—247

SANTHAKUMARI, V. AND
N. BALAKRISHNAN, NAIR,
1969.
A Commensalic hydroid from marine woodboring molluscs. *J. nat. Hist.* (London) 3(1) : 19-33

SANTHAKUMARI, V. 1970.
On the life cycle of *Eutima cammensalis*-sp. nov. (Eutimidae, Hydromedusae) *Mar. Biol.* 5(2): 113-118

SARASWATHY, M. AND
N. BALAKRISHNAN NAIR
1969
Biochemical changes in relation to the breeding cycle of *Nausitora hedleyi* Schepman (Bivalvia Teredinidae) *Curr. Sci.* 38(7): 158-160

UNNITHAN, R. V. 1970
Patterns of secondary growth and a revision of systematics in Microcotylidoidea and Gastrocotylidae (Monogenoidea). *Rec. Z. S. I.* 64.

VARMA, P. U. AND
P. G. KURUP, 1969.
Formation of Chackara (mud bank) on the Kerala Coast *Curr. Sci.* 38 (23) : 559-560

WELLERSHAUS, STEFAN, 1969
On the Taxonomy of Planktonic copepoda in the Cochin Backwaters (a south Indian Estuary), *veroo ffentlichungen des Institute furr Meeresforschung in Bremerhaven Band* XI :245-286

*Exchange programme Scholar from West Germany at the Biological Oceanography Division of NIO, Cochin.

ERRATA

Page	*Column*	*Line*		*Read*
10	1	7 (from bottom)	Magalore	Mangalore
11	2	3 (from bottom)	Auguest	Auguest
12	1	12	medium of	medium to
16	2	15 (from bottom)	photosynteesis	photosynthesis
17	2	10	absorptian	absorption
22	1	24	froms	forms
23	1	9	ocbr	ober
24	2	13 (from bottom)	dominat	dominant
27	2	2	stuctures	structures
29	2	11	trubidity	turbidity
36		4	maters	meters
40	2	18 (from bottom)	Technology	Technology
43	1	8	Director	Directorate
43	1	17 (from bottom)	Quasim	Qasim
44	1	1 (from bottom)	Dehadri	Dehadrai
47	2	15	Quasim	Qasim
47	2	13 (from bottom)	Curr. 38	Curr. Sci. 38