# INTERNATIONAL INDIAN OCEAN EXPEDITION

NEWSLETTER

Vol. III No. 4 INDIA March, 1966

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THE INDIAN NATIONAL COMMITTEE ON OCEANIC RESEARCH
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COVER PHOTO

Dr. P.V. Cherian, Governor of Maharashtra formally inaugurating the Training Programme in Oceanography at Bombay.

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## IN THIS ISSUE



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# INTERNATIONAL INDIAN OCEAN EXPEDITION

## NEWSLETTER

## INDIA

Vol. III No. 4 MARCH, 1966


### INDIAN PROGRAMME

### UNESCO—NATIONAL INSTITUTE OF OCEANOGRAPHY (CSIR) TRAINING PROGRAMME IN OCEANOGRAPHY

The inauguration of the training programme in Oceanography jointly sponsored by UNESCO-National Institute of Oceanography (referred in this News letter Vol. III No. 2) was held in the auditorium of the Bombay Natural History Society Hornbill House, Bombay, on 21st January, 1966. Dr. P. V. Cherian, Governor of Maharashtra who was the chief guest at the occasion formally declared the course open. This project is the outcome of India's activities in oceanography which received much impetus as a result of participation in the International Indian Ocean Expedition. The newly established National Institute of Oceanography (CSIR) attached great importance to the organisation of this training programme as it is an essential pre-requisite for promoting the growth of marine Science in India as well as in the neighbouring countries. The course was directed by Dr. N. K. Panikkar, Director, National Institute of Oceanography, in association with Dr. David A. McGill, Woods Hole Oceanographic Institution, U.S.A. who was also one of the special instructor in physical and chemical Oceanography.

In this training, 20 candidates from various institutions and universities in India and 5 from Ceylon, Malaysia, Singapore and Thailand participated. Following the inauguration there was a four-weeks course in general Oceanography in Bombay, after which the trainees were divided into four groups for a two-weeks specialised training in Physical, Chemical, Biological and Geological Oceanography. The Geological group received this part of the training in Waltair and the Biological group in Cochin while the physical and chemical groups continued to undergo training in Bombay. A team of 30 Scientists, from India and 11 Scientists from various other countries gave a total of about 90 lectures covering almost all the aspects under the different disciplines of oceanography. The lectures were illustrated by films and lantern slides.

A number of Institutions in Bombay, Cochin and Waltair co-operated by providing laboratory facilities and facilities for field work during this course. Among them special mention is made of: the Atomic Energy Establishment Trombay, Tata Institute of Fundamental Research, International Meteorological Centre and Directorate of Fisheries, Maharashtra in Bombay; Geology Department, Andhra University in Waltair, Oceanographic Laboratory, Kerala University, Fisheries Research Establishments of Government

of India and the various divisions of National Institute of Oceanography in Cochin. Training Cruises were undertaken on board *INS KISTNA* of Indian Navy, *R. V. Varuna* of Indo-Norwegian Project and *R. V. Mysis* of Fisheries Department of Maharashtra.

Informal seminars by participants and field trips of scientific interest were also part of this programme.

At the concluding session of the training held in the Multipurpose Hall of the Prince of Wales Museum, Bombay on 5th March, 1966, Dr. S. Husain Zaheer, Director General, Council of Scientific & Industrial Research, distributed certificates to the trainees. Dr. R. L. Fisher of the Scripps Institution of Oceanography, who was also the chief instructor in geology delivered the valedictory address. Dr. A. G. Evstafiev, Director, UNESCO, South Asia Science Cooperation office, Shri Prem Kirpal, Secretary, Ministry of Education, Government of India and Secretary General, Indian National Commission for UNESCO and Dr. N. K. Panikkar who spoke on the occasion stressed the significance and further need for such training programmes in this region. Mr. Khoo Hong Woo, a trainee from Singapore spoke on behalf of the participants expressing great satisfaction on the training received.

This training course which brought together scientists of various disciplines on a common platform is significant as it offered an occasion to establish contacts and understanding among young workers in the field of oceanography, a multidisciplinary science. Particulars regarding the trainees and instructors participated in this training are given below:—

**Dr. S.H. Zaheer presenting the certificate to one of the trainees at the concluding session of the Training Programme in Bombay. In the centre is Dr. N.K. Panikkar Director of the Training Programme.**

## TRAINEES

### Group I Physical Oceanography

| S. No. | Name | Country | Department/Institution |
|---|---|---|---|
| 1 | 2 | 3 | 4 |
| 1. | Shri P. K. Das | India | Physical Oceanography Division, National Institute of Oceanography, Ernakulam. |
| 2. | ,, G. Subba Raju | ,, | -do- |
| 3. | ,, G. R. Lakshmana Rao | ,, | Dept. of Meteorology and Oceanography Andhra University, Waltair. |
| 4. | ,, Panakala Rao | ,, | -do- |
| 5. | ,, L. V. Gangadhara Rao | ,, | Planning & Data Division. National Institute of Oceanography, N. Delhi. |
| 6. | ,, K. V. Sriramamurthy | ,, | Indian Naval Physical Laboratory, Cochin. |
| 7. | ,, V. R. Narella | ,, | Atomic Energy Establishment, Trombay. |

### Group II Chemical Oceanography

| | | | |
|---|---|---|---|
| 8. | Shri G.P. Basu Chaudhury | ,, | Geological Survey of India, Calcutta. |
| 9. | ,, P. Udaya Varma Thirupad | ,, | Physical Oceanography Division of National Institute of Oceanography, Ernakulam. |
| 10. | ,, S. R. Vijayaraghavan. | ,, | Marine Biological Station, Porto-Novo. |
| 11. | ,, S. R. Rao | ,, | Atomic Energy Establishment, Trombay. |

### Group III Biological Oceanography

| | | | |
|---|---|---|---|
| 12. | Shri U. K. Gopalan | ,, | Planning and Data Division, National Institute of Oceanography, New Delhi |
| 13. | ,, R. M. S. Bhargava | ,, | -do- |
| 14. | ,, S. A. Abidi | ,, | Biological Oceanography Division, National Institute of Oceanography Ernakulam. |
| 15. | ,, D. H. Mhasawade | ,, | Dept. of Fisheries, Maharashtra, Bombay. |
| 16. | Mr. Direk Dhamaniyom. | Thailand | Deptartment of Fisheries, Bangkok. |
| 17. | ,, Tongsueb Taweesith. | ,, | -do- |
| 18. | ,, Khoo Hong Woo | Singapore | Fishery Biology Unit, Zoology Dept. University of Singapore. |
| 19. | ,, A. S. Mendis | Ceylon | Dept. of Fisheries, Colombo. |

### Group IV Geological Oceanography

| | | | |
|---|---|---|---|
| 20. | Shri P. R. Chandra | India | Geological survey of India, Calcutta. |
| 21. | ,, T. V. Viswanathan | ,, | -do- |
| 22. | ,, P. S. N. Murthy | ,, | Physical Oceanography Division, National Institute of Oceanography, Ernakulam. |
| 23. | ,, Madhusudana Rao | ,, | Department of Geology, Andhra University, Waltair. |
| 24. | ,, B. Venkatanarayana | ,, | National Geophysical Research Institute, Hyderabad. |
| 25. | ,, Santokh Ditt Singh | Malaya | Geological Survey, Ipoh. |

## Particulars of Lectures Delivered by Various Scientists at Bombay in General Oceanography-I

| S. No. | Name of Lecturer | Department/Country | No. of lectures delivered. | Subject of lectures. |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| 1. | Dr. D. A. McGill. | Woods Hole Oceanographic Institution (WHIO) USA. (Associate Director of the Training Programme) | 7 | On various aspects of Physical and Chemical Oceanography. |
| 2. | Dr. V. V. R. Varadachari. | National Institute of Oceanography, Physical Oceanography Division, Ernakulam. | 11 | On various aspects of Physical Oceanography. |
| 3. | Dr. E. Brinton. | Curator, Indian Ocean Biological Centre, Ernakulam (SIO-USA) | 4 | On various aspects of Planktonology. |
| 4. | Dr. T. S. S. Rao. | National Institute of Oceanography, Bombay. (Deputy Director of the Training Programme) | 5 | On Marine Biology. |
| 5. | Dr. N. K. Panikkar. | National Institute of Oceanography, New Delhi (Director of the Training Programme) | 4 | On International aspects of Oceanography—IIOE. Laws of the Seas. Osmotic and Ionic regulation in aquatic animals and world fisheries. |
| 6. | Dr. S. Z. Qasim. | National Institute of Oceanography, Biological Oceanography Division, New Delhi. | 2 | Organic Production of the Marine food Chain. |
| 7. | Shri. R. Jayaraman. | National Institute of Oceanography, Planning & Data Division, New Delhi. | 1 | Distribution of dissolved gases especially Oxygen in Indian Ocean. |
| 8. | Dr. S. N. Dwivedi. | -do- | 1 | Racial studies in fishes. |
| 9. | Shri. Krishnaswami. | Tata Institute of Fundamental Research, Bombay. | 2 | Trace elements in Sea Water. |
| 10. | Dr. D. P. Kharkar. | Tata Institute of Fundamental Research, Bombay. | 2 | Geochemical Studies in the Marine environment. Date of Ocean sediments. |
| 11. | Dr. Rama. | -do- | 2 | Radionuclides in the Sea. |
| 12. | Dr. R. Viswanathan. | Atomic Energy Establishment, Trombay—Bombay. | 3 | Biological uptake of nuclides from sea water. Chemistry of dissolved & Particulate Matter in Sea and Studies involving $C^{14}$ as a tracer. |
| 13. | Dr. A. K. Ganguly. | -do- | 2 | Project Marina at the Atomic Energy Establishment, Trombay—Bombay. |
| 14. | Dr. B. S. Patel. | -do- | 2 | Radioecology of Marine environment, Effects of Temperature and Salinity, on Marine Organisation. |
| 15. | Dr. H. M. Iyer. | Atomic Energy Establishment, Bangalore. | 2 | Waves & Microseisms and Sea level & Tides. |
| 16. | Dr. C. V. Kulkarni. | Deptt. of Fisheries, Govt. of Maharashtra, Bombay. | 1 | Fishery resources of Maharashtra. |
| 17. | Dr. H. G. Kewalramani | -do- | 1 | Aquariology & Culture of Fishes. |

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| 18. | Mr. Edelman. | Food & Agriculture Organisation, Expert, Attached to Central Marine Fisheries Research Instt. Bombay. | 1 | Some problems in Oceanography. |
| 19. | Shri M.S. Narayanan. | Indian Naval Physical Laboratory, Cochin. | 1 | Propogation of Sound in the Sea. |
| 20. | Dr. Sukheshwala. | St. Xaviers College, Bombay. | 1 | Geology of Bombay & its surroundings. |
| 21. | Dr. (Miss) Y. Frietas. | -do- | 1 | Basic Microbiology. |
| 22. | Prof. N. K. Velankar. | Central Institute of Fisheries Education, Bombay. | 2 | Role of bacteria in the ecology of Ocean |
| 23. | Dr. E. V. Chelam. | International Meteorological Centre, Bombay. | 1 | Air-Sea Interaction. |
| 24. | Shri D. R. Sikka. | -do- | 1 | Climatology in relation to Oceans. |
| 25. | Dr. R. L. Fisher. | Scripps Institution of Oceanography, USA. | 11 | On various aspects of marine Geology and Geophysics with special reference to Scripps expeditions. |
| 26. | Dr. U. Aswathanarayana | Department of Geology, Andhra University, Waltair. | 4 | On History, Evolution, and age determination of Ocean basins. |

**AT WALTAIR FOR GEOLOGY**

| | | | | |
|---|---|---|---|---|
| | Dr. M. P. Rao. | Department of Geology, Andhra University, Waltair. | 2 | Continental shelf sediments and sedimentation in the Bay of Bengal along the east coast of India.<br>Submarine Canyons, their distribution and origin. |

## AT ERNAKULAM IN BIOLOGICAL OCEANOGRAPHY

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| 1. | Dr. McGowan | Scripps Institution of Oceanography (U.S.) | 1 | Biogeography of Plankton (Energy levels) |
| 2. | Dr. Wellershaus | German Scientist, Attached to Biological Oceanography Division, National Institute of Oceanography, Ernakulam. | 1 | Oceanography of Estuarine waters. |
| 3. | Dr. R. S. Glover. | Oceanographic Laboratory, Edingburgh, United Kingdom. | 1 | Biogeography of Plankton. |
| 4. | Prof. J. Krey. | Kiel University, West Germany. | 1 | Vertical distribution of microplankton. |
| 5. | Mr. D. Tranter. | CSIRO, Australia. | 1 | Seasonal Studies in the Indian Ocean. |
| 6. | Dr. G. Hempel. | UNESCO office of oceanography (Paris). | 1 | Significance of distribution of Fish eggs and larvae in Fisheries. |
| 7. | Dr. R. Fenaux. | French Scientist Visiting Scientist at the Indian Ocean Biological Centre Ernakulam. | 1 | Appendicularians of the Indian Ocean. |

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| 8. | Dr. S. Z. Qasim. | Biological Oceanography Division, National Institute of Oceanography, Ernakulam. | 1 | Hydrography & productivity of backwaters of Kerala |
| 9. | Dr. M. Krishnankutty. | -do- | 1 | Fish Populations. |
| 10. | Prof. C. V. Kurian. | Kerala University, Ernakulam. | 1 | Bottom fauna of west coast of India. |
| 11. | Dr. R. Raghu Prasad. | Central Marine Fisheries Research Institute, Ernakulam. | 1 | Productivity measurements in Indian Ocean. |
| 12. | Dr. B. N. Desai. | Biological Oceanography Division, National Institute of Oceanography, Ernakulam. | 1 | Sea weeds of economic importance and their distribution. |
| 13. | Dr. N. B. Nair. | Kerala University, Ernakulam. | 1 | Marine boring organisms and marine fouling. |
| 14. | Shri A. I. George. | Indo-Norwegian Project, Ernakulam. | 1 | Exploration of the fishery resources in the programme of Indo-Norwegian project. |
| 15. | Prof. P. N. Ganapati. | Andhra University, Waltair. | 2 | Hydrography of Godavari Estuary and Ecology of interstitial fauna. |

## INDIAN OCEAN BIOLOGICAL CENTRE, ERNAKULAM

### Consultative Committee Meeting.

The fourth meeting of the consultative Committee for Indian Ocean Biological Centre was held in Delhi and Cochin between 23-25 February and 1-3 March, 1966. Reports reviewing the administrative aspects and scientific activities of the centre were presented before the committee by the Director and Curator. In general, the highlights of the meeting were the discussion on the future of International collections after the International Indian Ocean Expedition and the various aspects regarding the specialist analysis and research work envisaged on these collections.

So far Indian Ocean Bilogical Centre has been mainly functining as a sorting centre and repository for international collections of Zooplankton where the training in sorting methods was imparted to scientific staff under the guidance of UNESCO Curator besides acquainting the senior sorting staff to the research problems relating to the planktonology of Indian Ocean. The sorting of the present collection is likely to be completed by the end of the 1967; then the centre may take up a vigorous research programme on the taxonomic, ecological and biogeographical aspects. A list of taxonomists who might be invited to collaborate in the analysis of International collections was circulated among the consultative committee members by R.S. Glover and S. Krishnaswamy. The working paper prepared by R. Prasad and L. R. Kasturirangan on the future of the IOBC, emphasised the need for further increasing the scientific man-power, and facilities and re-allocation of responsibilities of the existing staff in view of shifting to research.

Other important topics taken up for discussion included the routine sorting of International collections, preparation of IIOE atlases, International Indian Ocean Expedition, and Fourth Session of intergovernmental Oceanographic

commission. The Committee elected Prof. J. Krey (W. Germany) as the Chairman, whose terms as members of the Committee have expired.

The following is the list of participants:—

| | | |
|---|---|---|
| 1. | Mr. R. S. Glover (U.K.) | Chairman. |
| 2. | Prof. J. Krey, (W. Germany) | Member. |
| 3. | Prof. McGowan (U.S.A.) | Member. |
| 4. | Dr. M. E. Vinogradov (USSR) | Member. |
| 5. | Mr. D. Tranter (Australia) | ,, |
| 6. | Dr. E. Brinton (U.S.A.) | Representing IOBC |
| 7. | Dr. N. K. Panikkar (India) | ,, SCOR |
| 8. | Dr. R. Prasad. (India) | Indian Advisory Board. |
| 9. | Dr. K. K. Tiwari (India) | ,, |
| 10. | Dr. G. Hempel. (Paris) | UNESCO |
| 11. | Dr. Allan Be | Marin Scientist, Observer |
| 12. | Dr. R. Serene | Marine Science Expert, Observer. |
| 13. | Shri R. Jayaraman (India) | Representing N. I. O. |
| 14. | Dr. S. N. Dwivedi (India) | ,, |
| 15. | Mr. L. R. Kasturirangan (India) | ,, |

**Progress of Plankton sorting**

During January-March, 1966 a total number of 223 samples have been received at the centre. This includes 194 samples from *Africana* of the south African Division of Fisheries and 29 from R. V. *Vityaz* of USSR. Sixty nine samples processed during this period is the total of 40 from *INS kistna* and 29 from *R. V. Vityaz*. Re-sorting and re-checking work of 51 samples from *INS kistna* has also been completed within this period. Tabulation of station data including coding of position and time and of plankton groups has also neen initiated at the centre.

Dr. R. Fenaux, Station Zoologique, Villefranche-sur-Mer started his work at the centre on Appendicularia during January. He completed his studies by February and has now started studies on copellata collection.

After the IOBC consultative meeting, staff of the centre bade farewell to the retiring chairman of the Committee Mr. R. S. Glover and to the members Dr. Mc Gowan and Dr. Vinogradov

**INTERNATIONAL BIOLOGICAL PROGRAMME, ERNAKULAM**

Under the International Biological Programme preliminary organisational work had begun at Ernakulam (India) by the middle of 1964. This programme which commenced as a small unit under the Directorate of Indian Ocean Expedition has now formed part of the Biological Division of National Institute of Oceanography (India). Presently a study on the hydrography and primary productivity of Cochin backwaters forms the major scientific activity under this programme.

Six stations have been selected in this 200 sq. mile semi-enclosed estuarine water body receiving the rivers Periyar and Pampa for making observations on the variations of different parameters. In order to understand the dynamic conditions associated with these waters by virtue of its location, observations are being made on the vertical and horizontal variations in temperature, pH, Salinity, dissolved oxygen, electrical conductivity, chlorinity, alkalinity,

nutrients, light penetration, seston, plant pigments, particulate organic carbon, rate of photo synthesis, phytoplankton crop, zooplankton volume, bacterial populations and benthos. The following is a brief summary of the work carried out during the year, 1965.

*Temperature.* Maximum temperature (32°C) in the backwaters was in April and the minimum (26°C) in September. Surface to bottom variations during monsoon were about 3-4°C where during post-monsoon months these variations do not exeed 1°C. Sampling centers recorded a variation of pH within the range of 6.5-8.2 and the normal trend of variation from fresh water zone to the marine zone as well as from surface to bottom. Seasonal and spatial variations of salinity have been recorded and it shows a maximum (32.4‰) in April and a minimum (0.5‰) in September.

*Dissolved Oxygen.* Values obtained at the surface level during the pre-monsoon months (Feb.-May) were low but, were found to increase onwards the monsoon months. Changes in oxygen was found to be inversely related to changes in salinity. Maximum electrical conductivity in the backwaters was 0.052 mhos and minimum 0.0035 mhos, these found to correspond with respective chlorinity values. A direct relation between chlorinity and alkalinity values have also been obtained.

*Nutrients* :

In general the backwater is characterised by a high nutrient content. The concentrations of phosphate and nitrate increase from surface to bottom whereas the trend of silicate distribution was reverse even though the concentration was remarkably high. Nitrate distribution was also found to be similar to that of phosphate.

*Light Penetration* was studied by submarine photometer and lux meter and the visible transparency depth was recorded by Secchi disc. The minimum compensation depth during monsoon was found to be 2 meters which gradually increased up to 3.5 meters in January Surface illumination varies between 100,000 lux and 1500 lux depending on the brightness and cloudiness of the day. Secchi disc reading was less than 1 meter during monsoon and 1.5 meter during post monsoon. The highest seston values were obtained at the surface during monsoon and found to decrease towards the bottom where it reaches minimum during post monsoon.

*Plant Pigments* :

Spectrophotometric estimations were carried out of chlorophyll *a b c* and plant carotenoids. The most predominent pigments were found to be chlorophyll *c* and plant carotenoids. Chlorophyll *c* to *a* ratios were higher than 1 and generally fell within a range of 1.5—3. *Particulate Organic Carbon* determinations were made in the Institute fur Mecreskunde Kiel, Germany. Results indicate that values are higher at the bottom when compared to the surface and the average values are found to be 1.0 gc/m3.

*Rate of Photosynthesis* :

Results obtained by Gran's oxygen and $C^{14}$ methods do not tally fully. According to the present observations $C^{14}$ values were always found to be lower. By conducting experiments at a two hourly interval the diurnal rhythm in the rate of photosynthesis was determined and the possible correlation of this rhythm of the photosynthetic rhythm of the natural phytoplankton population is under investigation. Maximum production seems to take place at a depth 0.5-1 meter under suitable conditions. *Phytoplankton*: Dinoflagellates and diatoms constitute the major share of the crop. The recorded organisms include 17 species of Bacillariophyceae, 6 species of Dinophyceae and 1 species each of chlorophyceae and Cynophyceae. Similarly Zooplankton includes a good number of species under crustacea, mollusca, coelenterata, chaetognatha and fish eggs and larvae. Considerable abundance of zooplankton has

been recorded during the monsoon. The relation between the salinity changes and fluctuation of abundance in zooplankton is being studied.

Standard techniques have been applied in the collection and culture of samples for the study of bacterial population. Plate counts indicate that the number of bacterial population in back waters of Cochin is very high especially at mid-depths during monsoon months. The indol population and occurrence of coliform groups are of special interest in this region.

*Fish Population Studies*

A study of growth and mortality of the large scaled tongue sole, *Cynoglossus macrolepidotus* was studied by back calculating to length from the zone on scales. An estimate of the mortality rate was made by combining the length frequency distribution and the growth rate. The mortality rate was found to be approximately between 0.4 and 0.575.

*The Benthos*

Fortnightly sampling of the bottom fauna using standard gear from four different stations has been carried out since August, 1965. The population of benthos was very poor during the monsoon months. Mud samples from the bottom have also been collected and subjected to chemical analysis.

## INTERNATIONAL METEOROLOGICAL CENTRE–BOMBAY

The International Meteorological Centre has practically completed almost all the data collection and processing in connection with the meteorology programme of the International Indian Ocean Expedition. The India Meteorological Department received a large number of letters of appreciation from scientists in many countries for the excellent organisation of the symposium on the Meteorological Results of IIOE-held in Bombay in July, 1965 which served for an increased understanding of the Indian Ocean Meteorology. Arrangements are in progress for printing of the proceedings with financial assistance from W.M.O., Air India and INCOSPAR.

**Basic data collection and back ploting**

Basic data collections for the International Indian Ocean Expedition period 1963-64 have been completed. They are in the form of back plotted Master charts, analysed ozalid charts, microfilm copies of data and charts, punched cards, listings etc.

The Indian Ocean Master charts of 1963 and 1964 have been fully back-plotted.

With a view to illustrating the extent of data coverage in the Indian Ocean for analysis and research, a set of completely back-plotted and analysed charts for 1200 GMT of 7 July 1963 –Surface and six standard isobaric levels– were printed. These charts were distributed to WMO, Geneva, Members of the Executive Committee of the WMO, University of Hawaii and Metorological Services participating and co-operating in the International Indian Ocean Expedition.

Back plotting of aircraft reports received from Australia, R.A.F., Aden, Mauritius, South Africa and Cocos Islands upto December 1965 was completed. Synoptic data for eastern parts of Africa received from Nairobi for the year 1964 were also back plotted and punched. Radiosonde data of Research Vessel *Anton Bruun* for all available dates for the period January to October, 1964 were punched.

An exhaustive data survey was conducted to complete the collection and to catalogue all the meteorological data of the I.I.O.E. period 1963-64. Action was taken to obtain whatever data are yet to be received from the research vessels which took part in the I.I.O.E.

**Data processing**

Processing of surface data of island stations and upper wind data for 1963-64 has been completed.

The following computer programmes were executed:—

(i) Aircraft wind averages over the Indian Ocean.

(ii) West Coast of India moving average of rainfall.

Processing of all radiosonde data of Australia and Singapore and of a few selected stations from Russia and Nicosia was completed. Processing of ships' data for the period January 1963 to December 1964 was also completed.

**Weather Analysis**

Satellite cloud information which are being received from ESSA I with effect from 5.2.1966 cover a large area and are found very useful as a tool in Weather Analysis over the large data-sparse area of the Indian Ocean.

**Investigation and Research**

The following papers were presented by the Scientists of the International Meteorological Centre, Bombay at the International Indian Ocean Expedition Symposium and at the Fifth Conference of Forecasting Officers held at Poona in March, 1966:—

1. Cyclonic vortices on either side of the equator and their implication—by C. R. V. Raman—invited lecture on General Circulation over Indian Ocean.
2. Transport of water vapour over Arabian Sea and adjoining Indian regions during an active monsoon situation—by D. R. Sikka and M. R. Mathur.
3. Evaporation over Indian Ocean during 1963—by R. Suryanarayana and D. R. Sikka.
4. On the seasonal variation of certain meteorological elements in relations to low level atmospheric circulation over the Indian Ocean—by C. R. V. Raman, V. Srinivasan and Y. Ramanathan.
5. I.I.O.E. Data processing—J. M. Korkhao, R. Suryanarayana and Y. Ramanathan.
6. High level flow patterns in relation to weather development over India—by E. V. Chelam.
7. Vertical structure of wind, temperature and humidity at Minicoy—by M. B. Mathur.
8. On some aspects of the fluctuation of the sub-tropical jet stream over India during winter—by D. R. Sikka.
9. On some aspects of cyclonic storms over north Indian Ocean during I.I.O.E. period 1963-64—by M. B. Mathur and D. R. Sikka.
10. Convective activity in the equatorial trough zone over Indian Ocean revealed by TIROS—by V. Srinivasan and V. R. Narella.
11. The Arabian Sea Summer Monsoon—F. R. Miller and R. N. Keshavamurthy.
12. Some distinguishing features of strong and weak monsoon over India and neighbourhood—by K. M. Ramamurthy, R. N. Keshavamurthy and R. Jambunathan.
13. On the onset of the southwest monsoon rains along extreme southwest coast of peninsular India—by K. M. Ramamurthy and R. Jambunathan.
14. Some features of meridional circulation over the Indian Monsoon Area—C. R. V. Raman, R. N. Keshavamurthy, R. Jambunathan and Y. Ramanathan.
15. Stability of upper air flow patterns in tropical regions—by E. V. Chelam.
16. An objective method of forecasting daily rainfall over North Konkan and

South Gujarat during July and August —by K. M. Ramamurthy, R. Jambunathan and A. P. Loganathan.

17. Vertical motion in a steady state monsoon—by R. N. Keshavamurthy.

18. Tiros aids forecasting recurvature of storm—by R. N. Keshavamurthy and P. Sunderesan.

19. Tiros—Nepan study of the withdrawal or southwest monsoon and the autumn transition over India during 1965—by D. R. Sikka and Gurunadham.

20. Computer aids for forecasting tropical weather—by D. R. Sikka and Y. Ramanathan.

21. On the use of IBM Computer for the prediction of storm tracks—by R. Suryanarayana and D. R. Sikka.

Mr. Francis P. W. Mo, Chief of W.M.O. Mission, presented a paper on 'A diagnostic study using dynamical numerical process to compute the vertical and radial components of monsoon depression' at the fifth Conference of Forecasting Officers at Poona.

The following Scientific investigations have been completed:—

(i) Some aspects of broadscale distribution over Indian Ocean during northern summer and their relationship to low level circulation features—by V. Srinivasan.

(ii) Retreat of southwest monsoon from northern and central India and associated changes in the tropospheric circulation over India and neighbourhood during the Autumn Transition—by D. R. Sikka and G. Gurunadham.

(iii) Revised mean streamline charts over the Indian Ocean for January and July by C. R. V. Raman.

(iv) Vorticity of mean surface wind over the Indian Ocean—by C. R. V. Raman.

**Formation of the Indian Ocean and Southern Hemisphere Analysis Centre (INOSHAC)**

The International Meteorological Centre was formally closed down on 31.3.1966. However, as the experience gained by the International Meteorological Centre, Bombay, during the International Indian Ocean Expedition period in techniques of weather charts analyses and the new knowledge gathered about the meteorology of the Indian Ocean as a result of intensive research over a period of three years are valuable assets and in order to preserve and augment these assets further, the Government of India have been pleased to sanction the continuance of most of the activities of the International Meteorological Centre by the establishment in its place of a new institution which has been designated as the Indian Ocean and Southern Hemisphere Analysis Centre. This will function at the same place in Bombay and will improve on the work done during the expedition period.

ATLANTIS—II (US)

A brief report highlighting the work of Atlantis—II in the Red Sea and somali area during her cruise XV was published in this Newsletter, Vol. III No. I. During this cruise hydrographic stations and standard type water sampling including samples for primary production was carried out on all stations occupied (514-750) between Woods Hole and Durban. Samples of bottom water and water samples for hydrocarbon analysis were collected at certain places. Rain water samples were also collected wherever feasible and analysed for sodium content. Surface samples and samples at keel depth and five meters were collected throughout this cruise and analysed for salinity.

Analysis of the water samples were carried out on board for salinity, oxygen, organic

phosphorus, total phosphorus, nitrite, nitrate, silicate contents and for acidity. Samples were stored for analysis of deuterium, oxygen isotopes and trace elements. At several levels salt nuclei in the air were collected by impingent methods. In connection with the nutrient programme, plankton samples were collected and stored for analysis of the organic carbon, nitrogen and phosphorus content. In the southern Indian Ocean special plankton tows were made with a tin tow net in cooperation with East African Marine Fisheries Research Organisation. A bird observation programme had enthusiastic support, with several qualified personnel taking part. A small party was put ashore on Coco Island in the Cargados Carajos Shoals to observe the habitat of various types of sea birds. Geological samples and cores from the sea floor were taken throughout the Red Sea and Arabian Sea. At a rendezvous with the German R.V. *METEOR* off the coast of Oman, special free-fall corers were transferred, along with one scientist. The excellent cooperation of the *METEOR* permitted the taking of more coring samples from the Persian Gulf and the Arabian Coast. Piston cores, dredge samples, free–fall cores and pilot cores were taken in conjunction with the hydrographic water sampling. With the aid of an echosounding pinger attached to the hydrographic wire and the hydrographic weight replaced by a pilot corer, cores and bottom water samples were taken on a routine basis. The cores were stored frozen. It is of interest to note that cores and samples dredged from the shallow Bitter Lake have shown that halides are insultated from the water by a layer of gypsum. It is also interesting that one piston core 200 miles off the Somali Coast in 2000 fathoms was composed of shell, pebbles, and corals.

The meteorological programme was greatly enhanced with the cooperation of the U.S. Weather Bureau. Radiosonde observations were taken at specified intervals, along with standard marine surface observations. The Portman Meteorological Institute was in continual observational status. To aid in the Island Station, programme calls were made at Mombasa, Comores. Islands, Diego Garcia, Seychelles, Rodriguez, Mauritius. and Madagascar to service and repair meteorological and other type of instruments. Humidity gradients, total sky cloud coverage, solar and net radiation, precipitation, evaporation, salt nuclei observations were made continually. Wave observations, both visual and automatic, were taken at each station. Bathythermograph lowerings were made at each station and underway on an hourly basis. The magnetometer was streamed whenever the ship was underway. A salt-bridge GEK was also streamed whenever it was practicable. Because most of the Arabian Sea was in the magnetic equator the GEK was not used in the area. A towed weighted fish was used occasionally with streamlined fairings attached to the cable. The fairings permitted the weight to be towed at standard speed at depth in excess of 100 meters. Temperature and depth were sensed from the fish and the information recorded aboard ship. On the passage through the Suez Canal, a plastic tube open at the weighted end enabled sampling of the water near the bottom of the Canal.

A general–purpose computer and an automatic data acquisition system have been in almost continual use throughout the cruise. Programmes for the computer were being developed. Its primary use at present is the interpretation and computation of messages from the Satellite Radio Navigation system. It has been planned for the analysis of hydrographic data and the computation of wave power spectra.

Gradually programmes for the latter pur-

poses are coming into being. For instance, data from the expendable bathythermograph were fed into the computer while the BT was being dropped. The data acquisition system sequentially reads, digitises, and stores information from various sensors throughout the ship. During a cycle it is possible to include manual input of information, such as depth from the echo sounder. A system of bird-logging in coded form is presently being devised for storage and collection with other data.

## PLAN FOR SCRIPPS EXPEDITIONS

### Kani Expedition

During the period from February to September *Flip* and *Horizon* of the Scripps Institution of Oceanography was to undertake a series of operations primarily concerned with underwater acoustics. This was to be conducted in the Hawaiian area and off San Diego.

### Show Expedition

This is a joint programme in which Scripps ships *Argo, Flip* and *Horizon* will participate with *Teritu* the ship of the University of Hawaii and *Yaquina* the ship of the Oregon state University. University of Wisconsin Geophysical and Polar Research Centre, will also cooperate in this expedition which is planned between May and July, 1966. The objective of this expedition is to make a general geophysical survey of the Hawaiian Arch,–north of the Hawaiian Islands–from Kaui to Hawaii and around South-East end of the island of Hawaii.

### Jabia Expedition

This is sponsored by the office of the Naval Research and is expected to be undertaken between June and August, 1966. Investigation of the physical characteristics of the north edge of the Peru current is the major objective of this expedition.

### Report of the VI Cruise of R. V. Geronimo

A report on the VI cruise (July–Nov. 1965) of R.V. *Geronimo* of the Bureau of commercial Fisheries has been received here. The area of operation as has already been indicated in the earlier issue (Vol.III No.II) was western Atlantic Ocean, adjacent to Lesser Antelles and Carribbean sea. From the report it has been understood that the expedition has been very successful in locating grounds suitable for commercial tuna fishing. Thread herring (opisthonena) appeared to be the most abundant live bait found along Carolina Georgia and east Florida. Pensacola herring (Harangula) of Miami Beach and Spanish sardine (Sardinella) in Puerto Rican waters were the other important live bait species sampled. Observations on several other potentially rich bait fishing grounds indicate the availability in reasonable quantities throughout much of the southeastern United States and carribbean coastal waters in the July–November season.

A total of 44 tuna schools were observed during the cruise. From these, 48 fishes belonging to the following species were sampled. *E. alliteratus, T. albacores, K. Pelamis, T. atlanticus.* Exceptionally thick shoals of bluefin tuna *Thynnus albacores* and skipjack, *Katsuwonus pelamis at* 12°N and 65°W were observed. Numerous small schools of little tuna *Euthynnus alliteratus* mixed with blackfin tuna were observed in the Gulf of Honduras where the temperature data indicated the occurrence of an upwelling.

Extensive biological and general oceanographic observations were made throughout the cruise. Routine observation included oceanographic casts to depths of 500 or 1000 meters, Clark-Bumpus nets, primary productivity, bathymetric, bathythermometric and meteorological observations.

## AUSTRALIA

### HMAS. Diamantina Cruise—Dm 2/63

The Oceanographic cruise report recording the data for the second cruise of *Diamantina* has been received from the Division of Fisheries and Oceanography, C.S.I.R.O. Australia. The objective of this cruise was similar to that of cruise G 1/63 of *Gascoyne* mentioned in the previous issue of this Newsletter. The cruise was undertaken during May-June, 1963 between Fremantle and Singapore occupying most of the stations along 110°E. A total number of 34 stations were worked with various measurements such as bathythermograph casts, sub-surface hydrology, primary production, pigments, particulate carbon, and Zooplankton samples. Micronecton samples were collected only at 14 stations.

The method of collection and analysis applied here is the same used for cruise G 1/63. A glance at the data sheet for Zooplankton reveals that at station 75, (10°S, 110°E highest biomass value (164 mg/m³) has been recorded in vertical hauls by Indian Ocean standard net (IOSN.) But estimation in horizontal tows with Clarke—Bumpus sampler gives a maximum value of 253 mg/m³ from the same station at a depth range of 0.10m. Minimum values in IOSN was 3 mg/m³ from station 56 and in Clarke Bumpus sampler 2mg/m³ from station 64. Particulate carbon was found to be maximum (32$\mu$g/l) at station 55 and minimum (13 g/l) at stations 66 and 85.

### Summary of Cuise Dm3/65

According to a report recently received from Australia H. M. A. S. *Diamantina* worked 47 stations during the cruise Dm. 3/65 which she undertook from—Fremantle between October 25 and November 4, 1965.

**Activities include:**

| | | |
|---|---|---|
| Bathythermography | 38 | stations. |
| Subsurface hydrology | 38 | „ |
| Zooplankton | 18 | „ |
| Micronecton | 18 | „ |

This cruise was led by J. L. Bannister. N. Dyson, J. W. Prothero and L. R. Thomas were the other participant scientists.

### H.M.A.S. Gascoyne.

Cruise G. 8/65 of H.M.A.S. Gascoyne was completed on November 5, 1965 after working stations in seven days between Cairns and Brisbane with the following activities:—

| | | |
|---|---|---|
| Bathythermography: | 10 | stations. |
| Hydrology: | 10 | „ |
| Primary production: | 15 | „ |
| Pigments: | 6 | „ |

H. R. Jitts was the leader of this cruise in which F. N. Davies, J. L. Klye, T. C. Middleton P. N. A. Nirun (R.T.N.) and B. D. Scott took part.

## EXTRACTS FROM SCIENTIFIC PAPERS

### The Somali Current

The Somali Current remained as one of the major unexplored Ocean currents till recently. As a result of the investigations during the International Indian Ocean Expedition especially due to the work of *R.V. Argo* of Scripps Institution of Oceanography and *RRS Discovery* of the National Institute of Oceanography (U.K.) a good deal of valuable information on the Somali Current system as well as on the general circulation pattern in the north-western Indian Ocean has been obtained. Current charts based on collected information seem to suggest that the Somali current is a western boundary current of the same sort as the Gulf stream and Kuroshio, only with the important difference that it appears during the south-west monsoon and disappears during the rest of the year. This agrees with the theory of wind driven currents, because only from April to September is the pattern of wind stress over the tropical Indian Ocean theoretically suit-

able for intense northerly flow, along the east African coast.

Hydrographic stations as well as measurements of surface velocity by Von Arx's Geomagnetic Electrokinetograph (G.E.K.) indicated a well defined current running right against the coast with quite an abrupt off shore edge. Maximum speed ran about four knots, rather like Gulf stream. Apparently there is considerable inflow to the current from offshore waters. Farther down stream, *Discovery* obtained additional velocity measurements by taking radar fixes on prominent coastal features. Near 7° and 8°N they found surface speeds close to seven knots which is somewhat more than ever reported.

On the chart showing the distribution of surface temperature, Somali Current shows up as a cool, banded zone near the coast although rather indistinct near the equator. The current turns abruptly east away from the coast at about 6°N. To the north of the current a body of warm water appears to be moving westward into the Somali Basin from Arabian Sea and another body of warm water moving southward from the Gulf of Aden.

The lowest isotherm shown is 14°C just north of Ras Mabbar. The *Argo* found surface water just colder than 13°C within this area. Some of the upwelled water appears to be entrained into the northern edge of the Somali Current to form the remarkable narrow tongue of water colder than 20°C. Some of the water also seem to be moving northward towards to Gulf of Aden, part of which perhaps turning eastward north of the intrusions from Arabian Sea.

Somali Current shows its distinctness in the distribution of salinity. The upwelled water appears as a fairly uniform layer of low salinity spreading offshore, some in the Somali Current and some moving northward between two intrusions. There is a complex system of movement in the northern part of this area and according to Dr. Warren Wooster the actual pattern of flow varies considerably from one south-west monsoon to the next and even within a single monsoon, so that one should not regard this particular pattern as typical except in an overall way.

Below the near surface water at intermediate depths it is hard to infer anything definite about the flow pattern from the distribution of properties, but deep water below about 2500 meters is a uniform body showing only small horizontal variations and it is plainly evident from temperature, salinity, relationships that all the deep water in Somali Basin is essentially circum polar water which has spread northward from Antarctica. The average depth of 1.8°C potential isotherm was 2600 meters with a range in depth from 2500-2800. A narrow deep flow northward and north-eastward along the western boundary of the basin, then turning eastward with the bottom contours at around 10° North is a surprising feature. The property distribution at mid-depths are rather ambiguous with regard to the flow pattern and so it is not clearly known whether the deep current is connected vertically with the Somali Current in the near surface waters or whether it is an entirely separate current.

The present information suggests the need for further investigation in this area so as to get a fair idea of the conditions existing during different periods of the year. The work done by German R.V. *Meteor* may be able to provide substantial addition to the existing knowledge on this current system. (OCEANUS Vol. XII No. 1 October, 1965)

**Distribution of Chlorophyll and Phaeophytin in the Indian Ocean**

One of the classical problems in the field of phytoplankton ecology has been to differentiate between chlorophyll and its decomposition products. Since the absorption

spectra of many of the decomposition products are similar to that of chlorophyll, measurement of the optical density of the reabsorption band may over-estimate the chlorophyll concentration by the inclusion of the decomposition products of pigments. In his paper C. S. Yentsch presents the results of measurements of chlorophyll and phaeophytin made in the Indian and Atlantic Oceans by the method of Yentsch and Menzel (1963). Treatment of pigment extracts with acid is the basis of determination of total phaeotype pigment in marine phytoplankton. Also dealt in this paper, are the factors affecting the conversion of chlorophyll to phaeophytin in cultures and natural populations of phytoplankton. The ratio of fluorescence of unmodified samples to that of acidified (Fo:Fa) is 2.3:1.

Based on 2000 observations taken at 200 different stations in the western Indian Ocean the author has presented a chart showing the distribution of chloroplastic pigment. At majority of stations values range between 25-150 mg/m$^2$ and in the open ocean, values less than 50 mg/m$^2$ occurred frequently. Values greater than 150 mg/m$^2$ occurred off Somali coast. Regardless of the amount of pigments most of the stations are characterised by Fo:Fa ratio at the surface 1.5:1.7. Below 50 m the ratio increased with depth. In the surface waters no ratios below 1.3 were encountered while below 100m few ratios higher than 1.5 were measured.

Stations between the Somali and west Indian coast show that high total pigment content is generally associated with a mixed layer (uniform density) 50-150m deep. Stations with low total pigment content are identified with shallow mixed layer and stable water mass. These stations have total pigment maxima, a mixture of chlorophyll and phaeophytin occurring at or near the top of thermocline between 50 and 100m. Chlorophyll is generally in greater abundance than phaeophytin and the maximum concentration of the latter may be located 10-20m deeper in the water column.

*Pigments and Light Penetration*

Throughout the upper 50m. phaeophytin rarely exceeds 40% and at some stations it is unmeasureable. Below 50m. chlorophyll and phaeophytin percentage approaches equality and below 100 m the percentage of phaeophytin becomes larger than chlorophyll. The relationship between light penetration and chlorophyll phaeophytin percentage is not linear according to the author's observation. In the case of the shallow mixed layer the percentage of chlorophyll remains high and the percentage of phaeophytin remains low down to a depth where 30% of the visible light penetrates.

**Factors Affecting the Formation of Phaeophytin**

Experiments conducted to study the conversion of chlorophyll to phaeophytin due to prolonged darkness indicate that the stability of phytoplankton chlorophyll in the euphotic zone is dependent upon the mean light intensity reaching photosynthetic cell.

The end product of the decomposition of phytoplankton chlorophyll is a magnesium-free compound which may be phaeophytin, phaeophorbide or other products of porphyrin decomposition. Sources and pathways for the formation of phaeotype pigments have been diagramatically illustrated in the paper. The author says that grazing has a minor influence on the vertical distribution of phaeophytin as Zooplankton may ingest a considerable amount of chlorophyllous material which may presumably be convereted to phaeopigments due to the acidity of the gut and eliminated in the fecal pellets. It is suggested that the decomposition of plant

organic matter may transform chlorophyll to a phaeotype pigment, but here the role of bacteria needs further study.

The quantity of light appears to be the prime factor involved in the natural conversion of these pigments as prolonged darkness converts chlorophyll to phaeopigments which on expossure to light turns to chlorophyll.

The author observes that most of the change upon acidification is in the intensity of fluorescence; however, pheophytinsed cells appear orange as opposed to the deep red fluorescence of chlorophyll. Particulate matter collected from diatom cultures kept for long time in darkness contain particles which fluoresce orange red. The numerous amorphous orange fluorescing particles found in deep sea water samples are in the author's opinion remnants of phytoplankton cells. Observations on cultures and natural particulate matter indicate that the chlorophyll fluorescence is normally associated with an intact cell. (Charls S. Yentsch, Deep Sea Research Vol. 12, No. 5 Oct., 1965).

**The Floor of the Bellinghausen Sea**

Nearly all the major types of bottom are found north of the Antarctic Polar Front, including rocky outcrops, littered rocks and nodules (with or without current evidence) and soft undisturbed muddy bottom. In the deeper waters of the Bellinghausen Sea, scattered rocks and nodules, together with rock outcrops, are seen in the vast majority of the photographs, taken to study topography of this area. Of the 35 photographs from the crest and upper flanks of the Mid-Oceanic Ridge, 18 reveal rock outcrops, many of them craggy and several are clearly pillow lava. Five photograph stations reveal a sea floor strewn with rocks and nodules. Although the outcrops and nodule-strewn floor reveal abundant evidences of ocean currents, a scattering of 11 photograph stations intermingled in this distribution revealed no evidence of currents.

Immediately to the north of the polar front rocks and rock outcrops are found on the ocean basin floor as well as on the Mid-Oceanc Ridge. Many of the photographs from the ocean basin floor reveal evidences of current winnowing or scour. However, between the Antarctic polar front and the limit of rock outcrops scattered rocks are rare and most of the photographs reveal a muddy bottom which is anomalously smooth. South of the limit of pack ice there are increasing numbers of scattered, probably ice-rafted boulders on the muddy sea floor. Immediately off the southern tip of South America ripple marks and strong scour marks have been observed in depths over 4000 meters (Heezen and Hollister, 1964). South of this distribution of ripple marks is a prominent distributional pattern of manganese nodules and still further to the south the bottom is characteristically muddy with occasional ice-rafted boulders.

Ice-rafted boulders appear more frequently in sector immediately to the west of the Antarctic Peninsula. In this sector pack ice is penetrable to the shoreline each year, whereas further to the west, fast ice surrounds the continent during the Antarctic Peninsula the easterly Antarctic winds drift the bergs to the west before they are finally swept in the west-wind drift north of the ice-front.

The area between the polar front and the limit of pack ice is one of the most highly productive in the world and sedimentation rates in this area are generally considered to be orders of magnitute higher than in the area immediately to the north of the front. Thus the muddy, smooth bottom seen in this area is not unexpected. The almost total lack of photographic evidence of rafted boul-

ders in this region can be interpreted as evidence of a high rate of deposition. The smoothing seen in the photographs is certainly in part related to this high rate of deposition, but in many cases the photographs show scour marks which suggest important bottom currents which may smooth the sediments even in depths greater than 5,000 meters. Such evidence is also dramatically seen in the rock and nodule strewn areas north of the polar front. (Extracted from a paper Submitted to John Hopkins University Press—by—Charles D. Hollister and Bruce C. Heezen, 1965).

**Origin of Cyclones**

The mechanism which maintained Cyclones has been understood but the problem of their origin has not been understood. There are three main types of cyclones, the largest is called the frontal cyclone with about 1000 miles in diameter.

Tropical cyclones are intermediate in size with a range of 50-500 miles across and are called hurricanes or typhoons. Tornadoes or water spouts, as they are called are the smallest among cyclonic storms with a rotation confined to a region 100-200 yards wide.

In the frontal cyclones, the whole evolution is taking place in the lowest ten miles of the atmosphere. At the other extreme the cumulus clouds under which tornadoes are generated, may be taller than they are wide. The spreading out of the rising air called anvil cloud is rotating slightly more slowly than the surrounding air. Hurricanes have the same depth as frontal cyclones, but are usually 100-200 miles wide.

Thus we understand that a hurricane is a rotating mass of air containing many shower clouds spiralling inwards towards the centre. The basic pattern of low pressure is produced by the dipping down of the tropopause so that air of troposphere is replaced by the warmer air from the stratosphere. Near the centre winds of 60 knots or more carry the air round in an hour or two. Further out at the rim of the storm the winds are only 15 to 20 knots and at that speed, the air would take a day to circulate.

But superimposed on the rotation is an inflow down the air and thereby reduces centrifugal force on it. Since the force towards the low pressure is more than sufficient the air is drawn inwards. There is an outflow of smaller magnitude over a greater depth of air at higher levels. Most important of all, however, is the fact that as the air moves into the region of low pressure it expands and is cooled in the same way as it is cooled when it ascends to higher levels where the pressure is less. Altough the magnitude of this cooling is only one or two degrees centigrade it is enough to cause the transfer of heat from the sea to the air to be greater in the centre, simply because temperature difference between sea and air is greater there. The sea has a more or less, uniform temperature and so the region where the warming is most rapid and where clouds are found most profusely is where the air is coldest. In the absence of some contrary influence there would be areas of slightly higher pressure Consequently the hurricane could never get started unless there were a mechanism which would convert a cold core region containing all the shower clouds into a warm core or, low pressure region with strong rotation.

Each anvil as it spreads out and mixes and interacts with its new surroundings, re-distributes the momentum of the fluid in such a way as to reduce the rotation. The heat carried by water vapour from the sea is many times as great as any sensible heat it could carry so that although the heat is transferred, only a negligible amount of momentum accompanies it and the drag of the sea is much less important.

The simple case which illustrates the important results of anvil spreading in a rotating air mass is that of an annulus of air initially rotating uniformly i.e. like a solid. The effect produces a vortex sheet at the outer edge of the stirred region and a concentration of rotation at the centre. If a strictly circular region of the atmosphere were stirred in this way it would produce just the kind of vortex required to start a hurricane, for the whole depth of the troposphere would have its rotation organised together. This is in contrast with the frontal cyclone or tornado which sets the upper half in anticyclonic rotation (relative to earth) to begin with. The intense rotation at the top of the troposphere causes the stratosphere to be sucked down like the air in bath plug vortex and because it is so warm it inhibits the growth of slower clouds whose storminess makes the hurricane what it is. Consequently the hurricane has an eye at its centre where it is calm and often clear and sunny. Fairly soon after its birth the hurricane sucks the dry air of the atmosphere right down to the ground where this dry air mixes with the wall of cloud sorrounding the eye the rapid evaporation of cloud causes such strong cooling that a narrow but intense ring of down drought surrounds the eye, between it and the strong up currents of the wall of cloud beyond. If a very large region—say 100 miles across is stirred by anvil clouds the effect of the anvils would appear only after 4 or 5 days. If a small region say 15 miles across is stirred the effect is too small. Tornados are sometimes produced but they do not extend up to the stratosphere. In between an area of 100-200 miles across is just the right size to produce a big enough effect in a day or two.

(R. S. Scorer, Science Journal, Vol. 2 No. 3, March,' 66.)

## NOTES AND NEWS

### Chromium-51 as Radioactive tracer for Columbia River Water at sea

Radioactive tracers have become a very promising tool in the hands of oceanographers who attempt to unravel the path of mysterious movements of water masses, silts, sediments and the biomass. C. Osterberg, N. Cutshall, and J. Cronin of the Department of Oceanography, Oregon state University have used chromium-51 content of the Columbia river water as an indicator to trace its plume in the sea-water. This river carries about 25000 curies of radioactivity from Hanford Washington reactors. "We succeeded in following the plume of Columbia river from the mouth of river near Astoria, Oregon to a point in the ocean south west of Coos Bay, some 350 km. away by measurement of its Cr-51 content;" reported the authors. The suggestion for using Cr-51 as an indicator came from Osterberg et al who attempted to correlate the $Zn^{65}$ contents of euphausiids to Columbia river plume.

A large volume chemical apparatus was developed by Cronin, with which surface water samples of 600 litres could be pumped in through membrane filtres. Stable isotopes as chlorides of several radio-elements known to be in columbia river were added as carriers along with $Fe\,Cl_3$. After 30 mts of srirring the pH was raised to 9.5 by adding $NH_4OH$, forming a ferric hydroxide precipitate. Then a flocculating agent was added and after stirring for 5 mts. the mixture was allowed to settle and concentrated in the conical bottom of the tank. In the laboratory, precipitate was dissolved in hydrochloric acid and reduced to 800 ml. by heating. Samples were placed in a plastic bottle and analysed on top of a detector coupled to a nuclear data 130 AT multichannal analyser. Considerable speed of collection and

processing is mandatory, because of the short half life of Cr-51.

The dilution of plume with sea water as the distance from the river mouth increases may be calculated by correcting the Cr-51 activity of each 600 litre sample for the amount of sea water present in it (SCIENCE, Vol. 150, No. 3703, Dec. 1965).

## Conservation of Dolphins for Scientific Research

Dolphins are a group of marine mammals who are so friendly towards man with whom they always do their best to come in contact. There are examples when they saved the drowing people, played with children and helped the fishermen in locating fish shoals. Scientists in many countries are now making efforts to thoroughly investigate the anatomical, physiological, psychological and behavioral peculiarities of these animals. Soviet physiologists like J. Lily and others are of opinion that the comparatively large and complicated brain of dolphin is strikingly close to that of man. The sensitivity and perfection of the sense organs especially that of echolocator of dolphins are amazingly greater than any of the man-made instruments. Even the most important problems in hydrodynamics may find their solution in a closer study of the dolphins.

Scientists believe that a time will come when we shall be able to speak to dolphins using their language and so teach them our own. Experiments conducted by T. C. Lang and H. A. P. Smith at Port Mugu, California have shown that dolphins kept in separate tanks communicated through an electronic acoustic link in tight sequence when the acoustic link was connected. This experiment gave some information regarding the possible meaning of the various sounds they produce. (Science : Vol. 150 No. 3705, December, 1965). The blood oxygen content and the heart weight of deep diving species have been found to be greater than the coastal species (Ridgeway and Johnson, Science Vol. 151, No. 3709 Jan., 1966) Abilities of porpoise to act as messenger, guard and rescuer have been experimented during the U. S. Sea–Lab. II exploration in 1965.

All these indicate the importance of these marine mammals in the hands of scientists of various disciplines. But they are continued to be fished throughout the world and tinct. On this problem, answering to a question by a correspondent of *Izvestia* Mr. Alexander Ishkov, minister of Fisheries, USSR, said that it has been decided by the government to completely cease catching dolphins. (Izvestia–13-3-1966). A study of the live dolphins would bring much more benefits and he hoped that all the countries would follow their example in saving the dolphins for the sake of science.

## "KRILL" A New Sea Food

Norwegian Sea Fisheries Research Institute has begun investigation on "Krill" the luminiscent shrimp-like creatures. Mostly pelagic, they form the nutritious staple food for fin and blue whales. It is likely that these species which are available in abundant quantities from certain localities may form a new source to meet the growing food requirements in Norway. Krills are believed to be responsible for heavy echo-traces sometimes recorded by sprat fishermen. Attracted by light they come close ashore and sometime fished by bag nets up to 500 kg a night per net. More extensive experimental fishing using the light and bag technique and lights and fish pump has been planned by the Norwegian Institute. *Thysanossa inermis* the small krill and *Meganyctiphanes norvegica* the big krill are to two species commonly available in good quantities in

Norwegian waters. Research on this type of organisms may be of considerable importance to other countries having similar resources. (Austr. Fish. Newsletter, February, 1963).

**Problem of Disappearing Beaches**

How those thousands of tons of sand annually move into the under-sea canyons and by what all means sand is lost from the beach and nearshore, has been a geological mystery till today. Dr. James W. Vernon of University of Southern California has been engaged in an intensive study of the various forces acting on the California beach in effecting the loss of sand from the beach in ef- the patterns and paths of migration.

In this study he used hundreds of pounds of red and green sands placed carefully in mounds on the ocean floor at 15 points along California Coast. With underwater still cameras, time lapse and motion picture photography, frequent sample taking and personal observation during more than 400 SCUBA dives Dr. Vernon has been following the movement of the red and green sand along the coast.

According to his observations, waves along the California, coast approach the shore at a sharp angle, commonly as great as 45 degrees. As the waves enter shallow water, the accompanying surges at the bottom pick up sand and carry it shoreward into the surf where it is moved down cast by breaking waves until interrupted by a rip current, rocky headland or a submarine canyon. Rip currents funnel large amounts of sand through the surf and back out to sea where it settles to the floor and is caught up in the next shoreward movement. At rocky promotories sand moves seaward along the face of the rocks that jut into the sea and when it reaches the promontory point, again is moved towards shore by the passing waves. Some sand may be lost to deep water at these points. Where submarine canyons are near shore they intercept the sand moving in the near shore bed and as other studies have shown, once below the canyon rim, the sand moves seaward down the canyon.

A possible solution to the problem, Dr. Vernon suggests is to locate the sand deposits that have been funnelled of the beaches and pump them back again where they belong. (NODC. Newsletter No. 1/2-66 January-February, 1966.)

**First Meeting of SCOR Working Group on Micropaleontology on Bottom Sediments**

The first meeting of SCOR Working Group 19—"Micropalcontolagy of Bottom Sediments"—was held in Paris at the Laboratoire de Micropaleontologie, Ecole Pratique des Hautes Etudes, 8 Rue de Buffon on January 3-4, 1966. Four formal, half-day sessions were held, and discussions continued informally at other times.

The following members of the group, E. Seibold (Chairman), Mrs. A. P. Jouse, G. Deflandre, B. M. Funnell, T. Kanya and W. P. Piedel, were present throughout. Dr. K. N. Fedorov was present as an observer at two of the sessions and gave the group considerable assistance in its deliberations; Mlle S. Durand was present throughout in a secretarial capacity at the invitation of Prof. Deflandre and with the approval of the other members of the group.

Brief verbal accounts of marine micropaleontological activities in their own countries were given by each of the members present before commencing general discussions.

*Definition of field of interest.*

"The study of flora and fauna which contribute preservable microremains to bottom sediments of present seas and oceans, and their occurrence as fossils in these regions."

The original terms of reference were published in the Proceedings of SCOR, Vol. 1, No. 1 p. 25. The following amplification of the terms of reference was proposed, taking as a basis the draft terms of reference prepared by Professor Kort and comments received from National Committees and individuals.

(a) Discussion of the technical and scientific procedures used in micropaleontological investigations of marine bottom sediments.

(b) Discussion of the principles of systematics, stratigraphy and environmental interpretation as applied in the above field.

(c) Facilitation of comparison of submarine stratigraphy with that of land areas.

*Working Programme.*

It was decided to concentrate endeavours on organising the proposed Symposium and to postpone definite decisions on a future working programme.

*Symposium.*

The group received a generous invitation from the organizing committee of the second Oceanographic Congress offering the facilities for a symposium at the ensuing meetings in Moscow. As the time was too short to organise such a symposium the Committee expressed regret at the invitations, but agreed to ask the organising Committee to facilitate the micropaleonotologists by combining their contributions in one Session and also to organise a "Conversazione" on the subject.

Regarding the proposed symposium the group expressed the opinion to hold it in mid 1967 in Scandinavia. The object of the symposium is to bring together the widely dispersed active workers in this field for the exchange of ideas, experience and materials.

**Symposium on Marine Microbiology**

A symposium on Marine Microbiology was arranged at the occasion of the Autumn meeting of the Society for General Microbiology held in Aberdeen in September, 1965. The first discussion was concerned with the sea water as a culture medium and particular reference was made to the suspended matter in the natural waters. It was suggested that they change the physical and chemical environment sufficiently to prevent some organisms from growing and that by leaving the suspended matter in the medium it may be possible to culture certain organisms that cannot at the movement be cultured by traditional techniques.

Another topic for discussion was the dark growth of certain phototrophic algae which also have the ability to grow heterotrophically in the dark. The third session of the discussion was devoted to an account of the work progressing in various laboratories on the bactericidal effect of light on *Escherichia coli* in sea water. This led to a more general discussion of the effects of light in the visible range of bacteria and on possible protective effect of carotenoid pigments. (Nature Vol. 208 No. 20, 1965).

**Second International Congress on Marine Corrosion and Fouling**

The second International Congress on Marine Corrosion and Fouling has been planned to be held in Athens during 20-24 September, 1968. According to a communique released by the Permanent International Committee of Marine Corrosion and Fouling the Congress would be held in two sessions as follows:—

I. Corrosion and Protection of structures immersed into Sea water and emerged to marine atmosphere. Cathodic pro-

tection. Electrochemistry of sea water. Influence of the marine climate.

II. Biological and Bacteriological corrosion. Fouling. Biology and ecology of sessile organisms. Wood-borer organisms. Wooden structure. Combination of section I & II.

Further details regarding the congress can be had from the National Technical University of Athens, Laboratory of Physical Chemistry, 22-28th October, Str. Athens. Greece.

**A record fish catch by R. V. Varuna**

According to a report received here from the Director, Indo-Norwegian Project, R.V. Varuna continues her exploratory fishing on south-west coast of India side by side with research activities. The results of trawling operations during July-September, 1965 shows that in one of the cruises 1,500-2,000 kg. of fish in 1 hour and 25 minutes was caught from a station just beyond the shelf—a record catch of this vessel.

Trawling grounds located 5 miles of Quilon yielded approximately 500 kg. of fish per hour. During this period explorations off Alleppey showed the existence of good prawn grounds close to the shelf region.

**Sea water a Lubricant for undersea use**

Sulphur Compounds in Sea water can serve as a preferential lubricant for bearing components made of molybdenum or its alloys, say research chemists at the Aeronautical Materials Laboratory of the Naval Air Engineering Centre in Philadalphia. The lubricating effect that results is equal to that achieved with high-quality gears.

The finding could prove highly significant to the economics of future under sea exploitation. In operations such as mining and drilling, use of sea water for bearing lubrication could eliminate the need for expensive housings. Open conveyor belt and hopper systems, for example, could be used to bring mined material to the water's surface.

The current findings evolved from earlier work on solid-film lubricants at the naval laboratory by Neal D. Rebuck and Martin J. Devine. Sulphur compounds, Mr. Devine postulates, react by a temporary exchange of sulphur with molybdenum metal to form molybdenum disulphide as the lubricating agents. Heat generated by high load conditions present in deep sea operations would tend to accelerate the exchange reaction.

For sliding wear comparison tests, Rebuck and Devine used synthetic sea water that contained 0.8% by weight of sodium sulphate (the primary—sulphur compound in actual sea water, 0.4 to 0.8% by weight). In the tests, molybdenum was the bearing material and bronze, titanium, and various ASTM alloys the other surface.

In all cases, wear scar diameter with sea water was less than 5 mm. compared to more than 10 mm. with a distitled water control. Specifically, for pure molybdenum contacting bronze, wear scar diameter was 0.59 mm. With TZMAN engineering alloy of molybdenum containing 0.5% titanium and 0.08% Zirconium-against bronze, it was 0.75 mm.

Under-sea bearing assemblies, Devine says, would probably use molybdenum inserts or coated parts as one of the contacting surfaces. Searching for the least expensive combinations of metals, the chemists are screening those other than bronze-nickel, titanium, and beryllium alloys, for example—that resist salt water corrosion.
(Chemical and Engineering News, February 21, 1966—page 27)

**Soviet ship to explore fishing grounds in Indian Ocean**

Soviet research vessel *Mihail Lomonosov* is now about to start on a voyage from the port of Sevastopol to the Indian Ocean with the objective of studying the promising fishing grounds. Laboratory facilities on board have also been expanded to meet the requirements during the present investigation.

*Mihail Lomonosov* spent most of her time during past 10 years working in the Atlantic where the soviet scientists discovered a counter current in the equatorial region, which later on come to be known as Lomonsov Current. The last expedition completed by this vessel was in the North Atlantic during the past winter. The Dnieper computer installed on board facilitates quick processing of the collected data and as a result the vessel when returns home the data turns to publishable information in the form of scientific papers.

(Press release. Inf. Dept. Soviet Embassy)

**Endeavour Prizes**

Imperial Chemical Industries Limited, the publishers of the International Scientific review ENDEAVOUR, have announced the following subjects for a scientific essay competition with a view to stimulate interest in scientific writing among younger scientists who will not be above 25 years old on 1st September, 1966:—

1. Mechanisms of Morphogenesis.
2. The pattern of nuclear particles.
3. Micro circuitry.
4. Chemicals in Agriculture.
5. The cell surface.
6. Recent advances in thermochemistry.

All entries should be addressed to the Deputy Secretary, British Association for the Advancement of Science, 3, Sanctuary Bldg., Great Smith Street, London, S.W.1, so as to reach him on or before 1st June, 1966.

Five prizes totalling over £200 are offered and in addition winners will receive invitation to attend the whole of British Association meetings at Nottingham from 13 August to 7 September, 1966 with free travelling expenses and accommodation.

VISITORS

Visitors at the Indian Ocean Biological Centre and the various Divisions of the National Institute of Oceanography in Ernakulam are the following. This list is exclusive of the scientists who visited IOBC and other centres in connection with the consultative Committee meeting:

1. Prof. P. A. Paulose, St. Joseph's College, Darjeeling.
2. Shri D. Thirunarayanan, Senior Chemist, T.C.M. Ltd., Alwaye.
3. Prof. Selvaganapathy with a party of 40 students from K.M. College, Adirampatinam.
4. Prof. A. F. Bogdanov with a group of scientists from U.S.S.R. Research Vessel Akademik Knipovich.
5. Mr. M. S. Edelman, F.A.O., Fisheries Oceanographer attached to CMFRI. Bombay.
6. Dr. N. V. Rajagopal, International Fisheries Limited, Cochin.
7. Dr. A. S. Gladkikh, Institute of Medicinal Plants, Moscow.
8. Dr. J. M. Rabinovich –do–
9. Dr. J. A. Gubanov –do–
10. Dr. McIntyre, Marine Laboratory, Aberdeen.

PUBLICATION RECEIVED

1. GeoMarine Technology—Vol. I No. 9 Sept. 1965.
2. Fisheries Statistics of the Philippines. 1964.

3. Le monde sans Soleii by J. Y. Cousteau.
4. Indian Journal of Biochemistry (CSIR) —Vol. 2 No. 4 Dec. 1965.
5. CSIR News—Vol. 16 No. 1 to 6. 1 Jan. to 15 Mar. 1966.
6. IPFC—Current Affairs Bulletin—No. 44 Dec. 1965.
7. Vigyan Pragati (CSIR) Vol. 15 No. 2, Feb., 1966.
8. Journal of Bombay Natural History Society.
   Vol. 62 No. 1 April, 1965.
   Vol. 62 No. 2 August, 1965.
9. Research & Industry (CSIR)
   Vol. 10 No. 11 Nov. 1965.
   Vol. 10 No. 12 Dec. 1965.
10. Annual Report of Oceanographic observations (Korea) Vol. 13, 1964.
11. Hydrography of New Zealand offshore waters
    New Zealand O.I. Memoir 12.
12. The Fauna of Ross Sea—Mysidacea and sipunculida
    N.Z.O.I. Menoio 27.
13. A foraminiferal Fauna from the western continental shelf north Island, New Zealand
    N.Z.O.I., Memoir No. 25.
14. Anton Bruun Cruise 7, 8, 9 Reports Vol. 1 Vol. 2.
15. International Marine Science (UNESCO) Vol. III No. 4 February, 1966.
16. Boltin Bibliografico No. 2 of Universidad deoriente. Institute Oceanografico, Cumana-Venazula.
17. CSIRO. Australia – Oceanographical Cruise Report No. 23 (1965) DM 1/63.
18. Journal of the Marine Biological Association of U.K. Vol. 46, No. 1 Feb., 1966.
19. Biomass Atlas of net Zooplankton in the North-eastern Pacific Ocean 1956-64. Manuscript Report Series No. 201 of Fisheries Research Board of Canada.

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FORM IV

(As required under Rule 8)

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I, N. K. Panikkar, hereby declare that the particulars given above are true to the best of my knowledge and belief.

Sd/- N. K. Panikkar

Date — Name of the Publisher

*Redesignated as: Director, National Institute of Oceanography.