

AN INDIAN VIEWS THE INTERNATIONAL INDIAN OCEAN EXPEDITION

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Now that the International Indian Ocean Expedition (I.I.O.E.) is over, or at least the operational aspect of it, perhaps it is not out of place to indulge in some personal reflections—both about the various problems it has generated and those it has solved—which will supplement the review of Currie (1966) regarding what the I.I.O.E. set out to achieve and what were some of the preliminary results. It will be valuable to supplement this with a brief history of marine research in India, what I think I.I.O.E. meant to India, and in what way the nation has benefited by its own full participation in the programme.

My own association with I.I.O.E. began officially on the 1st August 1962 when I took up the post of Liaison Officer for the U.S. Programme in Biology during the I.I.O.E.; I was stationed at Bombay throughout the period of the expedition. By virtue of this position, I was not only looking after the interests of the U.S. Programme in Biology, but also maintained a close liaison with the Indian authorities who were responsible for the Indian Programme and with foreign countries participating in the expedition.

MARINE RESEARCH IN INDIA PRIOR TO I.I.O.E.

Sewell (1952) has given an account of the deep-sea oceanographical exploration in Indian waters, while Panikkar (1952, 1953) has dealt in great detail with the development of fisheries and oceanographical researches in India. I can add here very little to what they have already said, except perhaps to indicate some of the latest developments. I should, however, like briefly to recall some facts concerning marine research in India prior to I.I.O.E. Of all the different facets of marine science, marine biology is perhaps the oldest in India. Some of the more important early workers associated with marine animal studies in the Indian waters are Carter (Porifera), Canton, Day and Russel (fishes), Annandale and Kemp (Fauna of the Chilka Lake), Gardiner (Fauna of the Laccadive and Maldiva Islands), Chopra (Crustacea), Fauvel (Polychaeta), Herdman (Pearl Fishery Investigation of Ceylon), Gravely (Fauna of the Madras Coast), Sewell (Copepoda), and others, all working in

the early part of this century. The excellent book *The Naturalist in Indian Seas* by A. Alcock, published in 1902, gives a delightful account of the fauna and flora of the Indian Seas. Subsequently, there has been a large number of publications *mostly* dealing with the fauna of the beaches and inshore waters, and in this respect the contribution of the Madras University, Zoological Laboratories and the publications of the Madras Museum are most significant. Lt.-Col. R. B. Seymour Sewell's oceanographical researches on board H.M.I.S. INVESTIGATOR and R.V. MABAHISS in the Bay of Bengal and the Arabian Sea during the period 1925-1935 form an important chapter in the history of Marine Science in India (Sewell, 1925-38). His results were serially published by the Royal Asiatic Society of Bengal and deal with surface temperature distribution in relation to wind force, plankton studies, particularly of Copepoda, and description of various types of sediments in the Bay of Bengal and the Arabian Sea. The Reports of the John Murray Expedition include the results of R.V. MABAHISS. The Oceanographic Memoirs of the Andhra University, Waltair, Vols 1 and 2 (1954-1958), which deal with the results of the large number of cruises on board the Indian Naval Mine Sweepers conducted by the University during 1952-1955 under the leadership of Professor E. C. LaFond, Fulbright Visiting Professor of Oceanography, form another step in India's progress in marine research, particularly in the Bay of Bengal. These studies cover the physical oceanography, nutrient chemistry, plankton distribution, and sediment analysis.

Meanwhile, in 1947 the Central Government in the Ministry of Food and Agriculture set up the Central Marine Fisheries Research Institute, with headquarters at Mandapam, and this organization under the leadership of Dr N. K. Panikkar began carefully organized studies on various aspects of marine research relating to fisheries. A comprehensive scheme of sea-water analysis was initiated by the Central Marine Fisheries Research Institute in 1952 with the financial support of the Council of Scientific and Industrial Research; under this programme chemical laboratories were set up at Calcutta, Madras, and Bombay to analyse thousands of samples of sea water for salinity collected by Fishery and Merchant Navy vessels all along the Indian coastline. The Indian Naval authorities also set up a physical research centre at Cochin to study military oceanographical problems. In this connection the excellent progress made by the Forest Research Institute, Dehra Dun, in the study of marine fouling and boring organisms at different university centres all along the coast of India should be mentioned. The Universities of Kerala, Annamalai, Madras, Andhra, and Bombay have developed and expanded research and teaching facilities in marine science from 1950. Meanwhile, the Government of India constituted the Central Board of Geophysics in 1949 and an Oceanographic Committee to review problems of Oceanographic studies in India from time to time and with the ultimate object of setting up an Institute of Oceanography. Notwithstanding all this activity and expansion in the marine sciences, it should be emphasized that until 1960 there was no organization in India with sufficient funds and authority either to back up extended researches in oceanography or to co-ordinate marine studies at the national level; nor was there any organized projection of marine studies to suit India's requirements and goals. This gap was finally filled when the Central Government appointed an Indian National Committee on Ocean Research (I.N.C.O.R.) in 1960. The terms of reference of this committee were:

- (a) to draw up a co-ordinated plan for India's participation in the I.I.O.E.,
- (b) to advise on the allocation of a programme between Departments of Government, research organizations, universities, and other institutions,
- (c) to consider and approve detailed plans for research in the several scientific disciplines related to India's participation and to recommend financial grants,
- (d) to further and co-ordinate research programmes,
- (e) to advise the Government generally on all matters connected with India's participation in the expedition.

I.I.O.E. AND INDIA

It would appear from the terms of reference of I.N.C.O.R. that besides being responsible for India's participation in the I.I.O.E., the Committee also became the focus of all developments and research projects connected with oceanographical researches. The Committee and its working groups included almost all the important scientists representing various Indian institutions concerned in different branches of oceanography. The results of the Committee's deliberations led directly to the establishment of an Indian Ocean Expedition Directorate as a department of the Council of Scientific and Industrial Research, and to the allocation of sufficient funds and staff and thus ensured full participation of India in the International Programme. The subsequent establishment of the International Meteorological Centre at Colaba (Bombay) and the Indian Ocean Biological Centre at Cochin are well known to marine scientists the world over.

The genesis of the I.I.O.E. is now well known (Currie, 1966). The expedition sought to explore in detail the oceanography of the Indian Ocean and to make the area as well known as either the Atlantic or the Pacific. It was also fashionable for all who ever spoke on the programme of I.I.O.E. to draw attention to the enormous population increase of India and neighbouring countries and the inadequacy of food and protein requirements for undernourished people and to plead fervently for the exploration and exploitation of the food resources of the sea; if the speaker were a marine meteorologist, he would say how interesting are the reversing monsoons and how unpredictable or unreliable they are for Indian agriculturists; a geophysicist would stress the possibility of unknown oil resources in the shelf areas off India. In this way all sought to justify the many cruises, ships, and nations participating in the joint enterprise of the I.I.O.E. One must consider very carefully how crucial these problems were from India's point of view.

The food problem is without any doubt serious. India's exploitation of fishery resources has been growing every year and it is reasonable to expect that given more vessels and men, it should be possible to double the gross tonnage of fish landed on our coasts. The most interesting aspect of this problem, however, is the fact that 65-75% of marine fish landed annually in India comes from the west coast (Table I). This was pointed out by Panikkar and Jayaraman (1956) at the 8th Pacific Science Congress and the picture remains the same even today. The reason for the apparent scarcity of fishery resources off the east coast of India and the rest of the Bay of Bengal should be urgently investigated and considered quite separately from the problem as

to whether we are fully exploiting the available fishery off the west coast. Although in recent years mechanization of fishing vessels has increased, the fact remains that fishing is done mostly in nearshore waters while the vast shelf off the west coast remains totally unexploited. For example, off the Bombay and Gujarat coasts, the shelf extends out for nearly 200 miles and but for one or two vessels of the deep-sea section of the Food and Agriculture Ministry no large scale commercial trawlers are commissioned to fish these vast areas. Regular mapping of coastal areas rich in fishery resources was one of the immediate requirements of India.

Next we may consider the mineral resources of the sea. India lacks natural deposits of fertilizer salts and also rich deposits of fossil fuel. One of the ingenious suggestions was that the possibility of extracting nutrient salts such as phosphates and nitrates from the vast quantities of marine sediments dumped by the great river systems into the Bay of Bengal and the Arabian Sea should be considered. The possible accumulation of oil under the shelf

TABLE I
Marine fish landings of India (in metric tons)
(by the courtesy of K. V. Rao)

Year	East coast of India, including Andaman Islands	West coast of India including Laccadive and Minicoy group of islands	Total
1960	170,191	702,264	872,465*
1961	187,062	489,300	676,363*
1962	180,684	463,560	644,244
1963	185,850	469,634	655,484
1964	213,826	645,677	859,503
Annual Average	187,523	554,087	741,610

* Excludes trawler catches of 7000-8000 tons.

(offshore areas), particularly off Cambay, was also considered suitable for investigation, particularly since the nearby area of Anklesvar had yielded exploitable deposits of gas and oil.

Again, the mapping of coastal currents and the bathymetry of nearshore areas, and their importance for coastal navigation, defence, harbour construction, and so on, cannot be minimized. With the increase in industries and nuclear reactors, the question of pollution and waste disposal takes on added significance. Our knowledge of coastal bathymetry and bottom topography is totally out-of-date and the physical oceanography of the coastal currents is almost unknown; such as is known is based on visual observations of wind and water. Such observations needed to be immediately augmented by modern methods of sounding and Hi-Fix.

Finally, there is the study of the monsoons. Two problems are involved; first, how does the reversal of the monsoons affect the oceanic circulation in the North Indian Ocean, and secondly, how may the onset and intensity of

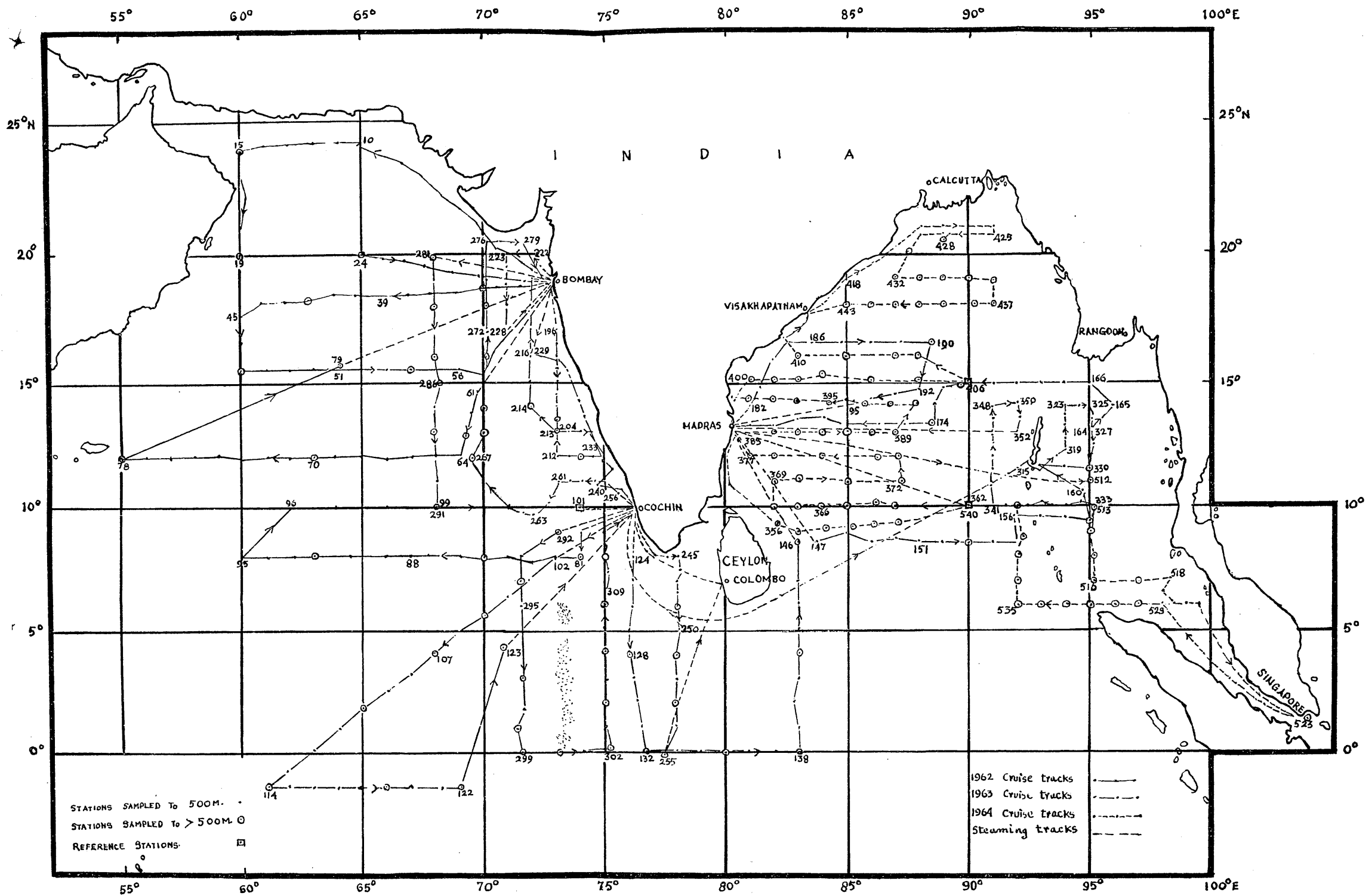


Fig. 1.—Indian programme during the I.I.O.E.; track charts of I.N.S. KISTNA, 1962–64.

[To face page 114]

the southwest monsoon be predicted. This second problem is of great agricultural importance since most of the ryots (farmers) in India depend on monsoon rains for the cultivation of summer crops (Kharif). One may illustrate this point by quoting from the 'panchangam' (Almanac, 1966), the prediction of the origin and rainfall in India for 1966-67; this shows the orthodox Hindu view of the monsoons on which our farmers pin their hopes. "This year [1966-67] a cloud by name 'Avartha' will be born at the summit of 'Meru' mountains [the present Vindhya system of Central India] and will cause 'medium' quantity of rainfall. There will be fear of war and famine in the country. The rain consists of 2 kolagas of rainfall and 4 kolagas of wind" [each kolaga measures 60 gavuda square and 100 gavuda height—each gavuda is variously described as equal to $1\frac{1}{2}$ to 12 miles]. Nobody has checked statistically how accurate these predictions are, but the fact remains that the farmer has no other dependable alternative for information on monsoons.

THE INDIAN PROGRAMME

These were some of the problems in which India herself was interested at the time of launching of the I.I.O.E. Quite rightly, therefore, the planners of the Indian Programme concentrated their efforts in these directions and confined their cruises and observations to yield an intensive study of the coastal areas, both in the Arabian Sea and the Bay of Bengal. With the inauguration of the 1st Scientific Cruise of I.N.S. KISTNA on October 9, 1962, by Professor Humayun Kabir, Minister for Scientific Research and Cultural Affairs, the Indian Programme of work during the I.I.O.E. was effectively launched. Besides I.N.S. KISTNA the Indian Programme included scientific cruises by R.V. VARUNA of the Indo-Norwegian project, R.V. CONCH of the University of Kerala, and F.V. BANGADA, an exploratory fishing vessel of the Ministry of Food and Agriculture, Government of India. All the cruise tracks and programme of work were co-ordinated so that a complete coverage of important coastal areas of both in the Bay of Bengal and the Arabian Sea (see Figs 1 and 2) was effected.

I.N.S. 'KISTNA'

The participation and programme of I.N.S. KISTNA in the I.I.O.E. is unique in many respects. The Indian Navy should be congratulated for placing the frigate at the disposal of the Indian National Committee on Ocean Research solely for Oceanographical work. This was a most welcome development for the future of this work in India since by this gesture of co-operation the Indian Navy's full support for I.I.O.E. was assured.

From Figures 1 and 2 it is clear that I.N.S. KISTNA has covered fairly well both the Bay of Bengal and the Arabian Sea and in the south right up to the Equator. Commencing in October 1962, I.N.S. KISTNA has completed 28 scientific cruises, and had it not been for the unfortunate Indo-Pakistan conflict in the middle of 1965, she would have successfully accomplished the rest of the cruises planned during the fall of 1965. The vast amount of data collected by I.N.S. KISTNA is now being analysed at the data and planning division of the National Institute of Oceanography.

Meanwhile, the International Meteorological Centre (I.M.C.) at Colaba, Bombay, functioned from 1st January 1962 with Professor C. S. Ramage as director. This centre was financed by the Council of Scientific and Industrial Research, and was manned by the Indian Meteorological Department. The United Nations special fund provided an I.E.M. 1620 Electronic Computer for data processing. The United States National Science Foundation had given liberal assistance through equipment and other services. The extended Indian Ocean Chart in use at I.M.C. covers the whole of the Indian Ocean plus adjacent areas. Reception of about 75 daily Radio Teletype broadcasts from Canberra, Nairobi, Singapore, and Pretoria, provided the bulk of the Southern Hemisphere coverage. Data exchanged with Tokyo and Moscow and some 40 Radio Teletype/Carrier Wave broadcasts received from Karachi, Aden, Colombo, Djakarta, and Saigon, supplemented by collections at the Meteorological communication centre, formed the coverage of the Northern Hemisphere. Ships' reports obtained over Radio Teletype circuits from Mauritius by the Indian Navy added to the coverage of the South Indian Ocean. On a typical day the total coverage amounted to:

Surface reports	1155
Ships	384
Upper air	429

Aircraft report from long distance international flights on three to four air routes.

At the I.M.C., synoptic charts are prepared for two principal times—00 and 12 hours Greenwich Mean Time—for surface and standard isobaric levels, namely 50, 100, 200, 300, 500 and 700 mb. Back plotting is also done after data reception of additional information from other centres. During the period of the I.I.O.E., perhaps the most important observations on the monsoons were carried out by specially instrumented research aircraft of the U.S. Weather Bureau Research Flight Facility and the Woods Hole Oceanographic Institution. In addition, a NOMAD automatic weather station was anchored in the Bay of Bengal half-way between Madras and the Andamans in April 1964. An Automatic Picture Transmission (A.P.T.) receiving equipment on loan from the U.S. National Science Foundation was installed at I.M.C. in December 1963, and this picked up pictures of cloud cover from TIROS VII and NIMBUS Meteorological Satellites during their orbits over the Indian subcontinent. It is too early to say that I.M.C. has solved the problem of the development of the monsoon or is able to predict the arrival of the monsoon accurately, but it has accumulated a vast quantity of information and the preliminary analysis of the data has improved our knowledge of the circulation pattern of the monsoon winds. In fact, for the first time meteorologists in India were able to get data from over the oceans for their studies and have come to realize that the weather pattern of the Indian sub-continent is greatly influenced by conditions in the sea.

The establishment of the Indian Ocean Biological Centre (I.O.B.C.) at Ernakulam marks a very important milestone in the history of marine biology in India. The Centre was organized by the Council of Scientific and Industrial Research (C.S.I.R.) in co-operation with U.N.E.S.C.O. The chief considerations which led to the selection of India for the location of the Centre were (from Indian Scientific Programme 1962-65):

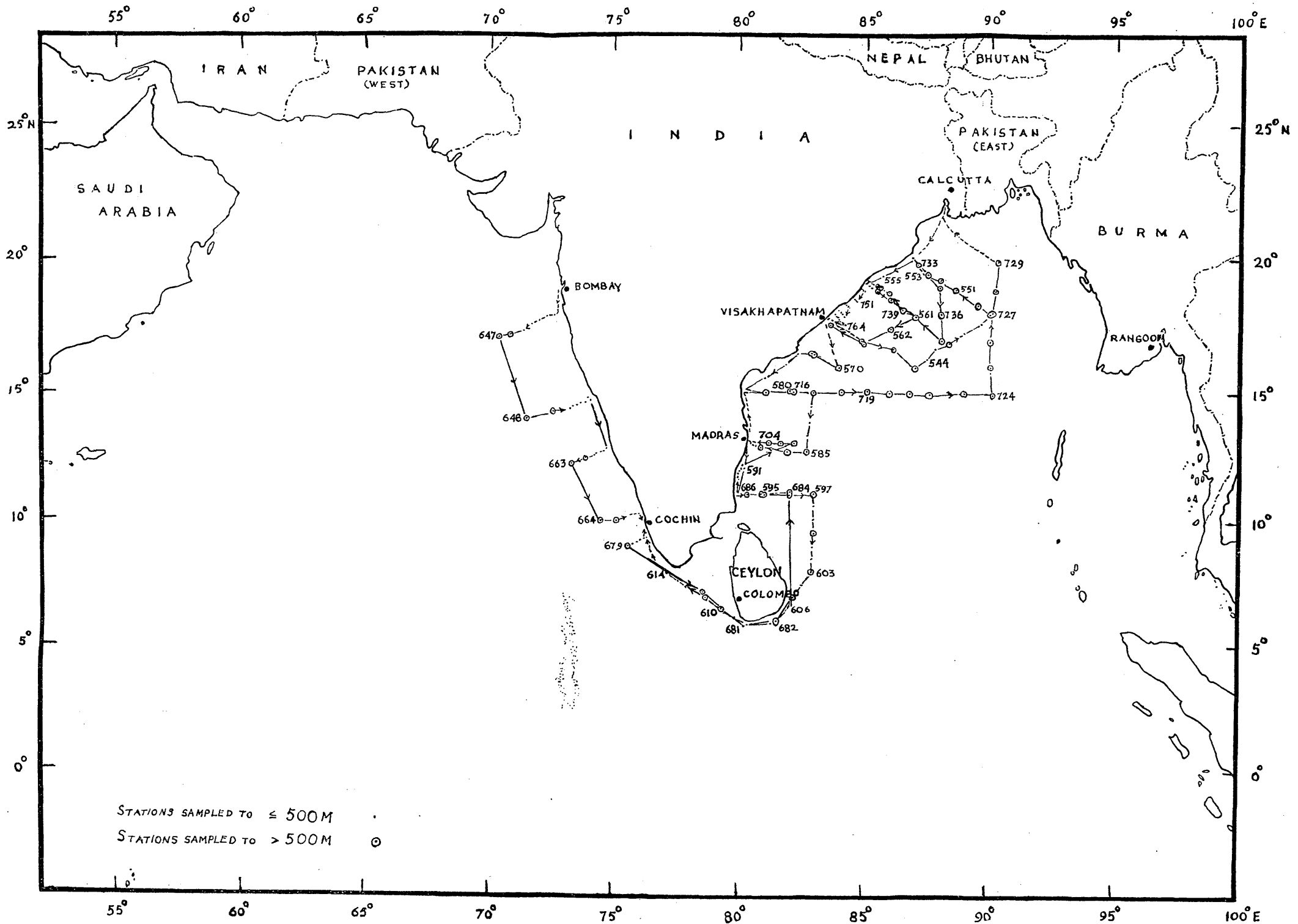


Fig. 2.—Indian programme during the I.I.O.E.; track charts of I.N.S. KISTNA, 1965.

[To face page 116]

1. Geographical location of India at whose ports many of the ships participating in the expedition were likely to call.
2. The very considerable interest in biological and taxonomic studies in India at scientific and university institutions.
3. The availability of a large number of trained biologists who could take up the work.
4. The advantage of a centre of this type in South Asia which would stimulate marine biological studies in the Asian region.

The principal functions of the Centre are:

1. Maintenance of a named reference collection of Indian Ocean material and duplication of it for laboratories throughout the world.
2. Sorting zooplankton samples taken by standard methods.
3. Examination of the sorted standard material or sending it to specialists throughout the world.
4. Sorting of the zooplankton samples at the request and expense of participating laboratories.
5. Training.

The development of this Centre in India has provided a unique opportunity for the training of biologists from India and other countries in the region. It is becoming almost a Mecca for visiting marine scientists and university parties from different parts of the country.

I.I.O.E. BENEFITS TO INDIA

The I.I.O.E. has achieved for itself the distinction of being one of the best examples of international co-operation between many nations both East and West. Indian scientists visited many neighbouring countries and the Indian ship I.N.S. KISTNA visited Singapore. India played host to scientists from many nations resulting in deep and abiding friendship. Many of the participating foreign research ships like R.V. ANTON BRUUN, R.V. VITYAZ, R.R.S. DISCOVERY, R.V. ARGO and R.V. HORIZON, provided facilities for ship-board training and research for many Indian scientists.

The expedition also provided opportunities for organizing seminars in which many young scientists from different parts of the country and senior scientists from abroad participated. An All-India Seminar on Marine Science was held at Waltair on 26–27th April, 1963, sponsored by the Andhra University, Waltair, the Indian National Committee on Ocean Research, the U.S. Programme in Biology and the U.S. Information Service. It was well attended and was a great success. At the time of the visit of R.V. HORIZON and R.V. ARGO at Cochin and then again at Calcutta during the visit of the U.S. Coast and Geodetic Survey Ship PIONEER seminars were arranged at which visiting scientists and their Indian counterparts participated in discussions. In July 1965 an International Symposium at Bombay on the Meteorological Results of I.I.O.E. was held and this was attended by a large number of foreign and Indian delegates.

As a finale to all this activity, a training programme was organized at the postgraduate level to train junior scientists in the subject and practice of Oceanography as a multi-disciplinary science during January–March 1966 at

Bombay. This was jointly sponsored by U.N.E.S.C.O. and C.S.I.R. A total number of 25 trainees were recruited from among the applications submitted by Indian and adjacent Asian countries to U.N.E.S.C.O. The break-up figures for the trainees were; India 20, Thailand 2, Singapore 1, Ceylon 1, and Malaysia 1.

THE FUTURE

While the Training Programme marked the end of I.I.O.E. activities, it also saw the birth of the National Institute of Oceanography (N.I.O.) of India. The Central Government approved the establishment of this institute as one of the national laboratories under the C.S.I.R. and appointed Dr N. K. Panikkar, Director of the Indian Programme under the I.I.O.E., as director of the new institute. All the activities started under the Indian Programme of the I.I.O.E., including the Indian Ocean Biological Centre, have now been merged into the National Institute of Oceanography.

The National Institute proposes to study various aspects of coastal oceanographical problems, coral reefs, oceanographical data for improved fishing and navigational charts, sedimentary history of the Indian Ocean basins, and prospecting for oil, ore, minerals, and phosphates in the sea.

Proposals are afoot for acquiring an oceanographical research ship for the institute. The institute also proposes to co-operate with other research organizations in India such as the National Geophysical Research Institute, Atomic Energy Establishment, Zoological and Botanical Surveys, and the Naval Research groups, and work on problems of mutual interest. The Institute may also have to concentrate specially on problems relating to desalination and also the pollution of coastal waters by big industries and atomic reactors.

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