

OCEANOGRAPHIC RESEARCH IN INDIA—PAST, PRESENT AND FUTURE

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(With a plate and a text-figure)

Several physical characteristics of the seas around India were known to our ancestors since ancient times. Although they did not have a proper understanding of the phenomena like currents, tides and winds, they utilized their empirical knowledge, based on experience and visual observations, for practical purposes. For instance, the biannual reversal of the direction of winds has been known to Indians and the Arabs for centuries. This knowledge they cleverly used for crossing the Arabian Sea for trade purposes. Similarly, as early as the Indus Valley Civilization period, our ancestors were fully aware of the phenomena of ebb and flood tides. This is evidenced by the remains of an excellent dockyard at Lothal which the Harappans constructed to receive ships at high tides. Studies carried out on this dockyard suggest that the Harappan Engineers possessed sufficient knowledge of the tidal range, periodicity and the effects of tides. The Indians also had some knowledge about the animal life in the sea. This is clearly reflected from the *Ain-e-Akbari* and the *Memoirs* of several kings of the medieval period which give information on the fish and fisheries of Hindostan.

The origin of oceanography in India can be traced as far back as 1871 when an officer of the Indian Museum, Dr. J. Wood-Mason, was sent to Andamans to explore the fauna

and flora of this region. He was perhaps the first person to carry out biological work in deeper waters off Andamans on board *S.S. Undaunted*. Immediately afterwards the Marine Survey of India was inaugurated in 1872. This was about the same time as *H.M.S. Challenger* sailed on her famous round-the-world cruises. Stimulated by the great success achieved by the *Challenger*, the Royal Asiatic Society of Bengal persuaded the Government of India to create a post of Surgeon-Naturalist to carry out work in Indian waters similar to that carried out by the *Challenger*. Thus in 1875, Dr. J. Armstrong was appointed as the first Surgeon-Naturalist. In 1881, a 580 ton survey vessel *R.I.M.S. Investigator I* was commissioned by the Marine Survey of India. On the request of the Government of India, the Admiralty agreed to give some of the equipment used on board *Challenger* for its use on *Investigator I* and thus the "oceanographic studies" in India began. These largely included biological collections, although occasionally observations on sea water temperature and bottom deposits were also made. *Investigator I* was scrapped in 1908 and replaced by *Investigator II*—a 1078 ton vessel, which was capable of cruising at faster speeds. However, it was not until 1910, when Col. R.B.S. Sewell took over as the Surgeon-Naturalist, that some observations on oceanography, other than biological studies, were started. These included the measurements of salinity and temperature of sea water, and some meteorological parameters like barometric pressure, air tempera-

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ture using wet and dry-bulb thermometers and velocity and direction of the winds. Due to the First World War, the work was temporarily suspended from 1914 to 1921, before it finally came to a standstill in 1926. However, the surveys carried out in the Arabian Sea, Bay of Bengal, Andamans and Laccadive Sea, revealed a wealth of knowledge of the marine animal and plant life in waters of the Indian coast. These are described in excellent publications brought out by the Royal Asiatic Society of Bengal.

Useful oceanographic data continued to be collected by research vessels which crossed the Indian Ocean during the course of their global expeditions. These included the Dana Expedition (1928-30), the John Murray Expedition (1933) and the Galathea Expedition (1950-52). As a result of these expeditions many interesting features of the Indian Ocean became known.

After independence in 1947, the need for maximum utilization of the resources of the seas around India began to be realized. The early efforts were evidently directed towards "food from the sea". Thus, the Central Marine Fisheries Research Institute was established in 1947 to carry out researches related to fish and fisheries. In the following years analysis of sea water samples collected by the various Naval and Merchant ships was also included in the research programmes. The Indian Navy established a Naval Oceanographic Laboratory at Cochin for researches on defence-oriented problems. At the same time, oceanography and marine biology started to be taught in some universities at the post-graduate level. Commendable work on physical oceanography and meteorology was carried out at the Andhra University during the period 1952-1958 and researches on some more disciplines of oceanography such as

geology and geophysics began to be undertaken for the first time in Indian waters. A Physical Oceanographic Wing was formed by the Central Board of Geophysics to carry out work on the physical aspects of oceanography.

However, thus far, a systematic approach to co-ordinate and expand the oceanographic work in India, according to country's needs, was lacking. Therefore, in 1960, the Government of India constituted the Indian National Committee on Ocean Research (INCOR) to meet some of the planning and coordination needs.

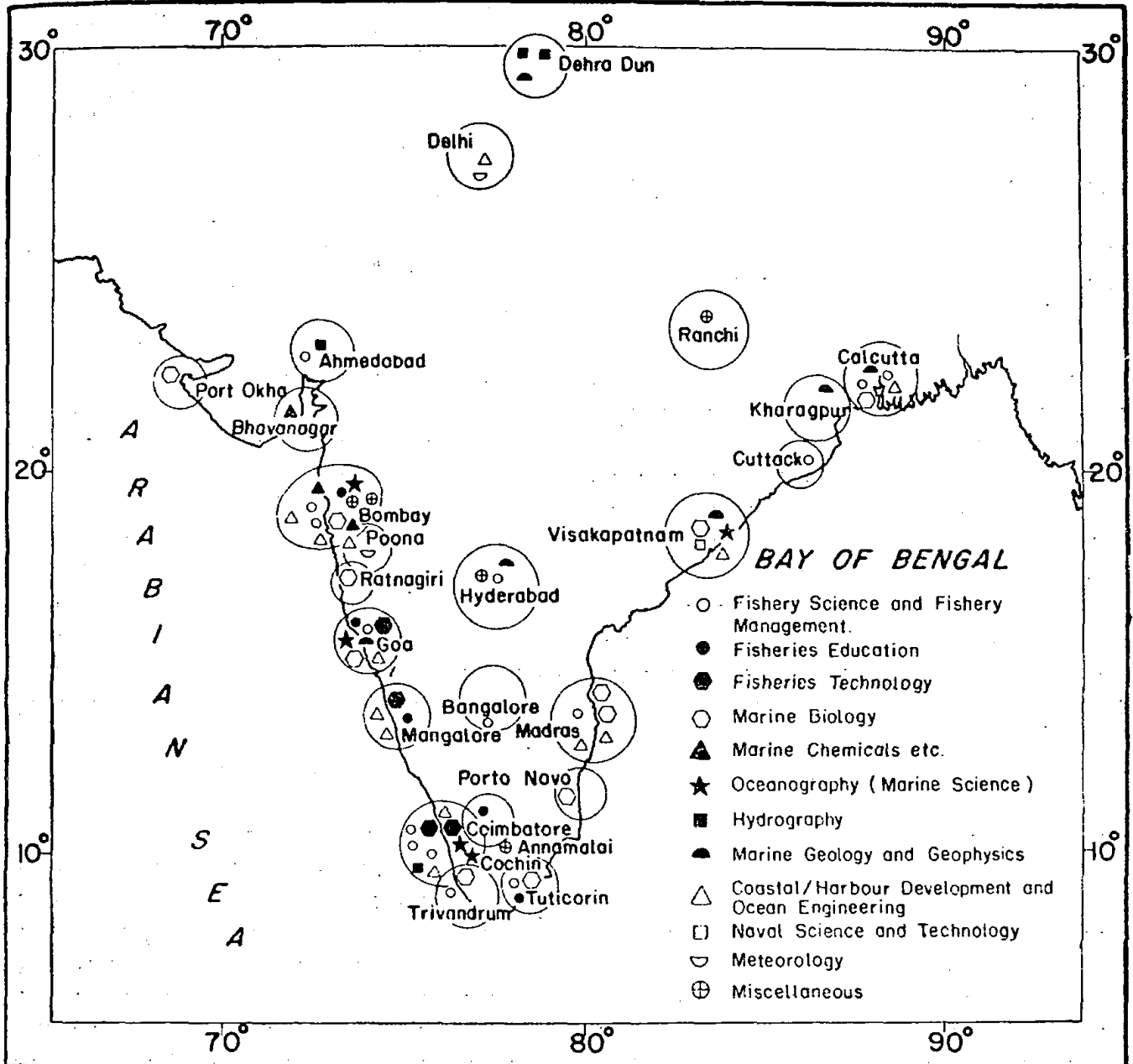
The International Indian Ocean Expedition:

Of all the world oceans, the Indian Ocean, even today, is the least studied. Most of the countries bordering the Indian Ocean are the most populous and at the lowest stage of economic development. It was, therefore, considered important to start this expedition so that new food and mineral resources could be explored for the benefit of these countries. Besides, the Indian Ocean poses several problems which are totally different from those of the other oceans. The land-locked nature of the Indian Ocean on its northern boundary and the bi-annual reversal of the direction of the winds known as the "monsoons" are the unique characteristics of this ocean. These considerations led to the development of a multi-national project, "The International Indian Ocean Expedition (IIOE)" co-sponsored by the UNESCO and Intergovernmental Oceanographic Commission (IOC). This expedition, in which 40 ships from 20 countries took part, started in 1962 and came to an end in 1965. A large amount of oceanographic data was collected from different parts of the Indian Ocean which helped in filling up the gaps in our knowledge of the seas around India. Because of the geographical position of our country and the scientific man-power it

OCEANOGRAPHIC RESEARCH IN INDIA

possessed, India became one of the active participants in the IIOE and played host to research vessels and scientists from different countries. Four ships from India took part in the Indian programme of IIOE. These were *I.N.S. Kistna*, *R.V. Varuna*, *R.V. Conch* and

M.F.V. Bangada. However, the bulk of the data from the Indian ships came from *I.N.S. Kistna*, a 90 metre frigate of the Indian Navy which was specially refitted for oceanographic work. Scientists from different disciplines went regularly on board *Kistna*. As a result of this



Location of institutions/organizations in India engaged in different activities related marine science and technology.

expedition, the country became aware of oceanography and developed a team of trained young scientists by the time the expedition came to an end. The expedition gave a firm base for the future oceanographic work in the country.

With the support of UNESCO and IOC, the Indian Ocean Biological Centre (IOBC) was established in 1962 at Cochin, for the study of zooplankton collected during the IIOE. The primary task of the IOBC was sorting of about 2,000 zooplankton samples, collected from the Indian Ocean, into various taxonomic components to be studied by specialists all over the world and also to store and maintain the archives of the samples. These tasks were successfully completed and the station data and displacement volumes of zooplankton samples were published in the form of several handbooks which also included the associated environmental data and research papers. The 10 atlases published by the IOBC summarise the distribution of the different planktonic groups in the Indian Ocean. These have been in demand throughout the world. The credit of most of the work done during the IIOE largely goes to the late Dr. N. K. Panikkar, who can be called the founder of modern oceanography in India.

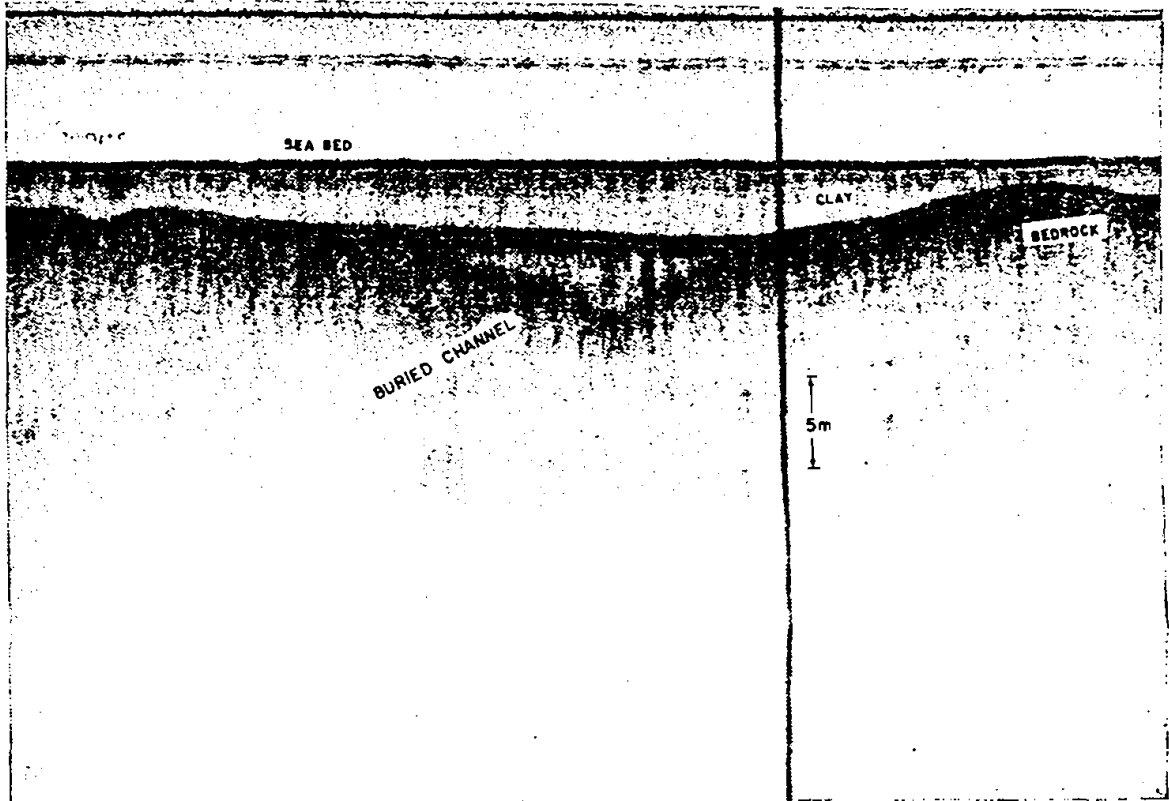
PRESENT

The National Institute of Oceanography:

The scope of the Indian National Committee on Oceanographic Research, which was initially set up by the Government of India for planning and coordination of the Indian programme of IIOE, was subsequently enlarged to cover all types of oceanographic activities in the country. This Committee strongly recommended that it would be in the national interest to consolidate the valuable experience

gained from our participation in the IIOE and that an institute having the status of a national laboratory be established in the country. The Government agreed to this proposal and thus the National Institute of Oceanography (NIO) came into existence on 1st January, 1966 as one of the national laboratories under the Council of Scientific and Industrial Research (CSIR). With its temporary headquarters in New Delhi, the NIO took over all the activities which were earlier functioning under the Directorate of Indian Ocean Expedition. Over the years, the NIO has grown into a very sizeable organization. It has its Headquarters in Goa and three regional centres at Bombay, Cochin and Waltair. Today NIO has seven divisions which cover Physical Oceanography, Chemical Oceanography, Biological Oceanography, Geological and Geophysical Oceanography, Marine Instrumentation, Ocean Engineering and Planning and Data processing. It has a staff strength of about 425.

The greatest impact on Indian Oceanography came with the commissioning of the first oceanographic research vessel of NIO *R.V. Gaveshani* on 31st December, 1975. This ship, has a displacement of 1900 tonnes and is equipped with some of the most modern oceanographic instruments. These include salinometers, current meters, CTD systems, proton magnetometer, sound velocity meter, side scan sonar, survey sonar, submarine photometers, bathythermographs, continuous temperature and salinity recorder and continuous wave recorder, in addition to various types of gears for the collection of water and sea bed samples upto 6 km depth. *Gaveshani* is also provided with most modern navigational and communication systems including the Satellite Navigational System (SATNAV) for accurate position fixing. The ship has four well-equipped laboratories on board. *Gaveshani* provides



Vertical profile of the sea bed showing the main features obtained by a seismic equipment installed in *R. V. Gaveshani*.



Picture of the sea bed taken by *R. V. Gaveshani* using a side scan sonar. Sediment cover (sand and clay) is recorded in light-tone and rock outcrops in dark-tone.

air-conditioned accommodation for 19 scientists and 45 officers and crew and has an endurance of about 25 days.

To date, *Gaveshani* has completed 48 cruises in the Arabian Sea and Bay of Bengal resulting in the collection of a large volume of data and information on the seas around India which have contributed a great deal to our knowledge about the Indian Ocean. Uptill June 1978, *Gaveshani* has surveyed more than 50,000 line kilometres in the sea and has worked at 920 stations. These cruises have resulted in the location of several potentially rich fishing grounds in the Arabian Sea and Bay of Bengal in addition to mapping of the sea bed for mineral resources. Using this ship, NIO has done a substantial amount of work for the Oil and Natural Gas Commission (ONGC) connected with the exploitation of offshore petroleum.

During the last few years NIO has fully utilized the expertise and indigenous technology available and has provided service and support to a number of industries and public sector undertakings in as many as 50 sponsored projects on such areas as resources survey, harbour development, submarine pipeline surveys, pollution control and protection of coast from erosion. These sponsored projects are of direct interest to the user community.

Under the project "food from the sea", NIO has located several rich fishing grounds, has mapped seaweed resources and has developed sea farming technology. Under the project "coastal development", one of the most important contributions of NIO has been the survey of 160 kilometre submarine oil pipeline route from Bombay High to Bombay for the ONGC. This pipeline has already been laid along the route given by NIO and the crude from Bombay High has begun to flow. Two other surveys for the submarine oil pipe-

line routes are underway. These are from Bassein oilfields to Hajira (200 km) and from Bassein to Tarapur (120 km). These surveys are the first of their kind done by an Indian agency and are entirely based on indigenous technology. They have not only saved valuable foreign exchange but have given confidence and self reliance to the country.

Along the coastline, various activities such as harbours, power plants, oil terminals, hotels, tourist resorts and industries are fast developing. About 36 projects have been completed by NIO for the coastal development programme including a number of projects for the control of pollution in the sea. These have been sponsored by private industries and public sector undertakings. The work has been extended to coastal areas of Gujarat, Bombay, Goa, Karwar, Mangalore, Trivandrum, Madras and Visakhapatnam. Recently NIO has completed a large project on the disposal of sewage in Bombay waters for the Bombay Municipal Corporation.

The problem of oil pollution along the coastline of India has also become alarming in recent years. Large quantities of crude oil are transported from the Middle East to the Far East and other places across the Arabian Sea. A part of this oil gets into the sea due to accidental oil spills or due to the unlawful dumping of the residual oil or bilge from the oil tankers into the sea. When the volatile fractions of the crude oil evaporate, the residue acquires a form of tar-like lumps or balls. These tar-balls find their way to the coast and adversely affect the recreational value of our beaches. Since oil pollution is a world-wide problem, it is essential for the international agencies to develop proper conventions so that suitable measures are taken to curb this problem.

The international projects in which NIO is

involved are: (i) Marine Pollution (Petroleum) Monitoring Pilot Project (MAPMOPP) under the framework of Integrated Global Ocean Station System (IGOSS) of IOC and (ii) Marine Environmental Monitoring and Marine Living Resources Assessment for the Indian Ocean Region under United Nations Environmental Programme (UNEP).

At present most of the instruments used for oceanographic research are being imported. Efforts are under way to develop some of the oceanographic instruments in the Institute to attain self-sufficiency in this field as far as possible. NIO has already developed instruments like current meters, salinometer, electronic sedimentation balance, bathythermographs and tide and wave recorder. Several other instruments like salinity-temperature and depth (STD) system are in advanced stages of development.

Besides NIO, several other organizations are also engaged in specific areas of research on oceanography, meteorology, marine biology and fisheries. Teaching and training are being done in the universities of Andhra, Annamalai, Cochin and Kerala. Sea fisheries research is being undertaken by the Central Marine Fisheries Research Institute, Cochin.

In recent years, the India Meteorological Department (IMD) has undertaken a series of observations in collaboration with USSR on the monsoon phenomenon. Preliminary studies conducted in 1973, known as the Indo-Soviet Monsoon Experiments (ISMEX), gave very interesting results. These are now being followed up by studies on a much larger scale. This project, called as Monsoon Experiments (MONEX), will help in understanding the phenomenon of monsoon whose appearance and disappearance have so far remained a riddle to meteorologists. In 1977, India carried out the Monsoon Experiment jointly with

U.S.S.R., but in the forthcoming MONEX-1979, several countries are participating and about 10 ships including *Gaveshani* will be fully involved in the programme.

THE FUTURE

Oceanography, the collective entity of all sciences, is relatively a young science for India. Considerable work has been done within a short period of about 12 years, during which time most of the infrastructure and manpower requirements have been built up. However, whatever has been done is a small fraction of what remains to be achieved. With the recent declaration of 200 nautical miles of Economic Zone, we have added a very large area, about 1/3 of the total land area of India, to our economic limits in the sea. This area needs to be intensively explored for the living and non-living resources. India's future oceanographic programmes are being planned to suit many urgent needs. With the discovery of oil off Bombay, a new era of oceanographic exploration has started. The vast continental shelf off the Indian coast must be extensively explored to locate similar structures. Search for offshore oil is likely to be intensified in the near future. NIO, being fully conscious of its responsibilities, is going to be actively involved in such studies. Major developments in the offshore oil exploitation are expected to be in the field of ocean engineering and technology. Offshore drilling platforms and sophisticated buoy telemetering systems for continuous data acquisition would have to be developed indigenously for successful exploitation of offshore oil. Similarly, a considerable amount of work will be carried out on the design of foundations of the structures to be built at sea.

Another field of potential importance is the optimum utilization of marine mineral resources. For this purpose, NIO is working in

collaboration with the Geological Survey of India (GSI) and the survey of almost the entire western continental shelf has been completed. More intensive studies are planned in the Bay of Bengal and in selected areas of the Arabian Sea. Deeper regions of the Indian Ocean are very rich in manganese nodules. It is hoped that very soon the country will be able to build up the necessary competence for the exploration and exploitation of manganese nodule.

The utilization of marine living resources is another area in which considerable effort will be put in, and for this, aquaculture or sea farming technology is going to create the greatest impact. Besides food, animals and plants of the sea are going to be used for many other purposes. Several important chemicals are likely to be obtained from seaweeds and marine animals such as corals, sponges, etc. These organisms are known to possess very interesting biologically active compounds which are different from those obtained from the land plants and animals so far. These chemicals have a rich potential for being developed into important drugs and pharmaceuticals. Realizing the importance of such studies, NIO has taken up a project on "drugs from the sea" in collaboration with the Central Drug Research Institute (CDRI), Lucknow.

It is known that most of the conventional sources of energy (fossil fuel) are exhaustible and hence many countries of the world are now seeking alternate sources of energy which will be unconventional and inexhaustible. Significant progress has been made in several countries including India for the utilization of energy stored in tides, waves, currents and temperature difference of water column in the sea. Preliminary studies carried out indicate that some areas of our country are very promising for harnessing tidal energy. Researches on this important aspect is likely to draw more and more attention during the forthcoming years.

The most significant contribution India will make during the next decade or so would be in becoming self reliant in undertaking the different challenging tasks of exploiting the sea and its resources for the benefit of its people. India will also provide support and expertise to many developing countries of the world in the field of ocean science and technology. The oceans will thus continue to hold the promise of meeting man's evergrowing needs for food, minerals, energy, chemicals, water, living space and climate. The new age into which we are moving in is not only the age of atoms, the electron and space, it is also the new age of the sea.