OCEANOGRAPHICAL AND FISHERIES RESEARCH IN INDIA

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Earlier Work

Although earlier investigations in Indian Seas were conducted by the British Naval Vessels from 1832 to 1862, serious attempts to study Indian waters were commenced only in 1872 with the inauguration of the Indian Marine Survey. The surgeon-naturalists attached to the survey ships were really the pioneers in marine studies of Indian waters. The Marine Survey was placed on a more permanent footing when the survey ship "INVESTIGATOR" was built during 1879 to 1880 and it is of interest to record that some of the apparatus used in this ship for work in Indian waters originally came from the gear used by H.M.S. "Challenger." The interest evinced in deep sea life by the Challenger Expedition was reflected in the special attention given to deep sea organisms of the Indian Ocean. Except for soundings and temperatures, the observations made were largely biological.

Sewell's Work on "Investigator"

In place of the "INVESTIGATOR I", a new ship of the same name was built and commissioned in 1908 commencing a new phase in oceanographic work in Indian waters with special reference to the temperature and salinity distributions up to a depth of 500 fathoms initiated by Sewell, who joined the ship in 1910. The work of Sewell on "INVESTIGATOR" continued till 1925 with the exception of a break of some years between 1914 and 1921 owing to World War I. Sewell's work brought out the general picture of hydrological features of the ocean. In a series of contributions published by the Asiatic Society of Bengal in 1925–35, the geography of the Andaman Basin, the nature of the sea bed and of the deep sea deposits of the Andaman Sea and the Bay of Bengal, the maritime meteorology of the Indian Seas, the temperature and salinity of the coastal and deeper waters of the Bay of Bengal and Andaman Sea, the topography of the Laccadive Sea and the coral formations in Indian waters were dealt with by Sewell. Additional oceanographic data were also obtained during this period from the results of the German Deep Sea Expedition "VALDIVIA" (1898–99) and

the Danish Dana Expeditions (1920–22) and the Dutch Snellius Expedition (1929), and to a smaller extent by traverses made by other survey ships.

John Murray Expedition

The third phase in the progress of Indian Oceanography relates to the period covered by the John Murray Expedition to the Indian Ocean on the research vessel "MABAHISS" led by Sewell. The region especially chosen was the Arabian Sea, to the west of Maldive and Laccadive Archipelago, in continuation of the "INVESTIGATOR" work. The expedition was able to confirm some of the findings of the Dana on the submarine contours and it brought evidence of the presence of submarine ridges running parallel to the Rift Valley system. The changes in the distribution of fauna in regions of the Arabian Sea were also clearly shown by the work of the John Murray Expedition, and a noteworthy discovery was made of the existence of large azoic areas off Arabia probably connected with petroleum formation. The results obtained by the John Murray Expedition have been dealt with in various volumes which have already come out, but the principal findings have been dealt with by Sewell in various papers.

Features of the Indian Ocean

Our present knowledge of the Indian Ocean has been summarized by Schott (1935), Sewell (1937), and Sverdrup *et al.* (1950). The fact that oceanographic information relating to the Indian Ocean is imperfect has been often stressed and with more intensive work it is possible that some of the concepts now current may require modification. This is especially so for that part of the Indian Ocean south of the Equator. The Northern part of the ocean is broadly divided into the Arabian Sea and the Bay of Bengal, each with further geographical sub-divisions. The topography of the Arabian Sea is characterized by the existence of a long series of submarine ranges, the Carlesberg Ridge beginning from the region of the island of Socotra and Gape Gardafui and extending to the southeast along the Chagos Archipelago and further south to the Island of Rodriguez. To the southwest of the Carlesberg Ridge and lying parallel to it lies the Mascarane Bank covering the Islands of Seychelles and Mauritius together with a series of reefs. To the north, the Carlesberg Ridge is continued by a different formation in the direction of Arabia and the Gulf of Oman; this ridge which is considered as the submarine continuation of the Kirthar Range of Sind is the Murray Ridge. The geology of these ridges and the sea floor require much further study before their origin could be established

with certainty. In the Bay of Bengal a north to south range, the Carpenter's Ridge, which probably is of volcanic origin, is situated to the west of the Andaman-Nicobar chain of islands. The mouths of the Indus in the Arabian Sea and the Ganga-Brahmaputra at the head of the Bay of Bengal have given rise to deep submarine gulleys (Indus Swatch and Swatch of no ground). The presence of the submarine ridges and gulleys substantially influences the circulation in the Northern Sector of the Indian Ocean. Further, there are widespread formations of coral reefs of the fringing and atoll types throughout the area except on the two sides of the Indian peninsula, although reefs are prominent around southernmost India and Ceylon, the Andaman-Nicobar group and the Laccadive-Maldive group. The reasons for their absence in most parts of the Indian Coast have not been satisfactorily explained, although it is usually attributed to estuarine influences and silting on the east coast of India and to the upwelling of colder waters on the west coast of India (Sewell, 1937).

Hydrologically the Bay of Bengal and the Arabian Sea present substantially different features and a careful study and interpretation of these differences might well explain the enormous disparity in fish production between the western and eastern coasts of India, the former contributing to more than two thirds of the total. The Bay of Bengal waters are generally less saline owing to the influence of the large rivers that empty into it. The eastern coast is also characterized by a well-developed estuarine fauna. On the other hand the salinity of the Arabian Sea waters is distinctly higher and the waters generally are of an oceanic character. Owing probably to the upwelling of deeper waters to the surface, the vertical mixing facilitated by the Carlesberg and Murray ridges and the turbulence resulting from strong S. W. Monsoon winds, the Arabian Sea waters appear to be richer in nutrients having extensive areas of high productivity. It is noteworthy that shoals of plankton feeding fishes like the oil sardine of Malabar (*Sardinella longiceps*) and the Indian mackerel (*Rastrelliger kanagurta*) largely contribute to the west coast fisheries of India.

Post War Interest in Fisheries and Oceanography

It may be said that the work carried out so far did not form part of any comprehensive programme for the investigation of Indian waters. Collection of further information has continued through the agency of survey ships and subsequent expeditions like that of the *Discovery II* and the *Galathea*. With the end of World War II, India, like many other nations of the world, was faced with problems of acute food shortage, and one of the subjects that received governmental attention was

the development of marine fisheries. It is natural that in connection with fisheries programmes a considerable amount of interest was also evinced in the further pursuit of oceanographical studies as an aid to the proper exploitation of marine fishery resources. A very small part of biological and chemical studies as a necessary ancillary to the development of fishery investigations was initiated in 1948 when arrangements for the systematic collection of hydrological data at selected fishery centres were made. These attempts to obtain hydrological data have been purely from the standpoint of fishery work and it cannot be said that they have been carried out in any systematic manner in the absence of a Fishery Research Vessel for regular cruising.

It is well-known that the arrival and departure of shoals of fish in any definite area are largely governed by their movements connected with their feeding and spawning habits, which are most intimately related to the physical and chemical properties of the sea water in which the shoals are located. In the sea there are periodical fluctuations in the physico-chemical conditions which may be annual, seasonal or even diurnal; these fluctuations are the combined results of the action of various meteorological and hydrodynamical factors. In addition to these more or less normal variations there may also be abnormal variations caused by geophysical disturbances or by factors unknown to us at the present time. A very systematic approach to these various problems is necessary to obtain a correct picture of sea fisheries of the Indian coast, which are largely seasonal and some of which, like sardines, show large variations from year to year.

Indian marine fisheries are largely seasonal in character and the causes governing the movements of shoaling fish and the reasons for the failure or shift of seasons of a given fishery are at present unknown. Similarly the fishing grounds have not been charted, though a beginning has been made in this direction for areas around Bombay. The area now exploited for sea fishing includes only the narrow coastal zone of five to six miles from the shore. Power vessels to exploit the off-shore fisheries have begun operations on a pilot scale in Bombay under the aegis of the Government of India and in Calcutta by the Government of West Bengal. In the not too distant future, it is expected that more vessels will be put into operation from different centres like Cochin, Madras and Visakhapatnam. The work of exploration of off-shore fishery resources and the charting of fishing grounds is one which calls for help from oceanographical studies as data on movements and composition of the water masses would be extremely useful.

Central Board of Geophysics

The Government of India constituted the Central Board of Geophysics in 1949 and an Oceanographical Committee of the Central Board of Geophysics reviews the problems of oceanographical studies in India from time to time with the ultimate object of setting up an Institute of Oceanography. This probably marks the first attempt in the country to think in terms of oceanography as an independent science which needs pursuit for its own sake without being subservient to the applied aspects of Fisheries, Harbour development, Coastal erosion, Tide Prediction, Survey and Navigation. It may be recalled that the Survey of India has for a long time been carrying out prediction of tides for thirty-nine ports from Aden to Singapore and it is also responsible for the mean sea level determinations. Expansion of tidal work is also contemplated by the Survey of India by placing tide gauges at most of the important ports and carrying out corresponding meteorological surveys with the help of the India Meteorological Department.

Extent of Available Data

The information on oceanographical topics available in India would therefore comprise (1) Salinity and temperature distributions as recorded by previous expeditions and part of which work is being continued with reference to Fisheries by the Central Marine Fisheries Research Station at Mandapam with the help of Fishery Naval and Merchant Vessels operating in Indian waters; (2) Data relating to tides, mean sea level and other physical aspects available with the Survey of India; and (3) Data on maritime meteorology available with the India Meteorological Department.

An extremely useful compilation of sea temperature, currents and meteorological data has been published by the Netherlands Meteorological Institute in the form of an Atlas in 1952.

Beginnings of Fisheries Research

Early attempts relating to research on marine fisheries of India were directed to experimental trawling operations by ships belonging to the Madras, Bengal and Bombay Governments and the scientific work relating to the biology of the Oil Sardine of the Malabar Coast. The trawling operations were commercially unsuccessful and fishery work in most provinces suffered neglect during the periods of economic depression that followed the first World War. The interest in the Sardine fishery of the west coast of India continued because of the disasters which this fishery suffered following the many successful years

for Sardines which led to the production of sardine oil becoming an important industry. Owing to the inadequacy of staff, lack of sufficient funds to carry out investigations with thoroughness, and the position of Fisheries as a Provincial Subject creating administrative problems when a fishery extends to two or more states, these efforts often lacked continuity. The first decision to tackle the marine fisheries investigation on an All-India basis was taken by the Government of India with the starting of the Central Marine Fisheries Research Station in 1947.

Central Marine Fisheries Station

This Central Institute was started in February 1947 for handling marine fisheries research on an All-India basis with temporary headquarters in the Biological Laboratories of Madras University until the permanent headquarters at Mandapam were ready for occupation. Buildings originally put up as a Naval Hospital by the Defense Department during World War II were converted into laboratories and temporary residential accommodation for the staff. Subsequently an aquarium was built with facilities for keeping organisms alive in circulating sea water and fittings to the laboratories were carried out. In addition to the headquarters station, there is a subsidiary research station at Kozhikode to deal with the special fisheries problems of the West Coast of India, and research units at Karwar in the Bombay State to deal with the mackerel fishery, at Narakkal in Travancore-Cochin to deal with the prawn fisheries and prawn farming operations, at Madras for handling studies on edible Mollusca and at Bombay for carrying out investigations on off-shore fisheries. In order to collect fishery data from the long coast-line of India, fishery survey assistants have been posted at twelve centres representative of the various divisions of the Indian coast-line extending from Kathiawar to West Bengal. The data gathered are analysed and computed at Headquarters, setting up for the first time a machinery for the collection of All-India marine fishery statistics.

Programmes of Marine Fisheries Research

The work of the institution is broadly divided into four categories, Fishery Survey, Fishery Biology, Marine Biology and General Physiology. Fishery Survey aims at assessing the marine fishery resources by computing fish landings and biological composition of catches to see if the marine fisheries in general are under- or over-utilized. Scientific study of exploratory work of the deep sea fishing vessels forms an essential part of the survey programme. The studies relating to Fishery Biology deal with the fish stocks, special habits, distribution, life-histories and such aspects of fish life as have intimate bearing on fisheries

problems. The major fisheries of India like the Sardines, the Mackerel, the Sharks and other less known categories of fishes are all investigated in detail in an attempt to understand the causes governing their abundance, and the efficiency with which the fish are caught and utilized. Subsidiary fishery resources like the prawns, the oysters, clams, etc. are also receiving close attention. Sea weeds which occur in considerable abundance in the sea and form a valuable raw material for the production of agar and other industrial products, are being investigated in detail to determine the extent of the resources. The third important category of investigations come within the field of Marine Biology dealing with the factors connected with the abundance of smaller forms of plant and animal life which ultimately form the food of fish. This is also correlated with studies on the chemistry of sea-water with a view to understanding seasonal changes in the occurrence of nutrient salts. Bacteriology of sea-water and fish products is also investigated with a view to arriving at enforceable standards in the handling of fish products. The physiology of fish and other commercially important forms of marine life are studied with a view to selecting suitable types that would be ideal for large-scale culture in coastal areas which could be developed into marine fish farms. The institution maintains a good library and a reference collection.

Correlation of Oceanography and Fisheries

In the above paragraphs some idea has been given of the approach to oceanographical and marine fisheries studies in India. There is need for a standing machinery to collect and integrate synoptic data on the hydrology and maritime meteorology of the waters that surround India. The emphasis so far received has been biological and although marine biological investigations on a considerable scale have been carried out at Visakhapatnam, Madras, Mandapam, Trivandrum, Calicut and Bombay, the full interpretation of these results has to await more intensive physical-chemical work. Preliminary chemical data on phosphates, nitrates, nitrites and silicates are already available for Madras, Mandapam and Calicut and it is hoped to extend these further in the near future. The greatest drawback, however, lies in the fact that studies have principally been carried out in inshore or neritic waters with few observations in the open sea. An attempt to obtain a clear picture of oceanographic conditions in relation to Fisheries has now been initiated by the Central Marine Fisheries Research Station from Bombay utilizing the facilities of deep sea fishing vessels operating from that port and especially in view of the excellent results in trawling operations to the west of Kathiawar, which has now been found to be

one of the richest fishing grounds in India. A new line of work to correlate fishery conditions with oceanography has been developed in the study of mud banks of the Malabar Coast where it has been established that the fine silt which settles soon after the southwest monsoon in the form of a submerged bank acts as a reservoir of nutrient salts, probably influencing the fisheries of that area. On the physical side, work has been started by the Indian Navy in the Port of Cochin. There is need for more detailed coastal surveys and accurate charts and maps for the entire Indian coast, and for this purpose the surveys which are being repeatedly carried out by the survey ships will, it is hoped, contribute a large amount of data.

Future Prospects

Oceanography is an infant science in India as compared with the status of the subject in the more advanced countries where work has been in progress for some years. Absence of adequate training facilities for physical oceanography at Universities and non-availability of suitable research vessels for oceanic work constitute the major obstacles to progress, but there is every reason to think that these will be overcome. The Andhra University on the East Coast of India has already formed a Department of Geophysics, and has initiated some work on physical and biological oceanography at Visakhapatnam. A few Indian Research Scholars are being trained abroad on the subject. Research Vessels for oceanographic and fisheries work are likely to become available under the Five-Year National Plan of the Government of India and substantial additions to equipment available for marine work are now being made at several centres of Research. These developments in a country situated in one of the least explored of oceans will be watched with interest by all students of Marine Science.

References

Ekman, S. 1953. Zoogeography of the Sea. Sidgwick & Jackson, London.

Gulatee, B. L. 1952. Tidal work in India. *Assoc. Oceanogr. Phys. Proc. Verb.* No. 5, 178.

John Murray Expedition. Various Scientific reports.

Koninklijk Nederlands Meteorologisch Instituut No. 135. 1950. Indian Ocean Oceanographic and Meteorological Data.

Panikkar, N. K. 1953. Fisheries Research in India—Pt. I. *J. Bombay Nat. Hist. Soc.*, 50.

Schott, G. 1935. Geographie und Oceanographie des Indischen und Stillen Ozeans. Hamburg.

Seshappa, G. 1953. Phosphate content of mud banks along the Malabar Coast. *Nature*, London, 171, 526-27.

SEWELL, R. B. S. 1925-35. Geographic and Oceanographic Researches in Indian waters. *Mem. Asiat. Soc. Bengal.*, Vol. 9.

———— 1937. Oceans round India: in Outline of Field Sciences of India, Calcutta.

———— 1953. Deep Sea Oceanographic Exploration in Indian Waters. *J. Bombay Nat. Hist. Soc.*, 50, 705-717.

SVERDRUP, H. U., M. W. JOHNSON and R. FLEMING. 1942. The Oceans, their Physics, Chemistry and Biology. Prentice Hall, New York.