The International Indian Ocean Expedition

Oceanographers will make full-scale "laboratory" studies of ocean-atmosphere relationships.

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Except for the glamor and excitement of working in far-away places, why are scientists particularly interested in studying the Indian Ocean? Many of the reasons are related to the monsoon. It is well known that the circulation in the Indian Ocean north of the equator changes markedly with the seasons. This change is particularly notable in the Arabian Sea, where there appears to be a complete reversal of the surface winds between January and July. This reversal is expected to have a marked effect on the biological production of the area. The regions of divergence and upwelling change with the seasons, and a given coastal area that, in one season, exhibits all of the characteristics of high productivity may be expected to have low productivity the following season. Partly because of their obvious economic consequences, the problems connected with the natural productivity of various oceanic regions have received considerable study in recent years. The relationships between oceanic circulation and primary production are complex and not easy to separate. One of the fascinations of the Arabian Sea is that one can study a single region under widely varying conditions. The fact that the Arabian Sea apparently has large untapped fisheries and that massive fish mortalities have been reported from the area are additional stimuli to investigation.

The International Indian Ocean Expedition (IIOE) is the name given to a concerted effort by scientists to learn as much as possible about the Indian Ocean during the next few years. It will include a series of oceanographic expeditions, in which at least 20 ships from a dozen countries will participate; the probable establishment of a marine taxonomic center somewhere in India; the operation of a laboratory ship for 2 years in the Indian Ocean for the purpose of studying marine biological problems; a series of geological and geophysical reconnaissance surveys of parts of the Indian Ocean; and an increase in the network of upper-air meteorological stations for studying the monsoon circulation.

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Reasons for the Expedition

Although there may be some disagreement concerning our level of understanding of the steady-state relationship between the mean wind field and the major ocean currents, there is little argument concerning our understanding of the transient problem of the effect of a variable wind field on ocean currents. All are agreed that the problem is very poorly understood. Furthermore, it is a problem that is not amenable to investigation with experimental models, and our best means of attacking it would seem to be to study it in a region such as the Arabian Sea, where the winds blow steadily in one direction for several months and then reverse themselves. Unfortunately, the monsoon circulation is not that simple, but in the Arabian Sea the oceanographer probably comes closer than in any other oceanic area to achieving a "full-scale laboratory experiment" on this particular problem.

Successful laboratory experiments presuppose properly designed instrumentation, and it seems likely that a certain amount of preliminary work will have to be done in this field merely to define the scale of the phenomena we are attempting to observe. The Arabian Sea may be a fine oceanographic laboratory but it has one major drawback. The weather during the summer months can be very bad. For example, the average wind in the Arabian Sea during July is about 30 miles per hour.

Although the equator is near the southern limit of the monsoon, it too is an interesting region to study. There is a seasonal reversal of winds along part of the equator and a reversal of surface currents. The most interesting problem, however, concerns the subsurface currents. Is there a swift, subsurface, eastward-flowing undercurrent in the Indian Ocean similar to that which has been observed in the Pacific and Atlantic oceans? There is as yet no completely satisfactory explanation for the Pacific and Atlantic undercurrents. However, because the other variables along the equator in the Indian Ocean appear to be different enough, it seems possible that a good knowledge of the subsurface currents of the Indian Ocean should help in evaluating the various conflicting explanations for the Pacific and Atlantic undercurrents.

The monsoon itself poses many interesting problems. The temporal and spatial relationships of the various events which, taken together, are referred to as the monsoon circulation have yet to be adequately described or explained. For instance, although the northern summer monsoon blows predominantly from the southwest at low levels, monsoon rains originate over southern China, apparently in response to upper tropospheric changes initiated southwest of India.

These are some of the problems that make scientists want to work in the Indian Ocean. Other prospective projects are the study of a western boundary current (such as the Gulf Stream) as it crosses the equator and the study of beach development under the reversal of strong, longshore currents. As our knowledge of the oceans increases, more and more often oceanographers ask themselves where they can go to observe a certain set of conditions in order to test a hypothesis. The Indian Ocean affords many opportunities for studies of this kind.

Many have claimed that the Indian Ocean is our least known ocean. In a

science in which so much is unknown there are many contenders for this rather dubious honor (the central South Pacific and the equatorial Atlantic among others), but there is little question that the Indian Ocean ranks very high on the list. Much of the effort during the next few years will be concerned with gathering biological, physical, chemical, and geological information about the land, ocean, and atmosphere, in order to provide a better description of the Indian Ocean area.

History

The International Indian Ocean Expedition was proposed at the initial meeting of the Special Committee for Oceanographic Research (SCOR) at Woods Hole, Massachusetts, 28 to 30 August 1958. At that time C. O'D. Iselin of the Woods Hole Oceanographic Institution was appointed convener of a small working group to consider exploration of the Indian Ocean. The Special Committee was established by the International Council of Scientific Unions (ICSU), and one of the reasons for its establishment was the fact that ICSU considered it important that international cooperation in field programs in oceanography be continued after the end of the IGY "on a broad basis and for a longer period."

The idea of a concerted effort in the Indian Ocean was further discussed, both informally and in formal sessions of SCOR, at the International Oceanographic Congress at United Nations Headquarters in New York, in September 1959. Shortly thereafter, SCOR asked Robert G. Snider to serve full time as Indian Ocean Coordinator. National committees were formed in many countries, including the United States.

In March 1960 the SCOR working group was reconstituted into three subcommittees under G. E. R. Deacon, director of the National Institute of Oceanography, England (*1*). Most members of the working group were able to meet in Copenhagen on 16 and 17 July 1960, at which time ideas and plans were exchanged and some matters of policy were decided. In the fall of 1960 the National Academy of Sciences Committee on Oceanography expanded its original panel for the International Indian Ocean Expedition to a series of five working groups (*2*). These groups were asked to prepare a program of work to be done in the Indian Ocean—work to be concentrated in a 2-year period beginning about July 1962.

In at least two ways the International Indian Ocean Expedition is similar to the International Geophysical Year: it requires cooperation from scientists from different disciplines and from different countries, and it is growing in size and scope well beyond the conception of the original proposal (*3*).

The original idea of SCOR can be seen in the name "International Indian Ocean Expedition." To most people, an expedition is a rather well-defined enterprise. An oceanographic expedition usually consists of a ship or a group of ships working together in an area on a given set of problems. Georg Wüst, director emeritus of the Institut für Meereskunde, Kiel, proposed such an expedition at the New York meeting in 1959. He suggested that all ships work together, making identical observations and in this way collecting the necessary data for a first-order physical, chemical, biological, and geological description of the Indian Ocean (*4*). As Wüst noted, the plan was similar in concept to that of the famed Meteor Expedition in the South Atlantic, of 1925–27. However, as the plans of the various national committees take shape it becomes apparent that the opportunity to work in the Indian Ocean means different things to different scientists. The idea of making a concerted attack on the problems of the Indian Ocean has caught the imagination of many people, and Snider, in his most recent report, was able to outline the plans of 20 different countries. As in most thriving enterprises, the report was out of date as soon as it was released.

United States Plans

Like the International Geophysical Year, the International Indian Ocean Expedition has no specific beginning or end. There will probably be a peak of activity in 1963, but there has already been a marked increase in the amount of work being done in the Indian Ocean. The Soviet vessels *Ob* and *Vitiaz* have carried out investigations in the Indian Ocean, as have the *Atlantis*, the *Vema*, and the *Argo* of the Woods Hole Oceanographic Institution, the Lamont Geological Laboratory, and the Scripps Institution of Oceanography, respectively. Oceanographic vessels from France and Japan have worked in the area recently, and there has been an increase in the oceanographic activities in several countries that border on the Indian Ocean, particularly in Australia.

The following are examples of projects planned as part of the U.S. National Program for the Expedition in the next 2 or 3 years.

1) The Woods Hole Oceanographic Institution is planning a program, in cooperation with the National Institute of Oceanography, England, to study the changing circulation pattern in the Arabian Sea during the two monsoon seasons. This work will begin in late 1962 or early 1963 and will include considerable work on the biological cycle related to these changing conditions.

2) The U.S. Coast and Geodetic Survey, in cooperation with the Committee on Mean Sea Level of the International Union of Geodesy and Geophysics, is planning to install 28 special tide gauges around the Indian Ocean, primarily to observe seasonal changes in sea level. It seems likely that seasonal changes are greater in parts of the Indian Ocean than anywhere else in the world.

3) The Scripps Institution of Oceanography of the University of California and the Narragansett Marine Laboratory of the University of Rhode Island are planning a joint expedition to the Indian Ocean, beginning in July 1962, to study the circulation in the vicinity of the equator during the two monsoon seasons. There will be two 3-month expeditions. During the first, the Scripps vessel will work in cooperation with one Australian ship. During the second, the work will be done in cooperation with several Japanese ships, with the National Institute of Oceanography, and perhaps with other groups.

4) It is expected that a "biological ship" will be stationed in the Indian Ocean for 2 years. This ship will be operated by the Woods Hole Oceanographic Institution and will be under the directorship of J. H. Ryther. It will serve as a kind of national facility for biologists from various parts of the country who would like to participate in the International Indian Ocean Expedition.

The U.S. Biological Program will consist of 2 years of operations in the western sector of the Indian Ocean, between the tips of India and Africa, during the calendar years 1963 and 1964. Approximately half the time will

be spent in making a series of meridional (north-south) sections between the land and the subtropical convergence (40°S) for studies of the systematics, distribution, and abundance of marine life in relation to water masses, current systems, and the monsoonal circulation. There will be sampling of all forms of life, from microorganisms to the large pelagic fishes and from the benthos to the surface flora and fauna. The other half of the ship's operations will consist of intensive ecological or physiological investigations of the flora and fauna in regions of particular interest (the Arabian Sea, the equatorial region, the Bay of Bengal, and so on) and of such biological phenomena as plankton blooms and red water, fish mortalities, and bioluminescence. During the same period, investigations of coastal and inshore waters, of islands, and of reefs are also planned, with landing of shore parties at such island locations as the Maldives, the Laccadives, the Chagos, the Seychelles, Mauritius, and Madagascar. Biologists interested in this program should write directly to John H. Ryther, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.

5) It is planned to establish, under UNESCO sponsorship, a marine taxonomic center somewhere in India. This center will serve as a preliminary sorting center for collections made in the Indian Ocean and at the same time will provide India with a reference collection of marine organisms from the area.

6) As part of an intensive study of the monsoon circulation, it is hoped to substantially increase the number of stations in the area that are capable of measuring winds at high levels. As part of this program, the United States hopes to man two weather ships stationed on the equator for a 2-year period. Besides providing meteorological observations, the two ships will be used for making intensive physical, chemical, and biological observations.

7) The IIOE provides an excellent opportunity for making more accurate calculations of the energy flux between the ocean and the atmosphere. Such observations and calculations can be made in several more or less independent ways, and it is hoped that four different techniques may be used for intercomparison.

8) Scripps, Woods Hole, Lamont, and the U.S. Coast and Geodetic Survey all expect to conduct reconnaissance-type geological-geophysical cruises in the Indian Ocean between now and 1964. (Lamont and Scripps have each had one such cruise to the Indian Ocean in the last 2 years.) Their programs will include gravity, magnetic, and bathymetric observations while the vessels are under way and coring, heat-flow studies, bottom photography, and seismic refraction observations while they are on station. Generally speaking, Lamont will work in the southern Indian Ocean, Scripps in the west-central region, and Woods Hole in the west Indian Ocean and the Arabian Sea.

9) The newly established National Oceanographic Data Center in Washington, D.C., will process much of the data from the expedition and will assist in the dissemination of data reports to interested persons in the United States and other countries.

Foreign-Policy Implications

Presidents Eisenhower and Kennedy have both endorsed the United States' participation in the International Indian Ocean Expedition. Although presumably the President of the United States is gratified whenever this country makes progress in science, it is probable that presidential endorsement of the IIOE signifies concern not so much with verification of theories of the equatorial circulation as with matters such as cooperation between oceanographic vessels of different nations, the development of oceanography in many of the countries bordering on the Indian Ocean, and the development of new fisheries industries in these countries from local programs growing out of the International Indian Ocean Expedition.

Whether science should be an instrument of foreign policy is no longer in question, if it ever was; the question now is how and under what circumstances it can be. The one point that does seem clear is that a scientific program, to be an effective instrument of foreign policy, must first of all be good science. A scientific idea or program that is pushed primarily for political reasons will ultimately fail, not only as science but as effective politics as well. It is important, therefore, that the International Indian Ocean Expedition be justified on the basis of its scientific program. If it can be, and if the various programs are carried out successfully, then there is reason to hope that it will also be effective in furthering international cooperation in science, assisting in the growth of science in underdeveloped countries, and attaining other objectives.

Scientists who wish to learn more details about any part of the U.S. program should address their queries to Robert G. Snider, Indian Ocean Coordinator, 30 East 40 Street, New York 16, New York, or to any of the chairmen or members of the various working groups. Questions about the programs of other countries should be addressed to Mr. Snider.

References and Notes

1. Members of the SCOR working groups are as follows. *Oceanography Subcommittee (Physical and Chemical, with liaison to Marine Meteorology)*: G. E. R. Deacon (National Institute of Oceanography), chairman; Günter Dietrich (Kiel University); Fritz Fuglister and Bostwick H. Ketchum (Woods Hole Oceanographic Institution); John A. Knauss (Scripps Institution of Oceanography); John C. Swallow (National Institute of Oceanography); Paul Tchernia (Laboratoire d'Oceanographie Physique, Paris); Michitaka Uda (Tokyo University of Fisheries). *Marine Biology Subcommittee*: Ronald I. Currie (National Institute of Oceanography, United Kingdom), chairman; B. G. Bogorov (Institute of Oceanology, Moscow); David H. Davies (South African Association for Marine Biological Research, Durban); George F. Humphrey (CSIRO, Sydney, Australia); Johannes Krey (Kiel University); Shigeru Motoda (Hokkaido University); N. K. Panikkar (Fisheries Development Office, New Delhi); John Ryther (Woods Hole Oceanographic Institution); John Steele (Marine Laboratory, Aberdeen). *Geology, Geophysics, and Bathymetry Subcommittee*: Robert L. Fisher (Scripps Institution of Oceanography), chairman; Bruce C. Heezen and John Nafe (Lamont Geological Observatory); Morris N. Hill (Cambridge University); G. Nanda (Naval Headquarters, New Delhi); Hiroshi Niino (Tokyo Fisheries University); Eugen Seibold (Kiel University); A. Zhivago (Geographia Institute, Moscow).
2. Members and observers of the NAS–NRC Committee on Oceanography IIOE Panel and working groups. *Panel on Indian Ocean Expedition*: Columbus O'D. Iselin (chairman), R. D. Fusselman, H. Arnold Karo, John Lyman, Arthur E. Maxwell, Roger Revelle, Joseph L. Worzel. *Working Group on Biology*: John H. Ryther (chairman), K. Banse, Alan W. H. Be, Howard Eckles, David Keck, David McGill, John A. McGowan, Dixie Lee Ray. *Working Group on Geology, Geophysics, and Bathymetry*: Robert L. Fisher (chairman), Preston E. Cloud, Charles L. Drake, Earl E. Hays, Bruce C. Heezen, Arthur E. Maxwell, George C. Shor, Jr., Harris B. Stewart, Jr. *Working Group on Meteorology*: Robert Fleagle (chairman), Jacob Bjerknes, Alfred K. Blackadar, Andrew Bunker, Earl Droessler, Donald Portman, Colin Ramage, Morris Tepper, Jack C. Thompson.
3. In the report of the first SCOR meeting in August 1958, a tentative total budget of about $4 million was given for the total expeditic → [*Deep-Sea Research* **5**, 75 (1958)]. It now appears that this sum will about cover the U.S. meteorological program.

→ G. Wüst, *Deep-Sea Research* **6**, 245 (1960).