CONSEIL INTERNATIONAL DES UNIONS SCIENTIFIQUES · INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS
SPECIAL COMMITTEE ON OCEANIC RESEARCH
(SCOR)

# INTERNATIONAL INDIAN OCEAN EXPEDITION

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## A PRELIMINARY PROSPECTUS

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## THE INDIAN OCEAN

Physical Characteristics - Although the Indian Ocean's 28,000,000 square miles cover over 14% of the earth's surface relatively little is known or understood about the region, which has an area five and a half times that of Antarctica and greater than that of Asia and Africa combined. The Ocean's behavior affects all of these continents yet only the most general features of its topography and circulation and the distribution of living organisms are known. For instance, more than three hundred times as many bathythermograph observations have been taken in the North Atlantic as in the Indian Ocean; almost half of the area has had no biological sampling and in most of the remainder observations range from 4 to 1 per 5° square.

The Indian Ocean has several unique characteristics. Nowhere else in the world is there a similar seasonal reversal of the prevailing wind. The wind system in that part of the Ocean lying above the equator is characterized by the two monsoons, one blowing from the Northeast for approximately six months and the other blowing from the Southwest for the rest of the year. This phenomenon has a vast but essentially still unknown effect upon the currents and organisms in the waters.

Another notable feature is the apparent productivity of this Ocean. In June 1957 a Russian ship not far from the main trade route between Colombo and the Gulf of Aden reported millions of tons of dead fish floating in an area some one thousand kilometers long and two hundred kilometers wide extending across the middle of the Ocean. Similar reports came simultaneously from British ships in the region. During the same year smaller fish kills were reported in nearby parts of the Arabian Sea. It is not known how the fish were killed, but the very size of this catastrophe gives some idea of the potential mid-ocean resources which are currently untapped. There is further fragmentary evidence of unusually high productivity.

The Indian Ocean is one of our last unexplored frontiers. Since 1873 less than two dozen vessels have carried out oceanographic investigations there. Modern techniques have only been used in quite limited areas. Limited coverage has left great gaps in both areas visited and in the nature, intensity and accuracy of observations. No systematic study has been attempted nor do the combined profiles of the observations reported give more than a preliminary picture of the Ocean's behavior and characteristics.

Socio-economic Characteristics - Many of the nations lying in the tropical and sub-tropical regions which surround the Indian Ocean are among the world's most densely populated countries, with continuing rapid growth. Over a quarter of the world's people live in these countries.

Population pressures on the existing food supplies result in prevalence of diseases attributed to protein starvation. Such protein deficiencies are common in India, Ceylon, Indonesia, Malaya and in parts of the east coast of Africa. Some of the nations bordering the Indian Ocean have a seafaring tradition and conduct extensive fisheries. To feed their crowded populations, they are interested in expanding these fisheries.

## EXPEDITION DESIGN

Participation - Under the non-governmental sponsorship of the International Council of Scientific Unions (ICSU) and its Special Committee on Oceanic Research (SCOR) scientists in the various nations experienced in oceanographic research will staff vessels provided by marine laboratories of these several nations. Scientists from countries unable to provide vessels will be invited to work on the Expedition's ships. Every effort will be made to obtain active participation by each nation bordering the Indian Ocean. The degree and nature of participation will depend to some extent on the ability of each country to provide funds, facilities and personnel, and in part on general interest in advancement of the science of oceanography.

Up to 1 December 1959 the following fourteen nations had formed National Committees for SCOR: Australia, China (Taiwan), Denmark, France, Germany (Federal Republic), Great Britain, Indonesia, Israel, Japan, The Netherlands, Norway, Union of South Africa, United States of America, and Union of Soviet Socialist Republics. It is reasonable to assume that vessels will be available from at least Australia, France, Great Britain, India, Japan, Union of South Africa, U.S.A. and U.S.S.R.; it is hoped that Germany, The Netherlands and the Scandinavian countries and possibly others will also be able to provide some ship time.

Timing of the Expedition - The period of peak activity will occur in 1962 and 1963. Preliminary plans will be completed by August 1960 and the first cruises in the coordinated effort will occur in late 1960. The Expedition will continue into 1964 and data analysis will undoubtedly continue past that date. An atlas incorporating the full findings is contemplated.

Because of the present scarcity of information on the Indian Ocean, there will need to be continuous revision and reexamination of the plans as new data are acquired. Every effort will be made to complete preliminary processing and analysis of data within six to eight months in order to redirect subsequent cruises. This fact, together with the importance of obtaining a series of observations of the same area in different seasons, makes it desirable to spread the program over several years rather than to have a major simultaneous effort.

Procedure - A preliminary and tentative cruise pattern for the entire Indian Ocean (see Appendix A) has been agreed upon by members of SCOR and National Committees. In regions where seasonal differences due to monsoons are significant, ships will cruise twice along the same track. To complete the pattern will require about ten ship-years of operation over a total of 180,000 miles.

Uniform standards for observation techniques and instrumentation will be established. Exchanges of scientists between ships of participating nations will be arranged. Existing World Data Centers will be used as repositories and new biological centers for analysis and custody of biological specimens will be established in the Indian Ocean area.

Ships participating in the Expedition will devote at least half of their time to work according to the coordinated grid and half to independent investigations determined by the scientists involved. The intensity of studies in a given area will depend on the nature of the phenomena anticipated; thus many more observations may be expected in the boundary currents at the borders than in mid-ocean. Division of national responsibility for the various segments of the coordinated plan will be negotiated at meetings in 1960 and 1961. All nations which have agreed to participate have also agreed to adjust their plans to the common program.

## PROBLEMS TO BE STUDIED

Physical Oceanography - Several fundamental oceanographic problems can be studied more efficiently in the Indian Ocean than elsewhere because of the reversal of the winds. Understanding the oceanic processes here will contribute to a knowledge of all oceans. The plan is to study basic questions such as: - How long does it take the winds to set up a current? How rapidly does this current deepen with time? What percentage of the energy required to maintain an ocean current comes from the winds and what part of it comes from the horizontal density gradients due to regional climatic differences? How does internal friction and how does friction with the bottom influence the velocity-depth distribution? What is cause and what is effect in the general circulation of the oceans?

The Indian Ocean is a vast environmental laboratory eminently suited for the investigation of these problems. It is a complete ocean system, yet small enough to be studied as a whole. While it is too large for a single nation's efforts it is ideal for an international cooperative endeavor. Extending from polar through tropical waters, and divided in its northern part into small oceans each subject to radical seasonal reversals of wind, it offers unparalleled opportunity for a wide variety of specialized investigations.

Chemical Oceanography - The Indian Ocean is unique among the world's seas in several ways. One of these, of course, is the extent of our scientific ignorance about it. From this point of view, the systematic collection of physical and chemical data during the survey will be very valuable, because for the first time it will be possible to describe the distribution of plant nutrients and dissolved organic compounds.

Perhaps a more significant singularity of the Indian Ocean is the fact that it is such a large basin closed off from exchange with other seas north of about 40° S. Into this vast gulf pour quantities of drainage water from the land carrying their burden of substances dissolved from the rocks and soil. Thus it is an ideal place to study the effect of runoff on the composition of sea water. For example, studies of elements such as copper and barium, with a relatively short residence time in the sea, should show concentrations markedly higher than in the Pacific or Atlantic.

In recent years the application of geochemical techniques to oceanic problems has added much to our understanding of residence times and of the rates of exchange between surface and deep waters. During the Expedition samples will be collected for carbon-14 dating, for analysis of carbon and oxygen isotopes, and for radium assay. This geochemical survey of an entire ocean will permit a much better evaluation of the circulation than has been possible where the sampling has been neither so systematic nor so extensive.

Meteorology - The meteorological objective is to obtain increased understanding of the energy exchange between sea and atmosphere, particularly near the air-sea boundary. To this end, basic research will be carried out on radiation input and on interaction of atmospheric pressure, winds, cloudiness, rainfall and evaporation with temperature, movement and roughness of the sea. A SCOR working group is drafting a list of desirable objectives in conjunction with various meteorological organizations.

Marine Biology - In addition to its effect on the circulation of near-surface waters, the monsoonal reversal of winds is expected to have important biological repercussions. Regions of upwelling and of high productivity should develop, decay, and shift from place to place, so that dramatic changes in the distribution and abundance of marine organisms can be anticipated. Nowhere else in the world ocean is it possible to study the interaction of atmosphere and biosphere on such a scale.

Standard biological collections and measurements made systematically over the whole area will define the biological "structure" of the ocean, the three-dimensional distribution of plants and animals. Integration of these observations will permit an assessment of the magnitude of the living resources. They also will provide the basic biological information -- the distribution of fish eggs and larvae, and of fish food, for example -- which are essential to the eventual understanding of fluctuations in the abundance and availability of commercial fish.

Since the War great advances have been made in the techniques for measuring primary production of organic matter. The widespread, systematic use of these methods by the ships of the Expedition will help us to assay, for the first time, the fertility of the Indian Ocean.

Marine Geology and Geophysics - Except for data collected during the IGY bottom topography and the crustal structure underlying the Indian Ocean are barely known. Old soundings delineate major structural components comparable to those of the Pacific and the Atlantic: trenches, undersea mountain ranges, a mid-ocean swell, and possibly fracture zones. The arrangement of these components and their relationship to the structures of the bordering continents are markedly different in the Pacific and Atlantic. Is the Indian Ocean a Pacific or an Atlantic type ocean? Precise modern soundings, in addition to clarifying this issue, will be of immediate use in providing a base map for all the other studies and data necessary for navigational charts, and it is even possible that they may uncover rich shallow-water fisheries at considerable distances from shore. Integrated geophysical studies - of the areal pattern of heat flowing from beneath the crust, the gravity field, the crustal thickness, and magnetic characteristics of oceanic and border areas - will certainly furnish basic information for the problems of ocean and continent development.

Intensive coring, dredging and bottom photography, will yield data on processes of sedimentation, productivity, climatic and magnetic changes during the last several millions of years, and the distribution of potential ores of manganese, nickel and cobalt in manganese nodules.

## PRACTICAL IMPLICATIONS

The proposed research will provide fundamental and valuable scientific knowledge. Some findings will have direct and immediate bearing on economic development and human welfare. Location of shoals and regions of upwelling will identify likely fishing areas. Studies of distribution, nature and seasonal variation in nutrients and marine organisms will indicate what to fish for and when. Preliminary quantitative estimates of fish population, when supplemented by exploratory fishing will suggest the magnitude of the fishery resource.

The data obtained will provide an essential part of the information on which decisions can ultimately be reached on the nature of fishery operations, markets and methods of marketing, extent of investment, and related development problems. A new source of protein could mean food for hungry people. If it came from the ocean, land and other capital devoted to protein food raising could be shifted to other uses. Marine organisms could also provide fertilizer and animal feed in areas now lacking adequate supplies.

Meteorological information, related to oceanographic knowledge, will be obtained on a synoptic basis. This may lead to better long range weather forecasting. The ability to predict the onset of the monsoon and to estimate variations in the quantity of rainfall bears directly on flood control and on water regimen for agricultural use. The understanding of variations in location and intensity of ocean currents can lead to more economic routing of ships. Such knowledge applied in the North Atlantic has resulted in savings of as much as 10% in fuel consumption.

Charting and sampling the ocean floor through soundings, cores, geophysical measures, dredging and photography provide information useful for navigation and fisheries, and may reveal resources of economic value.

Finally, as never before, intensive training and experience in oceanographic research will be available to residents of a maritime area. Possibly twenty vessels, with facilities for about three hundred and fifty scientists will operate on the Expedition. Exchange of scientists between ships and partial cruises by individuals will increase the number of training billets available and vary their experience. Data processing centers and biological classification laboratories will serve as nuclei for post-Expedition scientific development around the Indian Ocean.

In other parts of the world, the focus over several years on the International Indian Ocean Expedition would serve as a device to attract students to the field of oceanography, helping to relieve a world shortage of marine scientists.

## FINANCIAL REQUIREMENTS

Factors in Estimating Cost - Prior to detailed planning and scheduling, preliminary order of magnitude estimates of cost have been prepared using the most reliable projections and the most experienced professional judgment available.

Based on agreements made by SCOR representatives it may be assumed that marine scientists and oceanographic institutions throughout the world will commit time, vessels and efforts to the program. Also in accordance with SCOR agreements, it may be assumed that 50% of the time spent in the Indian Ocean will be devoted to the systematic study described above, the other half to special investigations individually chosen.

It is hoped that cost of ship transit to and from the site as well as the "uncoordinated" half of ship and scientist time there will be met by the participating institutions and countries as part of their existing program. Additional assumptions have been made regarding technical aspects as, for example, overall average speed of advance of ships along tracks in differing situations, time required by scientists for data analysis after completion of cruises, and cost of ship operation and of scientific staffs in different nations.

Using reasonable assumptions about the availability of ships and national cooperation (prior to firm national and institutional commitments) we have

estimated the following participation with corresponding costs. It should be emphasized that this is a very rough and preliminary estimate, and does not imply either a limitation or a demand on any country. It is given simply to illustrate the possible order of magnitude of the operation.

| Nation | Number of Vessel Trips | Ship Years | Ship Operation Cost | Scientific Staff Cost | Coordinated International Indian Ocean Expedition Cost To Be Funded (Generally less than 50% of total cost) |
|---|---|---|---|---|---|
| Australia | * | 1 1/3 | $ 400,000 | $ 360,000 | $ 380,000 |
| Denmark | 1 | 2/3 | 150,000 | 280,000 | 200,000 |
| France | 1 | 2/3 | 200,000 | 200,000 | 180,000 |
| Germany | 1 | 2/3 | 250,000 | 280,000 | 250,000 |
| Great Britain | 2 | 1 | 300,000 | 400,000 | 300,000 |
| India | * | 1/2 | 100,000 | 180,000 | 140,000 |
| Japan | 4 | 2 2/3 | 600,000 | 1,000,000 | 800,000 |
| Union of South Africa | * | 1 1/3 | 250,000 | 360,000 | 305,000 |
| U.S.A. | 7 | 4 1/3 | 1,550,000 | 2,400,000 | 1,860,000 |
| U.S.S.R. | 3 | 2 | 1,500,000 | 2,640,000 | 1,960,000 |
| TOTALS: | | 15+ | $5,300,000 | $8,100,000 | $6,375,000 |

Additional - Special training and equipment - $200,000 to $300,000

* Frequent cruises as scheduled

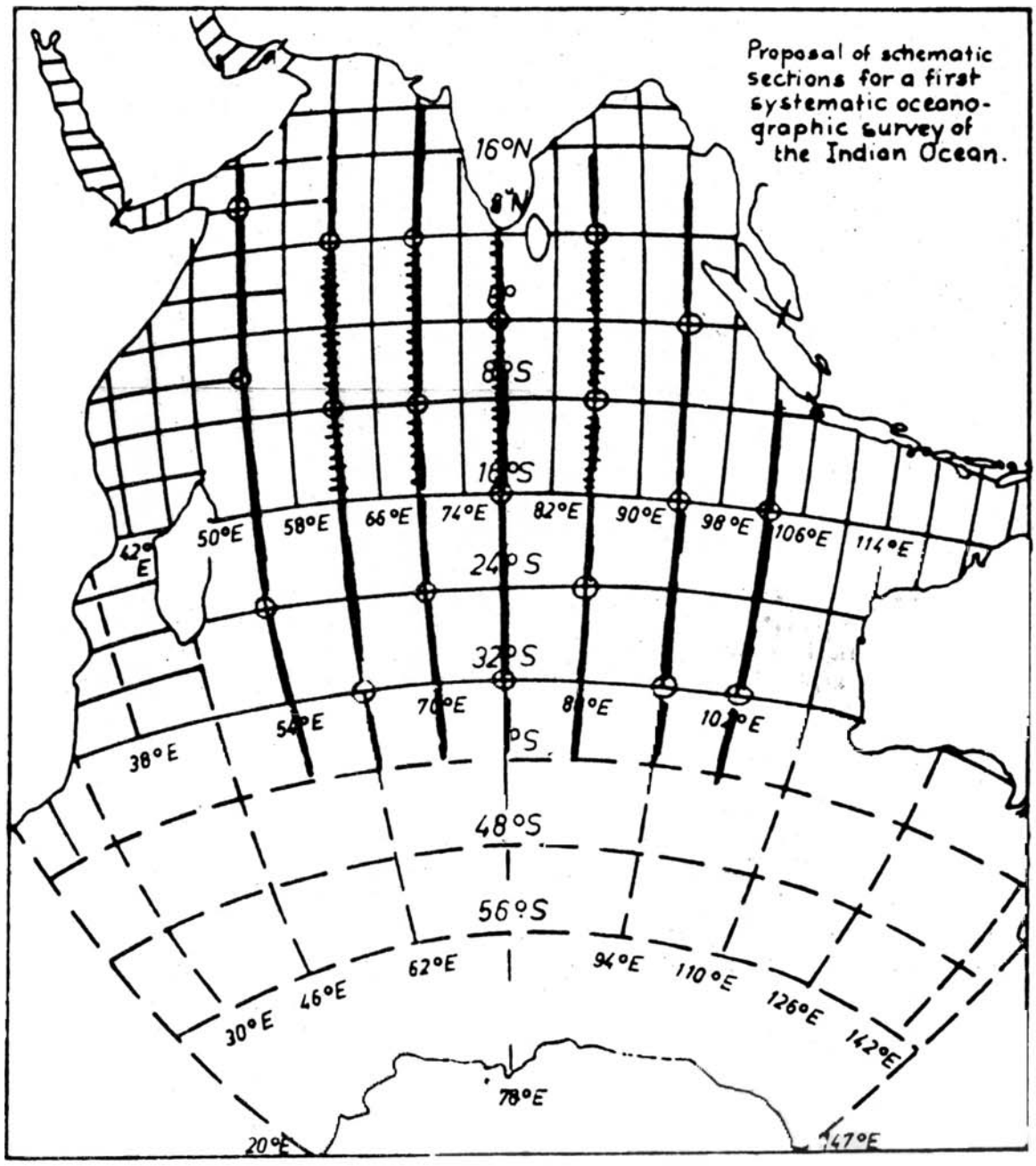
Of the total estimated cost - approximately thirteen and a half million dollars - about six and a half million dollars in new funds will be required to finance the Indian Ocean Expedition. This schedule would provide over 225,000 miles of coordinated research, allowing for development beyond the basic 180,000 miles as new problems for exploration arise.

Fund Sources - The $6,500,000 needed now will be solicited from governments, international agencies and private foundations. Here is an opportunity for support of basic research with a high potential for early practical application of findings. It is an opportunity for truly international scientific cooperation to benefit mankind. It is an opportunity for exploration of one of the last substantial unknown areas on this planet. It is hoped that the International Indian Ocean Expedition will attract development funds from individual governments, pre-investment and technical assistance funds from international agencies, training and equipment funds from private sources and basic scientific research funds from all sources.

NOTE: Detailed plans for research in the several scientific disciplines are being prepared by working groups. These will be discussed at the SCOR meetings in Copenhagen, July 9 and 20, 1960. Reports of the activity of SCOR and preliminary documents in some fields have been sent to National Committees for SCOR by its Secretary - Dr. Günther Böhnecke, Bernhard-Nocht-Strasse 78, Hamburg 4, Germany.

RGS/jas

21 January 1960




Repeated sections at SW-Monsoons and NE-Monsoons

Single sections

Systematic biological collections

Special equatorial biological studies

O Complete study of water column