The International Indian Ocean Expedition

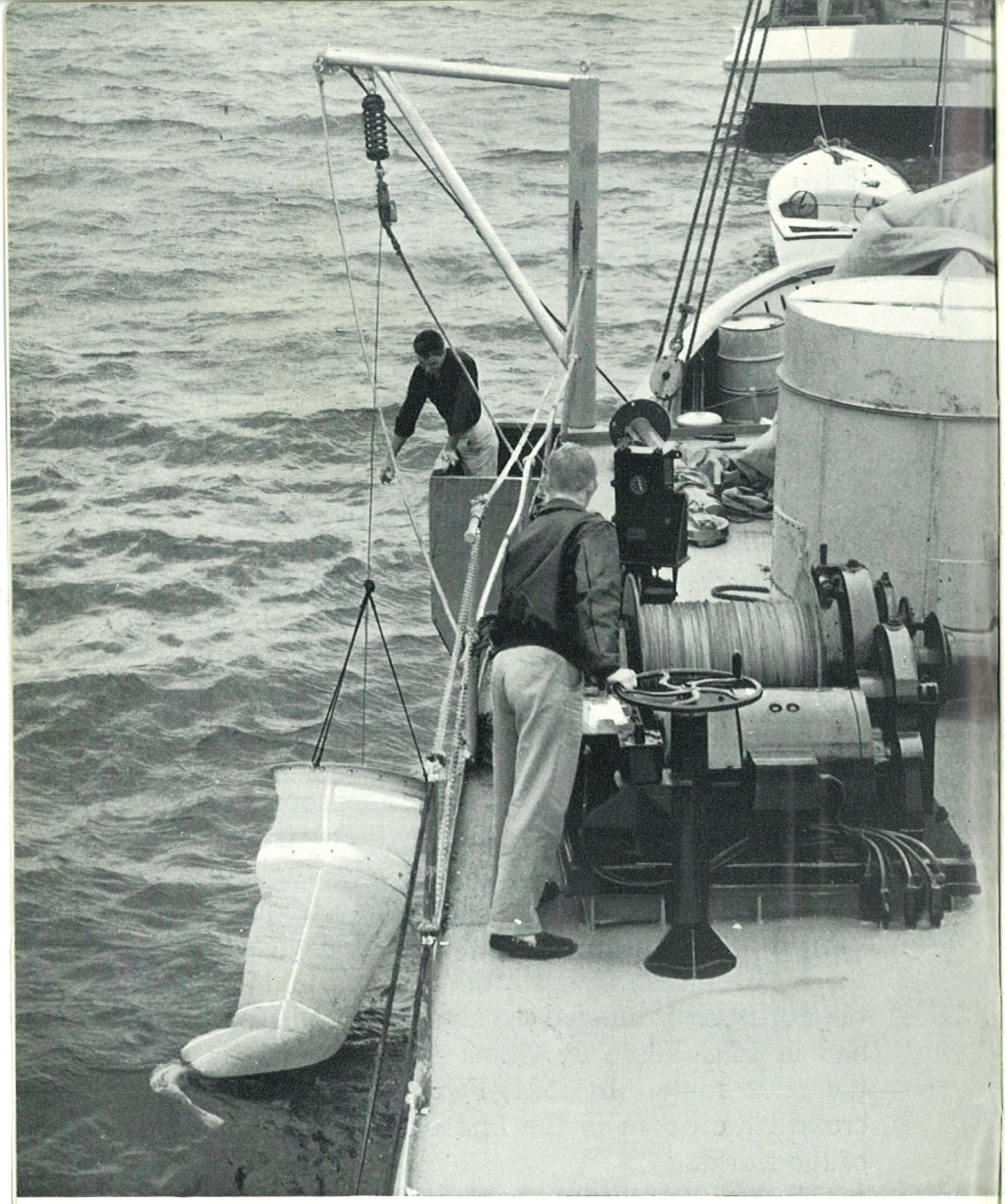
Cover design : RAY KOMAI

The International Indian Ocean Expedition

THE waters of the Indian Ocean cover over twenty-eight million square miles, a seventh of the earth's surface. A fourth of the world's population live around its rim.

There is some evidence that the ancient Hindus navigated the low latitudes of Bharat Mahasagar. But historians generally believe it was the Phoenicians who first explored its northern waters in the 7th century B.C. and to them it was known as the Erythraean Sea. Hippalus, an Egyptian navigator, who lived about the beginning of the Christian era, was the first to observe the regular monsoons of the Indian Ocean and to profit by these unique, alternating winds and currents. By the 9th century A.D., the Arabs were making frequent voyages. A Russian, Afanssy Nikitin, navigated the Indian Ocean in the 15th century. In 1486, the Portuguese rounded the Cape of Good Hope and in 1498 Vasco da Gama reached India by the same route. In 1521, Ferdinand Magellan crossed the ocean in the first circumnavigation of the world.

By the 19th century, the world's busiest trade



Biologists lower a plankton net to obtain samples of marine life.

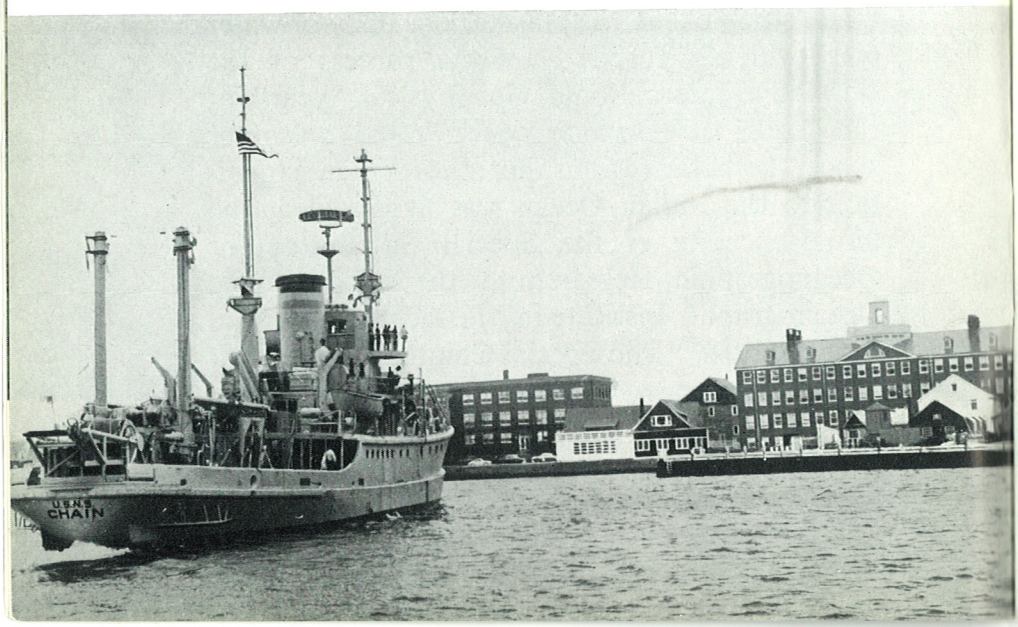
routes traversed the Indian Ocean. Modern scientific techniques in meteorology which developed near the end of the century, might have extended the already considerable weather lore of the area. But a combination of circumstances operated against this. Sail was replaced by steam. The Suez Canal was opened. And the Atlantic and Pacific trade routes grew in importance. The German ship *Valdivia* investigated the winds and weather of the Indian Ocean in 1898-99, and this was the first and last such expedition until a few years ago.

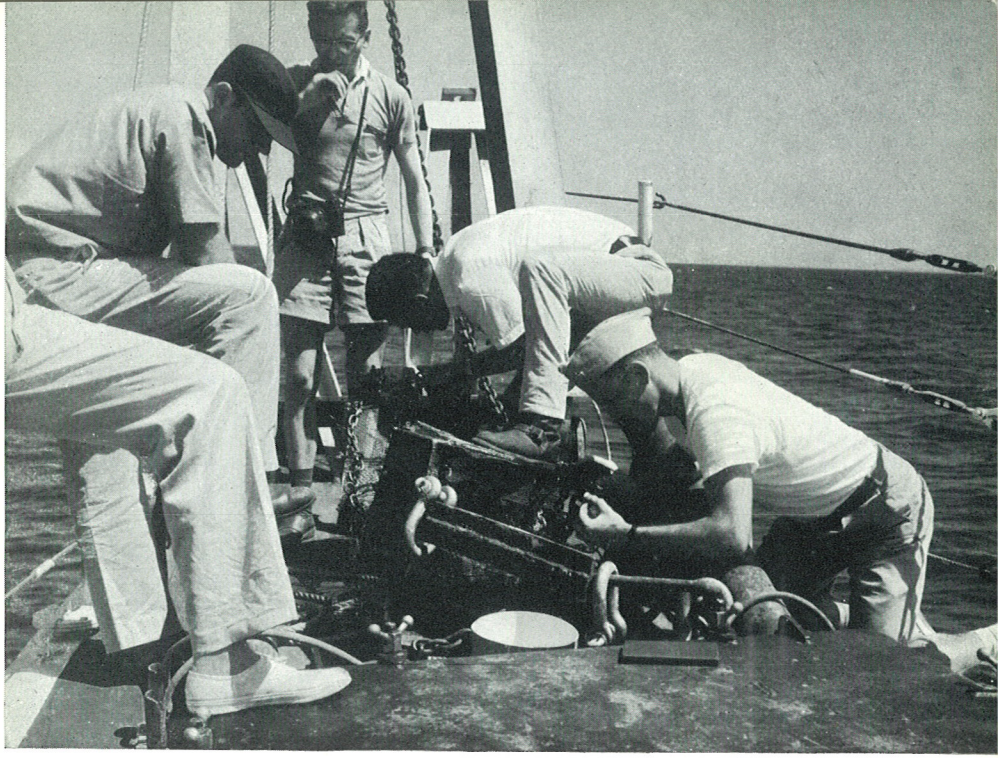
The *Valdivia,* and other ships in succeeding decades—British, Swedish, Danish; the international tradition is long-standing—contributed to a general understanding of Indian Ocean topography. But large portions of the ocean bed remained largely unexplored.

At mid-20th century, the need for a systematic study of the vast, mysterious body of water was evident. Inspired by the success of the IGY, the International Geophysical "year" of the late 1950's—which concentrated on outer space, the polar regions, inner earth—an expedition to the Indian Ocean was proposed at the initial meeting of the Special Committee for Oceanographic Research at the Woods Hole Oceanographic Institute in Massachusetts, in late August, 1958. The Special Committee had been

established by the International Council of Scientific Unions—which urged that international cooperation in oceanography be continued after the end of the IGY "on a broad basis and for a longer period". In 1961, an international meteorological planning meeting, largely financed by the United Nations Education, Scientific and Cultural Organization (UNESCO) was held in Bombay. Delegates from ten Indian Ocean countries, the United Kingdom and the United States, assisted by representatives from the United Nations and the World Meteorological Organization, accepted, with only minor modifications, the United States Working Group's international programme and outlined the extent of each nation's contribution.

The Woods Hole Oceanographic Institution, Massachusetts.





Geologists inspect rock samples from the ocean floor.

And so in 1961 began a great modern adventure—"to observe, describe, and possibly explain the circulations of ocean and atmosphere and exchanges across their interface, the chemical composition and distribution of living things in the ocean, and the bottom topography and coastal structure of the Indian Ocean". The results may some day confer immense benefits on the peoples who inhabit the bordering lands.

24,000 feet below the waves, a strange tripod fish springs along like a grasshopper.

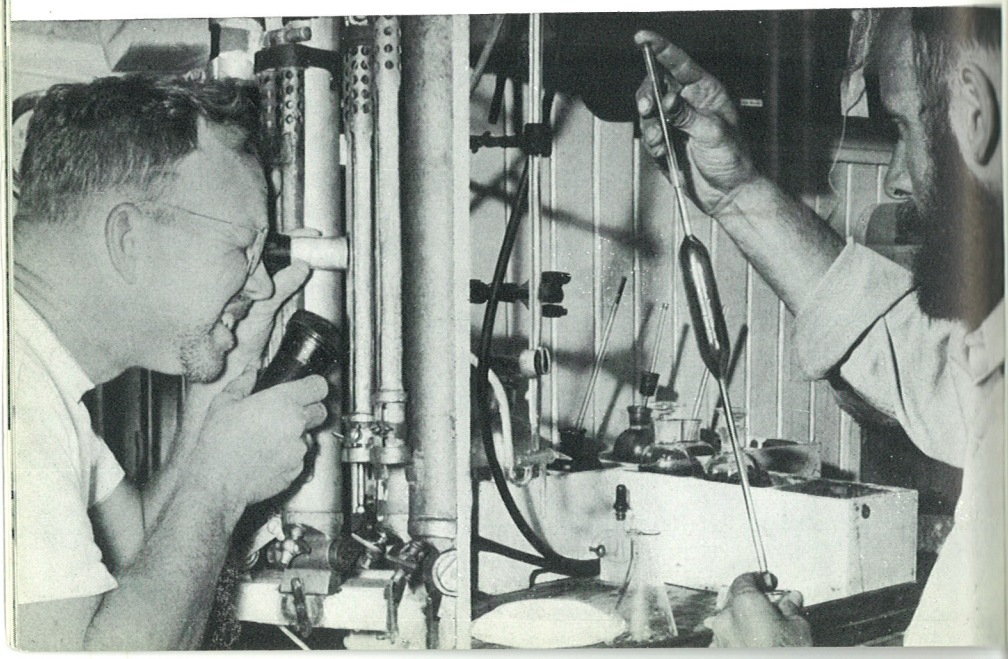
Forty-four nations are now members of the International Oceanographic Commission. Thirty-two nations are now taking part in the 40-ship, five year Indian Ocean Expedition. Now at the peak of its activity, it is expected to be formally completed by 1965.

More than a dozen new voyages of discovery have already taken place. In addition, most countries bordering on the Indian Ocean will provide shore stations and personnel for local observations, particularly on tidal changes and meteorology. The Government of India has provided facilities for a weather base, the International Meteorological Centre at the Colaba Observatory in Bombay. The Biological Centre

Scientists return to a "floating laboratory" after a dive to the top of an undersea mountain.

at Cochin sorts and separates specimens of marine life collected by all ships of the expedition and routes them to appropriate laboratories for study. Other countries plan to send scientific parties. Research aircraft from the United States Weather Bureau are being utilized. The United States has also anchored automatically-transmitting NOMAD weather buoys in the Bay of Bengal and the Arabian Sea. Meteorological rockets may be fired. America's TIROS and NIMBUS weather satellites, photographing vast cloud areas, will fill many gaps. And every commercial ship plying the Indian Ocean has been asked to make surface weather observations.

A scientist reads the temperature of a water sample in a Nansen bottle.

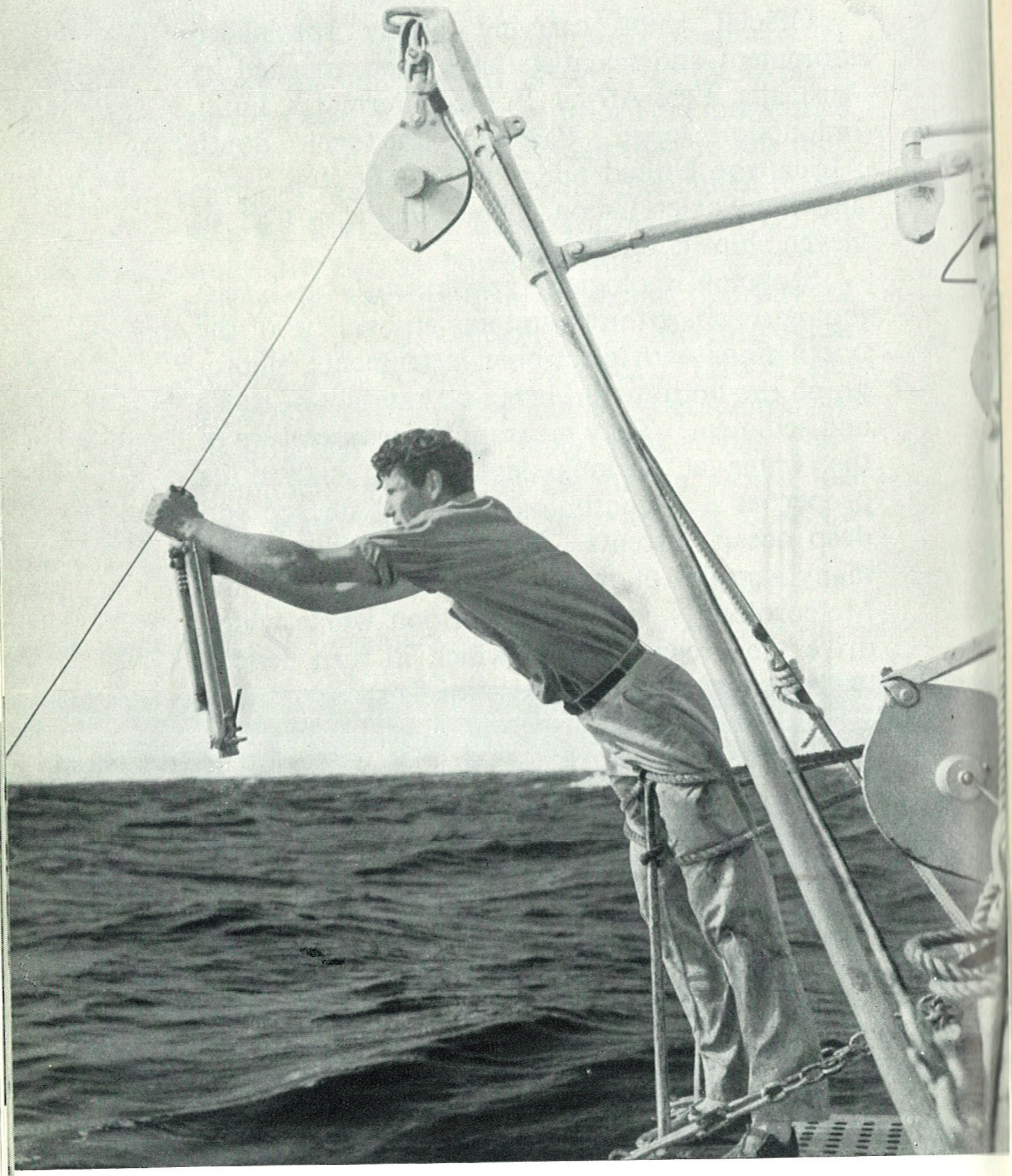


Official ships carrying highly specialized equipment and scientists have been assigned by Australia, East Africa, France, Germany, India, Indonesia, Japan, Pakistan, Portugal, South Africa, the United Kingdom, the United States and the Soviet Union. The American fleet of eleven ships is the largest.

Seagoing geologists, geophysicists and seismologists chart the mountains and valleys of the ocean floor with electronic instruments, photograph the bottom and bring up samples of rocks and sediment. They measure the temperature of the water at various depths and analyze its properties . . . continuously record surface and deep ocean currents. Marine biologists collect many samples of marine plant and animal life. Meteorologists study the monsoon winds which drive the ocean currents which in turn have a great bearing on the location of fish.

A quarter of the world's population live around the shores of the Indian Ocean. Many of these people are under-fed and undernourished and economically under-developed. And the human population is increasing. Yet the ocean depths so near to them harbor incredible riches which are virtually untapped.

The Indian Ocean, especially the waters of the Arabian Sea and the Bay of Bengal, is believed to contain one of the world's biggest



A series of Nansen bottles are lowered to pre-determined depths.

Visit of
U. S. Coast & Geodetic Survey Ship
PIONEER

A SEMINAR ON
MARINE SCIENCES

April 29-30, 1964

Birla Industrial and
Technological Museum,
Calcutta

SPONSORED BY:

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International Indian Ocean Expedition

PROGRAMME

WEDNESDAY. APRIL 29. 1964

9:30 a.m. Registration

10:00 a.m. Welcome—Dr. B. B. Malik, Vice-Chancellor, Calcutta University and Chairman, Hospitality Committee

10:15 a.m. Introductory Remarks : Mr. William O. Baxter, American Consul General

10:30 a.m. General Session—OCEANOGRAPHY (General)

Chairman : Dr. N. K. Panikkar. Director, Indian Programme, IIOE & Member-Secretary, I.N.C.O.R.

Chairman's Address—"India's Role in the Indian Ocean Expedition"

Talk : Dr. Harris B. Stewart, Chief Scientist, PIONEER
"Scientific Programme of PIONEER"

11:15 a.m. Coffee Break

11:30 a.m. General Session (Continued) :

Talk : Dr. Francis P. Shepard—"Submarine Canyons"

Papers :

1. Dr. R. Ramanadham—"Air Flow Studies Over the Ocean Surface of Waltair"
2. Mr. R. Jayaraman—"Swatch-of-no Ground"

Papers : 3. Dr. D. P. Kharkar—"Marine Investigations Based on Cosmic Ray Produced Isotopes"

4. Mr. C. Sreekumaran—"Natural Radioactivity in Marine Sediments"

LUNCH BREAK

2:00 p.m. Second Session—PHYSICAL OCEANOGRAPHY AND METEOROLOGY

Chairman : Dr. K. R. Ramanathan

Chairman's Address : "International Meteorological Centre"

Talk : LCDR. William D. Barbee—(subject to be announced)

Papers : 1. Dr. R. Ramanadham and Collaborators

(a) "Limnological Studies of the Chilka Lake"

(b) "Storm Tides at Visakhapatnam"

(c) "Some Observations of Currents in the Littoral Zone of the Waltair Beach"

2. Dr. J. S. Sastry—"The Mechanisms of Sediment Transport In and Around the Bombay Harbour Region"

3. Dr. F. R. Miller & Mr. R. Suryanarayana-"Energy Exchange Across Sea-Atmosphere Interface Around India"

3:00 p.m. Coffee Break

3:15 p.m. Third Session—MARINE PRODUCTIVITY AND RELATED ASPECTS

Chairman : Prof. Maxwell S. Doty

Chairman's Address—"Productivity of Marine Organisms"

Papers :

1. Dr. B. S. Bhimachar & Mr. V. R. Pantulu—"Hydrology and Biology of Some Indian Estuaries and Brackish Water Lakes"
2. Dr. R. Viswanathan and Others—"Distribution of Inorganic Phosphates in Northern Indian Ocean"
3. Dr. A. A. Ramasastry—"Salinity Maximum Below the Tropical Discontinuity Layer in the South-eastern Arabian Sea"
4. Dr. K. K. Tiwari—"Geographical Distribution of the Marine and Estuarine Representatives of the Family Palaemonidae (Crustacea : Decapoda : Caridea) With Special Reference to the Subfamily Pontoniinae"

THURSDAY. APRIL 30. 1964

10:00 a.m. Fourth Session—GEOLOGY AND GEOPHYSICS

Chairman : Dr. M. S. Krishnan

Chairman's Address—"The Structure of the Eastern Bay of Bengal"

10:20 a.m. Papers :

1. Dr. B. Sundararama Rao—"Geophysical Investigations for Ground Water Around Visakhapatnam"

Papers : 2. Mr. L. N. Kailasam—"Some Aspects of Geophysical Exploration Off the Madras Coast"

3. Dr. M. Poornachandra Rao—"A Resume of Marine Geological Studies at Andhra University"

4. Mr. H. N. Siddique—"The Significance of Heavy Minerals of Balasore Sand Dunes in Deciphering Sediment Transport Along Orissa Coast"

11:15 a.m. Coffee Break

11:30 a.m. Fourth Session (Continued) : GEOLOGY & GEOPHYSICS

Papers : 5. Mr. K. Venkataratnam—"Studies on Sediments of Chilka Lake, a Marine Lagoon Along the East Coast of India"

6. Mr. A. K. Chatterjee and Mr. S. C. Pant—"Recent Micro-Faunal Study and Its Implication in the Evolution of Andaman Group of Islands"

7. Dr. B. Sundararama Rao—"Field Application of Modified Tripotential Method"

8. Mr. P. S. Srivastava—"A Resume on Cruises of INS KISTNA in the Arabian Sea"

LUNCH BREAK

2:00 p.m. Fifth Session—GEOLOGY AND GEOPHYSICS (*contd*)

Chairman : Dr. Robert S. Dietz

Chairman's Address : "Some Problems on the Permanence of Ocean Basins"

Papers :

1. Dr. B. Sundararama Rao—"Investigation of Magnetic Properties of Basalts and Charnokites"
2. Dr. B. Sundararama Rao—"Investigation of Magnetic Parameters of Magnetites at High and Low Fields"
3. Dr. M. Subba Rao—"Studies on the Kakinada Bay on the East Coast of India"

3:00 p.m. Coffee Break

3:15 p.m. Papers :

4. Dr. B. Sundararama Rao—"Electrical Resistivity Soundings in a Part of Godavari Valley"
5. Dr. T. C. S. Rao—"Crustal Structure of the Ocean Bottoms"
6. Mr. Kelvin S. Rodolfo—(Subject to be announced)
7. Mr. Austin Weeks—(Subject to be announced)

4:15 p.m. Vote of Thanks

CLOSURE OF THE SEMINAR

PARTICIPANTS

Banerji, Dr. S.,	Geological Survey of India, Calcutta
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Bhattathiri, Dr. P. K.,	Atomic Energy Establishment, Health Physics Division, Bombay
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Chawdhury, Dr. A. N.,	Geological Survey of India, Calcutta
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Ganapathy, Dr. P. N.,	Professor of Zoology, Andhra University
Gupta Sarma, Mr. D.,	Geological Survey of India
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Kalidas, Mr. J.,	Geological Survey of India, Calcutta
Kharkar, Dr. D. P.,	Tata Institute of Fundamental Research, Bombay
Khosla, Lt. Col. K. L.,	Geodetic & Research Branch, Survey of India, Dehra Dun
Krishnan, Dr. M. S.,	Department of Geology, Osmania University
Krishnarao, Dr. P. R.,	Director General of Observatories, New Delhi
Kidwai, Mr. R. N.,	Department of Geology, Andhra University
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Pant, Mr. S. C.,	Geological Survey of India, Calcutta

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Rao, Dr. M. Poornachandra,	Dept. of Marine Biology, Andhra University
Rao, Mr. T. C. S.,	Directorate of Scientific Research, Naval Headquarters, New Delhi
Rao, Mr. N. Jaganmohan,	Dept. of Meteorology & Oceanography, Andhra University
Ramanathan, Dr. K. R.,	Director, Physical Research Laboratory, Ahmedabad
Ramaswamy, Mr. C.,	Deputy Director General of Observatories, New Delhi
Rama Sastry, Mr. A. A.,	Regional Meteorological Center, Bombay
Rao, Mr. B. R. J.,	Geological Survey of India, Calcutta
Saha, Dr. S. N.,	Geological Survey of India, Calcutta
Sastry, Mr. M. V. A.,	Geological Survey of India, Calcutta
Sanyal, Mr. S. P.,	Geological Survey of India, Calcutta
Sen, Dr. S. N.,	Director, Regional Meteorological Center, Calcutta
Siddique, Mr. H. N.,	Geological Survey of India, Calcutta
Srivastava, Mr. P. S.,	Indian Naval Physical Laboratory, Cochin
Srivastava, Mr. S. N. P.,	Geological Survey of India, Calcutta
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Suryanarayana, Mr. R.,	Directorate General of Observatories, New Delhi
Tiwari, Dr. K. K.,	Zoological Svrvey of India, Calcutta
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Viswanathan, Mr. T. V.,	Geological Survey of India, Calcutta

supplies of fish and other edible sea foods. If men are to tap this food supply with more assurance of success than mere reliance on "fisherman's luck", they must look to the oceanographer for help. The life of every marine animal is dependent, directly or indirectly, upon tiny plant organisms called phytoplankton, which form the "grass" of the sea. Deriving their own food from nutrient salts, chiefly phosphates and nitrates in the ocean, the microscopic algae are food for microscopic animals which in turn are food for edible fish. The planktons are carried by upwelling, ever-changing ocean currents and thus the big streams in the ocean determine in part the location of fish.

With a more certain knowledge of the Indian Ocean, with its almost inexhaustible supply of high protein food awaiting only the scientific skill to make it available, men of vision are

American and Indian scientists examine an organism which lives on the floor of the sea.

looking ahead to perhaps much different food than is eaten today.

No longer is it a dream or theory that algae can be extracted from the seas in large quantities. The Japanese have been doing it for years. Now it is a tasteless, grey-coloured powder. But with further progress in the rapidly-developing science of enzymology, it may soon be possible to transfer the enzyme flavours of present delicious food to algae.

An American biologist, James Bonner, predicts that before the year 2,000 we will be eating delicious steaks composed of extracted algae-protein, spiced with enzymes and made chewable by suitable, digestible plastic.

Before World War II many countries, notably Japan, investigated the possibility of using kelp, and other marine weeds, for food. High in protein and iodine needed to sustain life, kelp can be dried and made into bread, "meat" cakes and soups. Investigation into the growing, harvesting and production of marine weeds continues and many scientists and nutritionists are convinced that, with careful planning, one-third of our food can come from this source, packaged, frozen and ready for quick-cooking.

Scientists also believe man will find edible marine animals by the score which he has never eaten before and that ways will be found to bring

Examining specimens of marine life.

these animals from many thousands of feet below the water for transportation to food markets.

Fish farming—the systematic process of planting eggs and then reaping the harvest—is still another way of increasing resources. American experts believe that the world's catch of fish for food can be increased at least five-fold without depleting stocks, an immense increase.

But, as with all progress brought about through science, tremendous projects of fundamental studies must be undertaken. We must know more about the ocean currents, the biology,

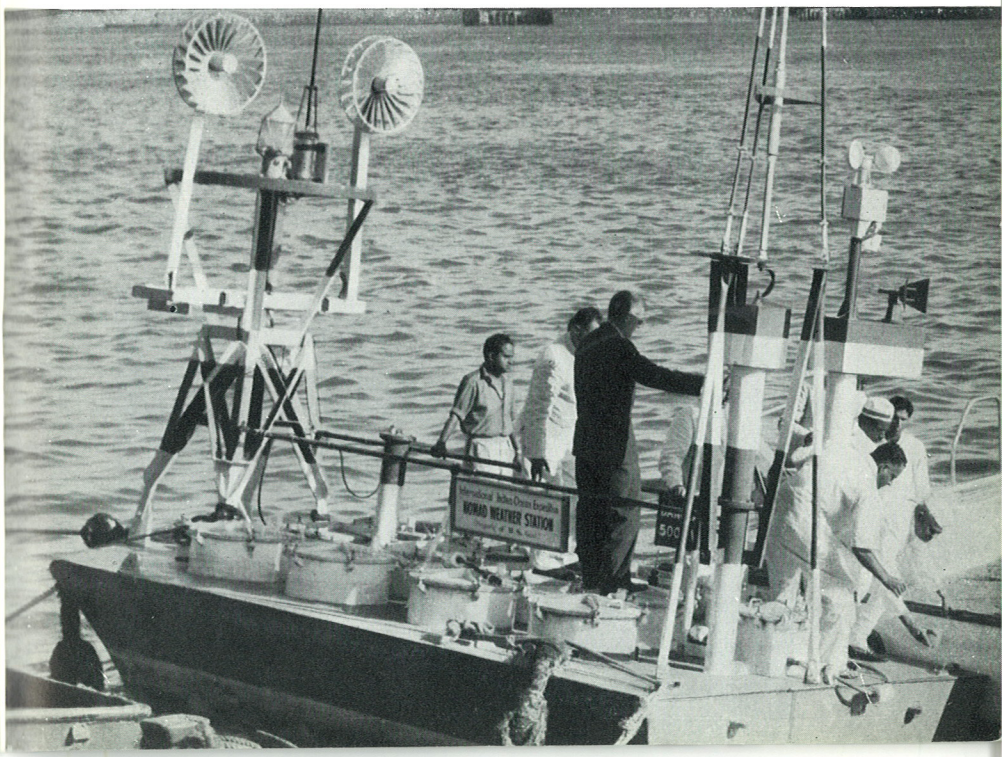
the geology and the physics of ocean waters before we can proceed towards full use of the ocean's potential for human beings.

Afloat and ashore, oceanographers by the thousands are making studies and accumulating data. Much oceanographic work has already been conducted by Indian scientists. Of particular significance is the work of oceanographers at Andhra University. Along the east coast of India, in fifty-five cruises with the help of the Indian Navy, they discovered an upwelling of water during the southwest monsoon months, a sinking or downward motion during the northeast monsoon months. The importance of meteorology is obvious and the implications for the production of marine food are profound. Upwelling areas are high-organic production areas where fish food will be available and where fisheries could be developed. Acting on the discoveries at Andhra University, American and Indian scientists aboard American research ships have charted potentially rich fishing grounds in several areas of the Bay of Bengal, especially around the Andaman islands.

It has also been discovered that besides upwelling in the Indian Ocean, dredging set up heavy productivity of phytoplankton, the grasses of the sea. Dr. T. S. Satyanarayan Rao, head of Indian participants in the United States pro-

gramme of Biology for the Indian Ocean Expedition, wrote at the time: it would appear that in these warm waters what is needed for high productivity is the "churning" of the bottom with the surface waters. Could Dr. Rao, one wonders, have been thinking of the Ramayana and the Mahabharata, of the legend, the Churning of the Milk Ocean? "The gods and demons churned and on the surface of the ocean began to appear one by one what are called the Chaturdasa Ratnam, nectar, and other precious things. . . ."

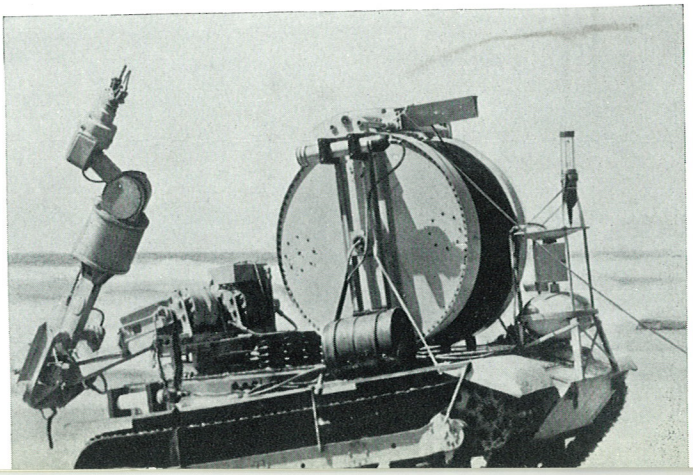
One of the automatically-transmitting "NOMAD" weather ships from the U.S. is stationed in the Bay of Bengal.

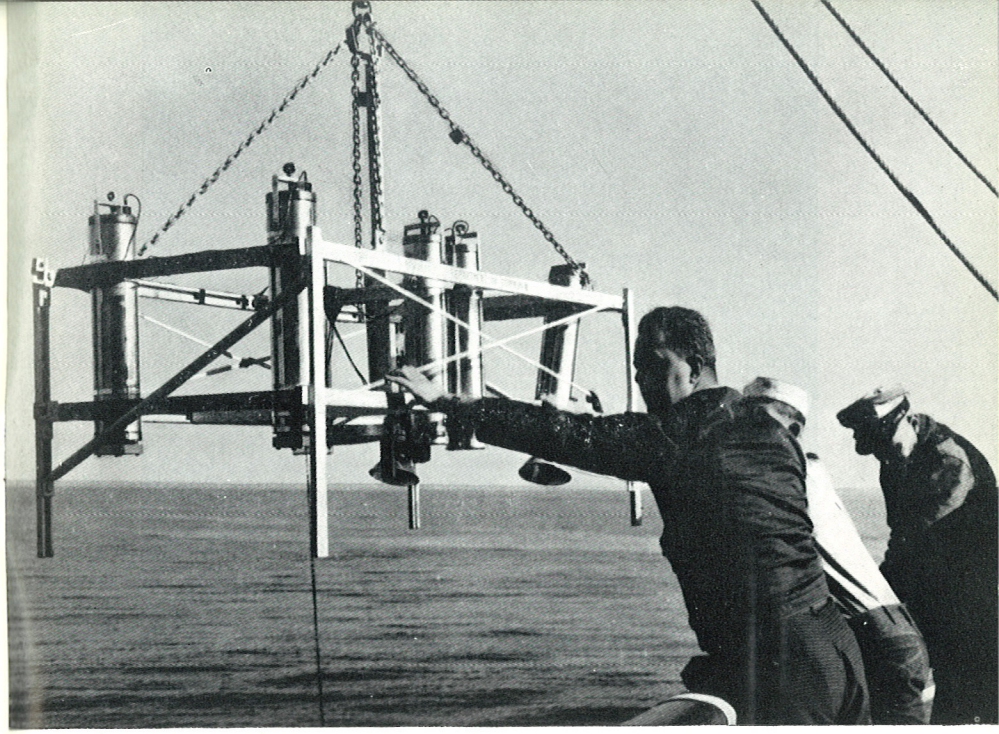


Other precious things. What, besides food? There are reasons to believe that gigantic deposits of oil, natural gas and almost all kinds of minerals lie beneath the ocean floor, which could add to world's dwindling supply. And scientists are gradually learning to retrieve economically valuable chemical substances from ocean water.

A successful completion of the Indian Ocean Expedition as planned will go a long way toward improving weather forecasts. This would not only be of immense value to Indian farmers. It would reduce the loss of life and destruction caused by seismic sea waves. It would make water transportation safer, faster, more profitable. Electronic computers may well be used successfully to forecast surface wind and sea

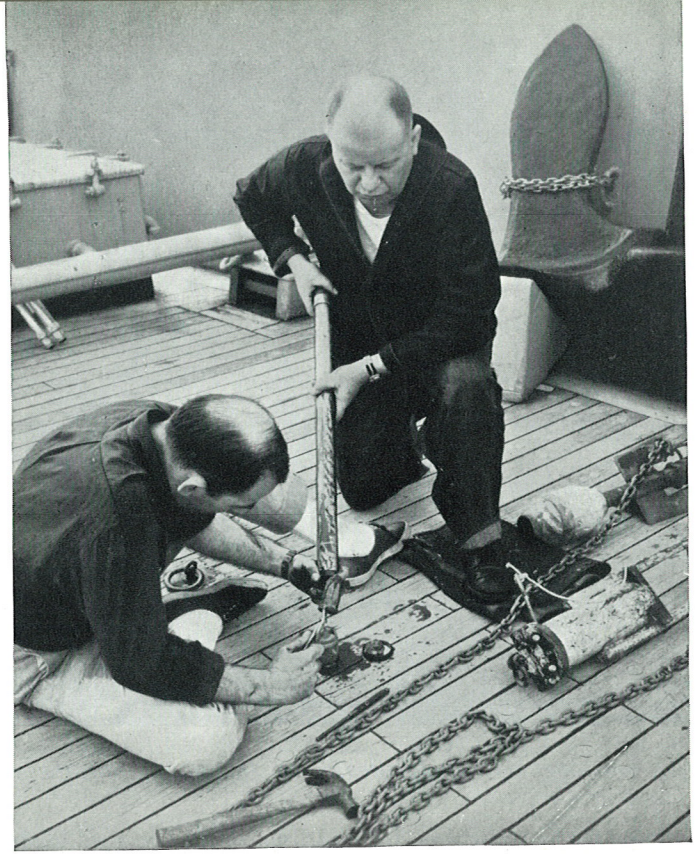
The Scripps Institution of Oceanography, California devised this underwater manipulator which crawls on the ocean bottom, equipped with a television camera and instruments to obtain samples of marine life.





A deep sea camera takes pictures many fathoms below the waves.

conditions and in developing an ocean-wide financially attractive ship-routing and cargo preservation service. Scientific ship-routing—calculating the best probable track a ship should take—is already saving ship operators millions of dollars in the Pacific and Atlantic Oceans. A successful Indian Ocean Expedition could lead to its introduction there. From the Red Sea through the doldrums to the storms of the Great Australian Bight, temperatures and humidities

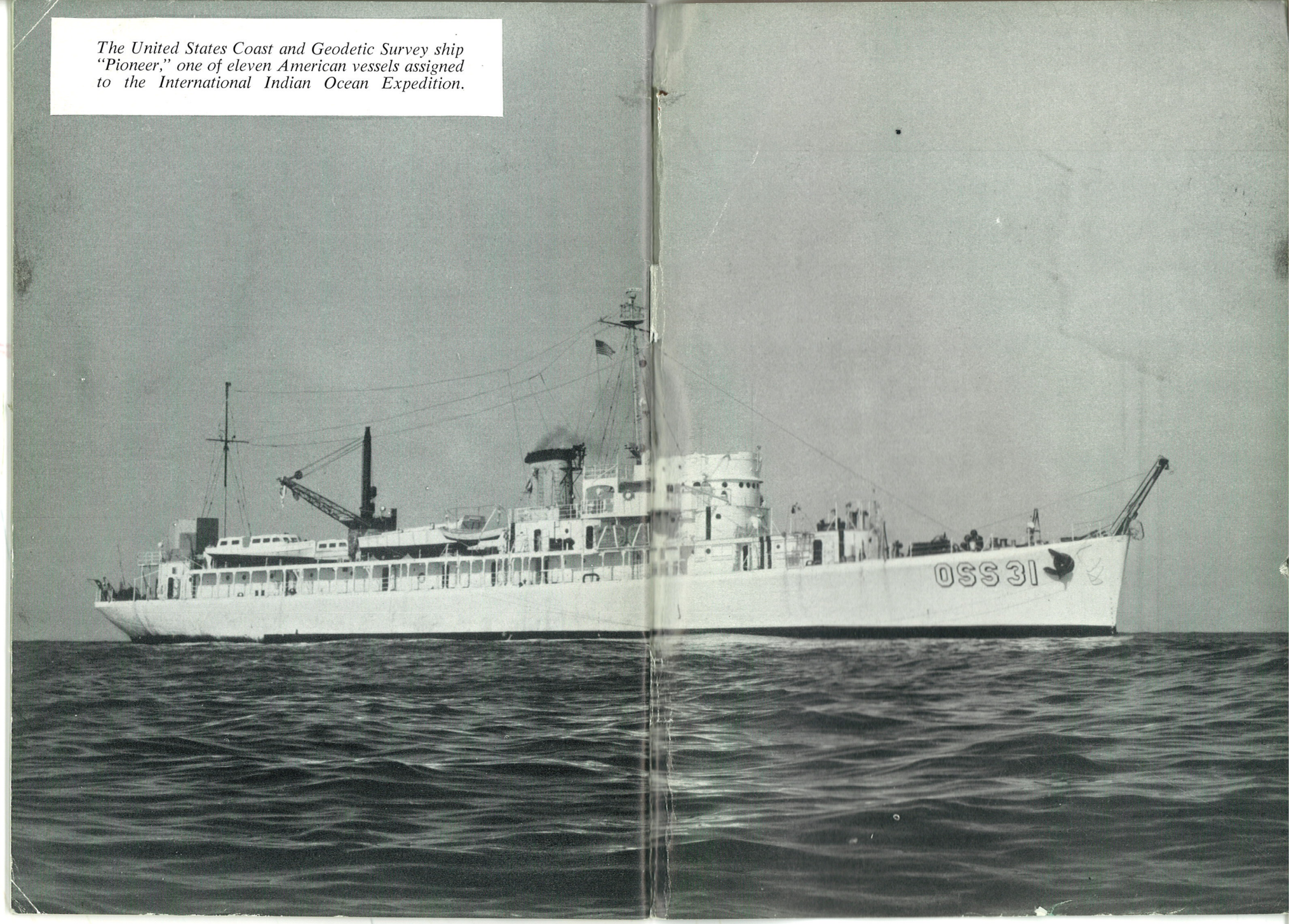


What is the ocean bottom made of? To answer this important question for oceanographers, a coring device brings up samples of sediment.

range widely. Cargo susceptible to these changes and stored in non-refrigerated holds demands constant attention. Skill in manipulating ventilation determines whether the cargo will arrive unspoiled.

At a time when scientists are turning so much attention to outer space, exploration of the ocean depths promises more immediate, more certain, more future rewards than almost any scientific venture. The ocean is truly a great storehouse of human needs—ours for the taking when we find the way now being sought by the ships and men of the International Indian Ocean Expedition and harness the seas for the service of man.

Here the coring device goes over the side.



The United States Coast and Geodetic Survey ship "Pioneer," one of eleven American vessels assigned to the International Indian Ocean Expedition.

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