The Discovery of Hydrothermal Vents

25th Anniversary CD-ROM

Report of the Decade: The International Decade of Ocean Exploration

National Science Foundation

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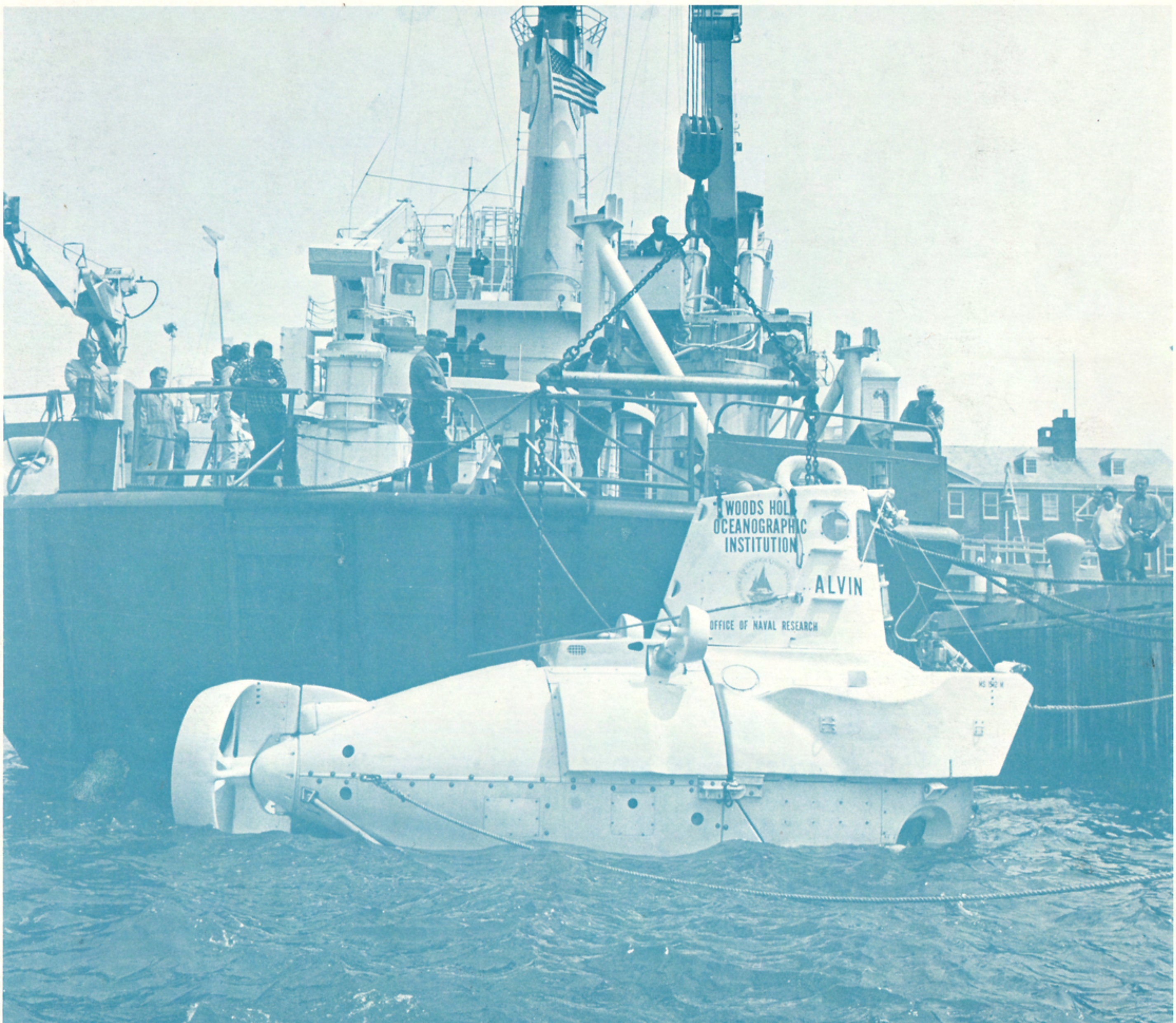
THE INTERNATIONAL DECADE OF OCEAN EXPLORATION



NATIONAL SCIENCE FOUNDATION
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Prolog

Study of the ocean has advanced far since its beginnings in 1872, when the converted warship H.M.S. *Challenger*, a full-rigged steam corvette, embarked on a three-year expedition that began the modern exploration of the ocean. A century later, the International Decade of Ocean Exploration (IDOE) marked a major turning point in that exploration and changed the science of oceanography. This section describes the origins of the IDOE, who supported it, and its goals. Following sections will discuss the individual projects within each of the four program areas established for the IDOE by the National Science Foundation.

Beginnings

The International Decade grew out of the many national oceanographic expeditions that were typical of ocean studies before and immediately after World War II. These expeditions were usually made by a single ship covering one or more ocean basins over several years. The resulting picture of the ocean was thus one of averages. Currents were seen as great steady rivers in the sea. The deep ocean was considered rather dark, cold, tranquil, and barren. Thus it was deemed entirely proper to describe ocean circulation and other properties by comparing observations separated by thousands of miles and tens of years. Biologists emphasized the taxonomy or classification of animals in the ocean primarily to work out the evolution of marine species and their biological relationships to one another and to terrestrial groups. In short, the ocean was seen as a rather static part of the planet.

Questions raised during the war showed the need for a better understanding of the ocean. Accurate navigation and the ability to detect submarines required far better knowledge of how sound travels in the sea. Amphibious landings demanded better wave forecasts and clearer definition of the relationships between ocean and atmosphere. Battles for the coral islands of the South Pacific showed our ignorance of these land masses and how they grew.

As a result of these needs, support for ocean research continued after the war, coming mostly from government agencies, especially the U.S. Department of Defense. Oceanography departments arose at many universities to train students, and continued government support led to research and ship facilities far beyond those available before the war.

These new resources also enabled multi-ship investigations of the ocean's dynamic features. The Gulf Stream studies in the 1950s showed that the "great river in the sea" actually meandered significantly and had reverse flows at certain depths. Although earlier studies had suggested these movements, confirmation was possible only by using more extensive facilities than those previously available to a single institution.

New instruments also played a major role in the postwar period. The Swallow float, designed by British oceanographer John Swallow, floated at a predetermined depth and emitted acoustic signals that could be tracked by a ship on the ocean surface. With this instrument, deep-ocean currents could be directly plotted for the first time, and they proved to be far more dynamic than predicted. The classical model of ocean circulation had currents moving sluggishly as thin sheets from their sources in the high latitudes and eventually mixing with surrounding waters until they lost their identity. Swallow's observations near Bermuda in the late 1950s showed that floats at different depths moved quite rapidly in several different directions, many of them following spiral paths rather than the expected uniform track.

Systematic studies of the ocean showed that careful surveys made in a short time period could identify features such as currents, discrete water masses, and other properties and could determine their importance with a precision not possible using averaged and randomly spaced observations. Later questions about the ocean's health and possible worldwide contamination of its surface argued for a baseline survey—a global examination of ocean conditions that would be a benchmark for future studies.

The International Decade of Ocean Exploration was a response by many nations to the increased awareness of the ocean's importance. In the 1960s, optimistic scientists forecast that millions might be fed with increased catches of fish from the sea. They told of billions of tons of scarce copper, nickel, and cobalt to be recovered from manganese nodules on the deep-ocean floor. In sharp contrast, other scientists depicted an ocean dying because of oil dumped from tankers on the high seas. And people were dying in Japan, apparently from eating shellfish poisoned by mercury that factories discharged into coastal waters. Another factor was the threat to the long-established legal regime of the open ocean. This threat arose from the developing nations' desire for a share in this new source of wealth.

From these diverse origins came the IDOE. Dr. Edward Wenk, of the University of Washington, described the Decade idea in his book, *The Politics of the Ocean.* The IDOE looked to a systematic program of ocean exploration motivated by anticipated uses of marine resources as much as by scientific curiosity. The new idea was not just a continuation or even a simple expansion of past research efforts. Instead, exploration of the seas was to be a sustained effort, a global venture rather than a patchwork of national programs or a loose collection of projects by individual scientists. It would bring together users as well as producers of scientific knowledge. It would help nations with modest ocean research capabilities to expand their programs. And IDOE projects would foster good will by exchanges between governments and collaboration between scientists.

Some original Decade goals were not pursued when it became clear that the funding levels originally anticipated would not be reached. Management of IDOE programs was hampered by less-than-ideal coordination among participating federal agencies and by an academic community unaccustomed to working on tightly coordinated projects. Thus some early goals were not met, including an ocean-monitoring system and the uniform application of research results to improve management of marine exploration. But most scientific goals were met and far exceeded.

For ocean-going scientists, IDOE meant an opportunity to use ships, new instruments, and the emerging technologies of computers and satellites to answer some of the most important and challenging questions in ocean science:

- The ocean's role in controlling climate.
- Interactions between ocean and atmosphere.
- Unknown processes of the sea floor.
- Physical and chemical interactions controlling the way pollutants are spread in the ocean.
- Links between ocean circulation and the rich productivity of the world's most important fisheries.

All these unknowns had been recognized in the 1960s. However, a concerted attack on them was beyond the resources of individual investigators or even nations. The IGY or International Geophysical Year (1957-58) had shown glimpses of the returns promised by large cooperative endeavors; IDOE provided funds and organization to attack these problems. The result: exciting discoveries of the 1970s have changed our view of the ocean and the way oceanographers will work there in the 1980s and beyond.

Launching the Decade

In 1966 the United Nations General Assembly asked the Secretary General to survey the marine science and technology work of U.N. member states and of intergovernmental and private international groups. He was then to suggest how best to come up with a wider program of international cooperation in this field. It was obvious then, as now, that nearly all ocean issues transcended national boundaries. U.S. President Lyndon B. Johnson reflected this awareness when he commissioned the research vessel *Oceanographer* in July 1966. He observed that:

> Truly great accomplishments in oceanography will require the cooperation of all the maritime nations of the world. And so...I send our voice out...calling for such cooperation, requesting it, and urging it.... We greatly welcome...international participation. Because under no circumstances, we believe, must we ever allow the prospects of rich harvests and mineral wealth to create a new form of colonial competition among the maritime nations. We must be careful to avoid a race to grab and to hold the lands under the high seas. We must ensure that the deep seas and the ocean bottoms are, and remain, the legacy of all human beings.

In March 1968, President Johnson endorsed the idea of an International Decade of Ocean Exploration. In a special conservation message to the Congress entitled "To Renew a Nation," he said:

> The task of exploring the ocean's depth for its potential wealth—food, minerals, resources—is as vast as the seas themselves. No one nation can undertake that task alone. As we have learned from prior ventures in ocean exploration, cooperation is the only answer.
>
> I have instructed the Secretary of State to consult with other nations on the steps that could be taken to launch an historic and unprecedented adventure—an International Decade of Ocean Exploration for the 1970s.

The Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) supported the Decade idea and went on to endorse "an expanded, accelerated, long-term, and sustained program of exploration of the oceans and their resources, including international programs, planned and coordinated on a worldwide basis." Support also came from the U.N. General Assembly in December 1968; its Resolution 2467D (XXIII) endorsed "an international decade of ocean exploration to be undertaken within the framework of a long-term programme of research and exploration." The Assembly also invited member states "to formulate proposals for national and international scientific programmes and agreed [upon] activities to be undertaken during the international decade of ocean exploration, with due regard to the interests of developing countries, [and] to transmit these proposals to...the IOC in time to begin the decade in 1970."

At its sixth session in September 1969, the IOC defined the purpose of the expanded program thus: "To increase knowledge of the ocean, its contents and the contents of its subsoil, and its interfaces with the land, the atmosphere, and the ocean floor and to improve understanding of processes operating in or affecting the marine environment, with the goal of enhanced utilization of the ocean and its resources for the benefit of mankind."

Scientists and engineers looked at the many questions posed by this unprecedented effort. Attention focused on scientific and engineering priorities, how to realize them, and possible results and benefits of the IDOE. In May 1969 the National Academy of Sciences and the National Academy of Engineering jointly reported on a scientific planning conference in *An Oceanic Quest, The International Decade of Ocean Exploration.* The report strongly recommended an IDOE and served as a basis for planning the Decade.

Responsibility for planning, managing, and funding United States IDOE activities went to the National Science Foundation. Major NSF goals were to:

- *Expand seabed assessment activities*—for better domestic and international management of marine mineral exploration and exploitation—by learning more about seabed topography, structure, physical and dynamic properties, and resource potential. This would also help industry plan more detailed seabed investigations.
- *Improve environmental forecasting* and thus help reduce

hazards to life and property and permit better use of marine resources. This would be done through improved physical and mathematical models of the ocean and atmosphere—models that would increase the accuracy, timeliness, and geographic precision of environmental forecasts.

- *Develop an ocean monitoring system* to help predict oceanographic and atmospheric conditions—through design and deployment of oceanographic data buoys and other remote sensing platforms.
- *Preserve the ocean environment* by accelerating scientific observations on the natural state of the ocean and its interactions with coastal areas. This would help scientists assess and predict ocean changes, whether natural or brought on by human activities. Scientists could also identify damaging or irreversible effects of waste disposal at sea and learn how various levels of marine life interact. This could prevent the depletion or extinction of valuable species as a result of human activities.
- *Improve worldwide data exchange* by modernizing and standardizing the way national and international marine data are gathered and used.
- *Accelerate Decade planning* to encourage international sharing of responsibilities and costs and to assure better use of limited exploration capabilities.

The National Science Foundation established the Office for the International Decade of Ocean Exploration in 1970 and received special funds from Congress for the United States IDOE program. Three areas were chosen for priority attention: (1) Seabed Assessment, (2) Environmental Forecasting, and (3) Environmental Quality. Living Resources was added as a fourth program in 1971.

IDOE Projects: Organization, Management, and Support

IDOE projects marked a significant departure from previous ocean science research. In the United States, that research was done primarily by individuals or small groups working in one of the four major subdisciplines (biology, chemistry, geology, physical oceanography). Most projects focused on relatively small problems in limited areas. There were indeed a few cooperative research efforts such as the International Indian Ocean Expedition in the early 1960s, but they were the exception rather than the rule.

The IDOE changed this by supporting large-scale, long-term research projects involving specialists from several disciplines. Thus IDOE projects were far larger and more complex than any before them. During the Decade, the National Science Foundation supported 22 major efforts at a total estimated cost of about $192 million. Individual projects ranged from about $1 million to more than $30 million and lasted from 3 to 10 years. Many involved joint support by other government agencies, principally the Office of Naval Research, the National Oceanic and Atmospheric Administration, and precursors to the present Department of Energy.

The projects stemmed from the scientific interests of the investigators, who also managed the various efforts. No single format or approach was required. Many of the large projects set up formal structures to handle ship scheduling, routine laboratory analyses, and intercalibration of instruments, and to ensure comparable techniques. Others had a less structured organization. Foreign scientists and facilities took part in most of the programs as full participants.

The long-term support for IDOE work permitted detailed planning for the projects and the necessary international contacts. A recurrent problem during the Decade was the long advance notice required for foreign scientists to arrange participation and funding. Clearance to allow research in foreign waters was also an occasional issue. IDOE's long-term support partially offset these problems. but U.S. funding cycles and management practices often did not match those of other countries.

Long-term support and detailed planning also boosted development of new equipment and instruments needed for the ambitious scientific undertakings. For example, sound-fixing and ranging (SOFAR) floats were developed to follow deep-ocean currents, much like the earlier Swallow floats. SOFAR floats were more cost effective: since they could be tracked from shore-based stations, no tracking ship was needed. Later, satellite-tracked surface floats provided comparable information for surface currents.

Finally, long-term support for IDOE projects helped ensure that the extensive field data were properly analyzed and widely distributed. A good example is the Geochemical Ocean Sections Study (GEOSECS), which resulted in the first modern chemical description of the ocean waters. Its data are the basis for many other ocean investigations. And they are a benchmark against which future generations will measure changes in the ocean due to either human activities or natural causes. GEOSECS data are published in atlases that bring together all the work, spanning more than 10 years, of the many investigators involved in the project.

Other efforts compiled existing data as a first step in further work. An example is the Manganese Nodule Project (MANOP). Its compilations on the abundance and composition of these nodules have focused attention on the possible mining of such materials from the deep-ocean floor.

The Nations in IDOE

The United States was one of 52 nations participating in the Decade research efforts. Many of the large projects were possible only because several countries pooled their scientists, equipment, ships, and other facilities. For example, MODE was a cooperative venture of the United States and the United Kingdom, while the ensuing POLYMODE was largely a joint effort of the U.S.A. and the USSR, with complementary work by Canada, France, West Germany, and the United Kingdom. Coastal upwelling research in the

Pacific was the joint work of Peruvian and American scientists, along with colleagues from other South American countries.

French and U.S. teams combined forces in the detailed surface-ship surveys and submersible dives that led to the discovery of active hydrothermal vents on the sea floor; Mexican scientists were involved in the RISE project that explored some of the eastern Pacific vents.

International cooperative projects have become an integral part of modern ocean science. Even now that the Decade has ended, oceanographers continue their joint exploration of oceans and their basins. Such projects are usually done under bilateral agreements between the United States and another country.