Helgoländer wiss. Meeresunters. 24, 7–15 (1973)

NOAA's Manned Undersea Science and Technology Program

J. W. MILLER & D. C. BEAUMARIAGE

Manned Undersea Science and Technology Program, Office of Marine Resources, National Oceanic and Atmospheric Administration; Rockville, Maryland, USA

KURZFASSUNG: **Das bemannte untermeerische Wissenschafts- und Technologie-Programm der NOAA.** Im August 1971 wurde in den USA ein bemanntes Untermeeresprogramm von der NOAA (National Oceanic and Atmospheric Administration) ins Leben gerufen, das die wissenschaftliche und technologische Erforschung der nutzbaren Schätze des Meeres mit Hilfe von Unterseebooten, Unterwasserlaboratorien und ähnlichen Systemen zum Ziel hat. Der vorliegende Bericht gibt einen Überblick über bereits in Angriff genommene und weitere in Planung befindliche Programme der NOAA.

INTRODUCTION

The goal of the program is "to develop, promote, and support a national, civilian, operational capability for man to work under the sea to achieve a better understanding, assessment, and use of the marine environment and its resources."

The first year's efforts were divided basically into three major categories: staffing and developing a program plan; developing and implementing operational research projects; and initiating a modest technology effort.

ORGANIZATION

It became apparent early that in order to address the overall goal just mentioned, a truly interdisciplinary staff must be established in the program office. Accordingly, the staff consists of marine scientists, engineers, physiologists, operations research analysts, and fiscal managers totalling twelve professionals as of July 1, 1972. While some expansion is anticipated, the overall philosophy is that of establishing a program management office rather than acquiring a large staff of operational field personnel. Organization charts showing the Manned Undersea Science and Technology (MUS&T) office and where it fits within National Oceanic and Atmospheric Administration (NOAA) are shown in Figures 1 and 2 respectively. The position of MUS&T within

NOAA clearly focuses the program emphasis on problems centered around marine resources.

In addition to organizing a program office within NOAA, it is essential to establish working arrangements and program review policies with the scientific and indus-

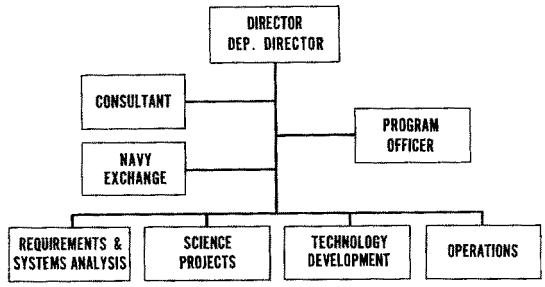

Fig. 1: Organization of Manned Undersea Science and Technology (MUS & T) Program

trial community as well as with state and federal agencies. It is also necessary to determine specific scientific requirements to ensure that the advanced technology program is responsive to user needs.

The following steps have been taken towards these ends: (1) The National Academies of Science and Engineering have formed an advisory body to help establish national goals and priorities for the use of manned undersea systems. This effort

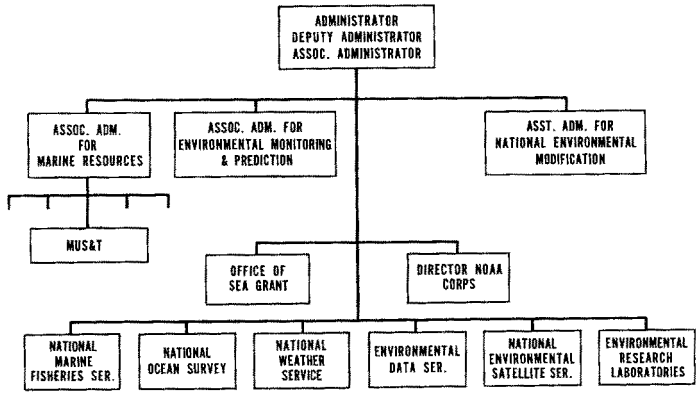

Fig. 2: Organization chart of National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce

will culminate in a five-day working meeting in October 1972. (2) Contacts have been established and requirements sought from other federal agencies through the Interagency Committee on Marine Science and Engineering (ICMSE). (3) Agreements have been made with the U.S. Navy with regard to sharing deep submergence system facilities, professional personnel, and joint participation in operational and biomedical

programs. (4) A contract was awarded to the University of New Hampshire with consulting assistance from the General Electric Company for the purpose of translating scientific requirements of the academic community for undersea research into meaningful engineering criteria and specifications leading to the development of advanced oceanfloor platforms.

In addition to the above, daily working relationships have been established within government, industry, and the academic community. While the formation of the MUS&T program within NOAA provides a management focus for civilian manned undersea efforts, it should be made clear that the overriding philosophy dictates, that the work be carried out primarily through contracts and grants with non-federal organizations. This policy is reflected in the following research programs carried out during our first year.

FISCAL YEAR 1972 OPERATIONAL RESEARCH PROJECTS

Operational programs were conducted on all three U.S. coasts, in British Honduras, the Bahamas, and in the Bering Sea. These projects entailed the use of eight different research submersibles and two ocean-floor habitats. A map showing the location of these projects may be seen in Figure 3. Personnel participating in these programs came from universities, industry, the federal government, Canada, and various

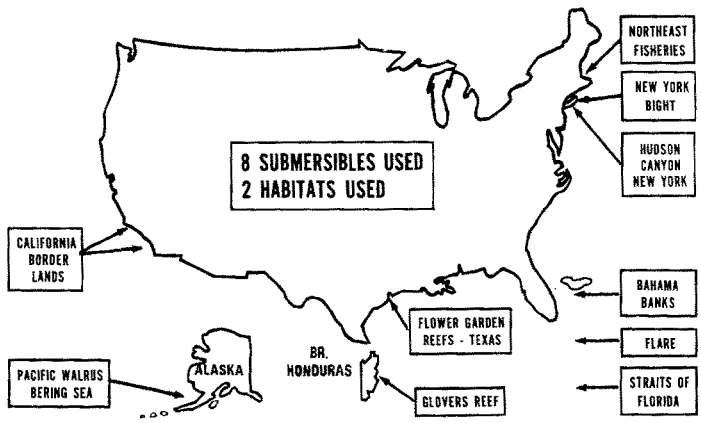

Fig. 3: Location of the FY (Fiscal Year) 1972 Science Projects

state agencies. Some of the programs were sponsored solely by the MUS&T office while others were supported jointly with other NOAA components such as Sea Grant and with other agencies including the U.S. Navy, Coast Guard, and the National Science Foundation.

The scientific content of the programs falls into three general categories: resource assessment, marine management including the effects of pollution, and marine ecological studies.

These projects, while selected individually, were chosen within the context of those national goals amenable to study with the aid of undersea systems. Some of these efforts will lay the foundation for longer-range programs leading to the solution of major national marine problems. Examples of such national problems are: (1) An impending energy crisis due to increasing depletion of inland fuel, oil, and gas resources. (2) The adverse impact on the marine environment caused by mounting disposal in our coastal zones of toxic, industrial, human and solid wastes. (3) A decline in the harvesting of fish and shellfish stocks. (4) The need to understand better the undersea physical oceanographic and dynamic processes. (5) The need to develop basic information to aid in preserving our national coastal zone and ocean assets in the face of increasing population and industrial pressures for utilization of the available land and water areas for recreation and development.

The solution of these problems and the full utilization of the potential of the ocean for economic, social, and environmental benefits requires a substantially improved understanding of underwater and bottom biological, chemical, geological, and physical characteristics. Many different types of platforms, including satellites, aircraft, ships, buoys, submersibles, and divers, exist which can carry the sensors needed to obtain the required data. Physical constraints, however, often prohibit the acquisition of certain data and limit resolution of other data when observations are made solely from instrument platforms mounted above or at the air/water inface. For example, deep water acoustic ambiguities, highly irregular bottom topography, and rough weather can seriously reduce the accuracy of measurements. The use of submerged platforms provides an excellent auxiliary means for gathering information not otherwise obtainable. Existing undersea systems, while lacking in sophistication and independence from surface condition, are proving to be essential for the understanding of even the relatively shallow areas of the continental shelves. Experience gained during our first year has indicated that many of our long held ideas about the oceans may need to be reexamined.

Let us briefly review some of the field projects carried out during our first year of operation.

RESOURCE ASSESSMENT

Northeast fisheries

Investigators from NOOA's National Marine Fisheries Service (NMFS) have long been concerned with the dwindling herring and lobster stocks in the Northeast. Hence a program, utilizing both one-atmospere and diver lockout submersibles, was begun in September 1971 to enable scientists from NMFS to observe herring spawning and population dynamics of lobsters first hand. Because of the current novelty of these techniques, part of this initial effort was devoted to training. Initial training in lockout diving was done using the Johnson Sea Link submersible. In September, the Perry submersible PC-8 made 33 dives and in June 1972 the Perry diver lockout submersible Deep Diver was used in the Gulf of Maine to continue these studies. One significant

early finding, however, was the discovery of offshore lobster beds at unexpected locations and concentration of shrimp and other fish stocks.

Straits of Florida

This program used the U.S. Navy submersible Alvin (operated by the Woods Hole Oceanographic Institution) for 13 dives to study sedimentary processes at six specific sites in the straits. Samples were obtained and observations made to determine relationships between erosion, sediment transport, and bottom current dynamics. The principal investigators were from the Atlantic Oceanographic and Meteorological Laboratory (AOML), Woods Hole Oceanographic Institution and the University of Miami.

Glovers Reef – British Honduras

In early December 1971, a submersible project was conducted jointly with the National Science Foundation at Glovers Reef, British Honduras. Participants in this mission were from: the University of Miami, Colorado School of Mines, University of Texas, and the University of the West Indies. The primary purpose of this project was the geological and biological exploration of a deep living reef to study its composition and origin. Using the General Oceanographic's submersible Nekton Beta, 29 dives were made in three study areas. Basic discoveries were made concerning the formation of carbonate platforms which related to the search for offshore fossil fuels.

POLLUTION STUDIES

New York Bight

The overall objective of this program is to study bottom dynamics in the New York area and to determine their relation to the movement of solid waste. The first two phases of a long-term program have been completed. Phase I was conducted in October 1971 when 15 dives were made by the PC-8 to perform initial sea floor reconnaissance to determine the extent and thickness of spoils areas and to generally examine ridge and swale topography. Phase II was conducted to depths of 150 feet in July 1972 using Deepstar 2000. The major goal here was to obtain information on sediment distribution and chemistry on the shelves. In addition to observing and obtaining samples, geological stations were established, consisting of emplacing in-situ current meters. This program is part of an overall NOAA study in this area and is a joint effort with scientists from AOML, Corps of Engineers, Westinghouse, NMFS, and Adelphi University. Also during Phase II, a biological assessment of a proposed dump site was made by scientists of NOAA's National Marine Fisheries Service. This site was found to be much richer in fauna than previous surface surveys had shown. Thus, the site was judged not suitable for dumping.

Hudson Canyon – New York

In June 1972, a series of dives using the U.S. Navy Alvin was made to depths of 5,000–6,000 feet in the Hudson Canyon to study the bottom dynamics (sedimentary processes). The overall purpose is to determine the manner in which such submarine canyons may serve as "pipelines" for the movement of sediment from the continental shelf to abyssal depths. Data will be obtained by direct observation, photographs, coring and emplacement of instruments. These dives were made by scientists from Woods Hole, AOML, and Lehigh University.

Southern California Borderlands

In June 1972, the Lockheed submersible Deep Quest made four dives totalling 40 hours bottom time to depths of 6,300 feet at toxic and radioactive dump sites off the coast of Southern California. The prime purpose was to determine the condition of the bottom and the overall effects of some 25–30 years of dumping in this area. The dives were made by scientists from Plessey Industries and the Lockheed Corporation.

In July 1972, four dives were made using the Deep Quest submersible to depths of 6,700 feet in the south part of the San Diego Trough. The objective was to study the movement of fine grain sediment from shallow areas into the deeper reaches of the submarine canyons. This study is part of an overall program designed to determine the role of submarine canyons in the dispersal of solid wastes. The dives were made by scientists from Rice University, MUS&T, and the Scripps Oceanographic Institution.

MARINE ECOLOGY

Three programs were conducted which can best be described as addressing the overall problem of ecology, biological productivity, and environmental baseline studies.

Bahama Banks Research Program (Hydrolab)

Using the Perry Hydrolab (a 2–4 man habitat) located at a depth of 50 feet near Grand Bahama Island, a series of saturation dives has been completed which began in December 1971. Seven dives involving geological investigations were made using the Perry submersible PC-8.

Included in a series of saturation diving science projects are studies of fish behavior, experimental fish traps, zooplankton surveys, the indexing of coral fauna and biota, bioacoustical investigations, measurement of photosynthesis and basic in-situ studies of water chemistry. Five 4–6 day missions were conducted from December 1971 to June 1972 by scientists from the federal government and several universities. The overall goal of this program, which will continue throughout 1973, is two-fold: first, to provide a relatively inexpensive training facility for marine scientists to exper-

iment with new underwater techniques; and secondly, to obtain detailed baseline data on the overall ecology of a major reef area. Reefs are sensitive environmental indicators of man's intrusion into the oceans. The techniques developed and the experience gained in this program can be used subsequently in other locations on the U.S. continental slopes and shelves.

Florida Aquanaut Research Expedition (FLARE)

This program commenced on January 27, 1972, with the first of nine saturation dives at four locations getting underway at Long Reef on the southeast coast of Florida.

This multi-discipline project, under the operational management of Woods Hole Oceanographic Institution, made use of the University of New Hampshire's habitat Edalhab supported by the Navy's research vessel Lulu which is operated by Woods Hoole Oceanographic Institution.

Although the scientific teams that took part in FLARE pursued different research goals, their primary objectives were similar, i.e., to increase the understanding of basic coral-reef ecology, and to test under the most stressful conditions, technological advantages to be realized from the use of a movable habitat supported by a surface vessel.

The studies included: reactions of fish to novel traps and holding devices, artificial reefs, effects of pollutants on reef metabolism, obtaining coral cores, detailed studies of coral algae, and comparison of biological productivity in areas of sewage outfalls and "clean" areas. Over 25 scientists participated as aquanauts in this program, which was concluded in late April 1972.

Pacific Walrus (Bering Sea)

In February 1972, the Perry PC-8 submersible was used in the Bering Sea as part of an on-going study of marine mammal productivity. The research was carried out under the International Biological Program with funding from the National Science Foundation and the Office of Naval Research. Participating in the six-week cruise were seven scientists from Johns Hopkings University, the Arctic Health Research Center, and the University of Alaska. The Coast Guard provided the ice breaker Burton Island as the scientific support ship.

The scientists undertook a study of the complex food chain extending from phytoplankton – to benthos – to the Pacific walrus, *Odobenus rosmarus*. The study also included an examination of the walrus population structure, social behavior, and reproductive biology. The PC-8 made a total of four scientific dives in and under the ice to support a program of intensive benthic sampling and inspection, and for observation of walrus feeding behavior. Some 3,000 walrus were sighted during the cruise. Their movements, vocalizations, feeding and resting schedules, and the organization and activities of mating groups were studied intensively. This program is basic to an understanding of Arctic marine biological productivity.

Flower Garden Reefs, Gulf of Mexico, Galveston, Texas

In June 1972, a series of 16 dives were conducted at depths of 200–400 feet using the General Oceanographic's Nekton Gamma submersible 120 miles south of Galveston, Texas. The objective of these dives was to obtain biological and geological baseline data by observation and collection of samples. The samples are being analyzed for pesticide and heavy metal content and have been found to contain significant amounts of mercury, cadium, and arsenic. Geological sampling of sediments was also carried out to determine the impact of the Mississippi River fanning out, upon the distant reaches of the Gulf of Mexico. The Marine Biomedical Institute of the University of Texas Medical Branch at Galveston, Texas, conducted the studies which included scientists from their organisation and the Texas A&M University.

TECHNOLOGY SUPPORT

While current funding constraints do not permit a major technology program at this time, modest efforts have been initiated in this direction. This portion of our total program is designed to support on-going projects and to develop the technical capability to achieve long-range national goals.

BIOMEDICAL PROGRAM

In addition to the marine science programs just described, a program was initiated to develop vertical excursion limits for divers saturated on nitrogen-oxygen breathing mixtures. Such information is necessary from a medical safety standpoint, and is essential in order to properly locate future ocean-floor laboratories so as to permit optimum vertical excursion ranges in steep topographic areas. These excursion ranges are being developed under contract with Union Carbide Corporation using their computer program. Portions of the resulting tables will be validated in the research hyperbaric chamber facility.

NOAA Diving Manual

A diving manual is under development by Potomac Research Inc. and Taylor Diving Company that will address problems of scientific diving as well as working diving for NOAA. This document will complement Navy manuals and will integrate information contained in many sources, i.e., universities and other organizations concerned with diving. Close liaison is being maintained with the Navy, the National Research Council on Underwater Medicine, commercial diving organizations, and those agencies currently having the charge of developing national diving standards.

FUTURE PLANS

It is anticipated that over the next few years an expanded program of undersea exploration, resource assessment and utilization will be developed.

With the expectation that the U.S. continental shelf regions will become, in terms of commodity acquisitions, natural extensions of adjacent land regions, a manned presence is indicated for versatile and detailed exploration, study, and training. The design and development of undersea systems, laboratories, power sources, communications, and life-support equiment will begin while extant regional science, exploration, and assessment programs will be continued and expanded. For these programs, the emphasis will be on resource assessment, pollution, ecological evaluations, locating fish and shellfish stocks, geology, and geophysics.

It is hoped that this program will provide wide access to the continental shelves by 1978 to scientists, engineers, and technicians on a routine, weather-independent basis.

Of necessity, a series of intermediate goals will be required. Near-term objectives call for the development of shallow (200–300 ft) ocean-floor laboratories, life support systems, and other technical support equipment. Currently available systems will be used whenever possible during this developmental phase.

Concurrent with the above, a biomedical program will be conducted to assure the safety of participating scientists and technicians during field operations and also to prevent any long-term deleterious effects resulting from exposure to hyperbaric environments.

We in NOAA are looking forward to an exciting future in the oceans and to the solution of at least some of our more pressing problems. Manned undersea exploration is but one of the many tools available. We think it is an important one.

SUMMARY

1. In August 1971, a Manned Undersea Science and Technology Program was established within NOAA (National Oceanic and Atmospheric Administration) of the United States.
2. The purpose of this program is to support the exploration and development of marine resources utilizing undersea systems. These systems include research submersibles, underwater laboratories, underwater habitats, and related systems and technology.
3. Several programs have been carried out utilizing the various systems mentioned above. The projects range from geological studies on the carbonate platforms of British Honduras, to undersea investigation of the Pacific walrus under the ice in the Bering Sea.
4. This paper describes the current program of the Manned Undersea Science and Technology Office, a review of the programs conducted to date, and a look into the future of NOAA's undersea efforts in science and technology.

First author's address: Dr. J. W. Miller
Manned Undersea Science and Technology Office
National Oceanic and Atmospheric Administration
Rockville, Maryland 20852
USA