MANNED UNDERSEA ACTIVITIES OF THE FEDERAL AGENCIES AND UTILIZATION OF MANNED UNDERSEA RESEARCH SUBMERSIBLES AND HABITATS DECEMBER 1972

INTERAGENCY COMMITTEE ON MARINE SCIENCE AND ENGINEERING
Federal Council for Science and Technology

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COVER. Habitat **HYDROLAB** and submersible **PC-8** operational off the Bahamas.

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Prepared for the
INTERAGENCY COMMITTEE ON MARINE SCIENCE AND ENGINEERING
FEDERAL COUNCIL FOR SCIENCE AND TECHNOLOGY
by the

MANNED UNDERSEA SCIENCE AND TECHNOLOGY OFFICE,
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION,
DEPARTMENT OF COMMERCE

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Section I. Introduction and Summary

PURPOSE

In view of the decreasing use of manned undersea research submersibles and habitats (referred to herein as undersea platforms), built during the 1960's, the Interagency Committee on Marine Science and Engineering (ICMSE) requested a study to determine the Federal requirements for manned undersea activities and the extent of undersea platform use. This report presents the findings of that study, conducted by the Manned Undersea Science and Technology (MUS&T) Office of the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) during 1972. The findings were presented to the ICMSE on October 19, 1972. The study concentrated on two major aspects of the Nation's manned undersea activities. The first aspect pertained to determining those Federal marine science programs, not including military-oriented programs, which were planning to use undersea platforms. The second aspect pertained to the status, as of October 1972, of the use and availability of manned, civilian-operated undersea research submersibles and habitats. These aspects were analyzed to determine the extent of undersea platform use that would be possible.

BACKGROUND

During the 1960's, industry invested over $100 million to develop over 50 submersible systems and three habitat systems. There were many reasons for these investments, such as to demonstrate technological capability in the competition for (primarily) Navy contracts and anticipation of substantial sales or leasing and greater oceanic exploration, exploitation, and use. The inventory and technological complexity of systems outstripped the needs of users, and the nonmission-oriented characteristics in many designs limited the utility of the systems to users. At the same time, Navy-owned systems began to meet Navy needs, and the Navy gradually withdrew support of essentially civil-oriented programs. The result was a drop in Navy lease funding from a high of approximately $2.2 million in 1968 to zero in 1971. At the time there was no civil agency focus, and a period of inactivity and decreased use of undersea platforms commenced.

At the same time, however, interest in using manned undersea platforms remained high and appeared to be increasing. A 1969 Navy study (by the Carroll committee) recorded 1,603 requests for submersibles for dives (984 by Federal agencies and 619 by academic institutions) when analyzing the use of a target $3.0 million lease fund. Of the 1,603 requests, 768 were recommended through an evaluation and priority system. Despite this interest, the recommendations of the study were not implemented.

During 1970, Woods Hole Oceanographic Institution reported a survey of 346 articles published during the period up to and including 1969. As published in "Research Submersibles in Oceanography" by the Marine Technology Society, the results showed that significant work is possible in biology, fisheries, physical oceanography, geophysics, acoustics, geology, and engineering site surveys when submersibles are available and that submersibles provide a unique capability for certain types of work. The report also noted that earlier efforts had submersible technology, not the development of users, as the primary goal. In addition, there were significant operational deficiencies in the existing systems. Many of these systems remain in today's inventory. For example, oil and power companies are using several of the submersible systems; in fact four submersibles are on long-term lease for oil field work overseas.

The (1972) "First Annual Report of the UNOLS Advisory Council to Federal Funding Agencies," issued by the University-National Oceanographic Laboratory System (UNOLS), an association of 18 major facility-operating academic institutions, recommended one shallow and one deep submersible on each coast,[1] and the establishment of a "charter fund."

[1] *Discussed in section III.*

During August 1971, the Department of Commerce's National Oceanic and Atmospheric Administration established a Manned Undersea Science and Technology (MUS&T) program to: "Develop, promote, coordinate and support a national civilian-operational capability for man to work under the sea to achieve better understanding, assessment, and use of the marine environment and its resources." During FY 1972, the MUS&T program used eight submersibles and two habitats to support over 130 investigators from academia, industry, and Federal agencies. During FY 1973, approximately 70 unsolicited proposals,[2] which would cost approximately $4.0 million for undersea facility and related support, were received. Invitations to use undersea platforms or a solicitation would substantially increase the proposal flow. Studies by the University of New Hampshire and the National Academies of Sciences and Engineering (section III) also show a broad base of potential users. There has also been considerable interagency cooperation and interest in many MUS&T-sponsored projects.

In order to review the requirements for programs which may involve manned undersea activities, the 12 member agencies of ICMSE were surveyed. The findings of that survey are summarized below.

SUMMARY OF FINDINGS

Ten ICMSE member agencies reported programs; 33 programs were of a civil nature and 13 were from the Navy. In general, the survey indicated a current need for the platforms, increasing future needs, and problems in matching users, platforms, and funds. Of the 36 U.S. submersibles surveyed as of October 1972, there are only 13 civilian-operated platforms without diver lockout[3] capability and three with lockout capability which were considered part of the usable civil inventory. Relative to the extent of utilization of the usable civilian undersea platforms as of October 1972 (prior to the study), the following estimates were made:

	Percent
Submersibles without lockout	40
Submersibles with lockout	67
Habitats	31

Based on the potential uses of the usable civilian platforms as extrapolated from current and planned programs of the Federal agencies, the use of current platforms in FY 1974-75 (as estimated in the summer of 1972) could, if adequately funded, be raised to the levels estimated below:

	Percent
Submersibles without lockout	86
Submersibles with lockout	167
Habitats	81

An independent survey by the University of New Hampshire in late FY 1972 of platform requirements of the U.S. scientific diving community also has an impact on the extent of platform utilization by Federal agencies. Taking this into account, full utilization of the usable submersibles without lockout would result and requirements for utilization of present habitats would be exceeded. In addition, there would be needs for additional submersibles with lockout capability. Another requirement which emerged in the Federal survey (and also in the University of New Hampshire study) was the need for scuba support ships[4] and interest in the use of a mobile (self-propelled in its deployed area) habitat.

CONCLUSIONS AND RECOMMENDATIONS

Assimilation and analysis of the information from Federal agencies with civil programs generally indicate a substantial body of potential users in addition to the current users. However, the current lack of use of available platforms can be attributed to a combination of reasons including: Short-duration needs for the platforms; their excessive cost due to mobilization and demobilization requirements if used on a project-by-project basis; and the need for a broader appreciation of the capabilities of this technology in some agencies. Therefore, a mechanism is needed to:

—Coordinate the use of national undersea platforms (present and future) to realize economics of operations and applications and provide continuity of support.

—Identify the need for these platforms and provide support for improvements in platforms as required in support of projects.

—Assist Federal agencies in planning the use of platforms and gaining access to platforms.

—Provide for replacement of platforms and new technological capabilities when needed for programs.

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[2] *As of October 20, 1972.*

[3] *Lockout is a term used to describe being able to internally pressurize a submersible's compartment (separately from the operator's compartment) to a level equal to external pressure so that divers could egress into the water (within diver depth limitations).*

[4] *A scuba support ship is used to transport and support scuba divers diving for relatively short periods of time to depths currently limited to less than approximately 200 feet.*

Of the three alternative methods for accomplishing these—(1) establishing a new coordinating committee; (2) expanding the functions of existing or related interagency groups; and (3) designating a lead agency—the designation of a lead civil agency was adopted by ICMSE. ICMSE also recommended that the lead agency make platform data available to current and potential users, explore the uses with other agencies, continue the accumulation of requirements and utilization data, defer new systems development until existing platforms are fully utilized or declared technically unsuitable, and transfer available technology to the civil sector whenever possible. The lead agency assignment was to the National Oceanic and Atmospheric Administration, to be performed by its Manned Undersea Science and Technology Office.

After presentation of the findings and recommendations of the study to ICMSE on October 19, 1972, ICMSE recorded its conclusions on page 33 of its report, entitled "Report of the Annual Review—Federal Ocean Program for Fiscal Year 1974" as follows:

"Title: *Utilization of Manned Undersea Submersibles and Habitats*

"Problem: Of the 50-60 submersibles produced over the last ten years, only 10-15 remain usable. Utilization of these is estimated at about 30 percent. The role of the Federal Government in assessing the need for submersibles and habitats and in assuring the continued availability of those considered necessary to meet marine research requirements needs to be clarified.

"A preliminary survey of ICMSE member agencies indicates that many have programs which potentially could benefit from the use of submersibles. However, among the civilian agencies, FY 1973 funds specifically earmarked for leasing them are included only in the NOAA budget as part of the Manned Undersea Science and Technology Program.

"Proposed Action: ICMSE recommends that NOAA, through its Manned Undersea Science and Technology Office, provide a continuing assessment of the Federal civilian agency needs for submersibles and habitats, and coordinate the utilization of available commercial and Navy assets by the civilian Federal agencies."

Section II. Manned Undersea Platforms

INTRODUCTION

In developing the study, undersea platforms were originally defined as existing submersibles and habitats available for operations or held in such condition that reactivation was feasible. Primary emphasis was placed on those systems available for lease or otherwise not fully committed to the sponsor's or owner's missions. A further stipulation was that to be considered, a system had to be certified by either the Navy or the American Bureau of Shipping (or capable of being certified) and that it be U.S. owned.

During the study it became obvious that there was another type of platform—a support ship for scuba divers—as implied by responses to the ICMSE survey, by the University of New Hampshire study, and by the output of the National Academies of Sciences and Engineering Manned Undersea Activities Workshop. The closest to this is now the R/V *MISS FREEPORT*, operated by the Marine Biomedical Institute of the University of Texas.

HABITATS

Table 1 summarizes the characteristics of the eight existing U.S. habitats, and table 2 their present status. Only one is in active use,[5] the Perry Foundation's *HYDROLAB* now at Freeport, Bahamas. The Puerto Rico Undersea Research and Development Company (PRURDC) and the Marine Resources Development Foundation's (MRDF) *PRINUL** became operational during late 1972. *PRINUL* is a state-of-the-art platform which is more of an undersea laboratory than a living quarters-type habitat. Built by Perry Submarine Builders, the laboratory corrects many

[5] *As of October 20, 1972.*

* *Though the actual habitat of the PRINUL program is called* LA CHALUPA, *the term* PRINUL *is used hereafter for the habitat.*

Table 1. Characteristics of U.S. habitats

Name	Owner	Depth		Personnel	Life support			Breathing gas	Comfort control		
Personnel		Present use	Capability		Typical	Maximum	Emergency		Heat	Cool	Humidity
		Ft	Ft		Days	Days	Days				
AEGIR	Makai Range	50–500	580	4–6	14	20	1	Mix	Yes	No	Yes
EDALHAB	University of New Hampshire.	42	50	2–3	7	7	—	Air	Yes	No	No
HYDROLAB	Perry Foundation	42	100	3–4	7	7	3	Air	No	Yes	Yes
LAKELAB	University of Michigan.	30	—	2	—	—	—	Air	No	No	No
PRINUL	PRURDC & MRDF [1]	50	100	4	14	14	2	Air	No	No	Yes
PORTALAB	University of Rhode Island.	30	—	2	—	—	—	Air	No	No	No
SEALAB I	U.S. Navy	—	200	4	11	—	—	Mix	—	—	—
TEKTITE	General Electric	50	100	4–5	14–28	60	3	Mix	No	Yes	Yes

[1] PRURDC: Puerto Rican Undersea Research and Development Company.
MRDF: Marine Resources Development Foundation.

Table 1. Characteristics of U.S. habitats—(Continued)

Name	Decompression	Size	Volume	Weight	Surface support
			Ft³	Lb	
AEGIR	Internal-surface	Two 8′x15′ cylinders and 10′ wetroom on 8′x42′ barge.	2,965	449,000	72′ support ship **HOLOKAI** for power and communications; otherwise self sufficient.
EDALHAB	Surface chamber	One 8′x11′ cylinder	560	28,000	Shore or R/V **LULU.** Carried and lowered by **LULU.**
HYDROLAB	Internal-bottom	One 8′x16′ cylinder with lockout trunk.	730	134,000	23′ unmanned life support buoy; daily resupply by small boat.
LAKELAB	—	10′ hexagonal, 7′ high	400+	9,000	Shore; intended as part of potential larger system.
PRINUL	Internal-surface or bottom.	Two 8′x19′ cylinders inside 20′x48′ barge.	3,150	267,000	36[1] unmanned life support buoy; tows at 5 knots.
PORTALAB	—	7′x11′ wide "mailbox"	143	—	Shore.
SEALAB I	—	9′x40′ cylinder	—	—	Integrated with a "Texas tower."
TEKTITE	Surface chamber	Two 12′x18′ vertical cylinders on 15′x34′ base.	1,975	310,000	Shore.

Table 2. Status of U.S. habitats

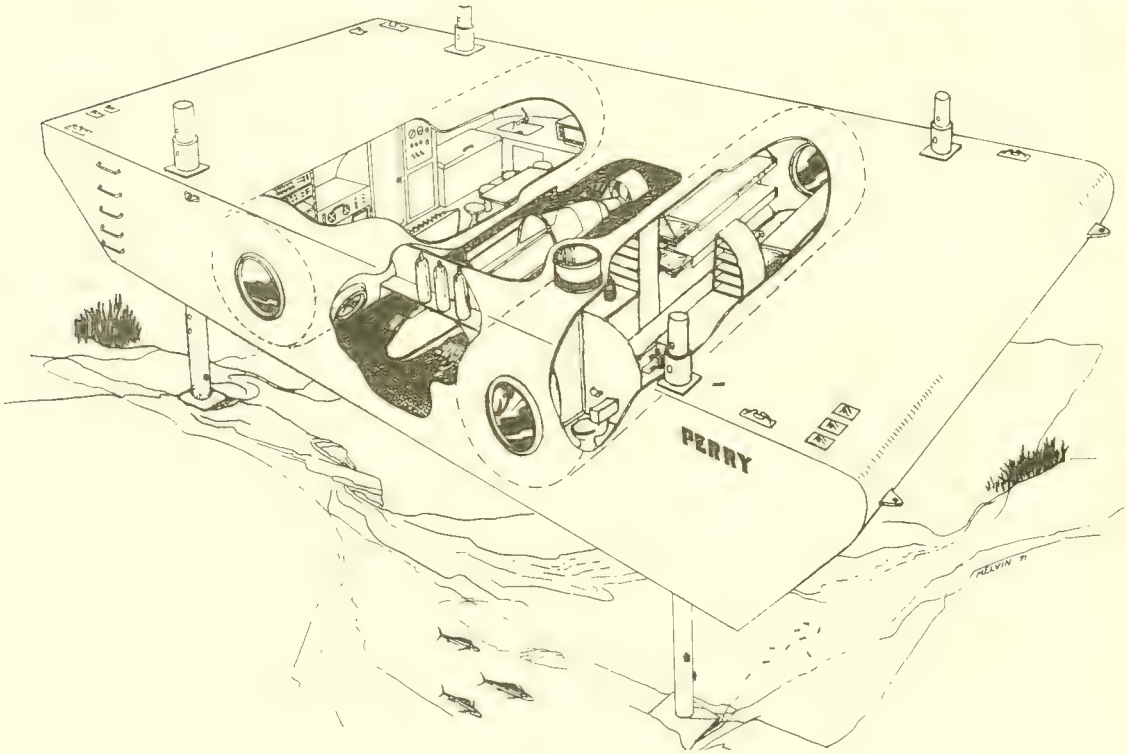
Name	Owner	Location	Remarks
AEGIR	Makai Range	Hawaii	Inactive; last used by Navy during 1971 at 200 ft. in Hawaii.
EDALHAB	University of New Hampshire	(With owner)	Inactive; last used by NOAA-MUS&T during project FLARE in January-February 1972.
HYDROLAB	Perry Foundation	Freeport, Bahamas.	In use. Under NOAA-MUS&T lease through June 1973.
PRINUL	Puerto Rico Undersea R&D Co. and Marine Resources Development Foundation.	Puerto Rico	Operational fall 1972; NOAA-MUS&T scheduled for nine diver missions through June 1973.
SEALAB I[1]	U.S. Navy	Panama City, Fla.	Used for Navy training at "Texas Tower" location.
TEKTITE	General Electric	Philadelphia, Pa.	Inactive; last used for **TEKTITE II** during 1970 at 50 ft. in Virgin Islands.
LAKELAB[2]	University of Michigan	Lake Michigan	New; periodic use and checkout by Univ. of Michigan; planned as part or larger system; small for operational use.
PORTALAB[2]	University of Rhode Island	Kingston, R.I.	New; periodic use and checkout by Univ. of Rhode Island; small for operational use.

[1] **SEALAB I** is not considered usable for scientific missions.
[2] Considered of very limited use for scientific missions.

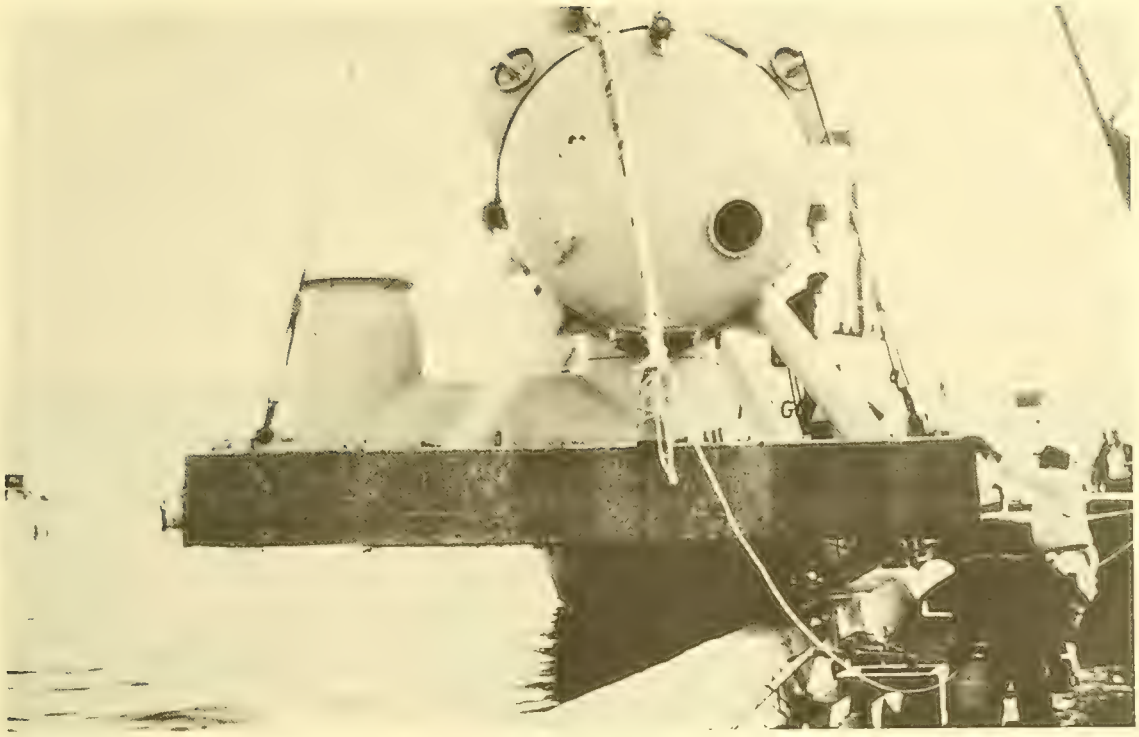
of the deficiencies of previous habitats designed for use in its depth range.

The Navy *SEALAB I* is currently mounted below a "Texas Tower" located in the Gulf of Mexico off the Naval Coastal Systems Laboratory at Panama City, Fla. It is used for training by the State University of Florida and is not suitable for undersea research. *AEGIR* and *TEKTITE*, which were early ventures away from the living-space concept of habitats toward a more laboratory-oriented concept, are inactive due to the reorientation of Navy programs a few years ago and the former lack of a civil agency focal point and moderate funding source for continued operations. *EDALHAB* was designed and built by the Engineering Design and Analysis Laboratory of the University of New Hampshire in the late 1960's. It is less sophisticated than *HYDROLAB*, *AEGIR*, or *TEKTITE*. *EDALHAB* requires either shore support or surface support such as the Woods Hole Oceanographic Institution's R/V *LULU* (mother ship to the submersible *ALVIN*).

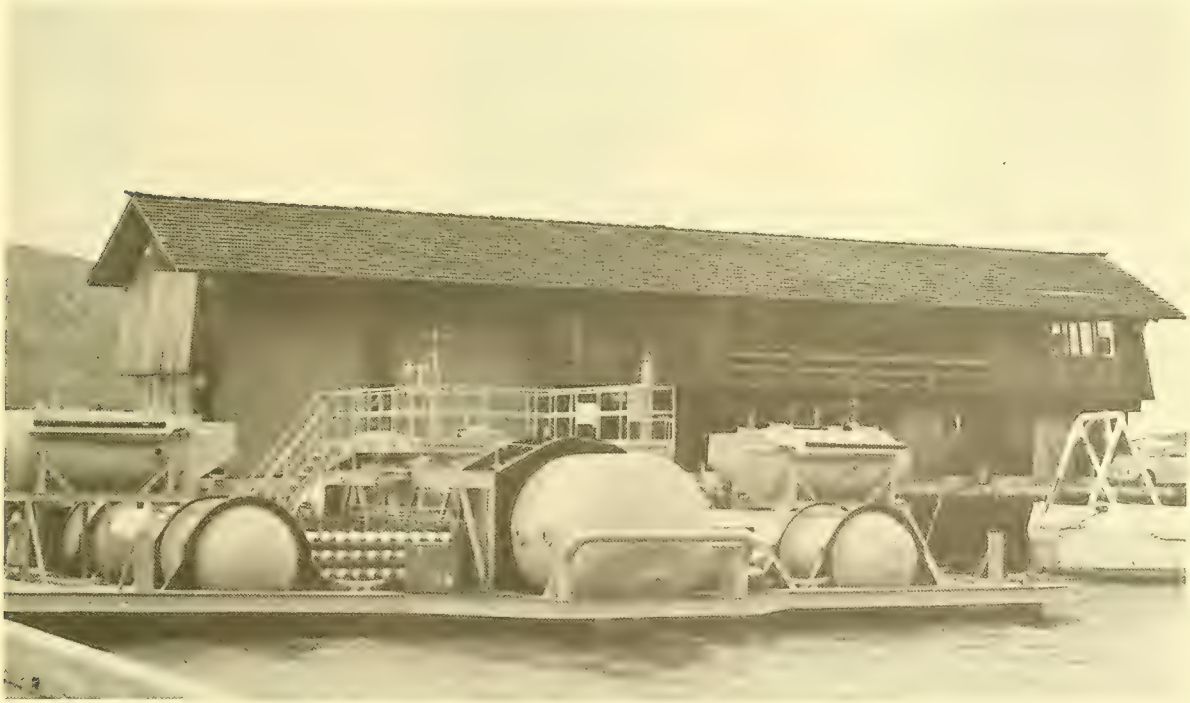
Two other new habitats have come into being recently, the University of Michigan's *LAKELAB* and the University of Rhode Island's *PORTALAB*.



Transportable habitat **PRINUL** (Puerto Rican International Underwater Laboratory) owned and operated by the Marine Resources Development Foundation, Puerto Rico.



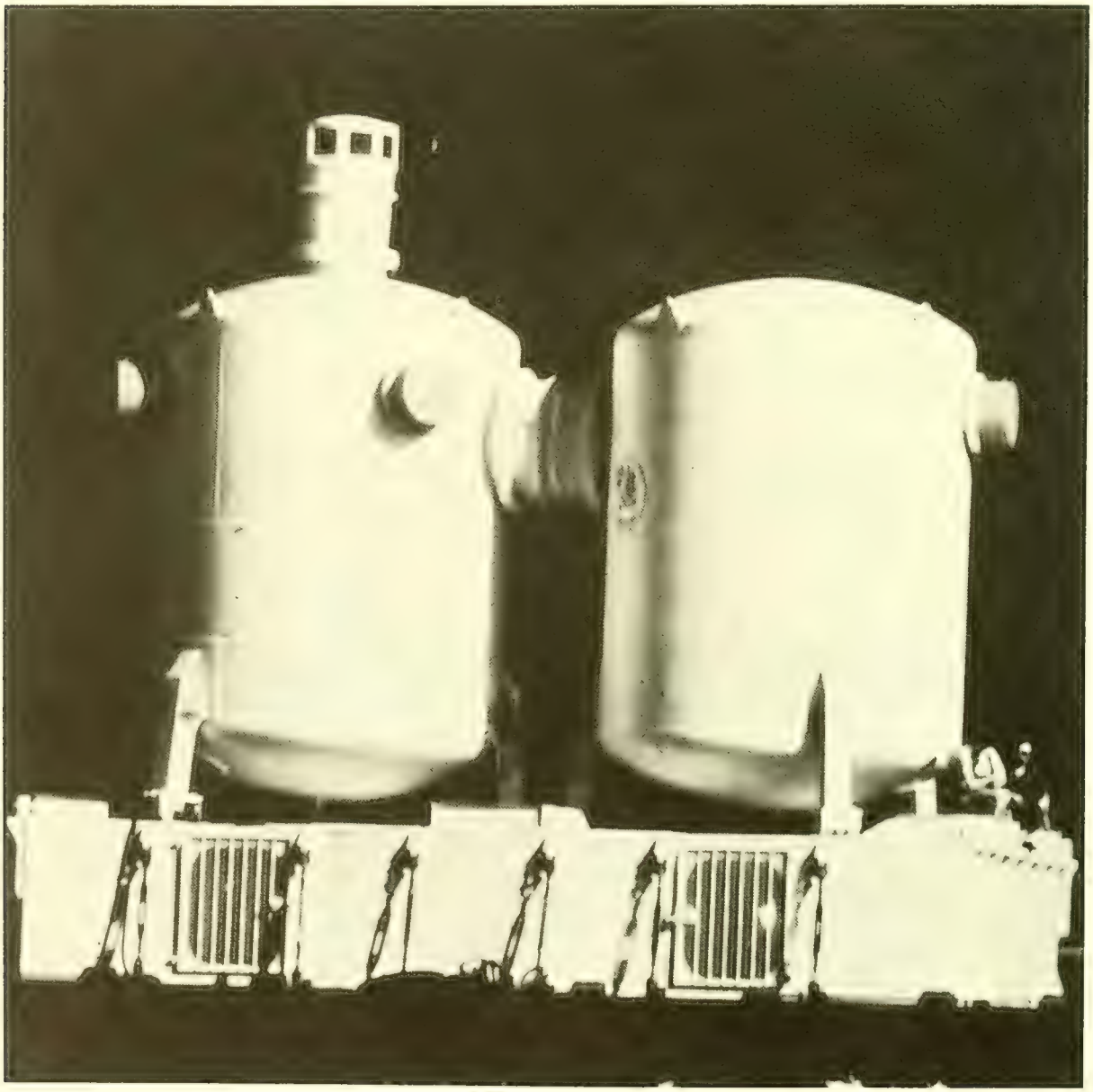
Habitat **HYDROLAB** being lifted from the dock into the sea for towing to an operational site.



Habitat **AEGIR** at the Makai facility in Hawaii.

LAKELAB and *PORTALAB* were both student projects and are small, Spartan, and dependent on shore support. It is questionable if either would be readily adaptable to the saturation diving missions generally conducted from habitats.

All existing habitats can be considered transportable, that is, they can be moved from place to place with varying degrees of difficulty. However, none is mobile—capable of changing location by perhaps 1 or 2 miles under its own power during a mission. There are only five habitats (*AEGIR*, *EDALHAB*, *HYDROLAB*, *PRINUL*, and *TEKTITE*) known to be able to support saturation diving and equipped at this time for research and investigations. Two others (*LAKELAB* and *PORTALAB*) may be usable for special operations. For inventory and statistical purposes, it was decided to consider *LAKELAB*, *PORTALAB*, and other small chambers as the equivalent capability of one habitat, making a total of six habitats. This "one" and two others (*EDALHAB* and *PRINUL*) will have been used about one-third of their available time. Two habitats (*AEGIR* and *TEKTITE*) have not been used since mid-1971. The *HYDROLAB* is being used by NOAA-



Habitat **TEKTITE II**

MUS&T, and there is sufficient interest in it to fully utilize available time. Assuming approximately 150 useful bottom days per year, the overall average utilization of the six platforms is approximately one-third.

Many of the more valuable investigations, which are ideally conducted from habitats or undersea laboratories, involve gaining knowledge of continuous environmental processes. These investigations often require the ability to revisit a site periodically over a period of time (frequently a year or more). Thus, the lack of regular scheduling for access at investigation sites reduced the availability of the platforms to investigators.

SUBMERSIBLES

Tables 3 and 4 list 36 U.S. submersibles with depth capabilities of 600 feet or greater whose existence and status could be documented. Of these, 26 are civilian owned and operated, one is U.S. Navy owned and civilian operated, and nine are Navy owned and operated. Table 5 summarizes the vehicle categories by three operating depth classes.

Those 26 civilian-owned and -operated are the survivors of the numerous submersibles built during the 1960's building boom, with a few built in recent years that were more mission oriented in their design. Others have been either scrapped or, as in the case of the *BEN FRANKLIN* (table 6), sold outside the United States.

Table 6 lists characteristics of Canadian-operated submersibles. Several Canadian firms have established U.S. subsidiaries to facilitate leasing to U.S. interests.

Although there is no formally stated or legislated requirement for submersibles used in civil programs to be either Navy- or American Bureau of Shipping (ABS)-certified (or capable of being certified), certification is an accepted prerequisite because of

Table 3. Characteristics of civilian-operated U.S. submersibles

Name	Owner	Status [1]	Maximum operating depth	Submerged speed			Life support	
				Cruising	Maximum	Endurance	Normal	Max.
			Ft	Knots	Knots	Hr	Man-hr	Man-hr
ASHERAH	Techoceans	O,N	600	1	3.5	12	48	48
SEA RANGER	Verne Engineering	O,N	600	—	4	60	30	120
SUBMANAUT	Submarine Services	N,S	600	5	10	100	48	48
TECHDIVER	International Underwater Contractors.	O,N	600	2	4	4	12	18
PC-8	Perry Oceans Services	O,C	800	1	3	8	48	48
SHELF DIVER	do.	O,L,C	800	2	3	6	40	60
BENTHOS V	Garrison Diving & Salvage Co.	N,S	1,000	2	3	4	96	96
GUPPY	Sun Shipbuilding & Drydock Co.	O,C	1,000	3	3	56	56	56
NEKTON ALPHA	General Oceanographics	N,O	1,000	2	3.5	6	10	48
NEKTON BETA & GAMMA	do.	O,C	1,000	2	3.5	6	48	48
SEA LINK	Smithsonian Institution	O,C	1,000	1	2	8	72	72
SEA RAY	Submarine Research & Development.	S,N	1,000	2	6	5	16	32
SNOOPER	Sea Graphic	O,N	1,000	1	3	6	10	10
PC-9	Taylor Diving & Salvage Co.	O,C	1,200	—	4	12	72	72
STAR II	General Dynamics	O,N	1,200	1	3	8	48	48
OPSUB	Ocean Systems	L,C	1,200	2	—	—	24	26
DEEP DIVER	Perry Oceans Services	N,S	1,335	2	3	4	40	60
BEAVER IV	International Underwater Contractors.	O,C	2,000	2.5	5	12	48	144
DEEPSTAR 2000	Westinghouse	O,C	2,000	1	3	8	36	108
STAR III	Scripps Institution	S,N	2,000	2	3.5	6	120	120
DEEPSTAR 4000	Westinghouse	S,N	4,000	0.5	3	8	12	48
DOWB	Santa Barbara City College.	S,N	6,500	0.5	2.5	26	195	195
DEEP QUEST	Lockheed	O,C	8,000	2	4	18	192	204
ALVIN	U.S. Navy	O,C	12,000	1	2	8	72	72
ALUMINAUT	Reynolds International	S,N	[2] 15,000	1.5	3.5	24	336	502

[1] O—Operational, whether employed or not; C—certified; N—not certified; L—on long-term lease overseas; S—in storage, either whole or partially disassembled.
[2] Approximately 8,000 without new hemiheads.

Table 3. Characteristics of civilian-operated U.S. submersibles—(Continued)

Name	Crew	Observers	Payload	Length	Weight in air	View ports	TV cameras	Manipulators	Submerged-to-surface communication
			Lb	Ft	Lb				
ASHERAH	1	1	200	17	—	6	0	0	Citizens band radio, underwater telephone
SEA RANGER	1	3	2,200	17	16,000	9	0	2	—
SUBMANAUT	2	6	6,000	44	108,000	8	0	0	Radio
TECHDIVER	1	1	200	22	5,500	17	1	0	Radio, underwater telephone
PC-8	1	1	200	19	11,000	9	0	1	Citizens band radio, underwater telephone
SHELF DIVER	1	3	1,200	23	17,000	25	0	0	do.
BENTHOS V	1	1	400	18	4,200	6	0	1	Underwater telephone
GUPPY	1	1	—	11	5,800	3	0	1	On tether cable
NEKTON ALPHA	1	1	50	15	4,500	20	0	1	Citizens band radio, underwater telephone
NEKTON BETA & GAMMA	1	1	350	15	4,500	17	0	1	do.
SEA LINK	1	4	700	24	17,900	4	1	0	do.
SEA RAY	1	1	350	20	8,429	8	1	1	Radio
SNOOPER	1	1	200	12	4,400	—	0	0	—
PC-9	1	2	2,000	25	21,000	21	—	—	—
STAR II	1	1	500	17	10,000	6	0	0	Radio, underwater telephone
OPSUB	1	1	—	18	10,400	13	1	—	On tether, underwater telephone
DEEP DIVER	1	3	1,200	23	16,550	20	1	0	Citizens band radio, underwater telephone
BEAVER IV	2	2	1,387	24	27,740	9	1	2	FM radio, underwater telephone
DEEPSTAR 2000	1	2	500	20	17,500	2	1	1	do.
STAR III	1	1	970	25	20,000	5	2	1	Citizens band radio, underwater telephone
DEEPSTAR 4000	1	2	500	18	18,000	3	0	1	FM radio, underwater telephone
DOWB	2	1	1,050	17	20,000	2	1	1	Radio, underwater telephone
DEEP QUEST	2	2	7,000	40	112,000	2	4	2	do.
ALVIN	1	2	1,500	23	32,000	3	1	1	do.
ALUMINAUT	3	4	4,000	51	146,000	4	2	2	do.

Table 4. Characteristics of U.S. Navy-operated submersibles [1]

Name	Owner	Maximum operating depth	Submerged speed			Life support		Crew	Observers
			Cruising	Maximum	Endurance	Normal	Maximum		
		Ft	Knots	Knots	Hr	Man-hr	Man-hr		
MAHAKAI	U.S. Navy	600	1.5	3	6	24	36	1	1
NEMO	do.	600	1	1	8	8	16	1	1
DEEP VIEW	do.	[2] 1,500	1.5	5	6	48	48	1	1
DSRV 1 & 2	do.	5,000	3	5	12	—	—	3	24
SEA CLIFF & TURTLE	do.	6,500	1	2.5	8	100	107	2	1
TRIESTE II	do.	20,000	2	3	12	72	108	1	2

[1] All operational and certified. Other U.S. Navy-owned and -operated undersea vehicles are **NR-1** and **DOLPHIN.** **NR-1** is a nuclear powered, undersea research and ocean engineering vehicle. **DOLPHIN** (AGS-555) is used as an ASW research submarine and is not considered readily applicable to civilian research.

[2] Currently Navy certified to 100 ft.

Table 4. Characteristics of U.S. Navy-operated submersibles—(Continued)

Name	Payload	Length	Weight in air	View ports	TV cameras	Manipulators	Submerged-to-surface communication
	Lb	Ft	Lb				
MAHAKAI	1,200	19	10,600	1	—	—	—
NEMO	—	6	—	1	—	0	Underwater telephone, UHF radio.
DEEP VIEW	500	16	12,000	1	—	0	do.
DSRV 1 & 2	4,300	50	73,900	3	3	0	do.
SEA CLIFF & TURTLE	700	26	48,000	5	1	1	do.
TRIESTE II	7,500	78	130,000	1	3	1	do.

Table 5. Summary of submersibles by depth class

Depth class	Total	Operational, no lockout	Operational, lockout	Not certified	Stored or uncertain	U.S.N. owned
600–2,000 ft.	21	10	2	10	4	3
2,000–6,000 ft.	6	1	1	2	2	3
6,000+ ft.	7	2	0	2	2	3
Total	34	13	3	14	8	9

Table 6. Characteristics of Canadian-operated submersibles [1]

Name	Owner	Maximum operating depth	Submerged speed: Cruising	Submerged speed: Maximum	Submerged speed: Endurance	Life support: Normal	Life support: Maximum	Crew
		Ft	Knots	Knots	Hr	Man-hr	Man-hr	
SEA OTTER [2]	Arctic Marine	1,500	1	3	6	48	48	1
PISCES I [3]	International Hydrodynamics, Inc.	1,800	1	2	9	18	76	1
BEN FRANKLIN [3]	Horton Maritime Industries.	2,000	2.5	4	32	—	6,048	2
SDL-1	Canadian Navy	2,000	1	2	8	40	204	1
AUGUSTE PICCARD [3]	Horton Maritime Industries.	2,500	6	6.3	10	—	2,160	5
PISCES III	International Hydrodynamics, Inc.	3,500	1	2	6	18	76	1
PISCES IV	Canadian Navy	6,000	1	2	8	—	108	1

Name	Observers	Payload	Length	Weight in air	View ports	TV cameras	Manipulators	Submerger-to-surface communication
		Lb	Ft	Lb				
SEA OTTER [2]	2	200	14	6,300	4	0	1	—
PISCES I [3]	2	450	17	15,000	2	1	1	Underwater telephone, UHF radio
BEN FRANKLIN [3]	4	10,000	48	[4] 125	27	1	—	do.
SDL-1	5	3,100	25	28,600	11	1	2	do.
AUGUSTE PICCARD [3]	40	40,000	93	[4] 165	46	1	0	do.
PISCES III	2	1,100	20	24,000	3	1	2	do.
PISCES IV	2	1,200	20	21,000	3	1	1	do.

[1] Operational and certified unless noted.

[2] Operational, not certified.

[3] Uncertain.

[4] Tons.

the potential risk to human life and the lack of adequate rescue capabilities. Thus, none of the seven (six submersibles without diver lockout and one with lockout) uncertified submersibles was considered in the national inventory for the purposes of this study. Of the first 13 operable and with no lockout, three (*PC-3, PC-9,* and *OP-SUB*)) are under long-term lease overseas. Of the three lockout variety, one (*SHELF DIVER*) is under long-term lease overseas.

Of the U.S. Navy's nine submersibles, two (*DSRV-1* and *DSRV-2*) are special-purpose rescue vehicles and one (*DEEP VIEW*) is in the process of being certified. *DEEP VIEW* has a design depth capability of 1,500 feet, but is currently certified to 100 feet. The *USS DOLPHIN*, an antisubmarine warfare research submarine, and the *NR-1* were not listed among Navy submersibles.

There are also four U.S. submersibles without lockout (*STAR III, DEEPSTAR 4000, DOWB*, and *ALUMINAUT*) in storage or uncertain status. *STAR III* was given to Scripps Institution of Oceanography and is in storage. It has not been surveyed to determine the effort and cost necessary to make it operational. *DEEPSTAR 4000* is in storage and can be reactivated. *DOWB* (Deep Ocean Work Boat) was recently given to the Santa Barbara Community College for use in its marine technician program. Plans for its use at sea are uncertain. *ALUMINAUT* is in storage and partially disassembled.

Of the 10 certified, operable U.S. submersibles without lockout that are not under long-term lease overseas, the Navy-owned and Woods Hole Oceanographic Institution (WHOI)-operated *ALVIN* is used essentially 100% of its available time; four (*NEKTON BETA* and *GAMMA, DEEPSTAR 2000,* and *DEEP QUEST*) are used an estimated one-third of their available time; and no use of five remaining could be documented. *ALVIN* is funded by a combination of Navy, National Science Foundation, WHOI, and charter funds (charter users have included NOAA/MUS&T). The four other vehicles used were funded by a combination of Federal, private, and commercial charters. Federal leasing was primarily by the NOAA/MUS&T program, at times in cooperation with other agencies (such as the National Science Foundation). The Perry *PC-8* was leased four times for the NOAA-MUS&T program during FY 1972 prior to an overseas lease through early 1973.

Of the operable U.S. lockout submersibles, the *SEA LINK* is used essentially 100% of the time in the Smithsonian Institution-Harbour Branch Foundation Biological and Geological Oceanographic Research Program. *SEA LINK* time was made available to NOAA/MUS&T for training in support of the NOAA Northeast Fisheries Project. *BEAVER* was not used at all, but was sold to International Underwater Contractors. *SHELF DIVER* is on long-term lease overseas. Unable to be certified, *DEEP DIVER* will be operated to depths not exceeding 100 feet in support of the *PRINUL* habitat.

NOAA-NAVY AGREEMENT ON SUBMERSIBLES

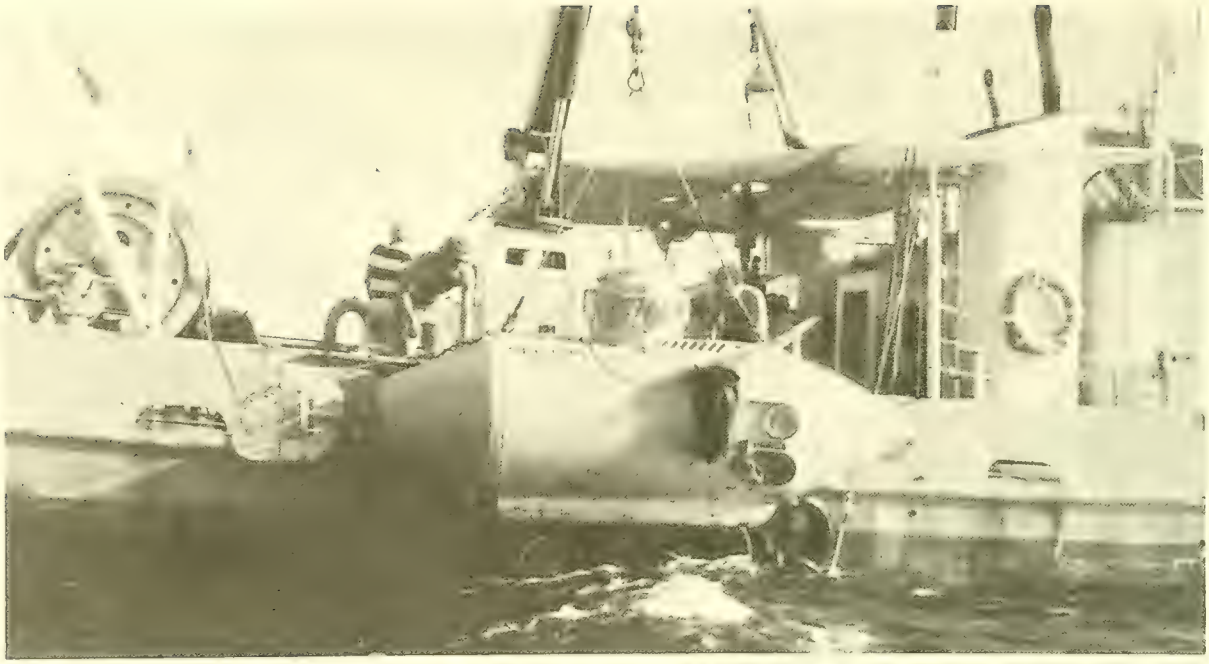
NOAA and the Navy are negotiating an agreement which will provide the MUS&T program with periodic access to Navy-owned and -operated submersibles for civil programs. A major provision of the agreement is that such access will not be in direct competition with U.S. civilian-owned and -operated submersibles.

In addition to the Navy making available periods of time during which NOAA/MUS&T can schedule operations, the planned agreement will also include provisions for opportunity dives by civilian investigators that are supported by other Federal agencies. Since the facilities were acquired and are operated in direct support of Navy missions, it is unlikely that large amounts of time will be available. However, the agreement is expected to provide civilian investigators with access to the excellent and unique capabilities of many Navy submersibles.

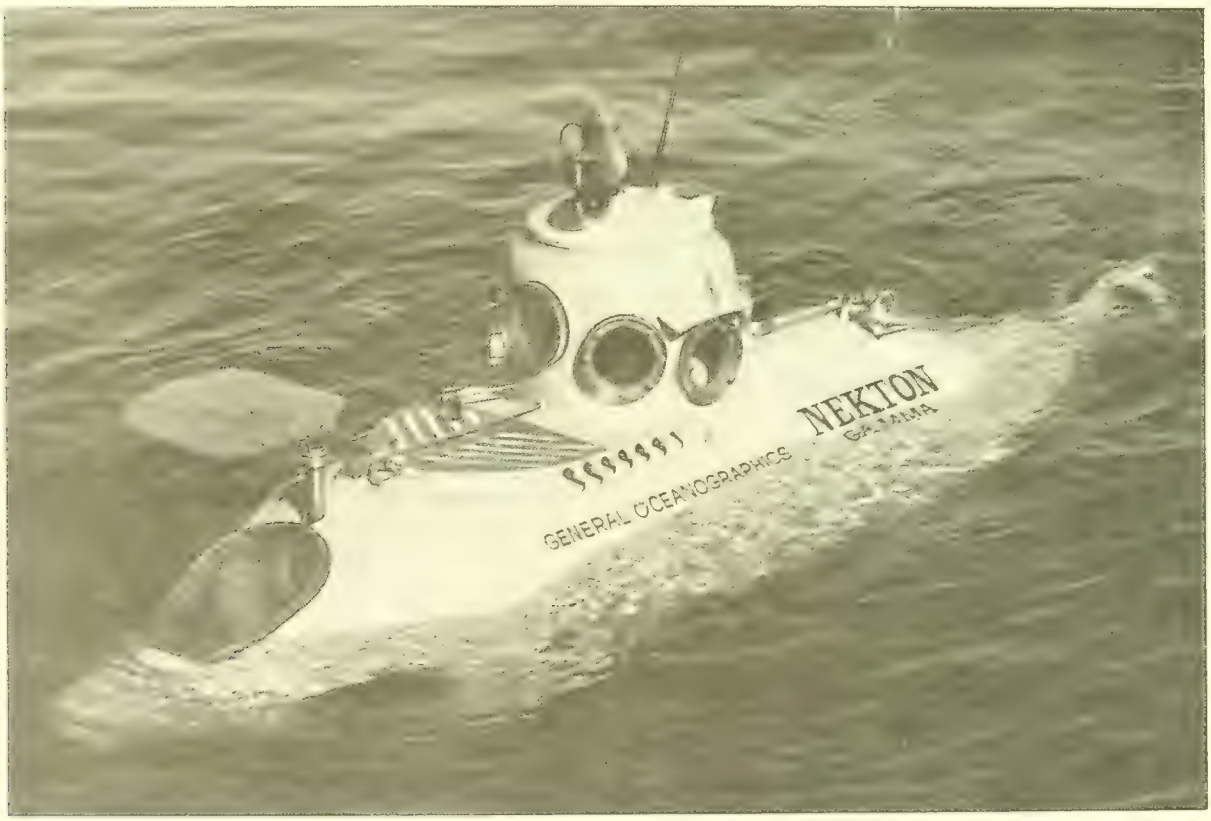
SCUBA SHIP CONCEPT

The study's survey of the Federal agencies revealed many requirements for the use of scuba divers in shallow waters, generally less than 100 feet. This indicates the possible need for a scuba diver support ship. There is no ship designated and operated to fulfill this need. The closest facility to a ship equipped specifically to support divers is the R/V *MISS FREEPORT*, which has been used by the Marine Bio-Medical Institute of the University of Texas Medical Branch at Galveston as the launch ship for research submersibles. The scuba ship would be equipped specifically to support biologists and geologists using scuba techniques. Such a ship could support "bounce" diving (diving without decompression) and, by including hyperbaric chambers, personnel transfer capsules, and similar equipment, support saturation diving from the surface. The concept requires further investigation, but is raised because of its apparent application to a number of programs. It could obviate the need for a submersible or habitat in some research programs. Such a ship could also function as the support ship for small research submersibles of the *PC-8* or *NEKTON* class and provide a complete base of investigations when high mobility is required.

Top, DEEPSTAR 2000; bottom, DEEPSTAR 4000.



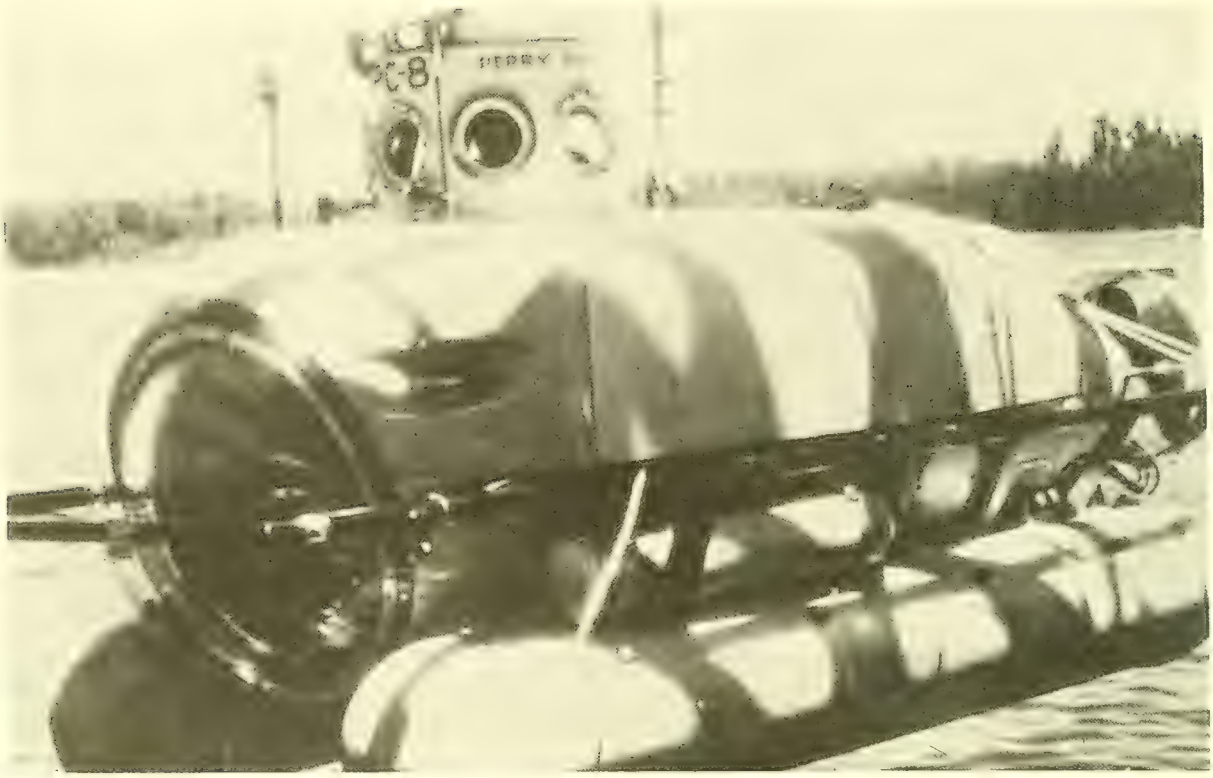
Submersible **NEKTON BETA** on support ship **SEA MARK.**



Two-person submersible **NEKTON GAMMA.**

Submersible **DEEP QUEST** and its support ship **TRANSQUEST.**

DEEP QUEST at work with manipulators in shallow water near Catalina Island.



Submersible **PC-8.**

Scuba diver carrying photographic equipment and instrumentation to the sea floor.

Section III. Related Studies and Efforts

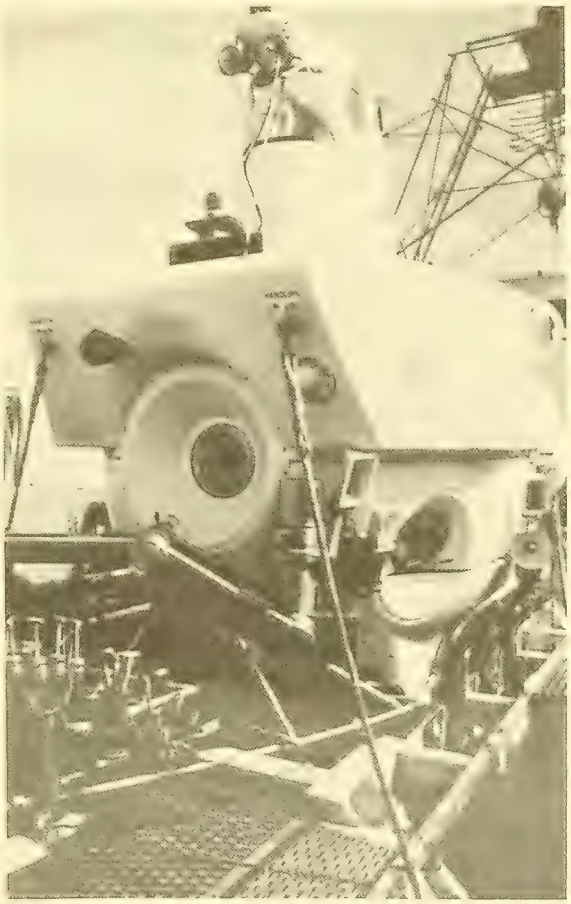
INTRODUCTION

As can be seen from the undersea platform utilization findings and the program descriptions in appendix C, the major Federal agency supporting U.S. civilian-operated platforms is NOAA/MUS&T. Two additional MUS&T-sponsored efforts which relate to platform utilization are: a study of the impact of scientific requirements on undersea laboratory design conducted by the University of New Hampshire, and a Manned Undersea Activity Workshop conducted by the Ocean Affairs Board of the National Academy of Sciences and the Marine Board of the National Academy of Engineering. Other factors in platform utilization are the recommendations by the University-National Oceanographic Laboratory System (UNOLS) that *ALVIN* be designated a National Facility and that a lease fund administered by UNOLS be established by Federal funding agencies. UNOLS has also indicated that one deep and one shallow submersible could be used on each coast.

MANNED UNDERSEA SCIENCE AND TECHNOLOGY PROGRAM OF THE DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NOAA's Manned Undersea Science and Technology (MUS&T) Office was established in early FY 1972 to develop, coordinate, and support a national, civilian operational capability for man to work under the sea in support of essential programs to achieve a better use, assessment, and understanding of the marine environment and its resources. MUS&T has strengthened the national base for the systematic pursuit of a nonmilitary manned undersea program. In addition to establishing liaison with concerned agencies, such as the U.S. Navy, Environmental Protection Agency, Department of the Interior, National Science Foundation, U.S. Coast Guard, National Institute of Occupational Safety and Health, and Army Corps of Engineers, 12 projects utilizing eight different submersibles, three habitats, and over 240 scientists were funded in FY 1972–73 through December 1972. Operations were conducted, many with the support of other agencies, on all three U.S. coasts, in Belize (British Honduras), in the Bering Sea and Puerto Rico as shown in figure 1. Table 7 shows the platforms utilized, and table 8 the distribution of resources and activities in FY 1972.

The MUS&T projects provided the opportunity for scientists and engineers from academia, industry,



The Navy's submersible **ALVIN**, operated by Woods Hole Oceanographic Institution.

Table 7. Undersea platforms used in fiscal year 1972 MUS&T projects

Platform	Owner	Date used	Dives (number)	Location	Purpose
ALVIN	Woods Hole Oceanographic Institution.	10/71	13	Straits of Florida.	Geology.
ALVIN	do.	6/72	17	Hudson Canyon.	Geology, pollution.
DEEP DIVER	Perry Oceanographics.	5/72	29	Gulf of Maine.	Fishery biology.
DEEP QUEST	Lockheed	6-7/72	8	Southern California.	Pollution survey, geology.
DEEPSTAR 2000	Westinghouse	7/72	6	New York Bight.	Pollution survey.
EDALHAB [1]	University of New Hampshire.	2-4/72	106	Florida, southeast coast.	Biology, geology, reef ecology.
HYDROLAB [1]	Perry Oceanographics.	11/71 5-6/72	201	Grand Bahama Island.	Biology, reef ecology.
NEKTON BETA	General Oceanographics.	12/71	30	British Honduras.	Geology.
NEKTON GAMMA	do.	6/72	16	Gulf of Mexico.	Reef survey.
PC-8	Perry Oceanographics.	9/71	33	Gulf of Maine.	Fishery survey.
PC-8	do.	10/71	13	New York Bight.	Pollution survey.
PC-8	do.	12/71	7	Bahama Banks.	Geology.
PC-8	do.	2/72	4	Bering Sea, Alaska.	Pacific walrus study.

[1] Habitat.

Table 8. Distribution of MUS&T activity

MUS&T program budget, FY 1972:	
Total	$1,484,000
Contract-grants	$1,129,000
Contract-grant distribution:	
Industry	58.5%
Academia	41.5%
Major-purpose distribution:	
Submersible lease-support	50.7%
Habitat lease-support	22.7%
Studies and analyses	26.6%
Investigators by source:	
Government	39.6%
Academia	51.0%
Industry	7.4%
Foreign	2.0%

and Government to gain access to the undersea environment for scientific studies and pollution and resource investigations. These projects were conducted in support of coastal zone conservation and management, surveying and assessment of living and nonliving resources, assessment of ocean dumping and environmental pollution problems, support of fisheries resource assessment and development, and marine mammal research.

Because of the availability of submersibles and habitats developed by industry and the Navy over the past several years, it was possible to supply and coordinate their use on projects sponsored by MUS&T jointly with other NOAA components, such as Sea Grant, National Marine Fisheries Service, Atlantic Oceanographic and Meteorological Laboratories, as well as with other Federal agencies including Navy, Coast Guard, National Science Foundation, and Environmental Protection Agency. To achieve maximum cost effectiveness, multipurpose programs involving several organizations were implemented whenever possible, particularly when such programs took place in a single geographical region.

The technology aspect of the program was mainly concerned with utilization and modification of available submersibles, habitats-laboratories, and instrumentation required to support the projects. The transfer of technology by industry, academia, and the Navy will continue to receive major emphasis, particularly in the diver support area. There are still many areas where technological innovation is required for man to realize the full potential of the undersea environment: improved equipment to measure diver physiological effects; improved life-support; improved navigation and communications equipment to increase efficiency and safety of diver operations; improved and new types of sampling and analytic equipment; and improved operational capabilities in submersible and undersea laboratory systems.

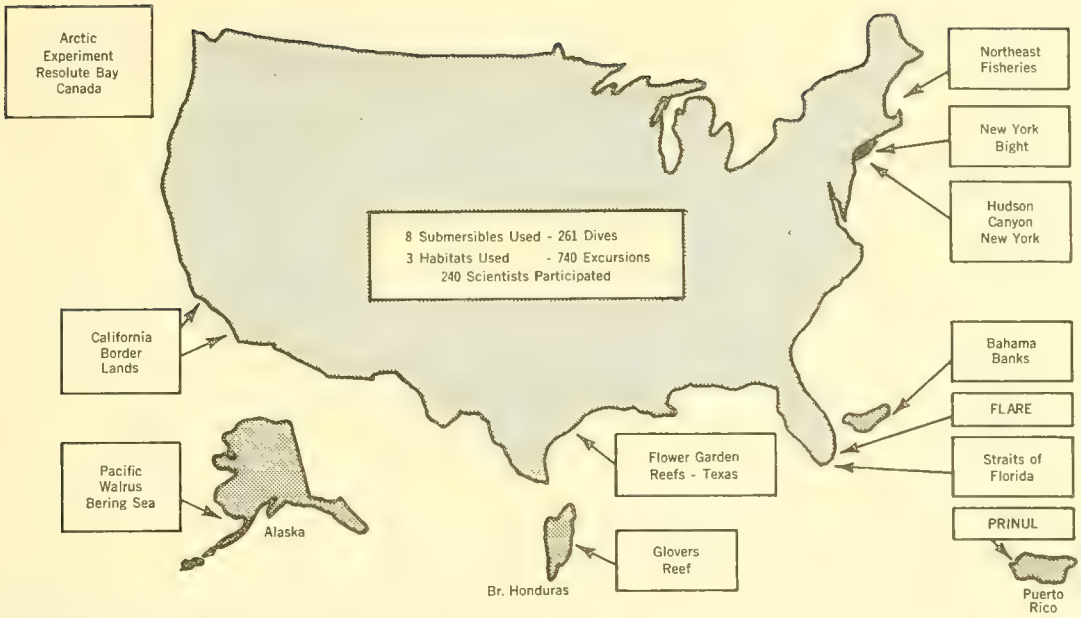


Figure 1. Fiscal years 1972-73 MUS&T science projects through December 1972.

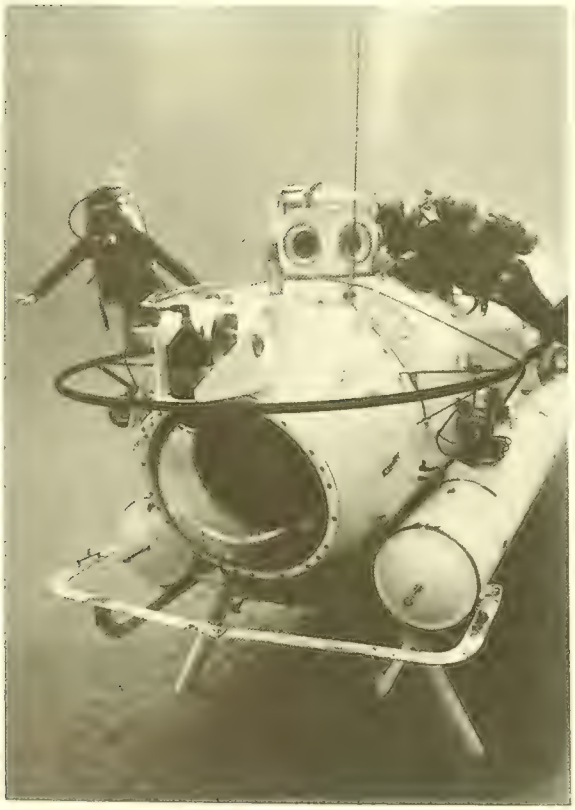
Wet swimmer transport vehicle **SHARK HUNTER.**

Approximately 70 unsolicited proposals have been received by the MUS&T Office during July-October 1972. The proposals are from academia, industry, and Government. The total funding requirement represented is in excess of $4 million (with about $2.8 million for platform leases). The MUS&T funding policy is that general funding is used to provide access to facilities and to pay special costs associated with the operation and not salaries of primary investigators. If proposals were solicited or general invitations to use certain platforms were issued, there would be a substantial increase in responses and requests for platform utilization.

UNDERSEA LABORATORY SYSTEMS STUDY

During late FY 1972, the MUS&T Office awarded a grant to the Engineering Design and Analysis Laboratory of the University of New Hampshire (UNH) to determine "The Impact of the Requirements of the U.S. Scientific Diving Community on the System Design, Operation and Management of Undersea Laboratories."[6] The following specific objectives were established:

[6] *The final report was delivered in January 1973.*



Lockout submersible **PC-15C** with divers.

—To identify and classify the types of research and development programs that would use the systems

—To classify the potential missions into groups of missions with each group requiring similar capabilities

—To estimate the utilization rate of systems by groups

—To survey the state-of-the-art of habitats and habitat technology

—To evaluate systems against mission requirements

—To develop preliminary designs of selected concepts

The effort involved visiting recognized scientists throughout the United States and concentrated on undersea laboratories (habitats with scientific work space). At the same time, the utilization of scientific divers and submersibles was also reviewed. The scientists interviewed receive support from many Federal agencies. The results of the UNH effort indicated that, if the programs were implemented, there would be a need for two submersibles without lockout, one submersible with lockout, three transportable habitats, and two scuba ships *in addition* to the currently accessible facilities (*HYDROLAB*, *PRINUL*, *ALVIN*, and *SEA LINK*). The geographic distribution of these facility requirements is shown in figure 2. A distinction is made between transportable and mobile habitats: A transportable habitat can be readily moved between missions, whereas a mobile habitat is one which can move under its own power during a manned mission. There is a general indication that, as utilization increases, there will be a need for mobility in addition to transportability.

With respect to the undersea laboratory, figure 3 shows the anticipated regional utilization and the nature of the underwater research. "Prime days" are the estimated days per year which could be utilized; "potential days" represent usage which would be anticipated to follow shortly thereafter if the laboratory were in place. The UNH recommended a Northeast system, a Pacific system, and a Florida-based system to satisfy estimated needs. The needs of the southeast Caribbean region and gulf region are partly serviced by *HYDROLAB* and *PRINUL;* however, the study noted the *HYDROLAB*'s depth limitation and *PRINUL*'s restriction to Puerto Rican waters.

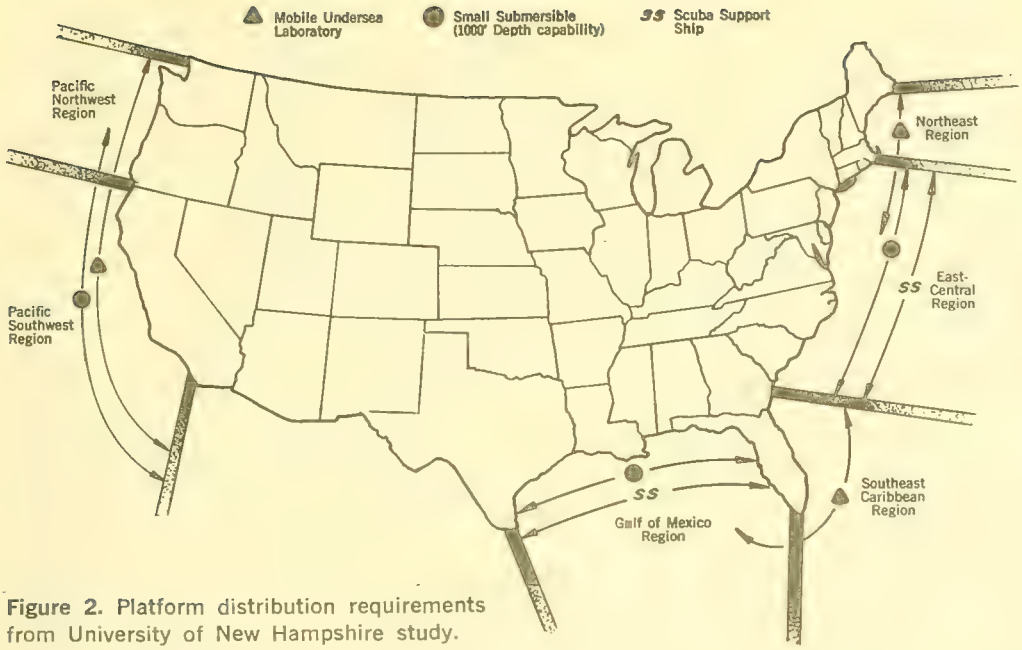


Figure 2. Platform distribution requirements from University of New Hampshire study.

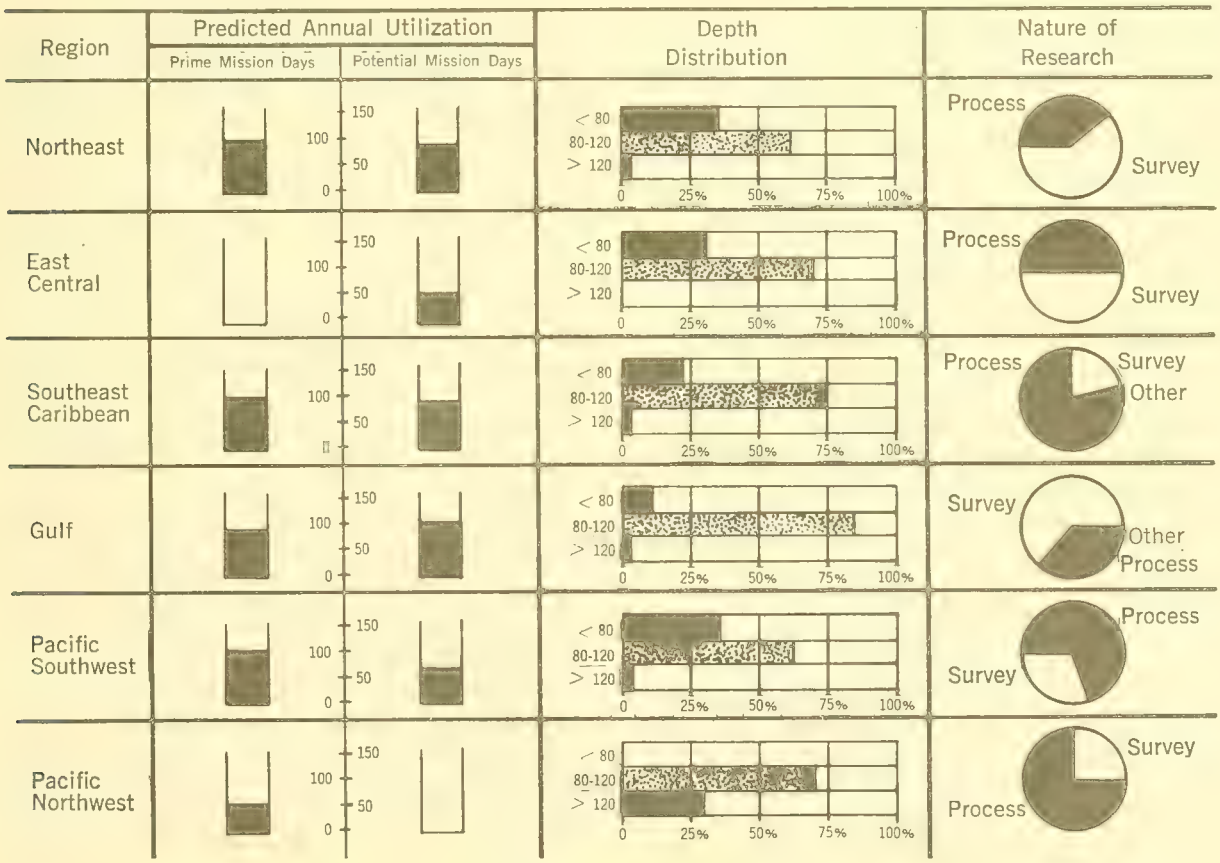


Figure 3. Regional needs of the scientific community for utilization of underwater laboratories (study by University of New Hampshire).

Scuba ships are indicated for the east central and Gulf of Mexico regions because of their utility to scientific divers and the physiographic character of the regions. In both regions it is frequently necessary to travel 10 or 15 miles offshore to be able to dive to depths exceeding 50 feet. Here, the use of a ship, rather than a habitat, to support divers is indicated.

MANNED UNDERSEA ACTIVITIES WORKSHOP

Responding to a recommendation of the National Academy of Science (NAS)-National Academy of Engineering (NAE) Committee Advisory to NOAA, a joint study by NAS Ocean Affairs Board and the NAE Marine Board was conducted to review and assess civil manned undersea activities. The NAS-NAE assembled a group of approximately 60 persons (about one-third each from Government, academia, and industry) in a workshop to answer the following seven questions:

—What should be the current and projected national civil goals for undersea science and technology requiring the presence of man, either directly or indirectly, both in the short and long term?

—What are, and what should be, the roles of the U.S. Government, academia, and industry with regard to the development of this undersea science and technology to support the national civil goals?

—What are the ways, including alternatives to the presence of man, to achieve these goals; and if man is primary, what are the alternate modes for his presence?

—What are the criteria by which programs to fulfill these goals can be evaluated?

—What limits the effectiveness of man in underwater science and technology programs? (I.e., institutional, technological, physiological, etc.)

—What are critical scientific and technical developments which may provide further breakthroughs?

—What programs are necessary and feasible for significant manned undersea activities under austere, constrained, and ideal budget situations?

The workshop was co-chaired by Dr. Alfred Kiel of the Massachusetts Institute of Technology and Dr. Adrian Richards of Lehigh University and held from October 17 through October 21, 1972. Participants were carefully selected to obtain balanced representation by organizations, background, and orientation toward manned undersea activities. By this means, it was the intention of NAS-NAE to insure an unbiased report specific and realistic enough to be acted upon. The Executive Summary section of the NAS-NAE study entitled "Civil Manned Undersea Activity: An Assessment" is presented below in its entirety.

EXECUTIVE SUMMARY

MANNED UNDERSEA ACTIVITY IN PERSPECTIVE

Manned undersea activity is not a new concept. For more than 200 years, man has salvaged wrecks and has built structures under water. Shortly after World War II, self-contained underwater breathing apparatus (scuba) became available, providing an inexpensive and simple capability for underwater activity. Underwater salvage and construction divers were soon joined by scientific and recreational divers.

By the early 1960's the first practical deep submersibles were in use in the United States and in France. The development of deep submergence vehicles (DSV's) provided the needed platforms for extending manned undersea activity beyond practical skin diving depths.

The rapid growth of skin diving and submersible activity since World War II was fueled by military needs and scientific and industrialized work capabilities. During the past few years, industry has continued to work in deeper water, farther from shore, and in more hostile environments.

Today the number of operational DSV's is considerably less than in the late 1960's. Only one company in the United States produces DSV's regularly, and only five commercial firms operate DSV's. Most submersibles are in semiretirement. The U.S. Navy with 11 DSV's is the largest world owner of these craft.

In the diving community, advances are still being made. But dives deeper than 40 meters, made on a frequent or prolonged diving basis, still pose complex physiological and technical problems that must be solved. At present, experimental diving activities belong in the hands of the professional divers. A few experimental saturated dives have been made to depths of over 600 meters but the costs of operating at these depths are high and consequently industry is developing less costly unmanned underwater work systems, or shirtsleeve-environment systems such as those for petroleum subsea completion systems.

In the past decade, operational sea floor habitats have been developed. The Navy's SEALAB, GE's

TEKTITE I, the Department of the Interior's TEKTITE II, and NOAA's MUS&T programs, along with similar programs conducted in Europe since the early 1960's, show that man can function productively for prolonged periods at modest depths on the sea floor at ambient pressure. Although skilled divers have reached considerably greater depths, the current practical limit for the non-professional diver's scientific and recreational saturation diving is approximately 40 meters. Operating costs and lack of the general availability of sophisticated life support equipment impose the limit. Deeper excursions from such saturation levels are practical and thus extend the useful limits of diving.

It is important to understand that most scientific manned undersea activity is of a secondary rather than a primary nature, and usually follows preliminary or detailed investigations made from other platforms, normally ships. DSV's usually are used to best advantage only after initial investigations made from ships have clearly identified problems that can be studied only, or most economically, from submersibles. Habitats are sited to best advantage only after ship-conducted surveys have delineated the most favorable location. MUA capabilities should and do compete with other platform capabilities (airborne, ship, buoy, and unmanned systems), and work jointly with them, in performing exploration and exploitation in the oceans.

PROGRAMMATIC GOALS FOR CIVIL MANNED UNDERSEA ACTIVITY

In considering what the goals for a manned undersea activity program should be, the following assumptions were made by the workshop participants with respect to the total federal ocean program:

- The gross annual federal ocean program funding has leveled off.
- A shift in emphasis is likely both in funding and in agency programming.
- New federal ocean program initiatives will be examined more closely for their relevance and economic justification.
- There will be a continuing MUA program involving industry, academia, and government.
- The recent reorganization of science and technology policy advisory functions (from the White House to the National Science Foundation) will probably change the pattern of planning and organization.

The goals recommended in this report have taken these assumptions into account. Many of the goals are not exclusively MUA goals but include major areas to which MUA can contribute. The goals below are presented in four major areas: science, industry, recreation, and government.

These goals are not ordered by priority; the workshop participants considered establishment of a ranking system premature at the present development level of MUA, which is embryonic in some areas and advanced in others.

SCIENTIFIC GOALS

- Support marine biological studies, including those related to the distribution of organisms, population dynamics, behavior, environmental stress and applied fisheries problems
- Study man's physiological responses during diving to ensure safety and achieve peak performance
- Study sea floor features and geological processes, including those related to marine mineral deposits
- Investigate natural changes in the marine environment, and those resulting from man's activities
- Conduct marine archaeological studies

INDUSTRIAL GOALS

- Inspect and maintain underwater pipelines, power cables, and sea floor structures
- Perform work where manned underwater activity offers an economic advantage
- Assess and recover living and mineral marine resources
- Direct and conduct salvage operations

RECREATIONAL GOALS

- Establish underwater parks and recreational facilities
- Promote safety of water recreational equipment and operations

GOVERNMENTAL GOALS

- Provide regulations and supervision to ensure safety and accommodate related interests
- Provide supplemental support for high-cost civil MUA facilities that are beyond the funding capacity of institutional users
- Maintain a vigorous program of MUA technology exchange between military and civil areas, and assist in cooperative efforts with foreign MUA programs
- Use MUA for safety and compliance inspections of sea floor structures, and for environmental monitoring
- Sponsor research to provide increased safety

for all aspects of MUA and promote research in the long-term health effects of diving
- Provide national guidelines and identify those areas where MUA can continue to contribute to the national ocean program
- Sponsor and/or provide incentives for joint programs with industry where risk or initial capital outlay is too great for private capital

To support these goals, the following technological improvements are needed:

- Increase the useful bottom time of manned submersibles and improve surface handling and underwater navigation systems
- Increase the ability to use external tools and manipulators from submersibles
- Increase the self-sufficiency of habitats
- Increase the capability and flexibility of divers
- Improve equipment and operational safety

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations were developed in the course of the study. It was agreed that a viable course of development for civil MUA must benefit the economy of the United States, contribute to our understanding of the sea environment, promote national security, and be undertaken with an understanding that the role of MUA in the accomplishment of these objectives must be evaluated with regard to other alternatives.

PRESENT AND POTENTIAL USES OF MANNED UNDERSEA ACTIVITY

Conclusions

- MUA can assist in the assessment and development of marine resources; in the establishment of standards for environmental protection of coastal waters; and in understanding environmental aspects of coastal zone management.
- MUA has demonstrated its potential in the marine sciences and in ocean engineering and work tasks in the sea.
- Civil MUA is limited more by uncertain funding than by facilities or capabilty. However, facilities could be improved.
- Industrial use of MUA has developed to an advanced stage in the United States with a trend toward complementary or associated use of unmanned undersea systems.
- Industry will benefit increasingly as the uses of MUA in the fields of marine biology and marine geology lead to increased capabilities in resource assessment and better environmental impact information.
- As economic advantages can be demonstrated, industry will make major commitments to MUA. At present, few areas seem to offer such potential. However, this should change as ocean engineering activities and offshore resource development mature.
- MUA should play an important role in proposed joint ocean research and utilization programs and in legal arrangements with other nations.

FACILITIES FOR MANNED UNDERSEA ACTIVITY

Conclusions

- Federally funded selected habitats, submersibles, and support capability are needed to support civil MUA. The technology for such facilities exists, but the commitment, as well as the costs of acquisition, long-term maintenance, and operation, limit their utilization.
- Additional provisions are needed for rescue and decompression facilities to accommodate the rapid growth of recreational diving.

Recommendation

- The U.S. Government should continue to make MUA facilities available in order to support selected projects; provide experience for marine scientists and engineers; assess and use existing technology; maintain and improve the national capability and posture for future programs; offer rescue capability; evaluate and conduct missions in support of major environmental programs; and support marine resource assessment, management, and conservation.

MANAGEMENT OF CIVIL MUA PROGRAMS

Conclusions

- A single, but not exclusive, focal point within the federal government should coordinate manned undersea capabilities for civil uses, and should not only encourage but help ensure the promotion of manned undersea activity that contributes to national objectives.
- The existing organizational structure for the federal ocean program can accommodate increased activity in civil MUA.
- The government should ensure that criteria and standards for MUA utilization are established so as to ensure safe operations. Multiagency planning and liaison with non-government agencies should help to ensure reasonable regulation. Such regulatory criteria should

make sure that viable research efforts on MUA are not needlessly constrained.

Recommendations

- In order to ensure appropriate emphasis and funding and to prevent unnecessary duplication, a single federal agency that possesses the capability and charter, should take the lead in the coordination of programs with other concerned agencies and should act as the civil focal point in the U.S. Government to take on the following functions:

  —Assist in contracting and in the guidance of prospective suppliers of submersibles and habitats in support of the ocean science community where government participation is required

  —Take the lead in an overall government and civilian assessment of the potential for use of military and industrial manned undersea activity, and develop its contribution for civil uses

  —Provide advisory review services to the federal government for manned undersea capabilities and activities

NOTE: The Interagency Committee on Marine Science and Engineering recommended a similar role for NOAA in October 1972 during the review of the Federal Ocean Program, and NOAA is so serving. This action was not addressed during the course of this study, but is referenced here and in Appendix B for information only.

- The University National Oceanographic Laboratory Systems (UNOLS) could be a mechanism for coordinating the use of MUA facilities by the academic community. These facilities should include DSV's and sea floor laboratories.
- Liaison and joint operations with foreign MUA programs should be increased with a view toward greater international participation in and cooperation with U.S. programs. Several nations now maintain active programs in MUA. Joint efforts with these nations would be beneficial to civil and government MUA in the United States and should be encouraged in both the government and civilian sectors.
- A nongovernment advisory group on civil MUA should be established. A continuing assessment is needed of civil MUA as it relates to U.S. interests in the oceans. A group of qualified representatives from industry and academia should perform these functions. One particular need is to establish criteria and guidelines for MUA research, components, systems, and operations.

PROGRAMS IN MANNED UNDERSEA ACTIVITY

Conclusions

- The present state of the federal ocean program suggests that near-term growth of civil MUA will be slow unless MUA can demonstrate more convincingly an economic justification for expenditures. The reduction of Navy submersible leasing has not been matched by a comparable increase in activity of the civil agencies, leaving an excess in civilian submersible capability.
- The maximum growth area for all aspects of civil MUA will probably be in its use for systematic programs aimed at understanding the coastal zone environment and resources and the related ecology.
- Technology does not severely limit the present use of MUA. The technology being developed through industry and the Navy needs to be transferred more effectively to other sectors.
- Continued research on diver physiology and underwater medicine is required to improve safety and equipment design for endurance diving operations.
- Too few selected undersea natural areas are preserved specifically for long-term scientific study and recreational use.

Recommendations

- Program planning for the federal ocean program should be monitored to ensure that civil MUA interests are represented, particularly when the civil sector can help solve problems in the federal program. The existing Interagency Committee on Marine Science and Engineering could expand to perform this function. The committee now coordinates 11 federal agencies that have marine interests.
- Better mechanisms are needed for the exchange of MUA technology between the Navy and the civil sector. The Navy at present has the largest MUA program, and is both the major contractor and customer to ocean science and ocean engineering. Many Navy MUA facilities could be used more effectively for civil MUA when the Navy can spare them and in accordance with current regulations.

The NAS-NAE study report, excerpted above, was issued in 1973.

UNIVERSITY-NATIONAL OCEANOGRAPHIC LABORATORY SYSTEM (UNOLS)

UNOLS is an association of 18 academic institutions which operate significant seagoing oceanographic facilities. The functions of UNOLS are to provide for community-wide coordination and review of the use of facilities, to increase the opportunity for access to those facilities, to assess the current match of facilities to the needs of academic oceanographic programs, to recommend priorities for replacing, modifying, or improving the numbers and types of facilities, and to assist Federal agencies in utilizing and funding ships and other facilities.

Included in the "First Annual Report of UNOLS Advisory Council to Federal Funding Agencies" is the following recommendation:

"Submersibles should be utilized more in university research than at present, both on an institutional basis and as National Oceanographic Facilities (including charter funding). Total support of about $1.3M in 1973 and $1.9M in 1974 should be about evenly divided between ONR, NSF, and NOAA (MUS&T Office). The two latter agencies should join in supporting at least two submersibles and a submersible 'charter fund' as UNOLS National Oceanographic Facilities."

Appendix I of the UNOLS report contains the following recommendations by the UNOLS Working Group for a University Submersible Facility:

—Two submersibles in the Atlantic and two in the Pacific, to provide a shallow-water capability (less than 1,000 ft) and a deep-water capability (greater than 1,000 ft) in each area. (One vehicle is *ALVIN*.)

—Not less than one-third of the total operational time to be available to the entire academic oceanographic community. (A facility operator can designate all or part of the time on any facility for this purpose and may change the allocation annually.)

—A fund to provide submersible support through lease, charter, or other short-term arrangements.

—A UNOLS appointed review committee to review proposals and allot time and funds.

The emphasis here is on submersible usage and research by universities. While a significant portion of federally funded marine science and engineering is conducted at academic institutions, there are many requirements with Federal agencies, non-UNOLS institutions, State agencies, and industry that must be considered. An interpretation of the UNOLS recommendations to accommodate all major interests ca nbe stated as follows:

—There is a significant university interest in using submersibles.

—There is a need for a designated focal group which can provide submersible time and funding.

—The funding of the overall research programs cuts across ICMSE agency lines and requires coordination to provide consistency and continuity in support.

Section IV. Analysis of Platform Requirements

HABITAT UTILIZATION

In the discussion of undersea platforms, the equivalent of six accessible U.S. habitats were identified. On the average, approximately one-third of the total capability is being utilized. Full utilization was assumed to be 150 useful bottom-working days per year. Time for setup, preparations, training, decompression, cleaning, maintenance, and the like is not included in these 150 days; nor is the time required to transport the habitat from site to site. Because investigations are frequently tied to environmental conditions or the life cycle of organisms being studied, 12 months per year scheduling is unlikely.

Based on the reported programs, as given in appendix B, the Department of Commerce, Corps of Engineers, Department of Health, Education, and Welfare, Department of the Interior, Atomic Energy Commission, Environmental Protection Agency, and Smithsonian Institution are potential users of three transportable habitats and one mobile habitat, as are academia and industry. The academia users whose basic research is generally supported by the National Science Foundation are believed to be reflected by the University of New Hampshire's finding of a need for three transportable habitats.

A requirement for a mobile habitat was especially indicated by Department of Commerce, Atomic Energy Commission, and the Environmental Protection Agency. This habitat would require the capability of repositioning itself in a limited area around the initial deployment site.

The present six habitats operate at an approximately one-third utilization rate. The program potential for full utilization exists, provided adequate support is made available. Thus, a trend from excess capability to a shortage situation could develop. However, it must be noted that the data obtained in this study with respect to the match between the capability of existing assets and user requirements for habitat capability is incomplete. Furthermore, there is no mobile habitat available, and the requirements for such a facility must also be analyzed further.

SUBMERSIBLE UTILIZATION

In the discussion of submersibles without lockout, 13 operable and acceptable U.S. civilian submersibles were identified. Without engineering and cost analysis beyond the scope of this report it is impossible to state how many of the three uncertified and four inactive submersibles can eventually become part of the national inventory. With the full utilization of *ALVIN* and three leased civilian-owned and -operated submersibles, and the approximately one-third utilization of four other submersibles, the average utilization of the 13 without lockout is now 40%.

There are available three submersibles with lockout (*SEA LINK*, *SHELF DIVER*, and *BEAVER MARK IV*. *SHELF DIVER* is on lease overseas. *SEA LINK* is fully utilized, and *BEAVER* has not been used for several years and is undergoing a refit. Average utilization is therefore about two-thirds. For this analysis it was assumed, for both lockout and nonlockout systems, that the full-year utilization of a platform was approximately 100 working dive days exclusive of mobilization and demobilization, training, maintenance, refurbishment, and transportation.

Based on the reported programs, the Department of Commerce, Corps of Engineers, Department of the Interior, Department of Transportation, Atomic Energy Commission, Environmental Protection Agency, and National Science Foundation are potential users of as many as six leased submersibles without lockout and three submersibles with lockout in addition to *SEA LINK*. Included in this estimate is the UNOLS recommendation of a shallow and deep submersible on each coast. The use of

Submersible **SEA LINK**.

Lockout submersible **BEAVER MARK IV.**

these facilities would be by the Federal agencies, academia, and industry.

Realizing the above projections would raise the utilization of submersibles without lockout to near full capacity and require two additional lockout submersibles. The results of the University of New Hampshire (UNH) study show an additional need for two nonlockout submersibles and one lockout submersible which, if added to the Federal agency requirements, would require additional facilities. However, the overlap between the UNH results and the usage factors included in this survey of Federal agencies has not been determined.

There were insufficient data to match a given program with a given platform, particularly in view of the limitations of platforms given in section II. In general, however, the proportion of programs concentrating in the Continental Shelf coincides reasonably well with the proportions of platforms capable of shelf operations. The same is true for the continental slope. A problem could occur if a depth capability in excess of *ALVIN*'s 12,000 feet (titanium sphere) is required. Only the partially disassembled *ALUMINAUT*, with newly machined hemiheads, would be suitable.

SCUBA SHIPS

Since the survey was designed primarily to investigate submersible and habitat utilization, the accumulation of data on requirements for scuba ships was generally acquired from questions on the use of divers. The preliminary analysis of the data indicates that one or two such ships could be used by a combination of agencies. It is believed that the results of the UNH analysis, which show a need for two scuba ships, reflect the requirements of scientists whose research is sponsored by the National Science Foundation as well as other supporting agencies.

SUMMARY

The requirements for use of national manned undersea platforms are influenced by a number of factors as shown in figure 4. This illustration indicates that other requirements that could involve Federal sponsorship, in addition to those derived in the survey of Federal agencies, were noted relative to their impact on platform utilization.

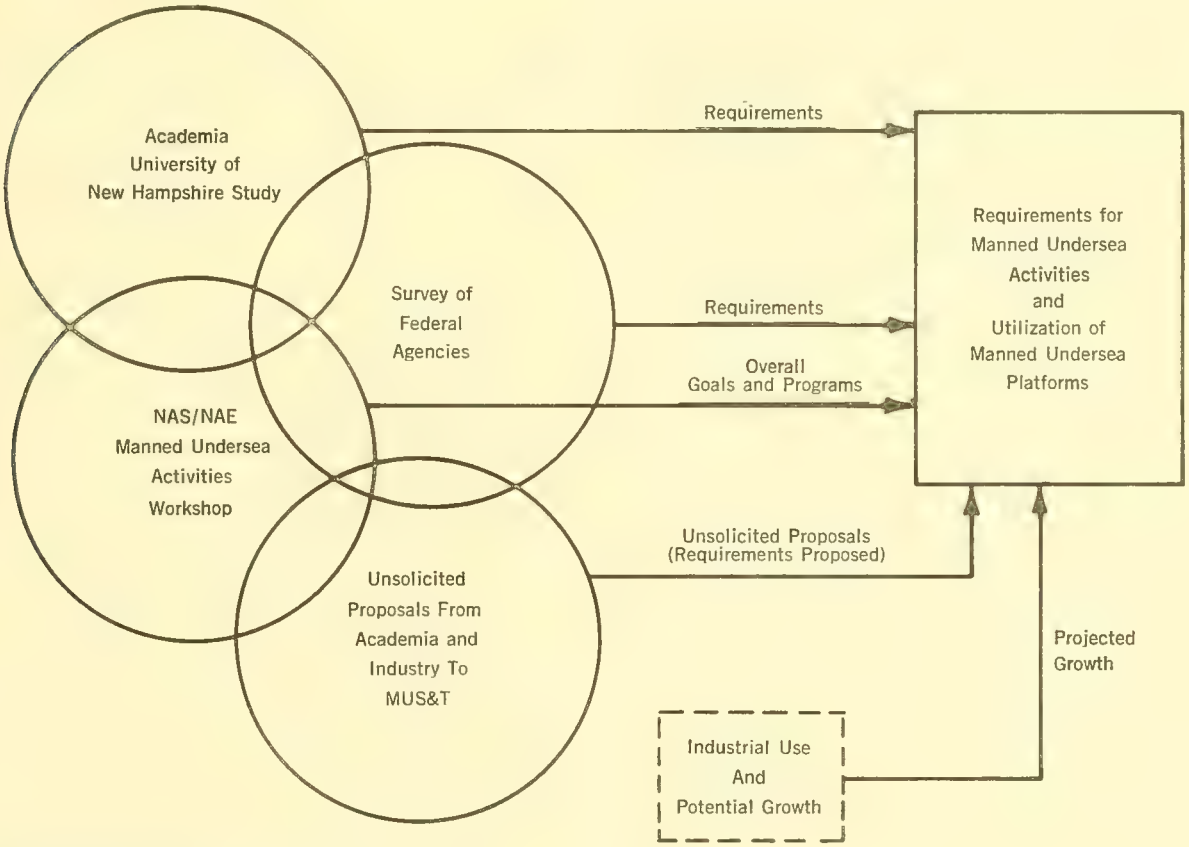


Figure 4. Developing requirements for use of manned undersea platforms.

The realization of potential Federal agency users may close the gap (fig. 5) between the national capability and utilization. Requirements of the academic institutions indicate additional facilities are needed. There already appear to be some shortages, such as insufficient submersibles with lockout, the lack of a mobile undersea laboratory, and lack of scuba ships. In addition, some of the platforms may not be suitable for efficient use for a specific application because of mismatches in characteristics, instrumentation limitations, environmental limits, and geographical location.

In most cases, no single civil program has sufficient requirements to fully support a platform for a full year. The intermittent use of platforms for short periods of time significantly raises the cost. The result is that funding requirements are excessive and therefore not programmed. Thus, funding and its continuity becomes a major problem in the utilization of platforms.

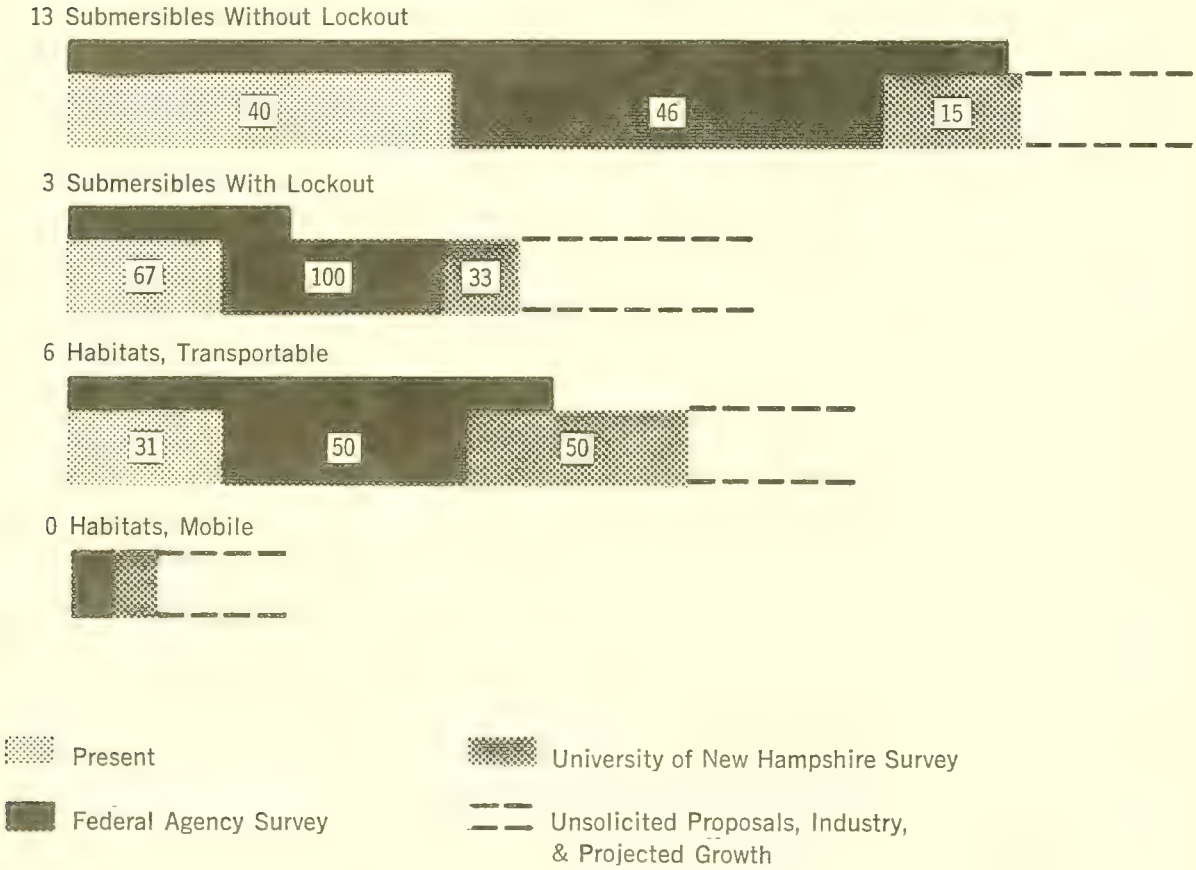


Figure 5. Present utilization rates (percent) of undersea platforms compared with utilization capabilities surveyed.

Appendix A. Survey of Federal Agencies

INTRODUCTION

In development of the ICMSE study requested on May 11, 1972, a survey was made to determine the extent to which Federal agencies had programs that required manned undersea platforms and to which the platforms were actually being used. The survey pertained to existing and planned programs for manned undersea platforms, not to what would be done if facilities were made available at no cost. Thus, the approach identified currently funded programs and those that could be expected to increase the utilization rates of platforms, while avoiding those that may not be supported. As noted earlier, approximately half of the 1,603 dives recommended to the Carroll Committee (which asked what would be done if facilities were provided) were not endorsed by that Committee.

SURVEY METHOD AND QUESTIONNAIRE

The questionnaire sent to the participating Federal agencies is shown on page 32. It emphasizes both the identification of programs and the specific capabilities required of platforms for use in the program. Respondents were contacted by telephone to obtain additional data when required in order to prevent misinterpretation and to provide platforms capability data to respondents not sufficiently familiar with some platforms. The questionnaire concentrated on existing and planned programs rather than specific operations which would or could be undertaken if facilities were provided. There were three reasons for this: First, it avoids suggesting many ideas which an offerer of platforms is not capable of or willing to support with funding; second, it identified potential platform utilization; and lastly, it provides for reporting programs which may not have reached the stage of detailed field operations planning. A major problem noted was that the level of reporting did not provide details to permit a good matching of existing platforms to program operations. This can be adequately corrected in the future based on the experience of this effort.

PROGRAMS REPORTED AND FINDINGS

Ten of the 12 member agencies of ICMSE responded with identification of programs that involve manned undersea activities (State and NASA had no requirements). Approximately 60% of the responses were on the questionnaire; however, there were some problems with the degree of completeness and specificity. Thus, in several cases, it was necessary to estimate the extent of platform utilization implied by the program.

Forty-six programs were identified from all sources. Of these, 13 were from the Navy and 33 from the nine other responding Federal agencies. The 46 programs are listed on page 33 and described in appendix B.

The Navy's programs requiring manned undersea platforms are generally satisfied by Navy-owned facilities. The Navy rarely leases civilian-owned and -operated platforms and has not since 1970. The Navy was responsible for developing *ALVIN* and supporting it at the Woods Hole Oceanographic Institution, but is phasing out that support. In the future, support for *ALVIN* must come from other sources.

Of the 33 programs reported by the eight civil agencies and the Corps of Engineers, five programs spend for facilities and eight others can if proposals are received. However, except for the NOAA/MUS&T program there is no specific allocation of funds for leasing identified. Except for two of the remaining 20 programs, there is a good potential for the regular use of manned undersea platforms, the actual use depending on a number of factors. A major impediment to the more extensive use of platforms in these programs is the intermittent, short-duration requirements for utilization. One or 2 days may be needed, perhaps five or six times per year. Coupled with the dispersal of geographic areas, the costs for use of the platforms becomes extremely large in proportion to the total program. Thus, the single uncoordinated use of a platform for a program is unattractive. At the same time, the large data acquisition capability of a platform can support not

INFORMATION SHEET

Federal Requirements Manned Undersea Operation

Institution or agency: _____

I. DESCRIPTION OF REQUIREMENTS:

Short title _____

Purpose/brief description of program: _____

Use of manned undersea operations in program _____

Participating organizations: _____

II. SPECIFIC REQUIREMENT FOR MANNED UNDERSEA OPERATION (where known):

1. Which of the following could be used: ☐ Submersible with lockout; ☐ Submersible without lockout; ☐ Fixed habitat, ☐ Mobile habitat; ☐ Scuba divers; ☐ Other (specify), _____

2. Depth range of operations: _____ m-average _____ m-maximum

3. Navigational accuracy: Surface _____ <10m _____ <100m _____ not vital
   Subsurface _____ <10m _____ <100m _____ not vital

4. Dive duration: _____ average (hr) _____ maximum (hr)

5. Frequency and No. of dives planned for operations (i.e., one per day for 2-week period) _____

6. Schedule: Planning period (dates) _____
   Operational period (dates) _____

7. Geographic area _____

8. Have you arranged for or planned on using a specific submersible/habitat (if yes, please specify) _____

9. Payload requirements: _____ observers; _____ ft^3 inside equipment space; _____ Power (amps, voltage, AC/DC, frequency, etc.) _____

10. What specific support equipment is required (i.e., cameras, manipulators, sonars, etc.)? _____

III. ADDITIONAL DATA.

A. Contacts. (Sponsoring agency) _____ (Name) _____ (Telephone number)
_____ (Address)

Principal investigator _____

B. Funding information:

	FY 72	FY 73 est	FY 74 est
Overall program funds ($X000)			
Manned undersea portion			

IV. ADDITIONAL COMMENTS: _____

Please return to:

Manned Undersea Science and Technology MR4
National Oceanic and Atmospheric Administration
Department of Commerce
6010 Executive Blvd
Rockville, Md 20852

only the primary program but other programs in the same or other agencies. Another factor is a lack of experience in many cases. Personnel are not familiar with what can be accomplished with the platforms or with the techniques for facility trade-off analyses, such as the surface ship versus the submersible versus the habitat versus the remote system.

There is a general trend among programs in the manner in which undersea platforms are usually considered for use. Programs usually start with surface ships investigations, move to remote techniques, then use divers when depths permit or use submersibles, and, if process studies are involved, move to habitats. At the same time, the platforms required tend to become more and more mission oriented rather than general purpose.

FEDERAL AGENCIES AND PROGRAMS

Department of Commerce

- Submerged Transportation Systems Study (MARAD)
- Deepwater Ports and Offshore Terminals (MARAD)
- Oceanic Monitoring, Assessment, and Prediction (NOAA)
- Arctic Assessment and Monitoring (NOAA)
- Manned Undersea Science and Technology (NOAA)
- Operational Equipment Observation and Evaluation (NOAA)
- Canyons, Sedimentation, and Bottom Boundary Layer (NOAA)
- Undersea Facility Educational Projects (NOAA)
- Marine Geology and Geophysics (NOAA)
- Fisheries Research (NOAA)
- Office of Sea Grant (NOAA)

U.S. Army Corps of Engineers (Civil Programs)

- Dredge Spoil Disposal Studies
- Offshore Operations Studies
- Offshore Facilities and Deepwater Ports
- Construction Effects
- Storm Damage Assessment
- Arctic Research

U.S. Navy

- Submarine Location, Escape, and Rescue (NAVSHIPS)
- Deep Ocean Technology (NAVMAT)
- Man-in-the-Sea, Continental Shelf (NAVSHIPS)
- Deep Submergence Bio-Medical Development (BUMED)
- Exploratory Development Projects (OCEANAV)
- Surface Supported Diving System (NAVSHIPS)
- Large Object Salvage System (NAVSHIPS)
- Deep Ocean Engineering and Research (ONR)
- Advanced Marine Technology (ONR)
- Operational Underwater Salvage (NAVSHIPS)
- Fleet and Facilities Support (NAVFAC)
- Acoustic Studies (NAVO)
- Ocean Engineering and Construction Technology (NCEL)

Department of Health, Education, and Welfare

- Decompression Table Standards (NIOSH)

Department of the Interior

- Underwater Interpretation and Research Within the National Park System (NPS)
- Geophysical Investigations (USGS)
- Sedimentology and Placer Mineral Deposits (USGS)
- Sport Fisheries Research (BSFW)

Department of Transportation

- Underwater Safety Program (USCG)

Atomic Energy Commission

- Estuarine and Adjacent Area Ecological and Radioecological Studies
- Oceanic Processes and Populations
- Power Package Recovery

Environmental Protection Agency

- Assessment of Marine Waste Disposal Areas (R&M)
- Water Quality and Ecology (OWP)
- Enforcement Action Evidence Collection (OE&GC)

National Science Foundation

- Oceanographic Research
- Research Facilities Support
- Franco-American Mid-Ocean Undersea Study (FAMOUS)

Smithsonian Institution

- Biological-Geological Oceanography

ABBREVIATIONS

MARAD—Maritime Administration
NOAA—National Oceanic and Atmospheric Administration
NAVSHIPS—Naval Ships Systems Command
NAVMAT—Naval Material Command
BUMED—Bureau of Medicine and Surgery
OCEANAV—Oceanographer of the Navy
ONR—Office of Naval Research
NAVFAC—Naval Facilities Engineer Command
NAVO—Naval Oceanographic Office
NCEL—Naval Civil Engineering Command
NIOSH—National Institute of Occupational Safety and Health
NPS—National Park Service
USGS—U.S. Geological Survey
BSFW—Bureau of Sport Fisheries and Wildlife
USCG—U.S. Coast Guard
R&M—Research and Monitoring
OWP—Office of Water Programs
OE&GC—Office of Enforcement and General Counsel

Appendix B. Descriptions of Programs Reported Which Are Current or Potential Users of Manned Undersea Platforms

DEPARTMENT OF COMMERCE (DOC) [1]

PROGRAM TITLE AND PURPOSE	REMARKS
Submerged Transportation Systems Study	
To perform a study of the economic feasibility and other implications of submarine transportation including vessel size, propulsion, hull designs, cargo types and handling, port facilities, environmental effects, and research and development needs. *Lead agency:* Maritime Administration. *Participating:* Other DOC, Navy, National Science Foundation, Department of Transportation, Atomic Energy Commission, and Environmental Protection Agency.	Could lead to new commercial shipping systems. There is a potential for some use of existing submersibles to test docking and other concepts in the future, to conduct site surveys for terminal facilities and to assist in submarine terminal construction.
Deepwater Ports and Offshore Terminals	
To perform studies of the need for and the economic, social, and environmental impacts of deepwater ports and offshore terminals, particularly for the importation of oil. *Lead agency:* Maritime Administration (MARAD).	Somewhat superseded by the special task force established by the White House in July 1972 to study these facilities; MARAD is participating in that study. Habitats may have a role in establishing and monitoring environmental baselines. Submersibles may aid site engineering studies and construction, plus making early environmental observations.

[1] *Department of State and National Aeronautics and Space Administration indicated no programs requiring manned undersea activities.*

PROGRAM TITLE AND PURPOSE	REMARKS
Oceanic monitoring, assessment and prediction	
To monitor the physical and chemical variables of the oceanic environment to make timely assessments, predictions, and warnings.	Planning stage; could involve the use of divers, submersibles, and habitats.
Lead agency: National Oceanic and Atmospheric Administration.	
Participating: All State and Federal agencies with responsibility in the marine environment.	
Arctic Assessment and Monitoring	
To acquire bathymetric, oceanographic, water quality, and resource data for the Arctic. As the search for petroleum and mineral resources increases the supply, support and transportation activities require additional information concerning the water and land under the ice. Included are the study of marine mammals, endangered species, and other living resources.	Primarily planning stage, although an investigation of Arctic walrus biological productivity has been conducted through NOAA/MUS&T. Involves primarily the use of submersibles.
Lead agency: National Oceanic and Atmospheric Administration.	
Participating: Other DOC, Department of the Interior, Environmental Protection Agency, Atomic Energy Commission, Department of Transportation, and State of Alaska.	
Manned Undersea Science and Technology (MUS&T)	
To develop, promote, coordinate, and support a national, civilian operational capability for man to work under the sea to achieve better understanding, assessment, and use of the marine environment and its resources. To conduct operations supportive of DOC missions in the fields of living resources and environmental surveys; nonliving resources, geology, and processes; marine management and pollution; and international-national scientific cooperation. To transfer and develop manned undersea technology for cost-effective civilian application.	Provides university, industry, and government scientists and engineers with access to facilities and specialized support; cooperative efforts with many ICMSE member agencies; DOC lead on U.S.-French and U.S.-Canadian efforts; technology development mission; and primary planned user of platforms.
Lead agency: National Oceanic and Atmospheric Administration.	
Participating: Corps of Engineers; Navy; Department of Health, Education, and Welfare; Department of Interior; Department of State; Atomic Energy Commission; Environmental Protection Agency; National Science Foundation; and numerous scientists from academia, industry, and government.	

PROGRAM TITLE AND PURPOSE	REMARKS
Operational Equipment Observation and Evaluation	
To observe and evaluate the performance of scientific and operational observation, measurement, and assessment equipment used by the NOAA Atlantic Oceanographic and Meteorological Laboratory and the NOAA National Marine Fisheries Service for comparison of surface and in situ methods.	Can use divers, submersibles, and habitats depending on the type of device involved.
Lead agency: National Oceanic and Atmospheric Administration.	
Participating: NOAA components.	
Canyons, Sedimentation and Bottom Boundary Layer	
NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML) and Manned Undersea Science and Technology (MUS&T) program investigations of submarine canyons as conduits for materials from the Continental Shelf to deep ocean areas. And to study sedimentation processes on the Continental Shelf and margins and bottom shear stress of flat and sloping bottoms, on the shelf and slope and the variations in shear stress over time.	Primarily uses divers and submersibles. MUS&T funds facility access.
Lead agency: National Oceanic and Atmospheric Administration.	
Participating: NOAA components, other Federal agencies, and scientists from academia.	
Undersea Facility Educational Projects	
To provide teaching institutions with the experience of building and operating undersea facilities and with the use of manned undersea equipment through Sea Grant.	Student projects have led to habitats at the Universities of Rhode Island and Michigan. Sea Grant is a supporter of scientific diving and participated with MUS&T in the Florida Aquanaut Research Expedition. Sea Grant is limited by law in support of facilities and assets.
Lead agency: National Oceanic and Atmospheric Administration.	
Participating: University of Michigan, University of Rhode Island, University of Hawaii, and others.	
Marine Geology and Geophysics	
Comprehensive oceanographic studies of currents, deep sea tides, sediments, paleotemperatures, biology, hydrography, and sea water chemistry in vicinity of selected seamounts, and the emplacement of bottom seismometers in studies of the Mexico Tectonic Plate Junction by the NOAA National Ocean Survey.	Submersible-oriented; MUS&T provides facility access.
Lead agency: National Oceanic and Atmospheric Administration.	
Participating: NOAA components, University of Hawaii, University of Mexico, Scripps Institution of Oceanography.	

PROGRAM TITLE AND PURPOSE	REMARKS
Fisheries Research	
Study and survey the fisheries resources in situ by the NOAA National Marine Fisheries Service to: assess resources, investigate the spatial relationship between deep sea asphaltic deposits and marine life, investigate biological productivity and survival of species, and test submersible survey techniques and compare them with surface-based techniques. *Lead agency:* National Oceanic and Atmospheric Administration. *Participating:* Government and university investigators.	Active user of divers and submersibles at present time; habitats may be used for process studies. MUS&T supports facility access and some university investigator special costs.
Office of Sea Grant	
Sea Grant colleges conduct research in the marine environment applicable to development of marine resources and technology and to understanding and assessment of offshore pollution. Provide education, training, and advisory services. *Lead agency:* National Oceanic and Atmospheric Administration. *Participating:* University investigators.	Responds to unsolicited proposals and may fund platform utilization as part of overall research. Coordinates manned undersea requirements with NOAA/MUS&T; no specific fund set aside for platform use.

CORPS OF ENGINEERS (COE)

Dredge Soil Disposal Studies	
Comprehensive studies of the disposal and uses of dredge spoils, such as the environmental and other effects of disposal and the use of spoils to develop artificial islands, barrier reefs, marshlands, and fish and wildlife refuges.	No programmed use of manned undersea platforms in these operational programs; however, need to test the feasibility of platforms as complement to surface-based techniques indicated. Potential submersible and habitat utilization. Divers are used for artificial reef inspections.
Offshore Operations Studies	
Study of the environmental and other effects of offshore mining of sand and gravel and of other activities for which permits are issued, such as dumping and construction. Investigation of submersible dredging.	Same as remarks on Dredge Soil Disposal Studies (above).
Offshore Facilities and Deepwater Ports	
Operations in support of the design, construction, operations, and maintenance of deepwater ports and offshore facilities.	(See earlier remark on these under Department of Commerce.)

PROGRAM TITLE AND PURPOSE	REMARKS
Construction Effects	
Baseline pre-project investigations, determining effects during construction, and determining past construction changes as part of an assessment of the effects of construction on the ecology of the coastal zone.	(Same as remarks on first two programs.)
Storm Assessment	
Determining the effects of major storms on estuarine and other coastal areas, such as an in-depth exploration of critical changes in the Chesapeake Bay ecology and bathymetry caused by hurricane Agnes.	Use depends on platform availability and cost, intermittent access required; primarily submersible and diver utilization. No use programmed at this time.
Arctic Research	
Investigation of engineering problems associated with the ice cover of the Arctic Ocean. These investigations include an understanding of ice fracture patterns, physical properties of ice, and driving forces as they relate to structures, and an improvement in bathymetric charts and ice characteristic measurement techniques.	Potential use of submersibles and divers under the ice. No use of platforms programmed at this time.

DEPARTMENT OF THE NAVY

Submarine Location, Escape, and Rescue	
To develop a capability to locate a distressed submarine and rescue surviving personnel. *Lead agency:* Naval Ships Systems Command. *Participating:* Naval commands, centers, offices, and private industry.	(Navy requirements are generally met by Navy-owned systems.) Deep Submergence Systems Project (DSSP) developed Deep Submergence Rescue Vehicles (DSRV's).
Deep Ocean Technology	
To advance the state of technology in the area of undersea operations and materials, including manned undersea operations. Includes test of titanium pressure sphere on *ALVIN*. *Lead agency:* Naval Material Command. *Participating:* Naval commands, centers, offices, and shipyards. Woods Hole Oceanographic Institution, and private industry.	Primarily oriented toward removing man in routine operations by the use of remote systems. Manned systems used in support of the development.

PROGRAM TITLE AND PURPOSE	REMARKS
Man-in-the-Sea, Continental Shelf	
To develop the techniques, diver tools, and diver life support equipment to enable divers to safely work at depths to 1,000 ft in support of Navy operations. *Lead agency:* Naval Ships Systems Command. *Participating:* Naval commands, centers, laboratories, offices, and bureaus, and private industry.	Surface-based orientation.
Deep Submergence Biomedical Development	
To conduct the biomedical research and to develop improved medical support to insure safe, effective manned undersea activity by present and future Naval operations. *Lead agency:* Bureau of Medicine and Surgery.	Studies of biomedical and physiological effects of diving; cooperative projects with NOAA-MUS&T.
Surface-Supported Diving System	
To develop an increased Navy capability to conduct surface supported, nonsaturated operational dives to depths of 300 ft. *Lead agency:* Naval Ships Systems Command. *Participating:* Naval Material Command, Oceanographer of the Navy, and Chief of Naval Operations (OP-23).	Surface-based support of divers; no undersea facility use.
Large-Object Salvage System	
The research, development, test, and evaluation of systems to provide an improved capability to salvage large objects from water depths to 1,000 ft. *Lead agency:* Naval Ships Systems Command. *Participating:* Naval commands, centers, and laboratories, and private industry.	Development project currently at specification stage.
Deep Ocean Engineering and Research	
Operation of the submersible *ALVIN* and the support ship *LULU* by Woods Hole Oceanographic Institution in support of ocean science and deep ocean engineering research. *Lead agency:* Office of Naval Research.	Provides support for *ALVIN* and related research; no other platform utilization programmed.

PROGRAM TITLE AND PURPOSE	REMARKS
Advanced Marine Technology	
Developing tools and equipment for the submersible *ALVIN* to further the capability to conduct scientific and engineering research and to test equipment, and funding to develop ocean research techniques. *Lead agency:* Office of Naval Research. *Participating:* Naval Material Command, Oceanographer of the Navy, and Woods Hole Oceanographic Institution.	Supports research tools for *ALVIN;* no other platform involved.
Operational Underwater Salvage	
To maintain a Navy capability to conduct salvage as required for national security, failure analysis, and safety of navigation. *Lead agency:* Naval Ships Systems Command.	May lease civilian-operated platforms in an emergency. Requirements generally satisfied by Navy platforms.
Fleet and Facilities Support	
The installation, operation, and maintenance of facilities, and such as weapons and navigation calibration systems to support the operations and readiness of the fleet. *Lead agency:* Naval Facilities Engineering Command.	Includes operation of Navy platforms: *TURTLE, TRIESTE, SEA CLIFF,* and *NR-1*
Acoustic Studies	
The study of ocean stability, ocean floor, and subfloor characteristics, biological populations, and ambient noise as related to acoustics. *Lead agency:* Naval Oceanographic Office.	Platform utilization unfunded.
Development of Ocean Engineering and Construction Techniques	
The study of soil characteristics as related to underwater construction and breakout; the grading of the sea floor for construction; and the engineering and assembly of underwater facilities. *Lead agency:* Naval Civil Engineering Laboratory.	Platform utilization unfunded.

PROGRAM TITLE AND PURPOSE	REMARKS
Exploratory Development Projects	
To conduct efforts directed toward the solution of specific problems short of major prototype development, to improve diver life support equipment and tools, and projects such as developing underwater construction techniques which require diver support.	Composed of approximately 12 separately funded and identifiable tasks.
Lead agency: Oceanographer of the Navy.	
Participating: Naval commands, centers, laboratories, offices, and bureaus; various U.S. universities and private industry.	

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE (HEW)

Decompression Table Standards	
To prevent osteonecrosis and decompression sickness in hyperbaric workers by preparation of new decompression table standards.	Does not generally involve at sea operations.
Lead agency: National Institute for Occupational Safety and Health.	
Participating: National Research Council Committee on Underwater Physiology and Medicine, Texas A&M University, American National Standards Institute.	

DEPARTMENT OF THE INTERIOR (DOI)

Underwater Interpretation and Research Within the National Park System	
To initiate a viable program of underwater development to provide for the interpretation and research of national park areas of the marine environment.	Planning for potential new facilities.
Lead agency: National Park Service.	
Geophysical Investigations	
The detailed investigation of geological features detected by surface means on the outer Continental Shelf, continental slope, and base of the slope as part of the investigation of shelf nonliving resources.	Currently uses divers; submersible operations may be used in some areas; no specific fund allocation for platform use; intermittent need for platform.
Lead agency: U.S. Geological Survey.	

PROGRAM TITLE AND PURPOSE	REMARKS
Sedimentology and Placer Mineral Deposits	
The detailed investigation of offshore sediments, particularly in the Arctic, that contain heavy metals, as part of placer deposit assessment. Investigation and delineation of sands, gravels, and elements contained or distributed therein. *Lead agency:* U.S. Geological Survey. *Participating:* Various Federal and State agencies and universities.	Currently using divers; submersible or habitat operations may be indicated in certain circumstances; no specific fund allocation for platforms use; intermittent need for platforms.
Great Lakes and Marine Sport Fisheries Research	
Research into the dynamics of fish populations, life cycles, and behavior; the effects and control of the sea lamprey populations of the Great Lakes; angler and commercial harvests; and environmental changes and their effects. *Lead agency:* Bureau of Sport Fisheries and Wildlife. *Participating:* Various Federal and State agencies.	Potential use of platforms for process studies; coordinated with NOAA National Marine Fisheries Service programs; no specific fund allocated for platform use.

DEPARTMENT OF TRANSPORTATION (DOT)

Underwater Safety Program	
To assure the safety of nonmilitary undersea activities through vessel and station regulation and inspection; to maintain knowledge of ongoing undersea operations; and to provide undersea Search and Rescue (SAR) services. To manage frequency allocations in the undersea acoustic communications frequency spectrum. Coordinate Coast Guard undersea mission support. *Lead agency:* Coast Guard.	Potential for issuing regulations on diving and facilities; may lead to a civil rescue capability; may be occasional platform use, although no funds are so allocated.

ATOMIC ENERGY COMMISSION (AEC)

Estuarine and Adjacent Area Ecological and Radiological Studies	
The study of the marine environment and its life forms with particular emphasis on the effects of radioactivity on the ecosystems. *Supporting activities:* Contractors.	Respond primarily to unsolicited proposals and can fund platform utilization as part of overall research program; platform use impeded by proportionately high cost for short-duration use; no specific amount set aside for manned undersea activities.
Oceanic Processes and Populations	
The study of Continental Shelf and deep currents, sediment transport, and shelf and deep fish populations as they may affect, or be affected by, radioactive material transport. *Supporting activities:* Contractors.	

PROGRAM TITLE AND PURPOSE	REMARKS
Power Package Recovery	
The recovery of nuclear power packages from aborted space shots to a depth of 2,000 meters. *Supporting activities:* Contractors, NASA, Navy, Coast Guard.	Requires infrequent, intermittent use of submersibles to locate and recover power supplies.

ENVIRONMENTAL PROTECTION AGENCY (EPA)

Assessment of Marine Waste Disposal Areas	
Measure and describe, through observations and collection of water sediment and biota, the fate and effects of various types of wastes (sludges, dredge spoils, and municipal sewage) in coastal waters and the Great Lakes. *Lead agency:* Office of Research and Monitoring.	Diver, habitat, and submersible applications, particularly the latter; work by in-house labs., academia, and industry; cooperative activities with NOAA-MUS&T; no programmed regular use of platforms.
Water Quality and Ecology	
Measure and describe the influence of water quality on marine ecosystems and the origin and fate of materials and substances detrimental to water quality. *Lead agency:* Office of Water Programs.	Diver, submersible, and habitat applications, particularly the latter for process studies; cooperative activities with NOAA-MUS&T; no programmed regular use of platforms.
Enforcement Action Evidence Collection	
The collection of evidence of environmental damage and the source of the damage-producing substances for use in civil and criminal litigation against alleged polluters of coastal waters and the Great Lakes. *Lead agency:* Office of General Counsel and Enforcement.	Intermittent need to collect firsthand observation evidence. Platform use, primarily submersibles, would depend on pending cases.

NATIONAL SCIENCE FOUNDATION (NSF)

Oceanographic Research	
The collection and analysis of physical, biological, chemical, and geological oceanographic data to extend man's knowledge of the oceans and their resources. *Lead agency:* Division of Environmental Sciences.	Responds to unsolicited proposals and may fund platform utilization as part of overall research; cooperative activities with NOAA-MUS&T; no specific fund set aside for platform use.

NATIONAL SCIENCE FOUNDATION (NSF)—Continued

PROGRAM TITLE AND PURPOSE	REMARKS
Research Facilities Support	
Provision of interim funding, in cooperation with the Navy, to support the submersible *ALVIN* to make *ALVIN* available to scientists from academia and institutions. The University National Oceanographic Laboratory System (UNOLS), an independent association of universities and institutions, has recommended that *ALVIN* be declared a "National Oceanographic Facility."	Provides "block" (full year) funding for "National Facilities"; time on facilities allocated on basis of scientific merit by UNOLS. UNOLS has recommended a lease fund for existing platforms.
Lead agency: Oceanographic Facilities Section.	
Franco-American Mid-Ocean Undersea Study (FAMOUS)	
A cooperative venture of NSF, DOC (NOAA), DOD, and France for the investigation of the Mid-Atlantic Ridge.	Use of *ALVIN* planned.
Lead agency: NOAA-International Decade of Ocean Exploration (IDOE).	

SMITHSONIAN INSTITUTION

Biological-Geological Oceanography	
Basic research in the marine environment, especially to observe the ecosystem through the transparent hull (of the submersible *SEA LINK*) and to send out divers to collect geological and biological specimens and data. Emphasized are the kinds, distribution, and ecology of marine organisms; the effects of pressure at ocean depth on marine organisms; and the kinds and distributions of sediments on the shallow sea floor.	Nearly complete utilization made of the *SEA LINK*.
Lead agency: Smithsonian in cooperation with the Harbour Branch Foundation.	

Appendix C. Manned Undersea Science and Technology Program, FY 1972-73

The activities of the MUS&T program (see fig. 1) during FY 1972 and the first half of FY 1973 can be summarized as follows:

Northeast Fisheries.—The New England fishing industry and investigators from the National Marine Fisheries Service (NMFS) have long been concerned with the dwindling herring and lobster stocks in the Northeast. A program was begun in September 1971 to enable scientists from NMFS to obtain firsthand observations of herring spawning and the population dynamics of lobsters. Because of the lack of experience with these techniques, part of the initial effort was devoted to training. Preliminary training was performed using the *SEA LINK* lockout submersible. In September the Perry submersible *PC–8* made 33 dives, and in June 1972 the Perry lockout submersible *DEEP DIVER* was used in the Gulf of Maine. In addition to providing new knowledge about the herring, significant new data was obtained on potentially valuable lobster and shrimp and other shellfish beds. The program continues into FY 1973, and operations in the fall of 1972 using ship-supported diving are expected to yield significant new in-situ data on the spawning of herring. Observers from the Environmental Protection Agency, the States of Massachusetts and Maine, and Canada have participated in the operations.

Straits of Florida.—This program used the Navy-owned, Woods Hole-operated submersible *ALVIN* for 14 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 data collected are significant in understanding the origins of geological structures in the area, the processes active in the area, and the distribution and fate of pollutants. The activities and results are reflected significantly in FY 1973 plans. The principal investigators were from NOAA's Atlantic Oceanographic and Meteorological Laboratory 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, or carbonate platform, to study its composition and origin. Using General Oceanographics' submersible *NEKTON BETA*, 29 dives were made in three study areas. Ancient carbonate platforms are an important source of offshore fossil fuels, and work on carbonate platforms, which continued during FY 1973 with operations using the *NEKTON BETA* in October 1972, is expected to yield important data for locating new fuel deposits and monitoring man's impact on reef ecosystems.

New York Bight.—The overall objective of this program is to study bottom structures and dynamics in the New York area and to determine their relation to the movement of solid waste. The first two phases of the program have been completed. Phase I was conducted in September 1971, when 15 dives were made by the Perry *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 1,500 feet in July 1972, using Westinghouse *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 will be established, consisting of in-situ current meters and dyed tiles of sand. The sand tiles dissipate slowly and will permit sediment tracing during later phases of the program. This program provides data for MUS&T efforts to investigate dump sites and will support the NOAA Marine Ecosystems Analysis (MESA) program. Operations were conducted with scientists from Woods Hole, AOML, Corps of En-

gineers, Westinghouse, NMFS, and Adelphi and Columbia Universities. During FY 1972, a similar project was initiated in the Southern California Borderlands, which will be described, and during FY 1973 it is expected that operations will commence to evaluate a proposed dump site in Puget Sound and related shellfish populations.

Hudson Canyon, New York.—In June 1972, a series of dives using *ALVIN* were made to depths of 5,000–6,000 feet in the Hudson Canyon to study the bottom formations and dynamics (sedimentary processes). A primary purpose was to determine the manner in which such submarine canyons may serve as "pipelines" for the movement of organic and inorganic materials from the Continental Shelf to abyssal depths. Because of their importance in many oceanic processes, there is also considerable interest in the origins of these features. Data was obtained by direct observation, photographs, coring, and emplacement of instruments. These dives were made by scientists from Woods Hole Oceanographic Institution, AOML, and Lehigh University. In addition to supporting activities in the New York Bight, this operation is part of a larger continuing program to investigate and perhaps ultimately model the processes in submarine canyons. This larger effort was also supported by activities in the Southern California Borderlands.

Southern California Borderlands.—In June 1972, the Lockheed submersible *DEEP QUEST* made four dives totaling 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, several dives were made using the *DEEP QUEST* submersible to depths of 6,000–7,000 feet in the south part of the San Diego Trough. The objectives were to study the movement of fine grain sediment from shallow areas into the deeper reaches of the submarine canyons. This phase was part of the overall program designed to determine the role of submarine canyons in the dispersal of solid wastes. Scientists from Scripps Institution of Oceanography, Rice University, Lockheed Corporation, and MUS&T participated.

Bahama Banks Research Program (HYDROLAB).—The Perry *HYDROLAB* (a 2–4-man habitat), located at 50 feet deep near Grand Bahama Island, is being used in a series of investigations commenced during FY 1972 and continuing through FY 1973. Included in a series are studies of fish behavior life cycles and biological productivity, 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 and geology. Five 4–6-day missions were conducted from December to June, 1972, by scientists from the Federal Government and several universities. In addition seven geological investigations were made using the Perry submersible *PC–8* in late 1971. Operations are to obtain detailed baseline data on the overall ecology of a major reef area, since 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. This is part of a larger program of reef ecology studies, which includes the FLARE project (to be described) and others, that will permit the comparison and contrast of areas in various parts of the United States and nearby. In addition, *HYDROLAB* provides a relatively inexpensive facility from which scientists can be trained in new underwater techniques and from which new instrumentation can be tested.

During FY 1973, operations will be conducted in Puerto Rico to obtain further ecological baseline and geological data. These operations will use the new, Puerto Rican government- and Marine Resources Development Foundation-sponsored *PRINUL* habitat. A MUS&T program-sponsored team made the first operational dive using the habitat from November 18 to December 1, 1972. In addition to supporting the overall program in reef ecology, this will also provide experience with a habitat of the latest design.

Florida Aquanaut Research Expedition (FLARE).—This program commenced on January 27, 1972, with the first of nine saturation dives at four locations (commencing at Long Reef) on the southeast coast of Florida. This multidiscipline project, under the operational management of Woods Hole Oceanographic Institution, made use of the University of New Hampshire's habitat *EDALHAB* supported by the Woods Hole-operated Navy research vessel *LULU*. Although the scientific teams that took part in FLARE pursued many 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 transportable habitat supported by a surface vessel. The studies included reactions of fish to novel traps and holding devices, effects of pollutants on reef metabolism, obtaining coral cores, detailed studies of coral algae, and comparing biological productivity in areas of sewage outfalls and "clean" areas. Over 25 scientists participated as aquanauts in this program which concluded in late April 1972.

Divers near habitat **HYDROLAB** deployed in 50 ft of water off the coast of Grand Bahama Island.

Pacific Walrus (Bering Sea).—In February 1972, the Perry *PC–8* submersible, supported by the Coast Guard icebreaker *BURTON ISLAND*, was used in the Bering Sea as part of a study of marine mammal productivity. The research was carried out under the U.S. International Biological Program and funded by the National Science Foundation, the Office of Naval Research, and NOAA. Participating in the 6-week cruise were seven scientists from Johns Hopkins University, the Arctic Health Research Center, and the University of Alaska. 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 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 and conserving marine mammals.

Flower Garden Reefs, Gulf of Mexico, Galveston, Tex.—In June 1972, 16 dives were conducted at depths of 200–400 feet using General Oceanographic's *NEKTON* submersible 120 miles southeast of Galveston, Tex. The objective of these dives was to obtain biological and geological baseline data by observation and selection of samples. The samples are being analyzed for pesticide and heavy metal content and have been found to contain significant amounts of mercury, cadmium, and arsenic. Geological sampling of sediments was also carried out to determine the impact of the Mississippi River fanning out on the distant reaches of the Gulf of Mexico. Continuation of activities which support reef ecology and resource location efforts during FY 1973 is expected.

Coast Guard ship with submersible **PC-8** en route to Bering Sea site for study of Pacific walrus.

Submersible **PC-8** operating in ice in the Bering Sea in study of Pacific walrus productivity.

PRINUL, Puerto Rico.—In November 1972, the Puerto Rican International Underwater Laboratory (PRINUL) project, sponsored by the Puerto Rican government, started operations off the southwest coast of Puerto Rico near Mayaguez. The MUS&T Office has sponsored scientific divers to conduct nine diver-missions pertaining to reef ecology studies, five through December 1972.

International scientific cooperation.—During FY 1973, preparations are being made for participation in the U.S.-French investigations of the Mid-Atlantic Ridge. These preparations are being made through a joint effort with the National Science Foundation and the Office of Naval Research. It is also expected that a joint U.S.-Canadian program will be conducted in the Great Lakes to further study physical and biological processes around the time of ice breakup and to gain further information on cold water diving.

Biomedical program.—In addition to the marine science programs, a program was initiated during FY 1972 and will continue during FY 1973 to develop vertical excursion limits for divers saturated on nitrogen-oxygen breathing mixtures. Such information is necessary, both from a medical safety standpoint and 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 with Navy cooperation. During FY 1973, equipment development is being initiated both independently and in cooperation with the Navy for medical support of divers. Significant cooperative agreements have been reached with the Navy in the biomedical and other fields. MUS&T participated with the Office of Naval Research in an Arctic ice diving experiment at Resolute Bay, Canada, during December 1972.

NOAA diving manual.—A civilian diving manual for NOAA employees is under development and will address problems of scientific diving as well as working diving. This document will complement Navy manuals and will integrate information from 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 involved in using or developing national diving standards. In conjunction with this and the U.S. Navy biomedical program, MUS&T is attempting to develop quantitative data on commercial, recreational, scientific, and nonmilitary governmental diving through an effort sponsored by the National Bureau of Standards. To improve overall safety, an analysis of scuba accidents is being sponsored by the Navy, Department of Health, Education, and Welfare, and the Coast Guard at the University of Rhode Island.

Undersea laboratory systems.—The habitats used in many of the well-known projects of the past were designed primarily to provide a sea floor shelter to sleep and eat and to demonstrate a technological capability. To determine the impact of manned undersea systems in the varied fields these systems can support, it is necessary to move into systems designed for operational capabilities. This differentiates laboratories from habitats. During FY 1972, a grant was awarded to the University of New Hampshire to determine the impact of the requirements of the scientific community on the designs of future undersea laboratory systems. (See pp. 00–00.)

Manned undersea activity goals.—Under the MUS&T sponsorship, the National Academies of Sciences and Engineering conducted a workshop to study the national goals and priorities in undersea science and technology requiring the presence of man. The culmination will be the report from a 5-day workshop during October 1972 to be distributed in mid-1973. (See pp. 00–00.)

Future programs.—With the current availability of undersea platforms, manned undersea efforts will tend to concentrate on critical technological and equipment gaps in civil undersea applications. The strengths and weaknesses of existing systems will be identified based on mission-oriented applications so that requirements for future systems can be formulated. Similar to the FY 1972–73 projects, MUS&T will continue to facilitate the coordination of undersea science projects and the utilization of available platforms in support of NOAA's mission and the related missions of other Federal agencies. Figure 6 is a bar chart showing that NOAA participants represented less than 20% in the projects conducted thus far.

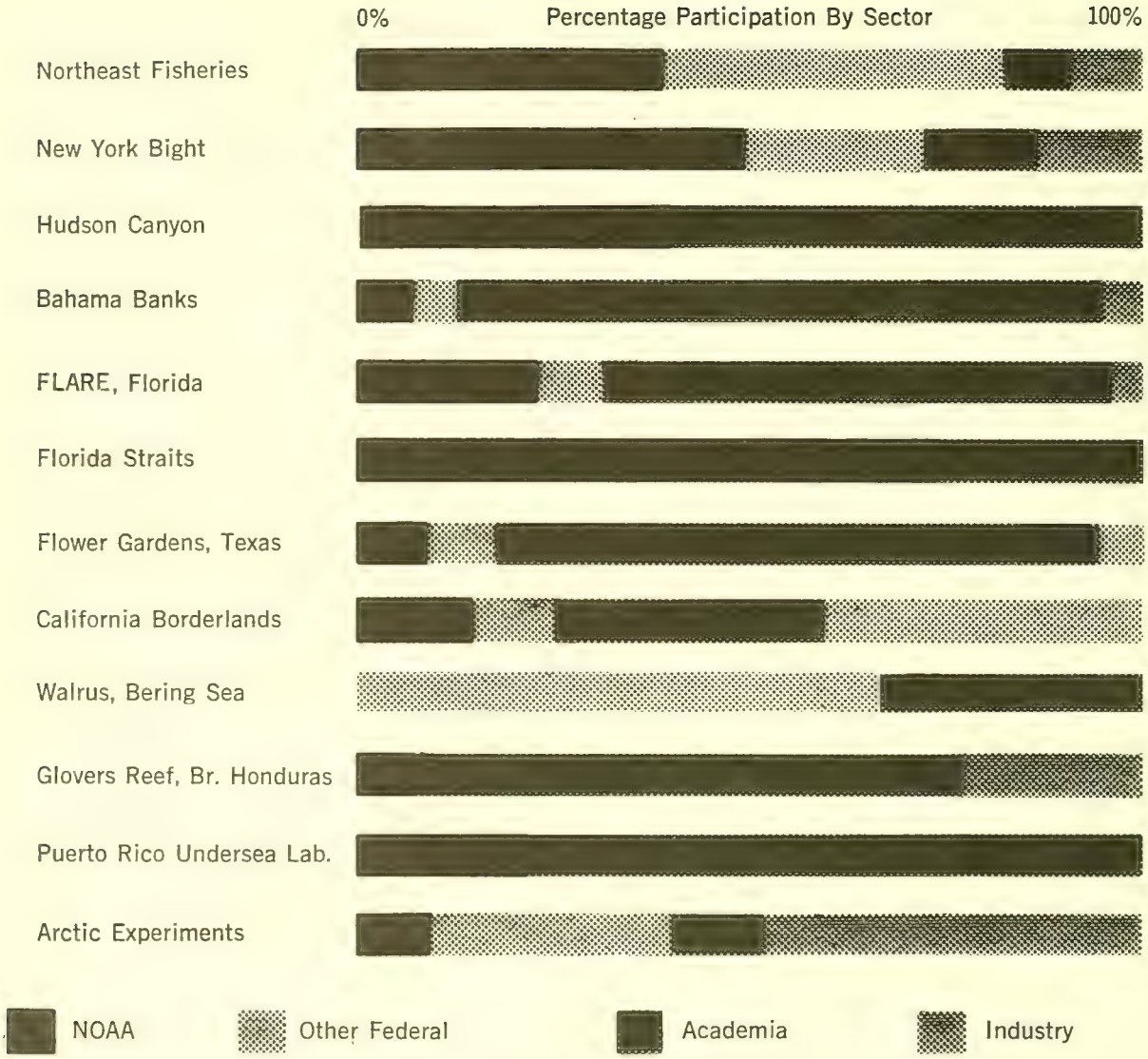
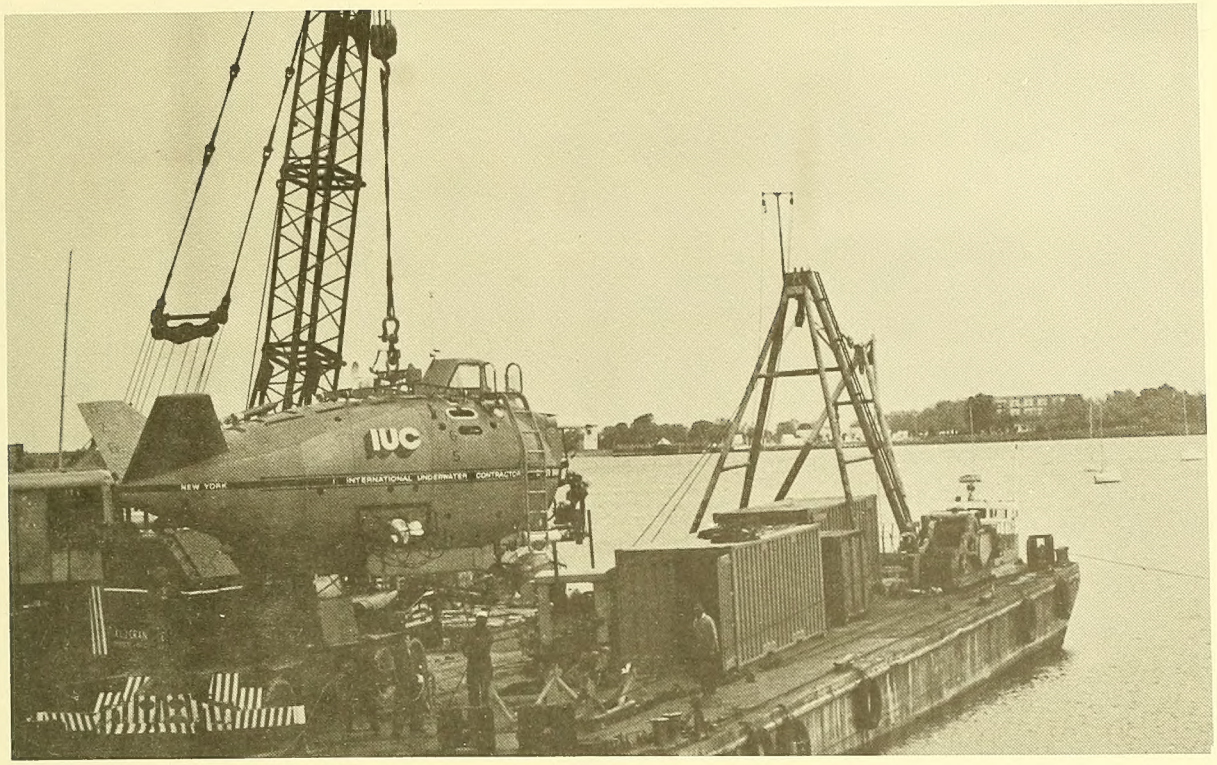
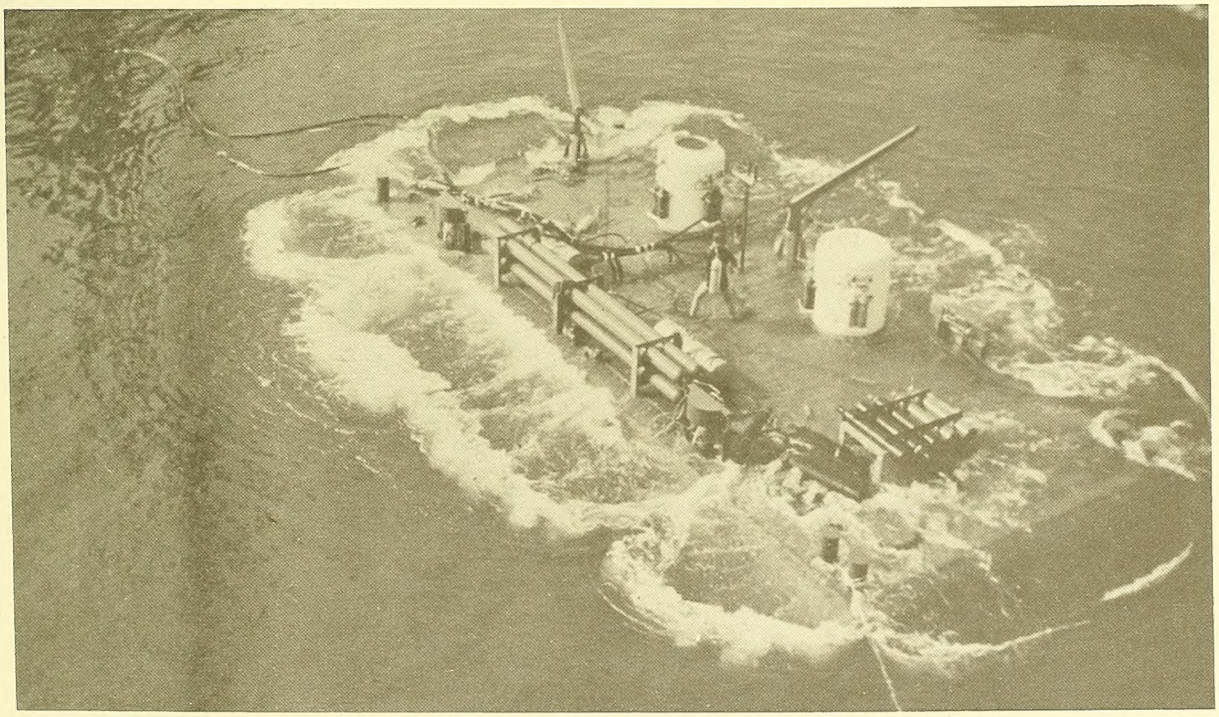


Figure 6. Participants in MUS&T science projects as of December 1972.



Lockout submersible **BEAVER MARK IV.** on support barge.



Transportable habitat **PRINUL**.

AMERICAN REVOLUTION BICENTENNIAL
1776-1976