PRESS HANDBOOK
SEALAB III EXPERIMENT
THE U.S. NAVY'S
MAN-IN-THE-SEA PROGRAM

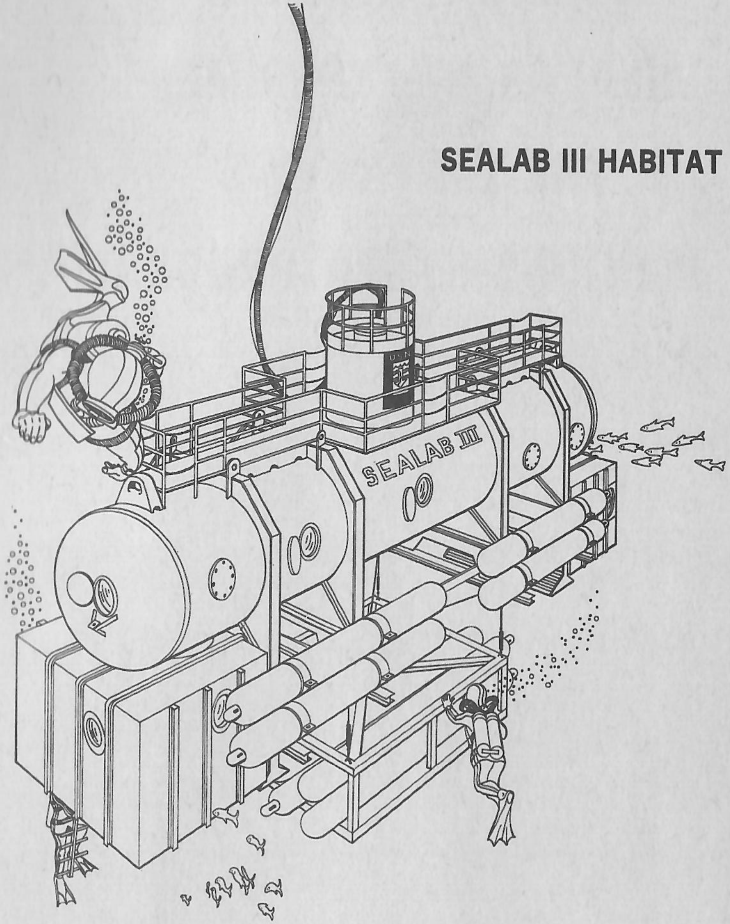
Command Information Bureau
SEALAB III EXPERIMENT
Building T-420
Long Beach Airport
Long Beach, California 90808

* * *

Public Affairs Office
DEEP SUBMERGENCE SYSTEMS PROJECT
6900 Wisconsin Avenue
Chevy Chase, Maryland 20015
(Area code 301 - 295-1590)

September 1968

SEALAB III HABITAT



THE CONQUEST OF INNER SPACE

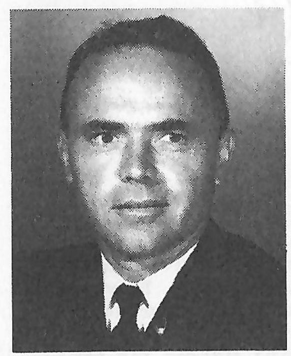
Welcome to the U.S. Navy's SEALAB III experiment, man's most ambitious effort yet undertaken to penetrate earth's last unexplored frontier--the ocean depths. Never before have so many men lived and worked on the ocean floor for so long and at so great a depth.

The importance of SEALAB III is not the establishment of records, but rather the evaluation of techniques and equipment being developed to extend man's capabilities in the deep ocean. These capabilities will enhance the Navy's underwater work in such activities as location, salvage, search, recovery, rescue, construction, oceanography, and applied research.

Some of these activities--such as salvage and construction--have direct non-military applications. In addition, several non-military experiments will be conducted during SEALAB III by personnel from the Department of Interior's Bureau of Commercial Fisheries. This work will have direct economic implications.

Thus, SEALAB III will aid man in his conquest of the deep sea--of Inner Space--to work, to mine, to harvest, to fish, and to play in the sea. But primarily, SEALAB III will further the U.S. Navy's ability to operate in the sea.

We of the Navy's Deep Submergence Systems Project, who are responsible for the development of techniques and equipment for deep-sea operations, are most pleased to have you with us as man takes this giant stride in the conquest of Inner Space. Welcome aboard.



W. M. Nicholson

Captain William M. Nicholson, U.S. Navy
Project Manager
Deep Submergence Systems Project
Department of the Navy

All photographs are
Official U.S. Navy
unless otherwise indicated

This handbook has been prepared by the Nortronics Division of the Northrop Corporation in conjunction with the U.S. Navy Deep Submergence Systems Project to provide a suitable description of the SEALAB III experiment for news media representatives covering the event. Nortronics provides engineering support for the SEALAB III experiment. All material for this handbook has been provided for public use by the Deep Submergence Systems Project.

SEALAB III PRESS HANDBOOK * CONTENTS

1.

FACILITIES AND ARRANGEMENTS FOR THE PRESS

Every effort is being made to provide adequate briefings, interviews, communications, transportation, working space, and background material for the members of the press covering the SEALAB III experiment.

The Command Information Bureau (CIB) at the Long Beach Airport (Building T-420) is the primary location for arranging to cover the various aspects of the SEALAB III experiment, conducting interviews, obtaining news releases and background material, etc. A subordinate CIB is located at the Naval Undersea Warfare Center pier at Wilson Cove on San Clemente Island.

Registration

Registration and issuing of special badges for the SEALAB III experiment will be done at the Command Information Bureau at the Long Beach Airport.

NEWS MEDIA REPRESENTATIVES MUST BE REGISTERED TO VISIT THE EXPERIMENT SITE; THEY MUST DISPLAY THEIR BADGES WHILE IN FLIGHT TO AND FROM SAN CLEMENTE ISLAND AND WHILE AT THE EXPERIMENT SITE.

Berthing and Messing

Berthing facilities on San Clemente Island are limited and spartan. Only news media representatives having unusual justification will be authorized to remain overnight on the island. Authorization will be made by the Officer-in-Charge, CIB, with the concurrence of the SEALAB III On-Scene Commander and the Officer-in-Charge, San Clemente Island.

News media representatives remaining overnight will be billeted on a space available basis. The charge for berthing is $2.00 per person per night and includes linens, blankets, and towel. Emergency toiletries may be purchased at the Navy Exchange on the island.

During visits to SEALAB III news media representatives may use the main dining hall in the Wilson Cove area. News media representatives are not authorized to eat on board the support ship ELK RIVER.

Meal hours at San Clemente Island are: breakfast 0530-0730; lunch 1100-1300; dinner 1700-1900. The cost per meal is: breakfast 85¢, lunch $1.50, dinner $1.65.

At times of peak news media interest there will be box lunches available at the Sub-CIB.

Equipment and Supplies

Typewriters, extensions of commercial telephones, and a TWX filing capability are provided in the CIB at Long Beach and the Sub-CIB on San Clemente Island. General office supplies will also be available. TWX filing will be done at collect press rates and written on forms provided by the CIB. TWX copy for filing during an adverse incident will be done in takes of not more than 250 words and will be handled on a first-come, first-served basis. Each take will be date/time stamped and a copy will be returned to the correspondent. Another copy will be made available upon transmission to provide a record of time of transmission.

Interviews

Interviews with Aquanauts and operational support personnel will be given on a pre-arranged basis. Interviews with Aquanauts in the sea-floor habitat will be processed on a first-come, first-served basis. Pre-programmed national network radio and television shows will be assigned specific time slots by the Officer-in-Charge CIB.

Photographs

A library of released SEALAB III photographs and proof sheets will be available at the CIB. News media representatives may pick up copies of stock photos; special orders of black-and-white photos will require a minimum of five working days and color photos will require a minimum of ten working days to process.

Sufficient copies of photos selected for release during the experiment will be available at the CIB to meet normal media requirements. All released photos will automatically be delivered to national and international wire service outlets in the Los Angeles area. Copies will also be available at the Pentagon in Washington, D. C.

News Releases

News releases are issued twice a day at the CIB in the form of situation reports. Additional feature and summary releases are issued periodically.

Copies of all previously released features and situation reports are available at the Long Beach CIB and at the Deep Submergence Systems Project Office in Chevy Chase, Maryland.

Radio

Radio requirements and requests will be co-ordinated by the Radio Officer, Media Section, at the Long Beach CIB. Limited radio recording facilities are available at the CIB.

Electrical outlets with 110 AC power will also be available in the surface support ship ELK RIVER and at the Sub-CIB on San Clemente Island. Beeper reports are available on a CIB telephone line and background music, sea sounds, etc., will be available at the CIB. (The noise

level at the CIB is relatively high during working hours and microphone wind screens will be required for recording at the experiment site.)

Radio recording supplies (i.e., tapes, extension lines) must be furnished by news media representatives.

Alternate power sources such as batteries should be provided for recording on San Clemente Island and aboard the surface support ship ELK RIVER.

Television

All television requirements and requests will be co-ordinated by the Television Officer, Media Section, at the Long Beach CIB. A television set with color-balanced lighting and B&W Marconi and Cohu vidicon cameras is available at the CIB to make black-and-white videotape reports after visits to San Clemente Island. Models of various SEALAB III components as well as a profile model of the ocean floor site are available on the set. Slide and film chain are also available for station identification or logos if these are provided by news media representatives. No videotapes can be supplied by the CIB.

Transportation

An eight-passenger aircraft is available for transporting news media representatives between the Long Beach Airport and San Clemente Island during the operational phase of SEALAB III. This phase ends when the last team of Aquanauts completes decompression.

Schedules for the press plane will be posted in the newsrooms at the Long Beach CIB and the Sub-CIB on San Clemente Island. Passenger lists will be made up on a first-come, first-served basis, and reservations must be made 24 hours in advance. NO NEWS MEDIA REPRESENTATIVES WILL BE FLOWN TO SAN CLEMENTE ISLAND UNLESS THEY HAVE BEEN REGISTERED WITH THE SEALAB III CIB AND ARE ON THE PASSENGER LIST.

During periods of anticipated maximum press coverage (i.e., initial Aquanaut entry into seafloor habitat, exit of first Aquanaut team from decompression), a larger press aircraft will be available. This will be a 40-passenger aircraft which can carry approximately 2,000 pounds of camera equipment.

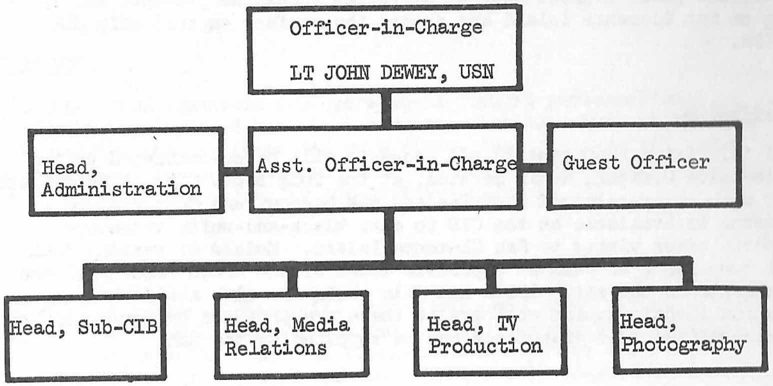
Working Spaces

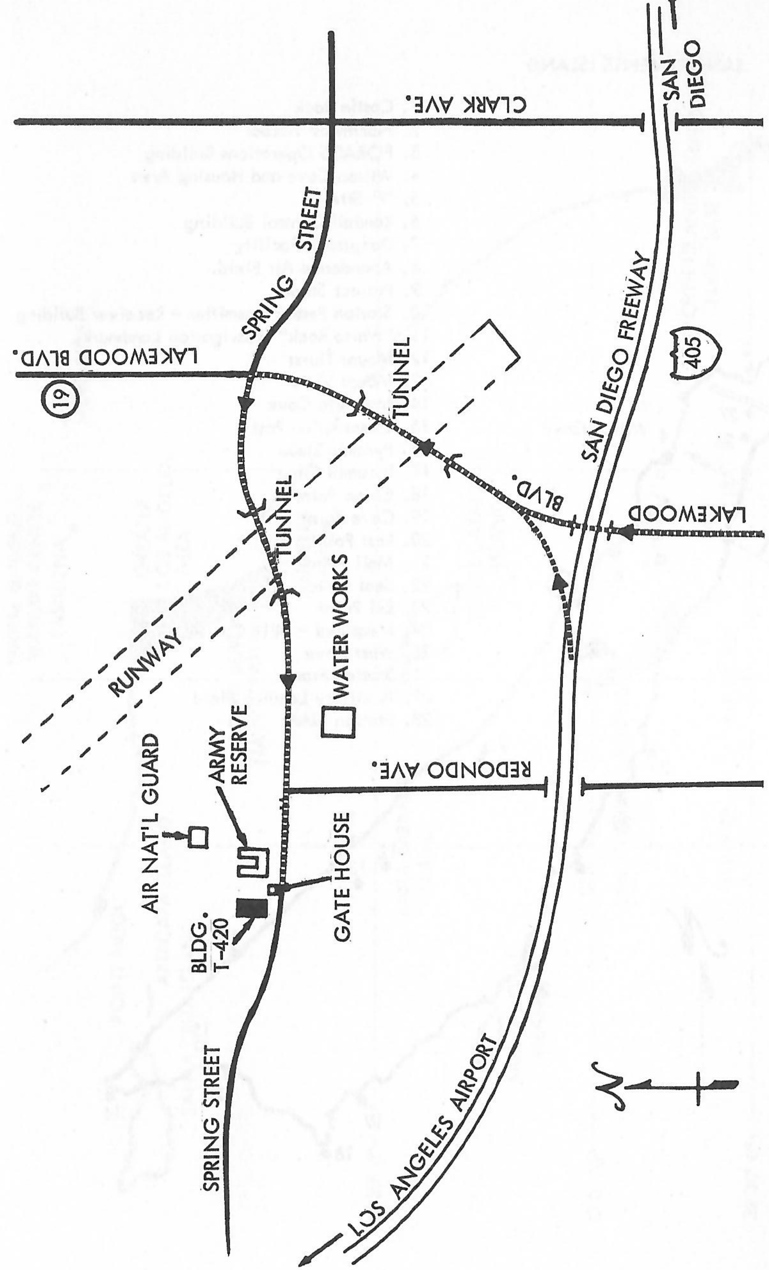
News media representatives may use the working newsroom at the CIB which is adjacent to a briefing theater which may be used for interviews when available.

A preview theater is available to view work-print motion picture footage shot by Navy photographers. A schedule of daily projections is posted in the newsroom.

Limited working newsroom facilities are available at the Sub-CIB on San Clemente Island.

QUICK LOOK: SEALAB III COMMAND INFORMATION BUREAU



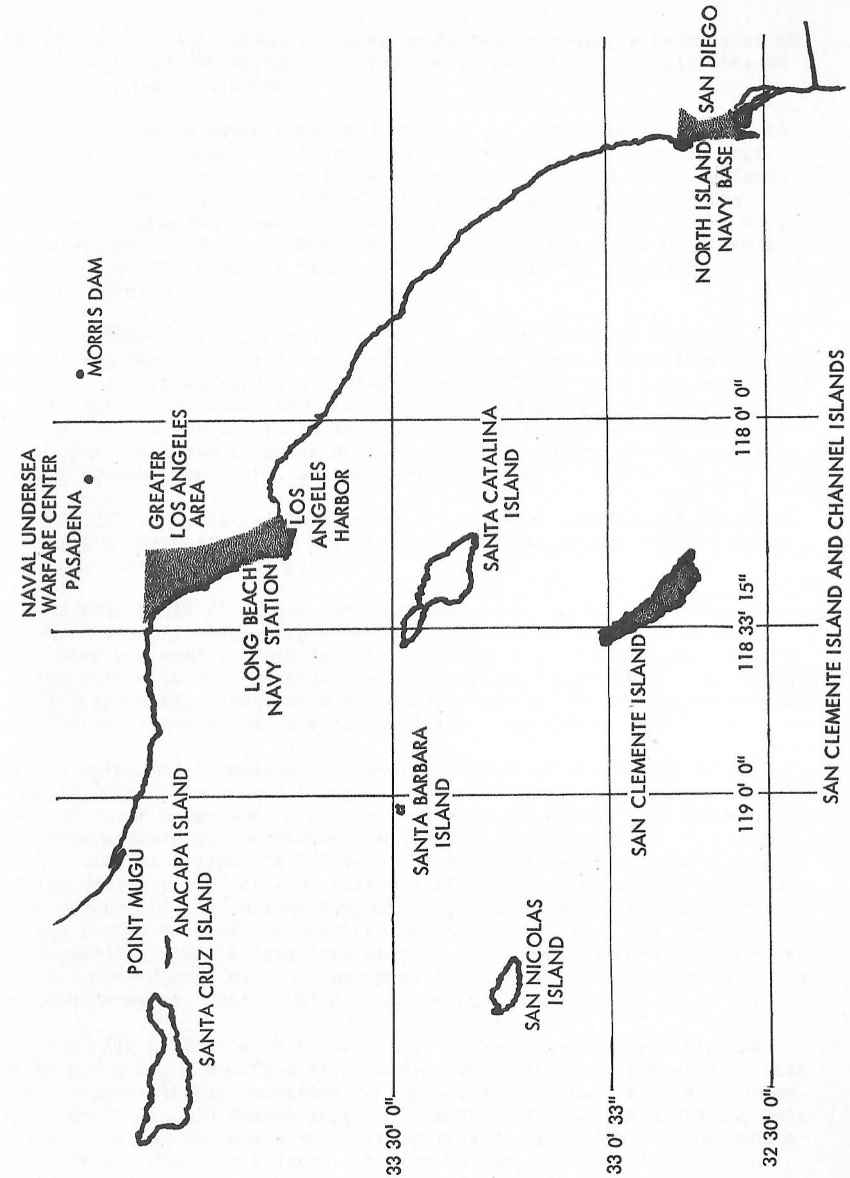


COMMAND INFORMATION BUREAU - LONG BEACH AIRPORT

SAN CLEMENTE ISLAND

1. Castle Rock
2. Northwest Harbor
3. FORACS Operations Building
4. Wilson Cove and Housing Area
5. 'P' Site
6. Randall Control Building
7. Deeptrack Facility
8. Abandoned Air Field
9. Project Stone
10. Station Peak Transmitter - Receiver Building
11. "White Rock" (Navigation Landmark)
12. Mount Thirst
13. Mount Vista
14. Mosquito Cove
15. Observation Post
16. Pyramid Head
17. Pyramid Cove
18. China Point
19. Cove Point
20. Lost Point
21. Mail Point
22. Seal Cove
23. Eel Point
24. Measured - Mile Course
25. West Cove
26. Station Frank
27. Auxiliary Landing Field
28. Station NAM

SAN CLEMENTE ISLAND AND CHANNEL ISLANDS



2. SEALAB III EXPERIMENT

The SEALAB III experiment is being conducted to evaluate techniques and equipment being developed to further Navy operational capabilities in the deep ocean invironment.

The experiment is being conducted off San Clemente Island which is in the Navy's San Clemente Island Range off the coast of Southern California. This range is used to test submarine-launched missiles (such as Polaris, Poseidon, and SUBROC), torpedoes, and other underwater equipment. The San Clemente Island Range is administered by the Naval Undersea Warfare Center (NUWC) at San Diego and Pasadena, California. NUWC is one of the Navy's primary "laboratories" for developing and testing underwater equipment and systems.

The development of techniques and equipment for specific programs to extend the Navy's underwater capabilities are under the management of the Navy's Deep Submergence Systems Project (DSSP) with headquarters in Chevy Chase, Maryland. DSSP co-ordinates work being done by a number of Navy activities and civilian academic and industrial organizations in support of these programs which include underwater search, location, rescue, escape, recovery, salvage, construction.

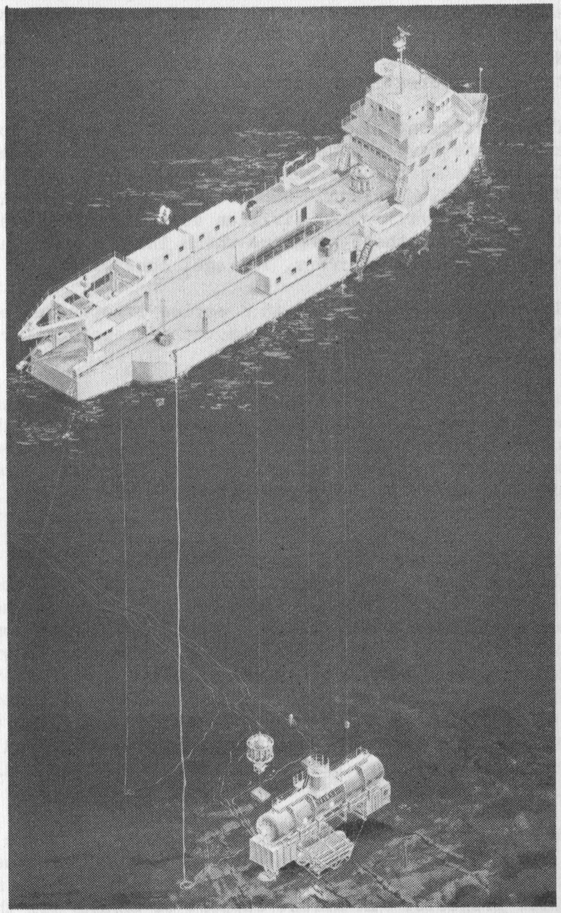
SEALAB III is the latest in a series of open-sea experiments conducted by the U.S. Navy employing the technique of "saturation diving" which is being used in DSSP programs.

During SEALAB III five teams of eight men each, including civilian scientists and foreign Navy personnel, as well as U.S. Navy divers, will occupy a seafloor habitat for consecutive 12-day periods. While on the bottom these "Aquanauts" will carry out experimental construction and salvage work, engage in oceanographic and marine biological research, and undergo a series of physiological and human performance tests.

By employing the technique of "saturation diving" the Aquanauts will be able to work on the ocean floor for an unlimited period, passing freely between their underwater house or "habitat" and the outside water without intermediate decompression. Rather, at the completion of a team's 12-day stay at a depth of 600 feet the Aquanauts will undergo a single decompression period of approximately six days in the safety and relative comfort of the surface support ship. (The decompression in saturation diving is based on depth rather than time, thus the six-day decompression would be required whether they spend 12 days of 120 days on the ocean floor; without decompression they would fall victim to the disease known as "bends" which could be fatal.)

The seafloor habitat will be serviced by the range support ship ELK RIVER (IX-501), a modified Navy landing ship (formerly LSMR-501). This ship is specifically outfitted to support a large number of Navy underwater projects. In direct support of SEALAB III the ELK RIVER has been fitted with the prototype Mk 2 Deep Diving System which will provide a means of lowering the Aquanauts to the bottom, bringing them to the surface, and providing them with proper decompression after they return to the surface.

Prior to the beginning of the ocean-floor program the habitat will be towed to San Clemente Island and lowered to a depth of about 600 feet just off an area known as Wilson Cove. The $57\frac{1}{2}$-foot-long habitat is designed somewhat along submarine principles: it uses water ballast tanks to attain positive or negative buoyancy while maintaining positive stability. During lowering operations the habitat will have approximately 9,000 pounds negative buoyancy.



An artist's concept of the SEALAB III experiment.

As the habitat is lowered into the depths a gas compensating system, which uses compressed helium provided from the surface support ship, automatically increases habitat pressure to a value slightly greater than ambient sea pressure. This gas is provided through an umbilical cable containing separate lines for breathing gas, power lines, communication lines, compressed air, and fresh water. This umbilical cable will be attached to the seafloor habitat for the duration of the experiment. However, the primary source of power and fresh water for the habitat will be through lines to shore facilities on San Clemente Island.

The habitat will also be connected to the surface support ship by an automatic dumbwaiter system. This system will enable transfer of food specimens, and equipment between the support ship and habitat. The system is fully automatic so that no surface support divers or Aquanauts need enter the water to handle the pressurized container.

The Aquanauts themselves will be raised and lowered in two Personnel Transfer Capsules (PTC). These can each transport four Aquanauts from the surface support ship to the vicinity of the habitat, with the Aquanauts actually swimming into the habitat. These Transfer capsules connect directly to the two Deck Decompression Chambers (DDC) in the surface support ship so the Aquanauts can remain under pressure until they begin decompression in the DDCs.

During the 60-day experiment the Aquanauts will conduct a comprehensive bottom program. Most of the activities will be conducted in the immediate vicinity of the habitat, but there will be some relatively long-range forays and excursion dives to greater depths. These dives can be accomplished without intermediate decompression when the Aquanauts return to the habitat. (The Aquanauts are more restricted in the distance they can travel toward the surface; of course, sudden return to the surface without decompression means instant death.)

For 60 days the suceeding teams of Aquanauts will live and work on the ocean floor, pushing forward man's incursion in this last frontier on earth.

When the bottom program is completed the last team of Aquanauts will secure the habitat and ride the PTCs to the surface support ship for their six-day decompression. The habitat will then be raised to the surface, buoyed, and towed to port. The ELK RIVER--with the last Aquanaut team still being decompressed--will also return to port marking the end of the operational phase of SEALAB III. Debriefings and press conferences will be held and the tedious process of evaluating the wealth of data developed in SEALAB III will begin. So, too, will begin the planning of the next phase of the U.S. Navy's Man-in-the-Sea Program.

3.

SEALAB III ORGANIZATION

The SEALAB III experiment is being conducted under the overall direction of the Commander, Naval Undersea Warfare Center, who has control of the test site in the San Clemente Island Range.

On-Scene Commander:

Commander J. M. Tomsky, USN

Commander Tomsky has executive authority over all phases of the actual experiment. Commander Tomsky is "double-hatted" during SEALAB III because, like most of his principal assistants, he has another Navy billet in addition to his position in the SEALAB III organization. Commander Tomsky is also Head, Ocean Engineering Branch, in the Deep Submergence Systems Project and as such is responsible for the development of much of the equipment and technology which is being tested in SEALAB III.

The On-Scene Commander has the following principal assistants:

Deputy On-Scene Commander and Special Assistant for Aquanaut Operations:

Commander M. Scott Carpenter, USN

Commander Carpenter, who piloted the second U.S. orbital space flight, is the Navy's senior Aquanaut. As Deputy On-Scene Commander and Special Assistant for Aquanaut Operations he acts for the On-Scene Commander in his absence or as delegated. He is responsible for the administration of the SEALAB III experiment and is an advisor for Aquanaut safety, operations, and equipment. (He is also Assistant for Aquanaut Operations in the Deep Submergence Systems Project.)

Principal Investigator and Medical Officer:

Captain George F. Bond, MC, USN

Captain Bond began the Navy's experiments in saturation diving and is a physician and submarine medical officer. As Principal Investigator and Medical Officer he is responsible for the health and safety of SEALAB III personnel including the Aquanauts, and directs the bio-medical program. (He is also Assistant for Medical Effects in the Deep Submergence Systems Project.)

Officer-in-Charge, Command Information Bureau:

Lieutenant John C. Dewey, USN

Lieutenant Dewey is responsible for the preparation and conduct of the SEALAB III public affairs program. This program seeks to inform the public and direct public attention to the nature, scope, and significance of the Navy Man-in-the-Sea program. (He is also Public Affairs Officer for the Deep Submergence Systems Project.)

Deputy for Ocean Science and Engineering:

Mr. Denzil C. Pauli

Mr. Pauli is responsible for the coordination and liaison of all Navy activities and other government agencies, scientific and educational institutions, and national and international groups involved in the various SEALAB III ocean floor programs. (He is also a physicist, Ocean Technology Programs, Office of Naval Research.)

Diving Operations Officer:

Captain Walter F. Mazzone, MSC, USN

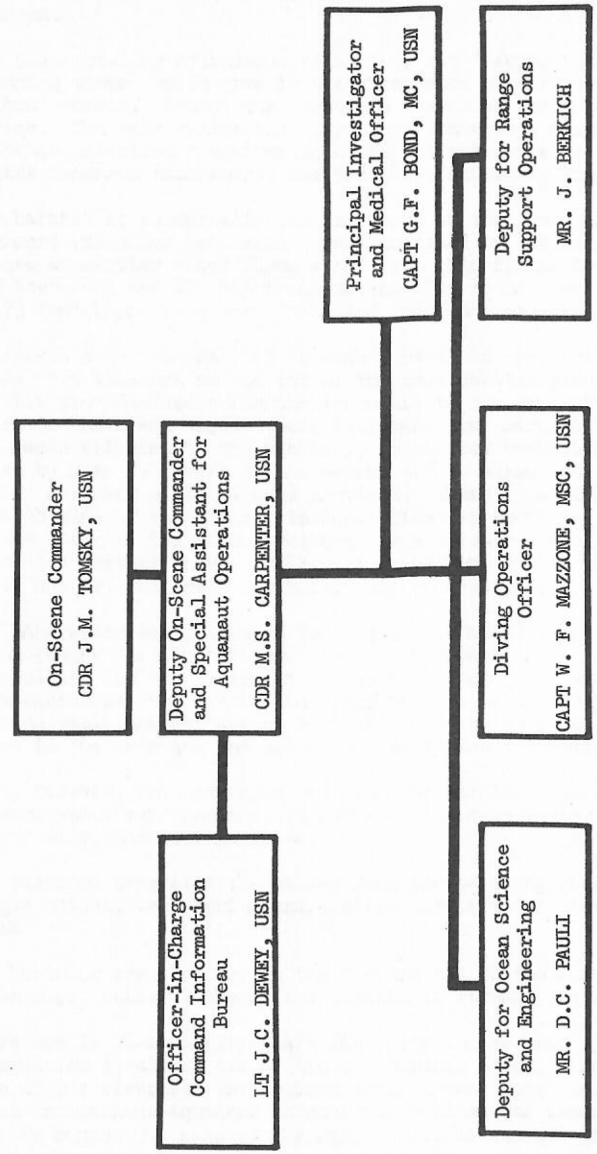
Captain Mazzone, an officer in the Medical Service Corps, is responsible for the supervision and direction of the compression and decompression cycles of the Aquanauts, the surface support diving operations, atmospheric monitoring of the diving system and seafloor habitat, and the engineering instrumentation monitoring of the habitat. (He is also Officer-in-Charge of the Deep Submergence Systems Project Technical Office.)

Deputy for Range Support Operations:

Mr. Joseph Berkich

Mr. Berkich is responsible for the operation of the surface support ship ELK RIVER, the mooring system, shore support facilities on San Clemente Island, the various surface support craft, range liaison, and handling of the seafloor habitat (including lowering and raising evolutions). (He is also Head, Ocean Range Operations Section, Naval Undersea Warfare Center.)

QUICK LOOK: SEALAB III ON-SCENE ORGANIZATION



SEAFLOOR HABITAT

The SEALAB III habitat was specifically designed and outfitted for use as a sea-floor laboratory (SEALAB) in the U.S. Navy's Man-in-the-Sea Program.

The 57½-foot-long cylindrical structure has "capped" ends and a small "conning tower" which give it the appearance of a railroad tank car without wheels. Inside the structure resembles the interior of a submarine. The main cylindrical structure contains a maze of dials, valves, switches, electronic equipment, a compact galley, a bio-medical and marine research laboratory, and berthing facilities for eight Aquanauts.

The habitat is essentially the same used in the previous SEALAB II experiment which has been extensively modified to reflect the experience gained in earlier ocean-floor work. The main cylindrical structure is 57½ feet long and 12 feet in diameter. Two rooms, each 12 feet square by 7½ feet high, have been installed under the main structure.

Aquanauts enter the habitat through a hatch in the diving station, the small room attached to one end of the main habitat structure. The diving station provides space for the Aquanauts to don and doff their diving gear, to check and adjust their equipment, to charge SCUBA tanks (from gas banks attached to the habitat), to control breathing gas being supplied by hose to divers in the water, and to clean and stow swimming gear. A shower stall is also provided. There is a 12-inch view port in each side of the diving station. Directly above the diving station, in the stern of the main structure, is a utility space. This utility space has another shower stall, a combination clothes washer-dryer, hot water heater, and space for additional gear stowage.

The laboratory area, located forward of the utility space, is the operations center for the habitat. It contains panels for monitoring and controlling the atmosphere in the habitat, the power and lighting system, communications, and special instrumentation. Laboratory tables, with sliding table leaves, are on both sides of the area and there is stowage space in the overhead and below the lab tables for equipment.

Going forward, the next area contains the habitat's galley. There is a 10-cubic-foot refrigerator, four-burner electric range, infra-red oven, double sink, and stowage space.

The washroom separates the galley from the berthing area. There is a single toilet, wash basin, and lockers for personal items of the Aquanauts.

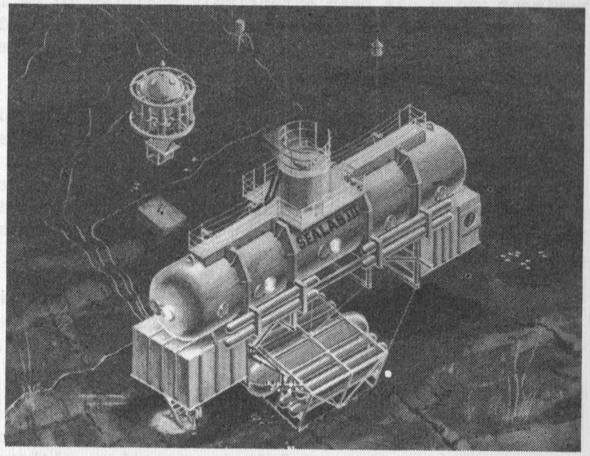
The berthing area, occupying the forward end of the main chamber, contains eight bunks, lockers, and additional stowage space.

There are 11 24-inch plexiglass viewports in the main cylinder providing observation of almost all of the surrounding water. (The number and size of the viewports was decided after a near-fatal accident in SEALAB I; an unconscious Aquanaut outside the habitat was rescued only when his bottles bumped the side of the structure...he was not visible from inside the habitat.

Directly below the berthing area is the observation room. The space is fitted with four large viewports. The habitat's freezer is also located in the observation room and there is a large bottom hatch which could be opened to provide direct access to the sea in the event of emergency.

Atmosphere

The atmosphere of the habitat at a depth of 600 feet will consist of 92.4% helium, 6.0% nitrogen, and 1.6% oxygen (see section on Man-in-the-Sea Program). Relative humidity will be maintained at about 70% with a



Artist's concept of habitat on bottom.

temperature of 90°F. The gas composition of the atmosphere will be established before and during the lowering operation; thereafter, while the Aquanauts are on the ocean floor, the atmosphere will be maintained by gas storage bottles attached to the habitat. The habitat ventilation system was modeled after the standard submarine system with lithium hydroxide (LiOH) CO_2 scrubbers and charcoal filtration.

There are eight 53-cubic-foot bottles mounted on the habitat proper and eight additional gas bottles mounted on the "clump" under the habitat.

Because of the higher thermal conductivity of helium (six or seven times that of normal atmosphere) and the resulting heat loss to the cold surrounding sea water, a "comfortable" temperature of about 90°F is maintained in the habitat. Two-inch cork insulation covers all metal in the habitat which is exposed to the sea. The deck of the main structure, diving station, and observation room are made of concrete with embedded heating cables and there are overhead radiant heaters.

Emergency Systems

Two external oxygen cylinders are used to replenish the habitat's atmosphere with oxygen. The oxygen is automatically bled into the habitat. A sensing device monitors the partial pressure of oxygen in the atmosphere. Upon detecting a loss in partial pressure the oxygen supply is opened automatically and an acoustic alarm is actuated. The oxygen is cut off when the required partial pressure is reached. Each oxygen cylinder has independent piping.

In the event of failure of the automatic sensing device a visual readout sensor is provided. Should both oxygen sensing systems fail a manual oxygen makeup system is provided. This includes two 1.35-cubic-foot oxygen bottles in the habitat.

Finally, an emergency Built-in-Breathing System (BIBS) is provided in the event the habitat's atmosphere becomes contaminated. BIBS manifolds are provided throughout the habitat, including the diving station and observation room and SCUBA mouthpieces, with hoses and regulators to fit the mainfolds, are provided at each bunk (a total of eight) and in the diving station (four).

Lowering and Ballasting Systems

The habitat complex is normally positively buoyant to facilitate handling and towing. A variable ballast system is provided for lowering and anchoring the habitat on the ocean floor.

The variable ballast system consists of three water ballast tanks plus about 2,000 pounds of portable lead pigs located inside the habitat and in trays outside of the habitat and on the "clump" suspended under the habitat. Ballast tank No. 1 is located in the small "conning tower" of the habitat, No. 2 in the overhead of the habitat, and No. 3 in the "clump" under the habitat.

The habitat is made some 9,000 pounds heavy for lowering by flooding No. 1 and No. 2 ballast tanks. The habitat is then lowered to the ocean floor by crane. Once the "clump" rests on the bottom the No. 3 ballast tank is flooded, providing a suitable anchor on the ocean floor. The habitat is attached to the "clump" by a series of cables. Although the ocean floor may be uneven, and hence the clump may be at an angle, the habitat can be maintained in a level attitude by means of automatic tensioning wires attached to the "clump" and the Aquanauts shifting the portable lead ballast in the habitat.

Finally, located beneath the diving station and observation room are two air-tight skirts, 18 inches in depth. The skirts provide a variable volume below each hatch to accomodate fluctions in the water level due to tidal variations and changes in the internal pressure of the habitat.

The following table provides the various buoyancy conditions of the habitat:

Status	Weight (Tons)*	Displacement (Tons)	Reserve Buoyancy (Tons)
Dry Weight for Lift	298.91	---	---
On Surface	306.13	327.29	+21.16
Ready for Lowering (flood No. 2 tank)	320.26	327.29	+ 7.03
During Lowering (flood No. 1 tank)	331.31	327.29	- 4.02
On Bottom (flood No. 3 tank)	348.02	327.29	-20.73
During Occupancy (skirts blown)	340.8	327.29	-13.51

*1 ton = 2,240 pounds

Thus, while the habitat is on the bottom the main structure will have a buoyancy of +39.39 tons and will therefore be positively buoyant and anchored to the seafloor by the "clump."

Diver Support

While the habitat is on the seafloor the Aquanauts will regularly exit into the surrounding water to perform work tasks and conduct experiments. They will use the Mk VIII semi-closed SCUBA rig when in the water, with their breathing gas supplied from umbilical hoses from the habitat or back tanks. (See section on Aquanaut Equipment.) The habitat diving station will have facilities for maintaining and charging the back tanks. Moored outside the diving station six umbilical hose storage racks, two holding 600-foot hoses for excursion dives and four 200-foot hoses for normal, at-depth operations.

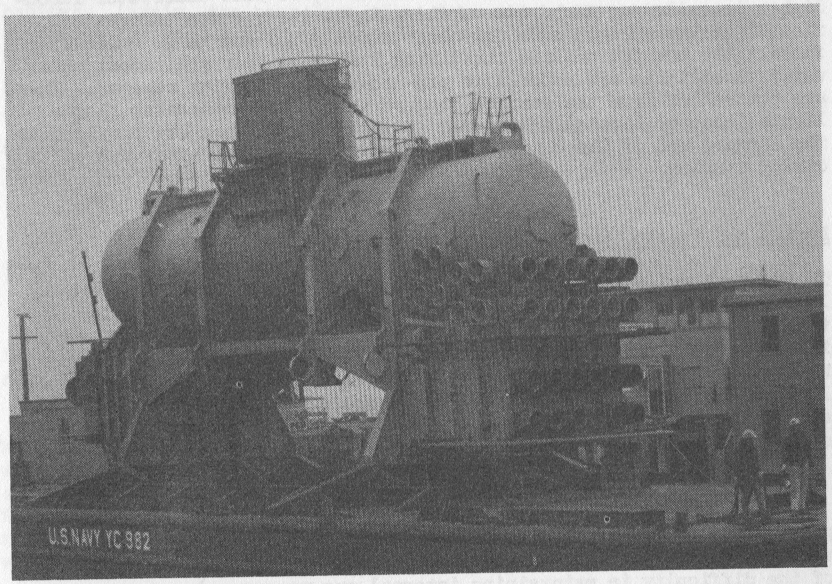
Electric Power System

The total capacity of the habitat power system is 152 kilovolt-amps (KVA) which is normally supplied from San Clemente Island via an underwater transformer bank. Alternate power, in the case of primary power failure, is supplied from the surface support ship ELK RIVER.

All habitat equipment operating on 440 volts is supplied from a main power panel. Three other panels are supplied by circuits from the main power panel. The 440-volt equipment supplied through the main power panel are: winch motor for the surface transfer system, hot water heater, ventilation power panel, flood-light transformers, infra-red oven, and washer-dryer.

The 120/208 volt distribution power panel is through three 37.5 KVA transformers which are supplied from the main power panel. This distribution power panel supplies the 120 and 208 volt loads throughout the habitat. The electric range and main habitat deck heating are supplied directly from this panel. All other loads are supplied via five area distribution panels, three in the main cylinder and one each in the observation room and diving station.

Electric heating cables embedded in the concrete decks of the habitat have adjustable area controllers to regulate automatically the amount of heat generated by the cables. In each case a transfer switch has



The seafloor habitat being fitted out.

been provided to enable manual on-off control should the automatic controllers fail. (Other electric heaters located in the habitat include 13 overhead radiant heaters, duct heaters in the air-conditioning system, and the water heater. These are individually controlled by switches in the area distribution panels plus an integral thermostatic control in the water heater.)

The habitat interior lighting system consists of overhead ligts, bunk lights, and hand lanterns.

The overhead lighting in each area is controlled by a high-off-low toggle switch. The "low" position is for normal usage and the "high" position for photographic lighting. In addition, the overhead lights in the laboratory and galley areas can be controlled from the surface support ship for photographic purposes.

Each berth has a small light which is controlled by the individual in the bunk.

Two red standing lights are installed in the main cylinder, one over the hatch to the observation room and one over the hatch to the diving station. There is also a red standing light over the entry hatch to the diving station.

Exterior habitat lighting consists of four 1,000-watt underwater floodlights installed on each side of the main habitat, seven underwater floodlights mounted outside the observation room, and three underwater floodlights mounted outside the diving station. Four additional underwater floodlights are mounted on pan-and-tilt units with cameras. These are controlled from the surface support ship. Two underwater floodlights (snooper lights) at the end of an extension cord are provided at the forward end of the observation room and two at the after end of the diving station.

Design and Construction

The habitat was constructed at the San Francisco Bay Naval Shipyard in 1965 specifically for use in the SEALAB II experiment. The design of the habitat was dictated primarily by experience in the SEALAB I experiment (in which two floats had been welded together to form the basic habitat). The design for the new SEALAB habitat was constrained by the limited time available before SEALAB II was scheduled to take place and a restricted budget. The influence of SEALAB I on the new habitat included:

1. The new habitat would be a pressure vessel capable of being pressurized prior to submergence. (SEALAB I habitat was a non-pressure vessel and had flooded several times during lowering operations because of the difficulty in maintaining internal gas pressure.)

2. The habitat would be unmanned during lowering and emplacement. (The importance of personnel safety was a paramount consideration.)

3. The habitat would be cylindrical and approximately 50 feet long and 12 feet in diameter. (SEALAB I habitat was cramped and indicated that the 50 by 12 foot dimensions would be optimum for up to Aquanauts and their equipment.)

4. The habitat should have four separate areas: entry, laboratory, galley and living space. (This basic arrangement worked well in SEALAB I.)

5. Special features must be included to hold habitat heat. (The coefficient of heat transfer of helium is approximately six times that of air, thus special provisions must be made for supplying and retaining heat in the habitat.)

6. Temperature in the habitat would be maintained at about 90°F, with a relative humidity of 60 to 70%. (These conditions were satisfactory in SEALAB I.)

7. There would be a maximum possible number of portholes in the habitat. (Again, the near-loss of an Aquanaut in SEALAB I gave the requirement for visual observation of the work area from the habitat a high priority.)

8. Internal habitat volume was to be reduced where possible by use of interior ballast tanks, dead spaces, etc. (Decreases in interior volume reduced the amount of helium required, thus reducing cost.)

9. The habitat would be painted white. (The international orange color of SEALAB I did not have the underwater acuity of white.)

10. An improved ballast system must be provided. (A major problem in SEALAB I was the ballast system, which included using 300-pound railroad axles as variable ballast; a most awkward system.)

With this data, the San Francisco Bay Naval Shipyard commenced final design and construction of the habitat. The steel selected for the main structure was 1-inch thick mild steel, Grade M, of Military Specification MIL 5-16113 and, as such, received extensive testing at the rolling mill. The plate was ultrasonically inspected at the shipyard. All welds were radiographed and found defect-free.

In general, standard shipyard procedures were used in all phases of construction and testing. Fabrication of the large, 24-inch view ports was extremely difficult because the tolerances were very close and hard to maintain in the face of normal welding distortions.

One of the most difficult problems was fabrication of the dished heads used to cap the main cylinder of the habitat structure. Once the design specifications were established, contract bids were let to the normal commercial suppliers of large dished cylinder heads. The SEALAB II production schedule demanded delivery in 30 to 45 days. None of the major steel companies could even approach the deadline. The large size of the heads (12 feet in diameter) coupled with a rash of back orders due to an impending steel strike, made normal procurement impossible. The earliest delivery that could be expected was five to six months after the scheduled start of SEALAB II.

Fortunately, the shipyard had the Navy's West Coast Shock Testing Facility and thus had a goodly amount of experience in controlled underwater explosions. The use of energy released in an underwater explosion to form metal was a novel idea, until 1965 used only to form relatively small and simple pieces. In this process the energy of the explosion is transmitted as a pressure pulse through the water, forming the steel against a die. The forming process lasts only a few milliseconds. The use of this process to form large and complex sections like the dished heads of the SEALAB II habitat had not previously been attempted.

Several problems became apparent: die design and construction, including the curing of the concrete form, handling and rigging, and configuration and size of the explosive charge. Briefly, a large die, $14\frac{1}{2}$ feet in diameter and $5\frac{1}{2}$ feet high, filled with a special-formula quick-curing concrete, was designed and build. A blank of steel was placed over the die and a vacuum was drawn under the blank. This vacuum was extremely important because any trapped gas would have to vent when the head was formed, thus wrinkling the edges. One hundred pounds of C-4 plastic explosive were rigged in two concentric rings with a central charge. The calculations for the explosives were extremely complex as were those for the depth of water at detonation.

The entire forming assembly, weighing 60 tons, was lowered 30 feet beneath the surface of San Francisco Bay using the shipyard's large gunning crane. The explosives were detonated and, in approximately 0.004 seconds, the first dished head for SEALAB II was formed.

The results were phenomenally good with only minor straightening being required. The second head was similarly formed. The heads checked with 1/16 inch of planned diameter and within 1/4 inch of palnned contour, well within acceptable parameters.

The significance of the feat can best be illustrated with exeerpts from a United Press International story in the Gazette (Berkeley, California), dated 18 November 1965, several months after the shipyard formed the dished heads for SEALAB II.

> Denver (UPI) - a metal shaping process...is being studied by Martin Co. and Denver University scientists for possible use in forming missile domes, side plates for ships, and other large structures.
>
> The technique was demonstrated Wednesday with the production of... ash trays.
>
> It involved the placing of a sheet of metal across a die or mold, then submerging the mold and metal in water. An explosive charge was detonated a few inches away, beneath the water, causing a shock wave to blast the metal into the mold.

> The experiment is being conducted under a one million dollar government grant by DU's Denver Research Institute and the Denver division of the Martin Company. It is expected to take three years to prove or disprove the process.

SEALAB III Modifications

On the basis of experience in SEALAB II, the 205-foot, 45-day saturation diving experiment conducted in 1965, several modifications were made to the habitat for its use in the SEALAB III experiment.

Ten-man teams in SEALAB II were found to be too large for "comfortable" living and efficient bottom operations. Accordingly, an optimum eight-man team has evolved resulting in improved habitat bunking arrangements.

The relatively crowded conditions of SEALAB II also led to installation of the two small rooms under the main cylindrical structure, one an observation room and one a diving station. Also, having the Aquanauts enter and leave the habitat through the diving station the humidity in the main habitat is reduced.

Finally, when the SEALAB II habitat was emplaced on the ocean floor it had a 6-degree list to port and a down trim of 10 degrees by the stern. This angle led to the habitat being referred to as the "tilton Hilton" by the Aquanauts and created some minor problems. To alleviate chances of the SEALAB III habitat being at an angle because of the ocean floor contours, the habitat was fitted with a "clump," a package consisting of a water ballast tank and eight gas bottles suspended underneath the main structure (between the diving station and observation room).

During emplacement the habitat has a slight positive buoyancy with the clump serving as an anchor. After the clump has settled on the bottom its water ballast tank (No. 3) is flooded and tensioning cables lock the habitat to a rigid position parallel with the true horizontal rather than the slope of the ocean floor.

QUICK LOOK: SEALAB III HABITAT

Length		Height (from ocean floor)	
overall	62 ft 6 in	diving station entrance	6 ft 6 in
main cylinder	57 ft 6 in	diving station floor	8 ft
Width		main cylinder floor	17 ft 6 in
maximum	19 ft	top of main cylinder	29 ft 6 in
main cylinder	12 ft	top of conning tower	38 ft

Clump

length 22 ft

width 19 ft

height 8 ft

Weight

dry weight to life 298.91 tons

(1 ton = 2,240 pounds)

Habitat gas requirement

helium 107,565 cubic feet

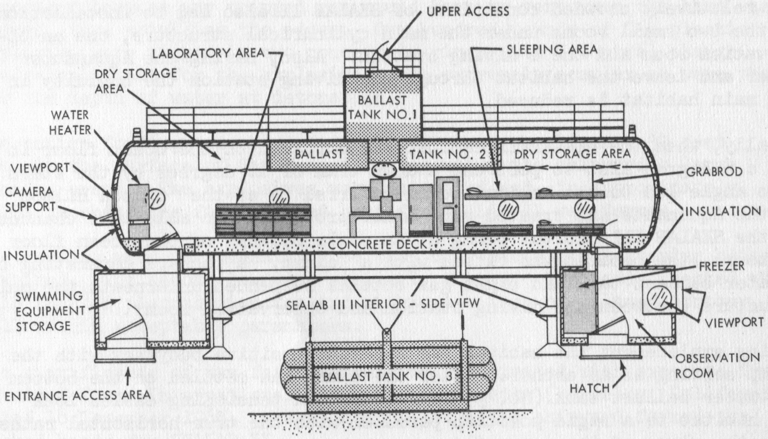
oxygen 1,935 cubic feet

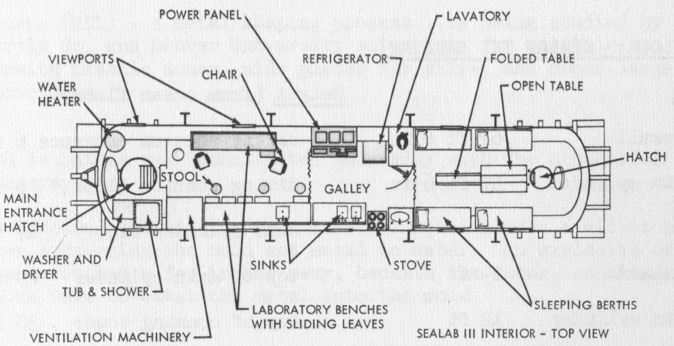
Gas bottles (53 cubic feet)

mounted on habitat 8 (2 oxygen, 2 emergency breathing gas, 4 diver breathing gas mix)

mounted on clump 8 (helium)

in habitat 2 (emergency breathing gas mix for BIBS)





5.

OCEAN FLOOR PROGRAMS

A series of comprehensive ocean floor programs are being undertaken in SEALAB III to further the U.S. Navy's knowledge and capabilities in the areas of oceanography, equipment engineering, construction, salvage, marine biology/ecology, human performance, and physiology.

The following descriptions cover the various programs and individual tasks and projects within these programs. A listing of these tasks and sponsoring activities will be found in the Quick Look at the end of this section. (More extensive data on specific programs are available from the SEALAB III Command Information Bureau.)

Oceanography

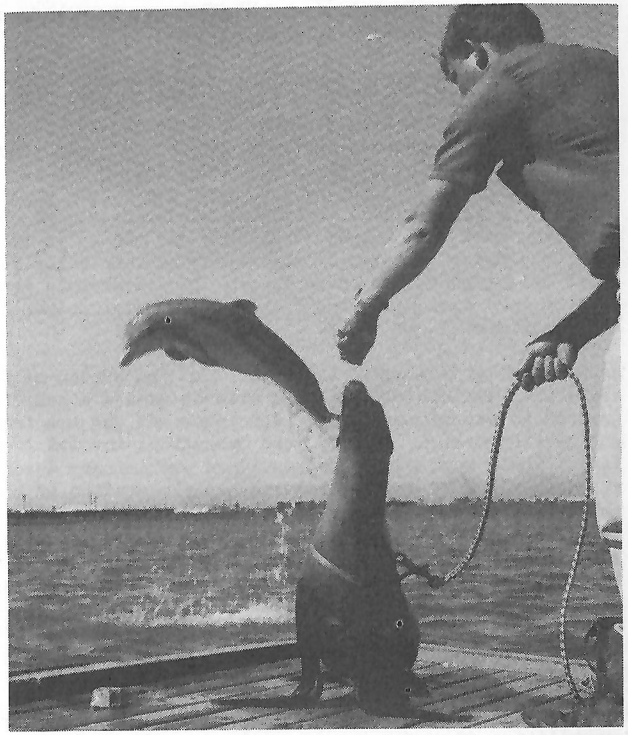
Within the oceanography program there are tasks being conducted in physical and biological oceanography, marine mammal use, geology, and bio-acoustics. This program will reveal more about the deep ocean environment. The data obtained in these tasks will aid in the development of improved capabilities for military, economic, and other uses of the depths. The oceanography tasks are:

Physical Oceanography: Installation of a number of devices on the ocean floor including current meters, thermographs, tide gauge, underwater oceanographic array, temperature recorder, bioluminescence meter, radiance meter, and salinity meter. The underwater oceanographic array--which is in addition to other measuring devices--will record temperature and current data at three levels above the bottom at least every two minutes. A falling-ball turbulence study, developed by Captain Jacques Cousteau, will investigate turbulence and eddies in the ocean by plotting the impact location of negatively buoyant balls released from a given height above the ocean floor. (Oceanographic measurements will also be made from the surface and in the water column during the SEALAB III experiment.)

Marine Biology/Ecology: Aquanauts from the Bureau of Commercial Fisheries will conduct work in this area to create a cadre of personnel trained in saturation diving techniques and who are familiar with engineering design, support, and operations involving seafloor habitation. Their work will also provide a preliminary assessment of the research value of observation and experimentation in the ocean environment. Further development of the undersea laboratory concept as a research technique for oceanographic and fisheries work can be expected to yield large benefits to marine resource development efforts. In this task diver-scientists will undertake a variety of short-term experiments including lobster transplant studies, light attraction studies of fish and invertebrates, and observations of fish species behavior and interaction. Another phase of bottom biology work will study light production by biological organisms.

Marine Mammal Uses: This effort will determine behavioral and physical capabilities of marine mammals and, secondly, help to develop training techniques which will employ these capabilities to support men working in the sea. During SEALAB II an Atlantic bottlenose porpoise named

"Tuffy" was used to demonstrate the feasibility of employing a marine mammal to aid a lost Aquanaut and deliver tools, messages, and other objects. Two wild sealions also befriended the crew of SEALAB II; they could be called by the Aquanauts and fed by hand, and surfaced in the well of the SEALAB II habitat to breath the helium-oxygen atmosphere before returning to the surface. Tuffy returns to the Navy Man-in-the-Sea porgram in SEALAB III along with another porpoise and two sealions. They will be used for search and rescue of lost Aquanauts, delivery of small items, propulsion aid, and to demonstrate search and rescue techniques for lost Aquanauts. Small items, such as tools and specimen containers, will be attached to a mammal's harness for delivery between the habitat and surface, habitat and divers, and two or more divers working in the open water. During the tests an Aquanaut will also use an acoustic device to signal he is lost; the mammal is expected to respond by picking up a tethered line at the habitat and carrying it to the Aquanaut.



Training "Tuffy" the porpoise and a sealion for work in the SEALAB III experiment.

Geology: The emphasis in geological oceanography will be observation of sedimentological processes such as transport, scour, and structural settlement which have heretofore been unattainable by conventional divers. Current measurements and time-lapse photography will be used in support of the sediment transport studies.

Bio-acoustics: During SEALAB III, efforts will be made to employ the advantages gained with bottom habitation in the identification of sounds produced by marine organisms. This work will involve placing hydrophones on the bottom at distances of 50 to 100 feet from the habitat and recording under "quiet" conditions as well as normal sub-surface operating conditions.

Engineering

Communications: This work will determine the effectiveness of communications equipment and gather fundimental data on helium speech in the areas of intelligibility with the BQC underwater telephone, helium speech unscrambler, and between Aquanauts inside the habitat; voice changes vs. time in a helium atmosphere; learning to understand helium speech vs. time on bottom; and general underwater communication tests.

Exposure Suit and Face Mask Evaluation: These tests are part of an effort to extend diver work time in the ocean depths by providing protective yet non-restrictive exposure suits and face masks. Electric-wire suits and hot water circulating suits will be used by the Aquanauts in SEALAB III. (There was limited testing with earlier electric-wire suits in SEALAB II.)

Engineering Evaluation: This effort will evaluate the effectiveness of various seafloor habitat systems and equipment. The data collected will provide topside personnel with current information concerning all life support systems in the habitat. This same data will later provide parameters and criteria for future seafloor installation designs. Major areas being studied are structural, such as ports, hatches, access openings, drains, ballast, penetrations; systems, such as the ballasting system, pressure control, plumbing, food storage, and habitability, such as space utilization, safety, and comfort.

Construction

The construction experiment in SEALAB III will help determine the ability of divers to assemble structures on the ocean floor. In this experiment four Aquanauts will assemble a repair and storage station near the seafloor habitat.

The Aquanauts will use an underwater "trolley" system, with a variable buoyance pod containing a hydraulic winch to provide lift, to move prefabricated sections of the structure along the ocean floor. The sections will be assembled with quick-connect/quick-release fasteners. A buoyant "chandelier" will be suspended over the structure to provide area lighting.

The completed station will be 10 feet high and have a 10-foot diameter with the bottom open to the sea to provide entry. A grillwork in part of the opening will serve as a floor. After the structure is assembled it will be blown dry and outfitted with shelves, interior lights, and other accessories for use as a repair and storage station.

Salvage

A primary purpose of the U.S. Navy Man-in-the-Sea effort is to improve underwater salvage techniques. Thus, a major portion of the SEALAB III experiment is devoted to this area of interest.

Bottom Stabilization: A chemical bottom overlay spray will be tested in an effort to reduce bottom turbidity to enable more effective work by divers.

Lift Systems: Four salvage lift systems will be tried during SEALAB III. These are (1) a small, rugged, self-contained lift system consisting of a 70-cubic-foot buoyancy pontoon and a hydrazine gas generator; (2) an 8.4-ton lift collapsible pontoon inflated by surface supplied air; (3) the Hunley/Wischhoefer Lift System which consists of a 25-ton salvage padeye, a variable buoyancy messenger buoy, and a remote coupling device for attaching the lifting point of the object being salvaged to the lifting wires of a surface ship; and (4) a small, self-contained variable buoyancy system including attachments for moving small objects (100-200 pounds) along the bottom.

Diver Tools: Four improved diver tools will be evaluated in SEALAB III, an explosive cable cutter, explosive stud driver, electric-powered hand tool, and oxy-arc burning equipment. The electric hand tool is a mulit-purpose device which works on the impact principle. This will aid diver work when no firm surface is available to help the diver steady himself against the effects of conventional torque tools. The problems of providing oxygen through hoses for deep-depth use of oxy-arc burning tools will also be examined.

Search Procedures: Improved methods of locating objects on the ocean floor will be tested, among them a "spider web" of light grid lines, lines carried between Aquanauts, and a new type of circling line. These tests will help divers locate objects within a work area when working in the murky, deep-depth bottom environment.

Biology

Bacteriology: During previous saturation diving experiments Aquanauts have developed infections and microorganisms have been transferred among personnel. The logical extension of this is to determine the susceptibility or resistance to infection of man in the seafloor environment. Related studies will also be conducted during the SEALAB III experiment.

EKG Telemetry: This task will study cardiac performance and body temperatures of Aquanauts at different depths, water temperatures, and conditions of physical and mental stress. Cardiac performance will be monitored by telemetering and electrocardiogram while the divers are in the water as well as in the seafloor habitat.

Heated Diver's Dress and Thermal Balance: This phase of the biology program will investigate body heat loss due to the helium-oxygen atmosphere of the seafloor habitat and the effectiveness of protective thermal equipment when the Aquanaut is in the water.

Sleep Studies: Investigations will be conducted in sleeping habits of Aquanauts exposed to prolonged living in the high-pressure, helium-oxygen, semi-isolated, and stress conditions of the seafloor habitat.

Human Performance

Speech and Manual Dexterity: These experiments are directed at determining whether there is any performance decrement at various depths with observations being made at the surface, 8 feet, 200 feet, 300 feet, 400 feet, 450 feet, and 600 feet. The performances being observed include helium speech, fine and gross manual dexterity, and associative memory.

Salvage Tasks: This task will measure diver performance during the execution of various work and salvage activities. The emphasis in the human performance program is on developing procedures and work doctrine rather than testing equipment.

Construction Tasks: The purpose of this task is to measure diver performance during several underwater projects involving the use of hand tools, moving and manipulating heavy pieces of equipment, and extensive co-ordination among Aquanauts as well as surface support personnel.

Visibility Tasks: This experiment is designed to test underwater visibility of Aquanauts in the open sea and in the seafloor habitat.

Crew Observation: This experiment seeks to develop a better understanding of the behavior of individuals and crews in the special environments saturation diving and the seafloor habitat. Some of the data will answer such questions as: How does man respond to this environment? What kind and how much work can he best perform? How will he get along with other divers? What will be his relationship to "topside" society? How will he react emotionally? How do his reactions compare to those of other men exploring unusual environments such as Outer Space, the Antarctic, Mt. Everest, and other remote areas. How should SEALAB crews be organized? During SEALAB III the Aquanauts will be observed by closed-circuit television, monitored by open microphones, and extensively interviewed in an effort to obtain answers to these and many other questions.

The above ocean floor programs have been formulated under the direction of the Office of Naval Research and during the SEALAB III experiment are under the direction of the On-Scene Commander's Deputy for Ocean Science and Engineering, Mr. Denzil Pauli. In addition, several other programs, related to the above, will be conducted during SEALAB III. These are:

PHYSIOLOGIC TEST PROGRAM

The SEALAB III Aquanauts will undergo extensive physiologic testing before, during and after the ocean floor experiment. Specific tests being conducted on Aquanauts include measurement of: oral body temperature, blood pressure, pulse rate, body weight, and body height. All tests begin three days before the individual Aquanauts are scheduled to descend to the ocean floor to obtain a satisfactory baseline for comparison of data procured during their period of bottom habitation. These tests are repeated for three days after they return to the surface or until the measurement return to normal pre-dive range.

Most of the physiologic testing is being carried out on Teams No. 1 and No. 2 so that changes, if they occur, may be assessed early in the experiment. In addition to the tests listed above, which will be made on all members of the first two teams, selected Aquanauts will serve as subjects for urine studies, electrocargiograms, respiratory studies, investigation of the effects of pressure on bone, exercise tolerance tests, electroencephalograms, and deuterium oxide studies of total body water.

This physiological test program will be conducted under the direction of the SEALAB III Medical Officer and Principal Investigator, Captain George F. Bond.

ATMOSPHERIC CONTROL

Detailed studies of the problems and capabilities of atmospheric control in seafloor habitation will be examined by the Naval Research Laboratory during the SEALAB III experiment.

AQUANAUT EQUIPMENT

In addition to Aquanaut equipment evaluation in SEALAB III which was described earlier in this section, the Westinghouse Branch of the Deep Submergence Systems Project will conduct studies in this area.

HUMAN ENGINEERING EVALUATION

Comprehensive studies of human engineering factors in living and working on the ocean floor are being examined during SEALAB III by specialists from the Deep Submergence Systems Project, the Office of Naval Research, and the Submarine Medical Center.

QUICK LOOK: SEALAB III OCEAN FLOOR PROGRAMS

Task Titles	Task No.	Lead Activity
OCEANOGRAPHY		
Physical	O-1	Navy Mine Defense Laboratory
Biology/Ecology	O-2	Bureau of Commercial Fisheries
Marine Mammal Use	O-3	Naval Undersea Warfare Center
Geological	O-4	Naval Oceanographic Office
Bio-acoustics	O-5	Naval Undersea Warfare Center
Biology	O-6	Naval Oceanographic Office
ENGINEERING		
Communications	E-1	Navy Mine Defense Laboratory
Exposure Suit & Face Mask	E-2	Same
Habitat Engineering	E-3	Same
CONSTRUCTION		
Structure	C-1	Naval Civil Engineering Laboratory
SALVAGE		
Bottom Stabilization	S-1	Supervisor of Salvage & Naval Civil Engineering Laboratory
Lift Systems	S-2, S-3 S-4, S-11	Same
Diver Tools	S-6, S-7 S-8, S-9	Same
Search Procedures	S-10	Same

BIOLOGICAL		
Bacteriology	P-1	Naval Medical Research Institute
Sleep Studies	P-2	Deep Submergence Systems Project
EKG Telemetry	P-3	Philadelphia General Hospital
Heated Diver's Dress & Thermal Balance	P-4	Naval Medical Research Institute
HUMAN PERFORMANCE		
Speech & Manual Dexterity	D-1	Navy Experimental Diving Unit & Office of Naval Research
Salvage Tasks	D-2	Supervisor of Salvage & Office of Naval Research
Construction Tasks	D-3	Naval Civil Engineering Laboratory & Office of Naval Research
Visibility Tasks	D-4	Navy Mine Defense Laboratory & Office of Naval Research
Crew Observation	D-5	Naval Medical Research Institute & Office of Naval Research
PHYSIOLOGIC TEST		Deep Submergence Systems Project
ATMOSPHERIC CONTROL		Naval Research Laboratory
AQUANAUT EQUIPMENT		Deep Submergence Systems Project
HUMAN ENGINEERING EVALUATION		Deep Submergence Systems Project, Office of Naval Research & Submarine Medical Center

TEAM ASSIGNMENTS

TEAM 1

Team 1 will make basic physiological measurements to confirm baseline data obtained in chamber tests at the Navy Experimental Diving Unit. This team will also set up the habitat and the oceanographic equipment to be used throughout the ocean floor experiment. Marine fauna concensus studies will be conducted to determine the marine conditions at the start of the experiment.

TEAM 2

Team 2 will concentrate on salvage tasks. Included in these tasks are the use of special lift equipments, hydrazine generators, stud guns, and cutting and other special tools. Evaluation of thermal protective clothing will be conducted by this team.

TEAM 3

The primary role of Team 3 is underwater construction requiring team effort and assembly. The team will transport heavy material over the ocean floor using special lift devices when precision positioning is required for assembly procedures. The oceanographic program conducted by this team includes a survey of the ocean floor biological life and behavioral activities.

TEAM 4

Team 4 will conduct intelligibility studies on Aquanaut life in the sea-floor habitat, including communications between Aquanauts in the water, between Aquanauts in the water and the habitat, and between the habitat and surface support ship. This team will also investigate soniserous marine life in the area, employing photographic and sound recording techniques. Aquanauts on this team will also investigate the materials involved in the construction work performed by Team 3.

TEAM 5

Team 5 will be responsible for completing specific tasks not finished by the previous teams. In addition, this team will investigate the geology of the area and the engineering properties of the ocean floor sediments in the area. A significant portion of this team's bottom time will be directed toward work in the outside water and evaluation of long-length umbilicals which are to be used in small object search and recovery operations. Finally, this team will prepare the habitat and other ocean floor equipment for recovery upon completion of the ocean floor phase of the experiment.

ALL TEAMS

Human behavioral studies will be conducted by all five Aquanaut teams and special human performance studies will be made in conjunction with the salvage work done by Team 2 and the underwater construction project of Team 3.

SEALAB III Aquanaut Wallace Jenkins is shown doning an electric-wire heated suit during the previous SEALAB II experiment. An improved electric-wire suit is being used in the current experiment.

6.
COMMUNICATIONS AND MONITORING

Communications and monitoring are key functions in the SEALAB III experiment. By its very nature, SEALAB III is probing heretofore unvisited areas of human endeavour. Never before have men and equipment operated so long at so great a depth. Thus, intensive and continuous communications and monitoring are required to determine the condition of men and equipment.

The task is difficult in the SEALAB III environment: the equipment must function in conditions of (1) high humidity, (2) high pressure, (3) low temperature, and (4) helium atmosphere. Further, man himself is hampered in communication because of the high pitch which helium imparts to his voice making his speech extremely difficult to understand (this is known as the "Donald Duck" effect).

Thus, extensive communication systems have been established linking together the seafloor habitat, surface support ship, divers in the water and in decompression, and shore support facilities. The communication systems consist of electrowriters, Bogen intercoms, open microphones, sound-powered telephones, UQC/BQC Sonic "underwater telephones," diver intercom, closed-circuit television and entertainment systems. All of these systems are controlled or monitored by the command van on the surface support ship ELK RIVER with all signals except the UQC/BQC being transmitted through the umbilical cable connecting the support ship and the habitat. (Diving system communications are discussed separately in another section of this handbook.)

Electrowriters

Two electrowriters are installed in the seafloor habitat, one in the laboratory area and the second in the observation room. These transmit information as it is written or drawn. This system does not require voice imputs and thus is not affected by helium speech distortion.

Bogen Intercom

There are two separate Bogen intercom systems in the SEALAB III complex with a total of seven intercom stations. One system connects a unit in the command van to the laboratory area of the seafloor habitat; the second system has intercom units located in the command van, at the diving station of the support ship, and inside the habitat in the lab area, observation room, and diving station.

Open Microphones

Open microphones are located in the habitat in the observation room, diving station, laboratory, galley, and berthing area. These provide continuous, one-way transmission to the command van and to San Clemente Island. The open microphones are used primarily for psychological studies but also provides an instantaneous warning capability in the event of trouble in the habitat.

Sound-Powered Telephones

Two sound-powered phone systems are provided between the command van and habitat in the event electrical power is lost. Both of the habitat phones are located in the lab area. A third sound-powered phone connects the habitat with the shore facility on San Clemente Island for use if the support ship is forced to leave the test area.

UQC/BQC "Underwater Telephone"

A battery-powered BQC voice communication unit is mounted in the habitat (transceiver in the lab area) for communication with the support ship in the event the umbilical cable is broken. This equipment uses sound waves to transmit human voices through the water. The BQC is compatible with the UQC underwater communications equipment mounted in the support ship (with transceivers in the diving station control room) and in the two Personnel Transfer Capsules.

Diver Intercom

The diver intercom system provides the primary means of communicating with Aquanauts performing tasks in the open sea. Up to six Aquanauts working in the water can be "plugged in" to the intercom system with the communication lines joined with their air hoses from the habitat. The Aquanauts' signals are switched through the habitat to the command van where helium unscramblers will make their voices understandable and return the signal to the habitat and back to the Aquanauts. A second "diver intercom" system will connect the habitat laboratory area with the command van, again providing for unscrambling of the helium-speech signals.

Closed-Circuit Television

There are four closed-circuit television cameras mounted in the habitat and three mounted outside the habitat. The interior cameras provide coverage of the galley, laboratory, diving station, and observation room. Monitors for these cameras are installed in the medical van and command van on the surface support ship.

Entertainment Systems

A television monitor is mounted in the habitat's lab area to enable the Aquanauts to view commercial TV programs. The video signals for this system originate in the command van and are transmitted to the habitat via the COAX patch panel in the ELK RIVER's instrumentation room. FM speakers are located in the berthing and lab areas for receiving FM music and general announcements (these signals are transmitted direct from the command van).

Engineering Instrumentation

The experimental nature of SEALAB III requires continual and accurate monitoring of conditions in and around the seafloor habitat.

The engineering instrumentation includes about 70 sensors, among them: flow sensors to monitor oxygen and helium content of habitat air; operating time sensors for water heater, washer-dryer, dehumidifier pump, freezer and refrigerator doors; dew point sensors for intake and discharge of dehumidifier; relative humidity sensors; thermostat setting sensors to monitor freezer, refrigerator, and deck heating; temperature sensors for habitat interior and exterior; power sensors for various motors and heaters and main electric power; pressure sensors for the habitat atmosphere and 16 gas stowage bottles; electrocardiograph (EKG) sensors with transducers located inside and outside of the habitat; and oxygen partial pressure meters to monitor the oxygen content of up to six Aquanaut breathing units simultaneously.

Most of these sensors provide data to an engineering evaluation console in the command van. The console has automatic recording devices to enable continuous unattended monitoring and provide data for later evaluation.

(In addition, a number of alarm systems are provided to activate when sensors indicate other than desired conditions.)

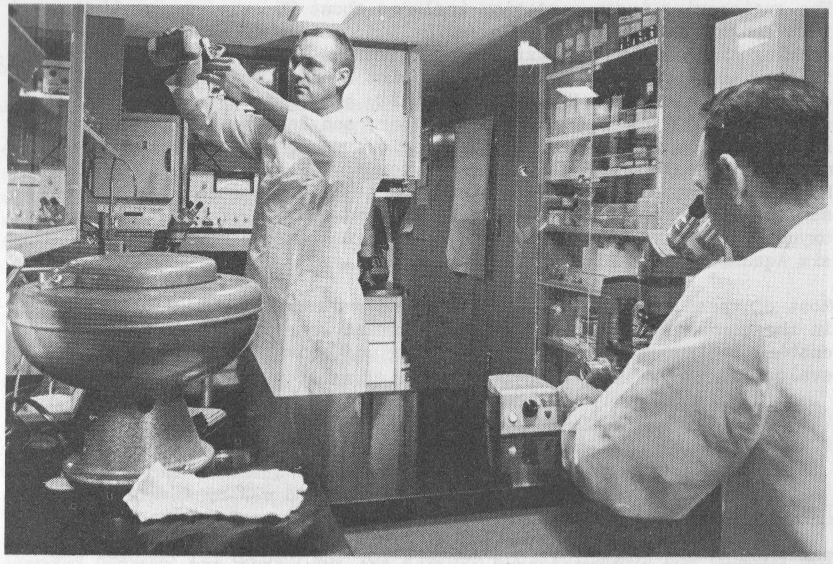
Integrated Command and Medical Vans

The command and communications centers for the SEALAB III complex are the Integrated Command and Medical (IMC) vans located on the surface support ship ELK RIVER.

The command van has dual communication stations which serve as monitors and switchboards for virtually all communications with the seafloor habitat. These facilities enable the SEALAB III on-scene commander and his staff to communicate with the habitat, Aquanauts in the water, shore and ship support facilities, and the diving system in the ELK RIVER. The engineering evaluation console is also installed in the command van. In addition, the van has an office for the on-scene commander.

The adjacent medical van has complete facilities for monitoring the atmosphere in the SEALAB III complex and the psychological condition of divers. The gas chromatograph in the medical van, which can sample air in the habitat and anywhere in the diving system, is manned at all times because of the fatal consequences of variation in the prescribed breathing gas mix for Aquanauts.

Other equipment in the medical van will allow Navy doctors to perform complete laboratory tests on Aquanauts while they are on the ocean floor (using blood samples brought up in the dumbwaiter system) and, of course, while the Aquanauts are on the surface before and after a dive. The histological parameters which can be measured by equipment in the medical van include electrocardiography, blood chemistry, urinalysis, gas uptake and elimination, culture studies, and respiration.



Technicians use the complex equipment in the integrated SEALAB III Medical Van (top) and Command Van (above)
(Northrop Nortronics Photographs)

Both vans are constructed of aluminum and are 26 feet long, 8 feet wide, and 8 feet, 7 inches in height. As mounted on the ELK RIVER they are connected by a flexible passageway. The vans have independent heating and air conditioning systems, which use electrical power from the ship, and a toilet is installed in the command van. During SEALAB III the vans are welded to the deck of the ELK RIVER and are designed for rapid removal for use ashore or afloat in later experiments and research.

QUICK LOOK: SEALAB III COMMUNICATION STATIONS (less Diving System)

	Command Van	Medical Van	Seafloor Habitat	ELK RIVER Diving Station	San Clemente Island
Electrowriter	2		2		
Bogen Intercom	2		4	1	
Open Mikes	M		5		M
Divers Intercom	2		2 + 6 for Aquanauts		
Closed-Circuit Television	M	M	7 cameras		
Sound-Powered Telephone	2		3	1	1
UQC/BQC Underwater Telephone			1		
FM Speaker			2		
TV Monitor		1	1		

NOTES: M = monitor; UQC/BQC receiver in ELK RIVER is part of diving system; FM speakers and entertainment TV monitor is seafloor habitat is switched through command van.

COMMAND VAN EQUIPMENT LIST

Equipment & Manufacturer	Purpose
2 Tape Recorders (Magnecord)	For audio communication recording for future analysis and records.
1 Intercom/Video Control (Nortronics)	Used to select remote cameras for viewing on the two monitors; also contains a 12-station, talk-a-phone intercom unit and a port-and-starboard diving system intercom-access unit.

1 Intercom/Video Control (Nortronics)	Same as above except for additional selection of remote cameras for viewing on the medical van monitor.
1 Speaker Panel (Nortronics)	Serves as audio output for station monitoring, including FM and video audio; the short-and-open-alarm circuit of the habitat umbilical cable is also mounted on this panel.
1 Speaker Panel (Nortronics)	Serves as audio output for station monitoring.
2 TV Monitors (Conrac)	Dual monitors used for video display of selected remote-camera output to monitor aquanauts in habitat, DDCs, and PTCs.
1 Speech Unscrambler Control Panel (Nortronics)	Controls primary station conversation switching of interstations for unscrambler input and output, tape recorder audio input, and station monitoring and output connections.
1 Speech Unscrambler Control Panel (Nortronics	Controls secondary station conversation switching (same as above, except no video recorder audio access).
1 FM Entertainment Panel (Nortronics)	Contains a complete AM/FM receiver with stereo speakers used to monitor either FM output or TV video recorder audio output as selected.
1 AM/FM Receiver (Fisher)	Serves as part of entertainment systems for AM and FM commercial reception.
1 TV Receiver (Conrac)	Serves as part of entertainment system for commercial TV broadcast reception.
1 TV Rotor Control (Nortronics Cornell-Dubilier)	Used to position TV antenna for directional reception.
1 Speech Unscrambler (Naval Applied Science Laboratory)	Used to unscramble speech affected by characteristics of helium atmosphere.
1 Speech Unscrambler (Singer)	Used to unscramble speech affected by characteristics of helium atmosphere.

2 Electrowriter Transceivers (Victor)	Used for facsimile transmission between command van and habitat/PTC/DDC complex.
2 Intercoms (Bogen)	Used as direct communication access. Primary communication station to lab; secondary station to lab, observation room, and diving station.
4 Audio Amplifiers (Dynaco)	Two each at primary and secondary communication stations.
5 Audio Amplifiers (Dynaco)	Used at primary communication station.
1 Summation Amplifier (Nortronics)	Summation and isolation buffer for unscrambler control panel output.
2 Mixer Amplifiers (Nortronics)	Composite mixing and amplification of multiple station input.
2 Intercoms (12-Station) (Talk-A-Phone)	Used for direct communication network between 12 stations located at primary and secondary station, medical van, habitat, DDCs, and shipboard stations.
Voltage Regulator (Sorensen)	Provides 110 v AC regulated line voltage for equipment power at primary and secondary communication stations, instrumentation recording station, and medical van instruments.
1 Circuit Breaker Panel, Voltage Regulator (Nortronics)	Contains circuit breakers to control 110 v AC regulated power output.
1 Power Supply, 28 v DC (Transpac)	---
1 Video Tape Recorder (Ampex)	Provides recording of video images received from the remote cameras for record and future analysis.
3 Multipoint Recorders (Westronics)	Used to provide a permanent record of habitat environmental, oceanographic, and engineering evaluation sensor outputs.
1 Galvanometer Input Control (Nortronics)	Provides a calibrating function for habitat data signals prior to recording on the oscillograph (flow metering and power sensors).

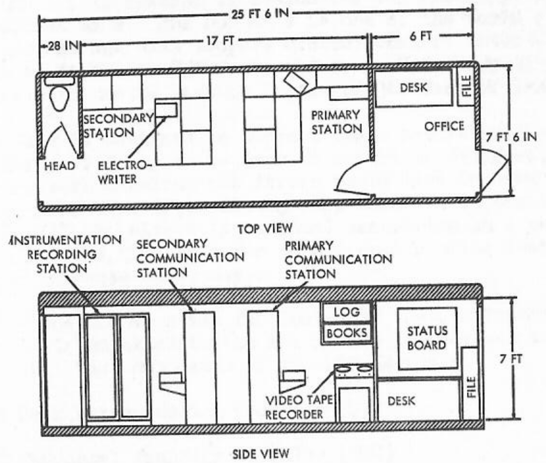
1 Oscillograph (Midwestern Instruments)	Provides a method of recording the outputs of the habitat flow-metering systems and power sensors.
1 Integrator Calibrate Panel (Nortronics)	Provides calibrating and signal conditioning of habitat data sensor outputs for input to the scanning system.
1 Magnetic Tape Recorder (Kennedy)	Provides a means of recording data sensor outputs from the habitat, controlled by the scanning system.
1 Digital Voltmeter (Dana)	Provides digital readout of scanned signals from the habitat.
1 Coupler and Clock (Ward/Davis)	Provides coupling and clock control for the scanning system reading habitat data signals.
1 Scanner Control (Dana)	Controls output of scanners to read habitat monitoring data on DVM or to record data on magnetic tape recorder.
2 Scanners (Dana)	Provides continuous scanning of data sensor outputs from the habitat (used in conjunction with scanner control).
1 Time Totalizing Panel (Nortronics)	Provides time-totalizing monitor for key functions in the habitat (refrigerator, freezer, washer-dryer, D/H pump motor, and water heater).
1 Gas Pressure Sequencer Panel (Nortronics)	Controls stepper switch in habitat to monitor gas storage pressures
1 Air Conditioner (Ellis and Watts)	Provides heat, cooling, and humidity control of the command van atmosphere.

MEDICAL VAN EQUIPMENT LIST

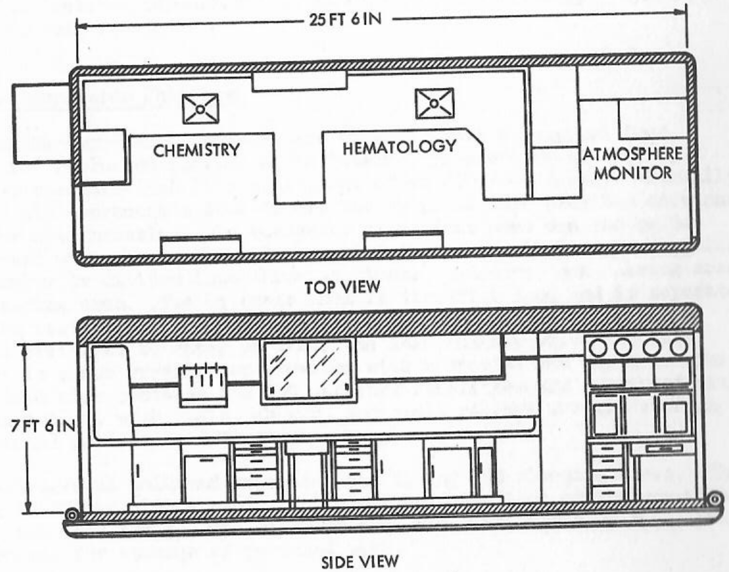
Equipment & Manufacturer	Purpose
1 Gas Chromatograph (Loenco)	Gas analysis
1 Gas Chromatograph (Hewlett Packard)	Gas analysis
1 Infrared Analyzer (Lira)	Carbon monoxide monitoring
2 Recorders (Texas Instruments)	Record gas chromatograph output

1 Spriometer (Wedge)	Respiratory measurements
1 Oscilloscope (Tektronic)	Respiratory measurements
1 Camera System (Tektronic)	Photograph respiratory measurements
1 EKG (Hewlett Packard)	Electrocardiographic studies
1 Flame Photometer (Baird Atomic)	Blood, urine, sodium and potassium determination
1 Coenzometer (MacAlaster Scientific)	Enzymology
1 Osmometer (Advanced Instruments)	Osmometry
1 Colorimeter/Spectrophotometer (Baush & Lomb)	General blood and urine analysis
1 pH/Blood Gas Analyzer (Instrument Labs)	pH and blood gas analysis
1 Air Conditioning Unit (Ellis and Watts)	Medical van cooling and heating
1 Autocytometer (Fisher)	Blood cell count
1 pH Meter (Coleman)	Urine pH measurements
1 Typewriter (Sears Roebuck)	Data logging
1 Barometer (Precision Theometer and Instrument)	Barometric pressure
2 Microscopes (American Optics)	Microscopic studies
1 Electrophoresis (Hyland-Photovolt)	Isozymes determination
1 Spectrocolorimeter (Beckman)	Blood/urine, calcium, and chloride determination
3 Water Baths (Thelco)	Determination temperature stabilization
1 Still (Corning)	Water distillation

1 Fume Hood (Lab Line)	Fume removal
1 Oven (Thelco)	General drying
1 Clinical Centrifuge (International Equipment)	General centrifuging
1 Hematocrit Centrifuge (International Equipment)	Blood centrifuging
1 Incubator (Thelco)	Culturing
2 Viscosimeters (Hess)	Blood viscosity
1 Sphygmomanometer (Baumanometer)	Blood pressure
1 Metric Beam Balance (Detecto)	Body weight
1 Spriometer, Dry Gass (Instruments Associated)	Pulmonary studies
2 Refrigerators (Stoneite)	Reagent storage
1 Freezer (Stoneite)	Provide sample freezing
1 Air Compressor (ITT-Bell Gossett)	Provide compressed air for flame photometer
1 Water Heater (Sears Roebuck)	General cleaning
1 Television Receiver (Conrac)	
1 Calculator (Wang)	Physiological calculations



COMMAND VAN



MEDICAL VAN

7.

DEEP DIVING SYSTEM

The SEALAB III experiment is evaluating the prototype of the Navy's Deep Diving System Mk 2. The DDS Mk 2 is one of the world's most advanced diving systems and will support conventional or saturation diving operations at depths to 850 feet. (Current U.S. Navy diving operations are limited to useful work at depths of 380 feet or less.)

The DDS Mk 2 is designed to support eight saturated divers, working in shifts for periods up to 14 days at depths to 850 feet. For normal underwater work missions the divers would live in Deck Decompression Chambers (DDC) aboard the diving ship when not on the bottom. However, in SEALAB III the divers (Aquanauts) are living in a seafloor habitat and will use the DDCs only for decompression after being on the ocean floor for 12 consecutive days.

The prototype DDS Mk 2 was fabricated at the San Francisco Bay Naval Shipyard and installed in the ELK RIVER, the surface support ship for SEALAB III. The components of the DDS Mk 2 are:

2 Deck Decompression Chambers (DDC)

2 Personnel Transfer Capsules (PTC)

2 Strength-Power-Communications Cables (SPC Cables)

2 Main Control Consoles (MCC)

plus related communication, electrical, and gas supply systems, winches, etc.

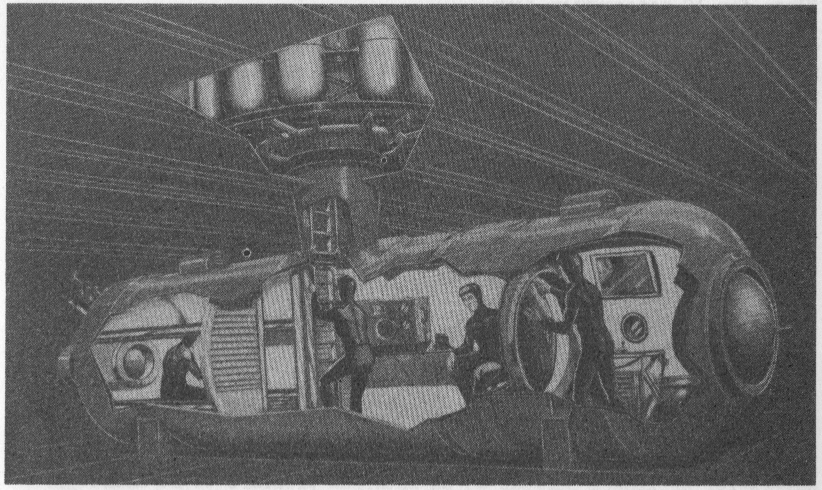
Deck Decompression Chambers

The Deck Decompression Chambers are each designed to support four divers for prolonged periods at an internal pressure to at least 378 pounds-per-square-inch (the equivalent of an 850-foot depth). Normally the DDC will accomodate four divers for up to 14 days plus the necessary time for decompression. In emergency situations more men can be decompressed with the duration dependent only upon available gas supplies. The chamber is divided into three sections: entrance lock, living area, and sleeping area. The entrance lock is five-feet long and is separated from the rest of the chamber by a pressure hatch. This arrangement enables personnel to enter or leave the main chamber while the main chamber is under pressure or provided with a special gas mixture. This outer lock also contains the DDC sanitary facilities and is fitted with a flush toilet, wash basin, shower, and small cabinet for the storage of personal articles and first aid equipment.

A non-structural bulkhead separates the living and sleeping areas. The former is fitted with a table, which can be folded out of the way when not in use, and seats. The sleeping area has four submarine-type bunks and lockers for stowage of personal gear.

At the sleeping end of the DDC is a small lock for passing in medical supplies food, and other small items.

The life support system for each decompression chamber consists of two loops, either of which can be operated independently. They can be operated simultaneously when there are increased demands on the system. Each loop consists of a CO_2 absorber, condenser, filter, heater, control valves, and associated gauges and piping, all of which is external to the DDC. The system is designed to meet the normal requirements for four men at a depth range of from 0 to 850 feet seawater; inside temperature ranges are maintained at between 75°F and 95°F.



Each DDC has an emergency Built-In-Breathing System (BIBS) which can supply oxygen or helium-oxygen gas mixtures to breathing masks in the event the chamber's atmosphere becomes contaminated. Each DDC manifold can supply five masks.

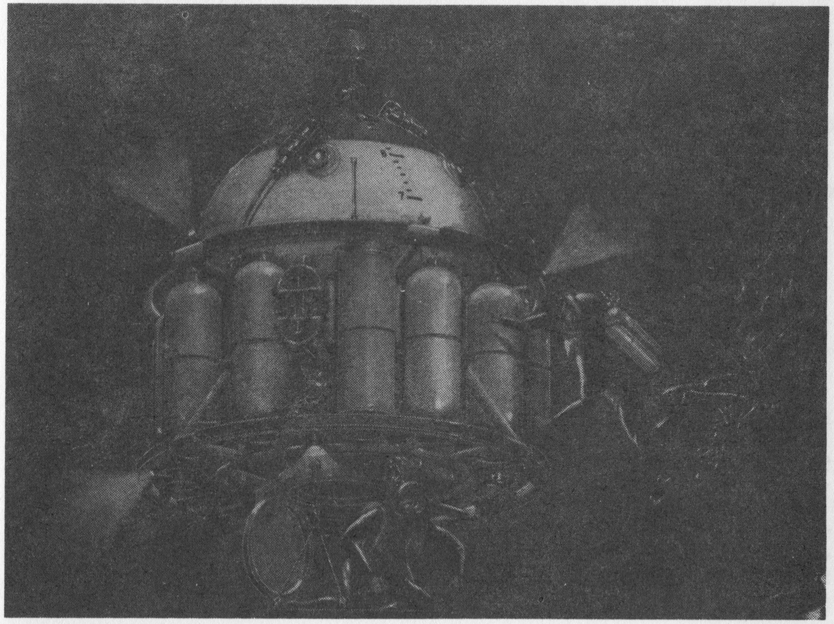
Personnel Transfer Capsules

The two Personnel Transfer Capsules are used to transport divers between the DDCs and the ocean floor. The PTC can also support divers working on the ocean floor, providing them with breathing gas through hoses and with a rest station. After the divers complete their mission the PTC returns them to the surface under pressure (to 378 psig) and mates directly to the DDC to enable the divers to pass freely into the decompression chamber for rest or decompression.

With conventional diving equipment the divers are brought to the surface slowly on an open stage, actually undergoing decompression as they are brought up. The PTC-DDC system enables the divers to be returned to

the surface quickly and safely; enter the decompression chamber without being exposed to surface atmosphere; and then undergo carefully monitored and controlled decompression in relative comfort. These features are available for both conventional and saturation diving operations.

The PTC has seating for four divers and can support four divers for eight hours during normal operations and 24 hours in an emergency. This support includes breathing gasses, rations, drinking water, and provisions for body warmth. Safety equipment in the PTCs include seat belts and crash helmets to prevent body injury when the PTC is being handled in rough sea conditions.



Breathing gas for the PTC is provided by ten gas bottles containing oxygen (1), and helium (5), and helium-oxygen (4). Each bottle holds 1,200 cubic feet of gas. Four stowage racks are provided outside the PTC for 200-foot hoses to enable divers to work in the proximity of the capsule using the bottled breathing gases.

Access to the interior of the PTC is through the large bottom entrance hatch. The hatch is large enough to enable divers with SCUBA rigs to have easy entrance. Four viewports in the PTC enable divers inside the chamber to view divers working nearby.

The PTC can also be used as a dry, one-atmosphere observation chamber to carry observers to the ocean floor for inspections of the experiment area.

During operations the PTC has positive buoyancy. A winch is provided in the base of the capsule for hauling the PTC to the bottom, the winch cable being attached to an anchor or "clump." Explosive release studs are fitted to both the hauldown cable connection and the Strength-Power-Communication Cable, which raises and lowers the PTC, so that either or both cables can be blown clear in the event they are severed or fouled. (The hauldown cable is 3/8-inch galvanized steel, 1,200 feet long.)

Strength-Power-Communications Cable

The Strength-Power-Communication Cable is designed to provide the strength, electric power, and communications connection between the support ship and Personnel Transfer Capsule during a diving operation.

The SPC Cable has an inner core of electrical wires which carry communication and instrumentation signals, and electrical power. The outer sheath is made up of galvanized improved plow steel wires and has sufficient strength to lift a flooded PTC from the ocean floor to the surface and an internally dry PTC from the ocean floor to the deck of the surface support ship.

The SPC Cable is 1,400 feet long and is stowed on a drum winch on the deck of the support ship.

Main Control Consoles

The DDS Mk 2 has two Main Control Consoles which mount the instrumentation and controls for the Deck Decompression chambers. Each MCC controls only the adjacent DDC, but both MCCs have communications equipment for communicating with divers in both DDCs and both PTCs. In the event that the communications traffic to one MCC becomes too heavy for its operator(s) to handle, the operator(s) at the second can assist the first.

To provide monitoring and control of diving system gas, electricity, communications, and instrumentation in the most efficient and convenient manner, the consoles have been divided into functional areas for one-man operation during routine activity such as when the PTC is mated to the DDC or the PTC is resting on the bottom. This arrangement also provides for optimum two-man control of all operational functions during periods of increased activity.

Infrequently used controls and displays required for charging, monitoring, and venting the DDC outer lock are located on the left wing of the MCC. The left side of the main panel contains controls and displays similar to those on the left wing for the inner lock. The right side contains displays of primary usage such as television monitors, PTC

displays, decompression clocks and timers, and digital readouts for pressure. A desk for log keeping is located in the right wing. The right wing also contains electrical control, indication, test, and calibration equipment as well as a second desk area.

The major components of each MCC are: electrical temperature indicators, flow meters, closed-circuit television monitors, digital clock, ground detector and alarm units, tape recorder and tape recorder remote unit, pressure gauges, digital volt meter, sound-powered telephone and switch units, pressure gauges reading in both pounds-per-square-inch and depth in feet of salt water, underwater telephone (UQC), oxygen monitoring and control units, helium speech unscrambler, and electrowriter unit.

Communications

The DDS Mk 2 is tied to the SEALAB III complex with a number of communications systems. These include intercoms, electrowriters, closed-circuit television, sound-powered telephones, and the UQC/BQC underwater telephone. All DDS Mk 2 communications are tied to the command van except the UQC/BQC underwater telephone. In addition, the closed-circuit television is tied to the medical van. The following Quick Look matrix shows the various communications equipment in the DDS Mk 2, detailed descriptions of this equipment may be found in the section of this handbook on Communications and Monitoring.

Finally, the DDC control room in the ELK RIVER is tied to the command and medical vans and other shipboard stations by a special 12-station intercom and closed circuit television. (There is also a closed-circuit television monitor in the DDC control room.)

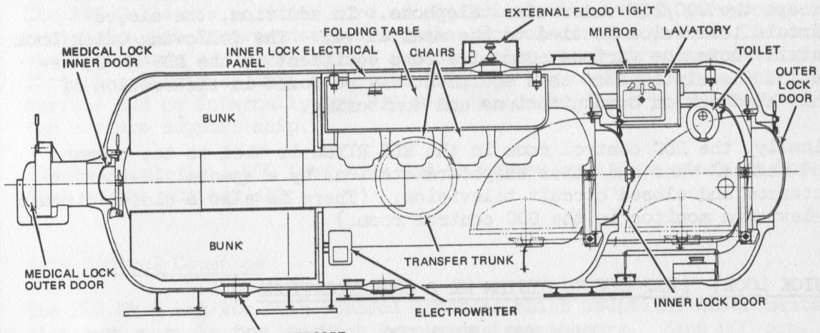
QUICK LOOK: DEEP DIVING SYSTEM Mk 2 COMMUNICATIONS

	Each MMC	Each DDC Inner Lock	Each DDC Outer Lock	Each PTC
Intercom	1	2	2	1
Electrowriter	1	1		1
Closed-Circuit TV	M	C	C	C
Sound-Powered Telephone	1			
UQC/BQC Underwater Telephone				1

NOTES: M = monitor; C = camera

DDC CHARACTERISTICS

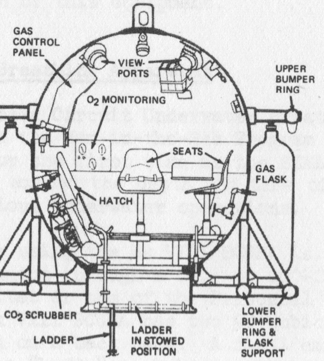
Overall chamber length	24 ft $1\frac{1}{4}$ in
Internal diameter	7 ft 6 in
Floor width	4 ft 10 in
PTC-DDC hatch diameter	2 ft 6 in
Medical lock length	24 in
Medical lock diameter	$17\frac{1}{4}$ in
Power source	120 Volts A-C
Instrumentation	depth, partial pressure of oxygen and carbon dioxide, humidity of chamber gases
Internal pressure	378 psig (maximum)



PTC CHARACTERISTICS

Overall height	9 ft $10\frac{1}{2}$ in
Internal diameter	7 ft
Power source	440 Volts A-C from ship
Instrumentation	partial pressure of oxygen, internal pressure, differential pressure to sea
Buoyancy	1,000 lbs positive
Weight in air	25,000 lbs

Life support	4 dives for 4 hours at 850 feet
Viewports	8 6-inch diameter
Construction	HY-80 steel



8.

AQUANAUT EQUIPMENT

The deep ocean is alien to man: While in the water he cannot breath without a special gas supply, he cannot withstand the cold for sustained periods, he cannot see very far, he cannot find his locatation easily, he cannot communicate effectively with other men, if he strays too far above a prescribed depth he will suffer "bends," and if he is not properly decompressed after being exposed to underwater pressures he will be crippled or killed by the "bends." Thus, the Man-in-the-Sea effort requires extensive equipment to enable man to live and work in the ocean depths. The SEALAB III experiment is providing a large-scale, in situ testing of much of this equipment.

Mk VIII Underwater Breathing Apparatus

The Mk VIII Semi-closed Circuit Underwater Breathing Apparatus was developed for use in the Man-in-the-Sea Program and is being used on an operational basis for the first time in the SEALAB III experiment. The Mk VIII SCUBA helps extend the depth and time of saturation diving beyond that of previous underwater operations.

The primary mode for using the Mk VIII SCUBA is with breathing gas being supplied to the Aquanaut through a 600- or 200-foot umbilical connected to the seafloor habitat or one of the Personnel Transfer Capsules. For emergency use the Mk VIII SCUBA has two 90-cubic-foot gas tanks which the Aquanaut carries on a back pack. A final emergency procedure available is to use a "buddy" mask-hose attachment on the back pack. This "buddy" mask-hose enables the Aquanaut to use his tank-carried gas while bypassing his regular breathing system. Also, the "buddy" mask-hose attachment can be used by another Aquanaut, swimming alongside, who has lost the use of his SCUBA equipment.

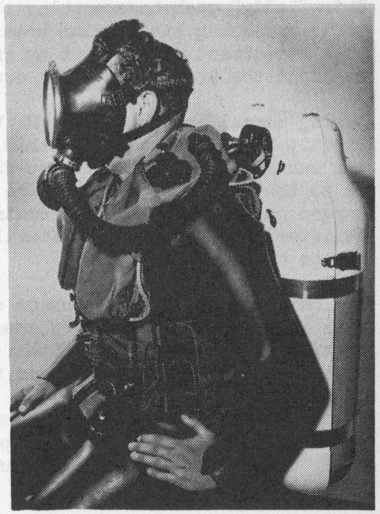
During normal operations the Mk VIII SCUBA is used in a semi-closed circuit breathing mode. In this mode the Aquanaut's exhaled gases enter the exhalation bag. About one-fifth of the exhaled gases are then vented to the open sea (to allow the addition of more oxygen in a helium-oxygen gas mixture). The remaining exhaled gases then flow through a canister where baralyme (primarily barium and calcium hydroxides) absorbs carbon dioxide.

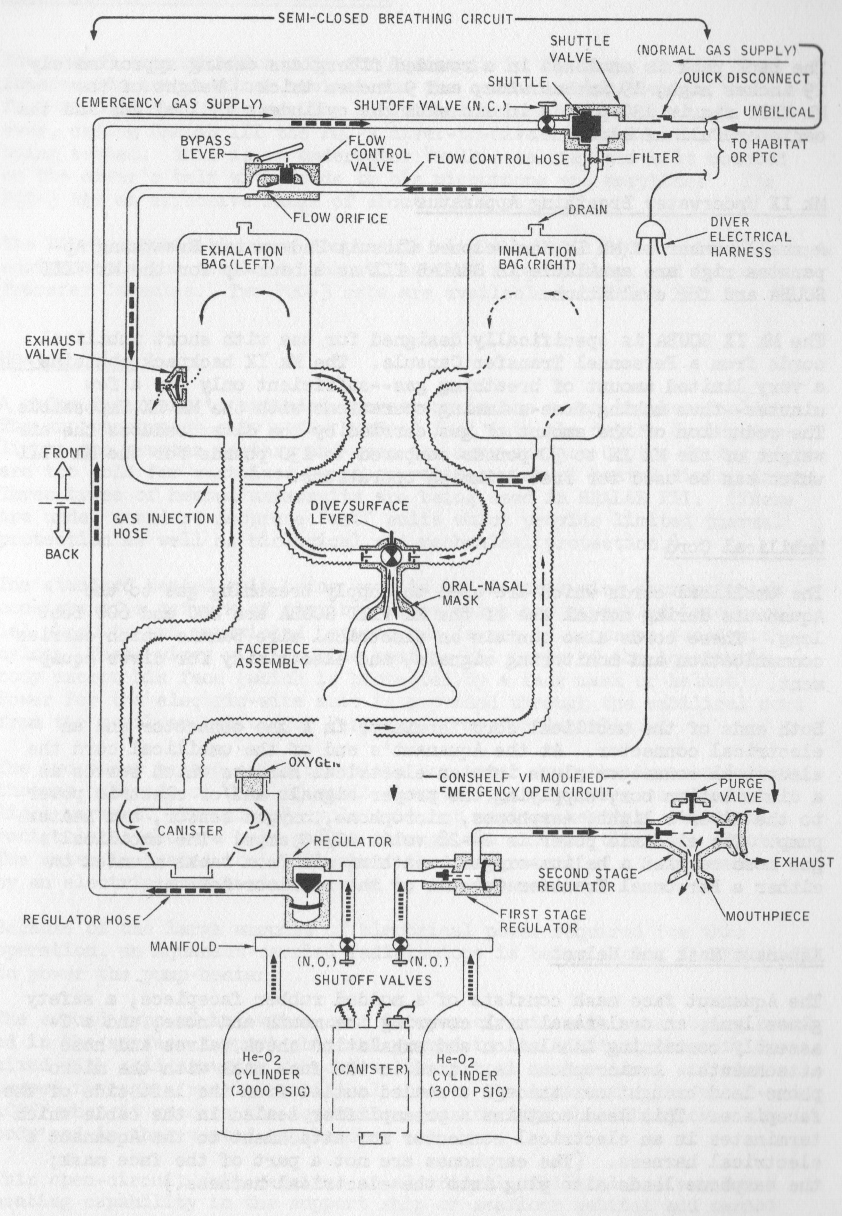
The canister outlet contains an oxygen sensor which automatically transmits an indication of oxygen concentration to an indicator at the diving station of the seafloor habitat. Personnel in the habitat can then advise the Aquanaut by intercom to adjust his gas intake accordingly.

After the exhaled gases have been circulated through the baralyme canister they are mixed with a gas mixture supplied through the umbilical cord, enter an inhalation bag, and are then fed to the Aquanaut through a SCUBA mouthpiece.

The emergency modes of operation for using the two back tanks, either in open or semi-closed circuit with the SCUBA mouthpiece or in the open circuit with the "buddy" hose-device. In the semi-closed mode the back tanks will provide Aquanaut about an hour's supply of breathing gas at a depth of 600 feet.

Mk VIII Semi-closed Circuit
Underwater Breathing Apparatus





Mk VIII Semi-closed Circuit Breathing Apparatus (Schematic)

The back pack is enclosed in a rounded fiberglass casing approximately 29 inches high, 19 inches wide, and 9 inches thick. Weight of the Mk VIII rig is 130 pounds in air with the cylinders full of gas and the canister full of baralyme.

Mk IX Underwater Breathing Apparatus

A small number of Mk IX Semi-closed Circuit Underwater Breathing Apparatus rigs are available in SEALAB III as a back-up for the Mk VIII SCUBA and for evaluation.

The Mk IX SCUBA is specifically designed for use with short umbilical cords from a Personnel Transfer Capsule. The Mk IX backpack contains a very limited amount of breathing gas--sufficient only for a few minutes--thus making free-swimming operations with the Mk IX impossible. The reduction of the amount of gas carried by the diver reduces the air weight of the Mk IX to 30 pounds compared to 130 pounds for the Mk VIII which can be used for free-swimming operations.

Umbilical Cord

The umbilical cords which are used to supply breathing gas to the Aquanauts during normal use of the Mk VIII SCUBA are 200 and 600 feet long. These cords also contain an electrical wire bundle which carries communication and monitoring signals, and electricity for diver equipment.

Both ends of the umbilical cord terminate in a gas connector and an electrical connector. At the Aquanaut's end of the umbilical cord the electrical connector plugs into an electrical harness which serves as a distribution box, supplying the proper signals and/or electric power to the diver's light, earphones, microphone, oxygen sensor, and heater pump. The electric power is 24-28 volts AC/40 amps. The umbilical's gas hose carries a helium-oxygen breathing mix from tanks mounted on either a Personnel Transfer Capsule or the seafloor habitat.

Aquanaut Mask and Helmet

The Aquanaut face mask consists of a molded rubber facepiece, a safety glass lens, an oral-nasal mask covering the mouth and nose, and a T-assembly containing inhalation and exhalation check valves and hose attachments. A microphone is fitted in the face mask with the microphone lead brought out through a sealed outlet from the left side of the facepiece. This lead contains a preamplifier sealed in the cable which terminates in an electrical connector for attachment to the Aquanaut's electrical harness. (The earphones are not a part of the face mask; the earphone leads also plug into the electrical harness.)

A clam-shell helmet is being evaluated in the SEALAB III experiment. This is a plastic helmet with a face lens which completely encloses the Aquanaut's head.

PQC-3 Diver-to-Diver Communication

The normal communication mode for Aquanauts in the water is the diver intercom to the seafloor habitat and the communications van on the surface support ship (see section on Communications and Monitoring). However, during SEALAB III the PQC-3 diver-to-diver communication device is being tested. This is an underwater "walkie-talkie" which is mounted on the diver's belt with leads to his microphone and earphones. The PQC-3 has an effective range of about 1,000 yards.

The PQC-3 capabilities are compatible with the UQC-1/BQC-1 communications equipment in the seafloor habitat, surface support ship, and Personnel Transfer Capsules. Two PQC-3 sets are available in SEALAB III.

Heated Suits

A major deterrent to extended operations in the ocean has been cold. The sun penetrates only a few hundred feet into the depths during daylight; the greater depths, and even the near-surface depths during night, are too cold for sustained human operations without heated diving dress. Three types of heated undersuits are being used in SEALAB III. (These are under standard neoprene "wet" suits which provide limited thermal protection as well as biological and mechanical protection.)

The standard heated suit being used is an electric-wire garment which consists of a network of flexible wires which are assembled into parallel circuits and sandwiched between two layers of neoprene faced with nylon. These wires will provide heat to all parts of the Aquanaut's body except his face (which is protected by a face mask or helmet). Power for the electric-wire suit is provided through the umbilical cord from the seafloor habitat or Personnel Transfer Capsules.

The two other heated suits circulate hot water over the Aquanaut's body through hundreds of feet of small diameter plastic tubes sewn into a light garment. The closed-cycle suit, at maximum heating conditions, recirculates about a half gallon through the suit 16 times per minute. The water is heated to 105°F--about the temperature of a hot shower--by an electric pump-heater carried by the Aquanaut.

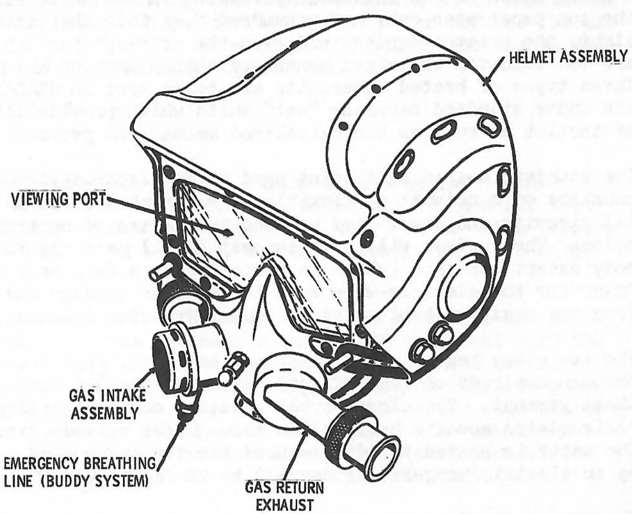
Because of the large amounts of electrical power required for this operation, an Aquanaut-carried radioisotope is being tested in SEALAB III to power the pump-heater.

The second type of hot-water suit is open-circuit with water being heated in the surface support ship and pumped to the habitat, where it is mixed with cold seawater to achieve the proper temperature, and then pumped through a special umbilical cord to the Aquanaut. The water--at 105°F when it reaches the Aquanauts--goes through the tubing over his body and is then vented to the open sea.

This open-circuit suit requires an additional umbilical and a water heating capability in the support ship or seafloor habitat and cannot be used from a Personnel Transfer Capsule. However, the Aquanaut has less weight to carry than with the closed-circuit suit which requires the diver to carry the heating element with him.

Aquanaut Depth Gauge

Each Aquanaut has a wrist-strap depth gauge which indicates pressure differential from 600 feet (the approximate depth of the seafloor habitat). This device provides the Aquanaut with an immediately available indication of how far above his saturation depth he is working. This data is vital because of the danger from "bends" should a saturated diver move too far above his saturation depth without proper decompression.



CLAMSHELL HELMET

Aquanaut clamshell helmet.

9.

AQUANAUT FOOD

The Navy is taking advantage of the latest commercial food preparation and packaging techniques for feeding the Aquanauts in the SEALAB III experiment.

The meals for Aquanauts consist principally of precooked frozen entrees, canned soups and vegetables, frozen and ready-to-eat desserts, fresh and frozen bread and rolls, and a variety of "goodies" for snacks.

The frozen entrees are provided in four-man portions, the first time the Navy has provided pre-packaged food in such a small number of portions on an operational basis. This packaging will reduce preparation time and waste. These entrees include veal parmargiana, baked lasagne, chicken legs, baked ham, and salisbury steak.

SEALAB III's menu is designed to provide each Aquanaut with attractive food and a daily diet of 4,500 calories. This is some 750 to 1,000 more than the average Navyman consumes in a day. The extra calories are not expected to add extra pounds to the Aquanauts because of their high body heat loss in the helium-oxygen environment of the habitat and the physical exertions when working in the open sea. The menu for SEALAB III provides a six-day cycle of meals, thus the Aquanauts will repeat the menu once during their 12-day stay on the ocean bottom.

The habitat is equipped with an infra-red oven which heats food uniformly throughout, a distinct advantage in the atmosphere which conducts heat rapidly. Frozen or refrigerated foods can be cooked quickly and with a high degree of control in the oven. The oven opening is 14½ inches by 21½ inches, providing the capability of simultaneously heating meals for an entire eight-man team of Aquanauts.

In addition to the infra-red oven, the habitat has a four-burner electric range for heating food and beverages. Other galley features include a freezer, double sink, ten-cubic-foot refrigerator, and storage space for dry foods. (There is a 15-cubic-foot freeze box in the observation room.)

A full 60-day supply of dry provisions was loaded in the habitat at the Long Beach Naval Shipyard before it was towed to the experiment site off San Clemente Island. Frozen foods for 36 days (three teams) and a four-day supply of bread and rolls were loaded just before the habitat was lowered to the ocean floor. The frozen provisions are being replenished periodically and fresh bread and rolls are sent down to the habitat every four days.

The Navy Subsistence Office in Washington, D. C., overcame a number of food preparation problems in planning the menu for SEALAB III. For example, fresh eggs cannot be used because their yokes give off a toxic sulfide gas in the pressurized, helium-oxygen atmosphere of the seafloor habitat. Similarly, frying or grilling in this environment will produce a toxic gas called acrolein.

Dehydrated foods are not being used in SEALAB III because when the containers of dehydrated foods are opened under the almost 300-pounds-per-square-inch pressure at depth the contents are often reduced to powder.

The exception is frozen dehydrated shrimp which is included in the menu because of its high popularity with Navymen. (The shrimp containers are opened before they are stocked in the habitat so that the pressure inside the containers will increase at the same rate as the ambient pressure as they are lowered to the seafloor.)

Cooking pancakes also presents a problem: helium permeates the batter as bubbles form and prevents the pancakes from cooking through. Frozen, pre-cooked pancakes eliminate this problem. Also, because of helium's heat-absorbing characteristics it takes longer to boil coffee and other liquids and they cool considerably faster than they do in air.

Specific food items for SEALAB III as well as the infra-red oven were tested in a submerged habitat at the Navy Mine Defense Laboratory at Panama City, Florida. This habitat, submerged in relatively shallow water, was able to simulate some of the conditions of SEALAB III.

QUICK LOOK: AQUANAUT FOOD

Days 1 and 7

Breakfast: grapefruit juice, ready-to-eat cereals or instant oatmeal, pancakes, butter, syrup, sliced ham, coffee, cocoa, milk

Dinner: hot roast turkey sandwich, cranberry sauce, french fried potatoes, tomato and cucumber salad with dressing, cookies, orange sherbert, coffee, tea, milk

Supper: beef stew served over hot biscuits, buttered lima beans, sweet pickles, cherry chiffon pie, coffee, tea, cocoa

Snacks: chicken-noodle soup, crackers, cheddar cheese, sardines, peaches.

Days 2 and 8

Breakfast: tomato juice, ready-to-eat cereals, creamed chipped beef on toast, pecan coffee cake, butter, mild, coffee, tea

Dinner: hamburgers on buns, potato salad, buttered peas, onions, pickle relish, celery hearts, radishes, pound cake with strawberries, tea, milk, cocoa

Supper: veal parmagiana, baked lasagne, tossed salad with French dressing, bread, butter, vanilla ice cream with caramel sauce, salted peanuts, coffee, tea, cocoa

Snacks: bean with bacon soup, bologna sandwiches, orange juice

Days 3 and 9

Breakfast: fruit cocktail, ready-to-eat cereals or instant oatmeal, cheese omelet, Canadian bacon, toast, butter, jelly, milk, coffee, tea, cocoa

Dinner: shrimp with cocktail sauce, beef pot roast, potatoes hashed in cream, buttered corn, olives, bread, butter, German chocolate cake, coffee, milk, tea

Supper: chicken legs in gravy, buttered rice, buttered green beans, cole slaw, bread, butter, apricots, coffee, tea, cocoa

Snacks: vegetable soup, crackers, salami, tomato juice

Days 4 and 10

Breakfast: orange juice, ready-to-eat cereals, corned beef hash, cinnamon nut coffee cake, butter, milk, coffee, tea, cocoa

Dinner: chili con carne served over Frito corn chips, shredded lettuce with French dressing, hard rolls, butter, fruit gelatin, oatmeal cookies, coffee, tea, milk

Supper: baked ham slices, horseradish, macaroni and cheese, buttered lima beans, dill pickles, bread, butter, vanilla ice cream with raspberries, coffee, tea, cocoa

Snacks: green pea soup, crackers, Swiss cheese, pineapple slices

Days 5 and 11

Breakfast: grapefruit juice, ready-to-eat cereals or instant oatmeal, plain omelet, hot biscuits, butter, milk, coffee, tea, cocoa

Dinner: salisbury steak with mushroom gravy, french fried potatoes, buttered peas, garden salad with French dressing, bread, butter, lemon chiffon pie, coffee, tea, milk

Supper: roast pork with gravy, candied sweet potatoes, cranberry sauce, lettuce chunks with salad dressing, bread, butter, spice cake with butter cream icing, coffee, tea, cocoa

Snacks: chicken-noodle soup, crackers, tunafish, pineapple juice

Days 6 and 12

Breakfast:	orange juice, ready-to-eat cereals, French toast, butter, syrup, milk, coffee, tea
Dinner:	frankfurters, mustard, Spanish rice, buttered green beans, green onions, celery hearts, olives, bread, butter, peaches, cookies, coffee, tea, cocoa
Supper:	sliced beef with gravy, rissole potatoes, simmered tomatoes, pineapple and cottage cheese salad, bread, butter, coffee, tea, cocoa
Snacks:	vegetable soup, crackers, peanut butter, jelly, milk

10.

RANGE SUPPORT

The SEALAB III experiment is being conducted at the Navy's Ocean Engineering Test Facility, San Clemente Island Range, off the coast of Southern California. The SCI Range is used primarily for the test and evaluation of underwater equipment such as missiles (Polaris, Poseidon, SUBROC), torpedoes, sonars, mooring systems, and salvage equipment. The available water depths, surface weather conditions, adjacent support facilities, and proximity to major naval activities, such as shipyards, hospitals, and the DSSP Technical Office, provide an excellent site for the SEALAB III experiment.

The SEALAB III experiment site is in a test area off the northeast coast of San Clemente Island. This site is approximately 60 statute miles south of Long Beach, California.

The scope and complexity of underwater operations conducted at the SCI Range have required the acquisition of the large range operation ship ELK RIVER (designated IX-501). The ELK RIVER is especially configured to support the programs of the Navy's Deep Submergence Systems Project (DSSP) including the SEALAB experiments and related work in conjunction with DSSP's Man-in-the-Sea and Large Object Salvage System work.

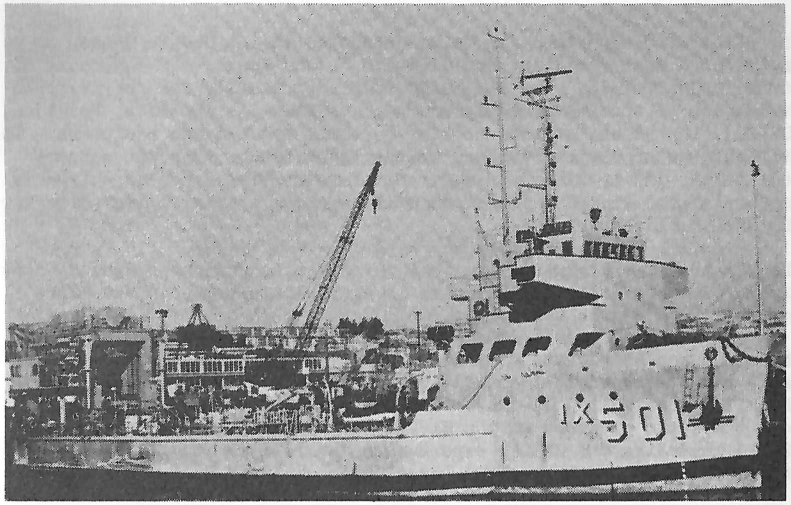
During SEALAB III the ELK RIVER will be moored over the seafloor habitat to provide facilities for command, communications, monitoring, medical laboratory support, and decompression during the experiment. An umbilical cable between the ship and habitat will carry communication, instrumentation, gas, gas sampling, power, and water lines. Similarly, an umbilical cable between the habitat and San Clemente Island will carry primary water and power lines, and an emergency communication line. (This elaborate umbilical system is required because of the experimental nature of SEALAB III; future operational Navy seafloor habitats will be independent of surface support for extended periods.)

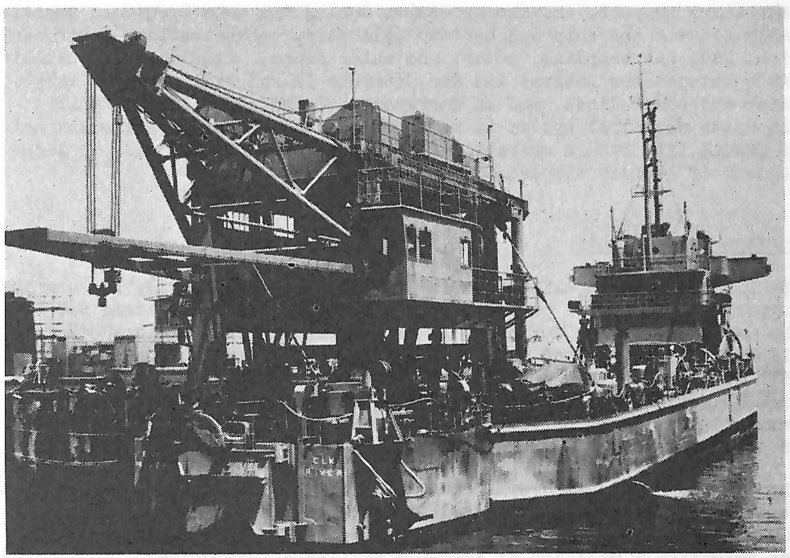
Surface Support Ship

The ELK RIVER was modified from a landing ship specifically for use in support of underwater programs of the Deep Submergence Systems Project. She was built during World War II as the Landing Ship Medium-Rocket 501 (LSMR-501), a $203\frac{1}{2}$-foot ship designed to support amphibious landings with rocket, gun, and mortar fire. She was completed too late for service in World War II and subsequently was "moth-balled" for future service. (Three of her sister ships were reactivated in 1965 for use in the Vietnamese War.)

The ELK RIVER was withdrawn from the mothball fleet in 1966 for modification to a range support ship, being redesignated IX-501 in lieu of LSMR-501 to reflect her new "miscellaneous" support duties. The ship was extensively modified at Avondale Shipyards (New Orleans, Louisiana) and the San Francisco Bay Naval Shipyard.

The ship's LSMR design has a "U" shaped hull, the bottom of which could be cut through easily to provide a sheltered opening (center well) for the lowering and raising of equipment. The principal changes made to





Range support ship ELK RIVER (IX-501) being fitted out at San Francisco Bay Naval Shipyard.

the ship were (1) lengthening her hull $21\frac{1}{2}$ feet, (2) providing an open center well for handling underwater equipment, (3) installation of 8-foot wide sponsons to increase deck space and improve stability, (4) installation of a conventional bridge structure forward, (5) fitting and instrumentation room and related electronic equipment, (6) fitting a 65-ton-capacity travelling gantry crane to lift submersibles, and (7) installation of the prototype Deep Diving System Mk 2 (see section on Diving System in this handbook).

Thus modified, the ELK RIVER's pertinent dimensions and characteristics are:

Displacement	1,100 tons
Length overall	225 feet
Beam	50 feet
Draft	9 feet
Propulsion	Diesels, 1,400 shp, 2 shafts
Speed, maximum	11 knots
Speed, curising	7 knots
Navy crew	25
Civilian staff	20

A detailed description of the ELK RIVER's characteristics and equipment is given in the Quick ook at the end of this section.

Support Ship Mooring

During SEALAB III the ELK RIVER is held over the seafloor habitat in a five-point mooring. The two seaward mooring lines (away from San Clemente Island) are anchored to cemented piles with a holding power, horizontally, of about 50,000 pounds, The two shore lines are fitted with 13,000-pound Navy stockless anchors. A fifth (bow) line, with a 13,000-pound anchor, could be secured if required as could a sixth (stern) line with a 13,000-pound anchor. A tensiometer is attached to each mooring line so that tension can be ascertained at all times.

Support Ship Operations

The Deep Diving System Mk 2 in the ELK RIVER provides complete diver decompression facilities and, with its Personnel Transfer Capsules, has the means of lowering and raising Aquanauts to and from the seafloor habitat in a pressurized environment.

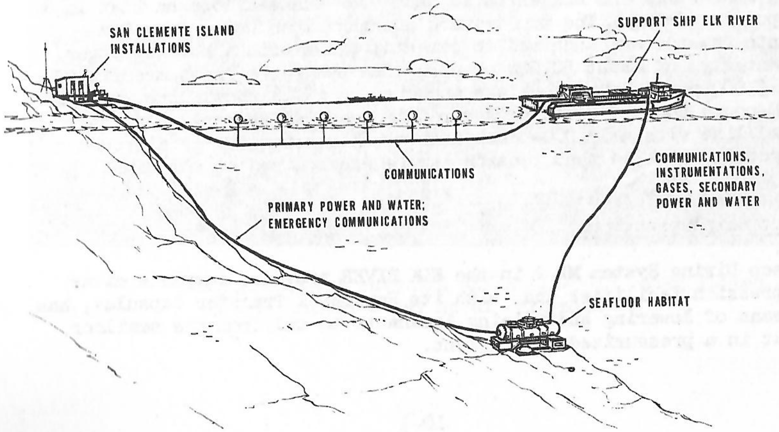
The ELK RIVER also provides stowage for the various gases required in the SEALAB III experiment: oxygen, helium, and mixtures of helium and oxygen. The habitat is charged with its initial helium-oxygen atmosphere from the ELK RIVER while being lowered to the ocean floor. Once on the bottom normal habitat gas replenishment is from the attached gas bottles. (This independence of surface-supplied gas while on the bottom is an added safety feature in the event the umbilical cable is broken or the ELK RIVER is forced to leave the area because of adverse surface weather conditions.)

The command and communications center for SEALAB III is the command van installed on the deck of the ELK RIVER. Similarly, the physiological monitoring and medical center for the experiment is the medical van, installed aft of the command van on the ELK RIVER. (These vans are described in detail in the section on Communications and Monitoring in this handbook.)

An umbilical cable from the ELK RIVER to the habitat carries communication, instrumentation, and gas sampling lines connecting the two vans with the habitat.

This umbilical cable contains a bundle of separate cables and hoses: a power cable, signal cable, habitat gas charge line, pneumatic service line, potable water line, gas sampling and high-pressure helium charge line, habitat gas sampling line, and mixed gas Mk VIII SCUBA charging line. Power and water are provided from the support ship to the habitat only on an emergency basis, the primary sources of habitat power and water being through an umbilical cable from San Clemente Island. By means of a cross-connecting manifold inside the habitat, the shore-to-habitat water line can be used to replenish the water storage tanks in the support ship ELK RIVER. The normal fresh water delivery rate to the pressurized habitat is five gallons-per-minute.

The ship-to-habitat umbilical cable is 1,000 feet long; the shore-to-habitat water line is approximately 9,000 feet long while the shore-to-habitat power cable, which goes through an ocean floor transformer, is 9,000 feet long. The following diagram shows the overall umbilical cable system in SEALAB III:



San Clemente Island

The Naval Undersea Warfare Center operates San Clemente Island to provide ranges, facilities, and support personnel for projects requiring a remote site or ocean environment for research, development, test or evaluation.

The terrain of San Clemente Island affords excellent sites for photometric and radar instrumentation. Steep cliffs overlook deep, clear water along the eastern shore of the Island. These abrupt contours are in contrast to the smooth terraces which descend to the west-side beaches, extending beneath the ocean surface to create a broad expanse of relatively shallow water along the entire length of the Island. The topography of the Island permits easy access to virtually any vantage point, facilitating movement of instrumentation.

San Clemente Island is 22 nautical miles long and $3\frac{1}{2}$ nautical miles at its widest point. Maximum elevation is 1,962 feet (Mount Thirst.) It has clear skies, and calm waters approximately 300 days of the year.

The geographic location of San Clemente Island provides a virtually unlimited expanse of open sea to the west and south. Los Angeles, Long Beach, San Diego, and Pacific Missile Range headquarters at Point Mugu are all within 30 minutes' flying time.

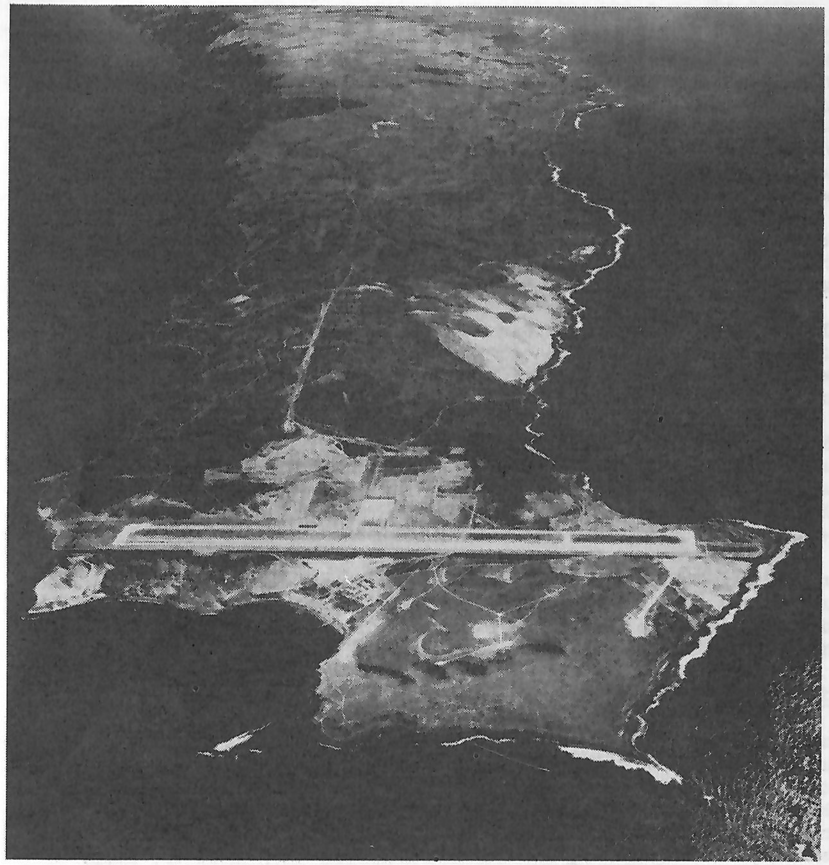
The SEALAB III test area, designated "Alabama", comprises a 3- by 5-nautical mile region adjacent to the eastern shore of the Island, extending southward from Wilson Cove. Depths vary from the shoreline shallows, with a smooth hard-sand bottom, to 4,000 feet and a soft sedimentary bottom.

In addition to the ELK RIVER, the SCI Range has a modified 56-foot landing craft specially outfitted as a diving support vessel. A large range of diving, salvage, and support ships are available from naval activities at San Diego and Long Beach for specialized work.

History

San Clemente Island is one of a group called the Channel Island which are separated from the mainland by the Santa Barbara Channel. In older books and maps they are usually known as the Santa Barbara Islands. The Channel Islands, which extend northwest to southeast for about 160 miles, include San Miguel, Santa Rosa, Santa Cruz, Anacapa, San Nicolas, Santa Barbara, Santa Catalina, and San Clemente. In all, there are about 20 islands in the group.

The islands are of volcanic origin. About a quarter of a mile off the northwestern end of the Island is Castle Rock which some believe is the core of the volcano that may have formed San Clemente Island. The crater within is said to be 40 feet deep. Perhaps the most dominant features of San Clemente Island are its thousands of caves, some below water level. At the northwestern end of the island are sand dunes, somewhat



of a mystery because of the absence of sandy beaches. These dunes move and change with a characteristic ripple of their own, rippled by heavy winds into "waves," then smoothed out again, but always standing in hummocks 40 to 50 feet high.

There is a report of the remains of a prehistoric shark being found in Chalk Canyon in 1937. The remains were said to have indicated a shark some 60 feet long, possibly dating from the Pliocene Geological Period over a million years ago.

Radio carbon dating indicates the earliest human inhabitants of the Channel Islands occupied Santa Rosa Island some 7,000 years ago. Indians probably lived on San Clemente Island at least 4,000 to 5,000 years ago. The earliest Indians on San Clemente Island obtained their food from the sea (the only animals on the island at the time are believed to have been small foxes and dogs). The Indians of the Channel Islands were noted for their boats which were large hollow hulls made of planks, rather than the dugouts and canoes common to mainland Indians.

There are indications that the Chinese and possibly Japanese visited the Channel Islands before they were "discovered" by the Spanish. One Chinese account claims to describe an exploration of the California coast and Mexico in 499 A.D. The Spanish followed in the 16th Century, charting and settling the southern California and Mexican coasts. The discoverer of California, a Portugese named Juan Rodriguez Cabrillo, who landed at what is now San Diego Bay on 17 September 1542, reached San Clemente and Santa Catalina early on 7 October.

San Clemente--at the time named for one of Cabrillo's ships--was not again visited by Europeans until a Spanish party landed there in 1595. A Spanish explorer named Don Sebastian Vizcaino explored the Channel Islands in late 1602, giving the islands the names we now use. The first true Spanish settlement was established in California in 1776 and increased interest in the Channel Islands followed. However, there was no settlement or mission established on San Clemente and the Indians were taken off to the mainland for work.

The Island was transferred to the United States with California in 1848 and at the turn of the century the first settlers were raising sheep and horses. The U.S. Navy began developing San Clemente Island as a test facility for underwater ordnance in 1949, with the Bureau of Naval Weapons (now Naval Ordnance Systems Command) and the Amphibious Force, Pacific Fleet, sharing military use of the island.

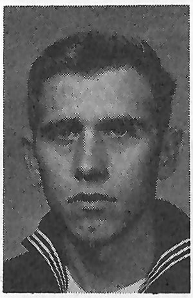
QUICK LOOK: SPECIAL FEATURES OF THE ELK RIVER (IX-501)

INSTRUMENTATION ROOM	1 tape recorder (Video + Audio) Underwater photo camera controls Underwater TV controls Underwater CTFM sonar controls Oceanographic instrumentation console and racks
PHOTO ROOM	Darkroom and camera maintenance shop
CENTERWELL	55 ft by 9 ft with sliding bottom-closure doors
ELECTRICAL POWER	4 250-kw 440 v, 3-phase 60 cycle generators (one required for ship operation) 1 20-kw 120/208 v, 60 cps, 3-phase, 4-wire generator, voltage and frequency regulated for ship's instrumentation 2 5-kw 110 v generators 2 5-kw 120/208 v 400 cycle, 3-phase frequency converter 1 30-kw 120/208 v 400 cycle, 3-phase generator Shore power connections
COMMUNICATIONS EQUIPMENT	4 UHF radios 8 VHF radios 2 MHF radios 1 Hull mounted UQC and 1 portable BQC underwater "telephones" 1 Intercom for project operations 1 Radio dial telephone to SCI exchange only 1 Shipboard dial telephone system 16 Shore phone connections 3 Sound power circuits (maneuvering, damage control and winch control) 2 Public Address Systems (ships and project operations)

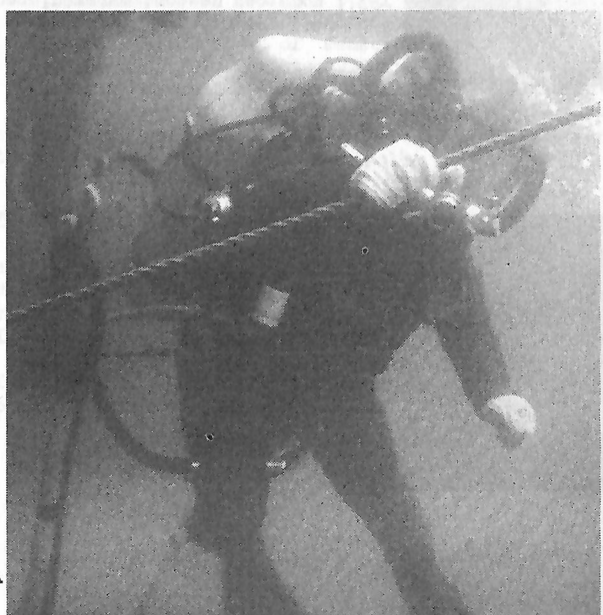
NAVIGATION EQUIPMENT	Surface search radar, fathometers, Mk-19 Mod 3 Gyrocompass, and electronic positioning system (LORAC B)
CENTERWELL LIFT EQUIPMENT	2 20,000-lb traction winches with storage reels for 20,000 ft of 1-1/8 in. nylon rope 4 20,000-lb winches for supporting centerwell equipment with single drums containing 6,000 ft of 3/4 in. cable 2 10,000-lb instrumentation cable reels, with slip rings and 6,000 ft of 1-1/2 in. composite cable
CRANES	Traveling gantry crane capable of 130,000-lb lift over the stern or through the centerwell, running on rails the full length of the main deck aft of superstructure 2 4,000-lb jib cranes for working the main deck, and special frame for working the centerwell 2 35,000-lb hoists fairleaded to lifting bars which can be mated to the sides of the well 1 20,000-lb hoist which moves transversely on a monorail
MAINTENANCE FACILITIES	Electric shop, electronics shop, divers shop, photo shop, and work shop

SEALAB III AQUANAUTS

This section contains brief biographies of the 54 U.S. and foreign navy and civilians who have qualified to serve as Aquanauts in the SEALAB III experiment. Forty of these men will live and work on the ocean floor during SEALAB III. The remainder will be surface support divers, based on the support ship ELK RIVER (IX-501). All have undergone the same rigorous training program, both in saturation diving and in individual specialization areas. Should any Aquanauts be forced to drop out of the bottom program because of illness or other reasons he will be replaced by one of the surface support divers. Additional information on all of these men is available from the SEALAB III Command Information Bureau.



Hospital Corpsman First Class FREDERICK W. ARMSTRONG, USN, entered the Navy in 1959. After attending the Hospital Corps School he served with Marine units at Camp Pendleton, California, and on Okinawa. Upon return to the United States in 1962 he underwent additional training at the Clinical Laboratory School in San Diego, and subsequently served at the school until 1964. He then was assigned to the naval dispensary at the Nuclear Power Training Unit, Idaho Falls, Idaho. He attended diving school in 1966 after which he was assigned to the DSSP Technical Office. (Born Peoria, Illinois 1941; hometown Peoria, Illinois; married; three children)



Aquanauts train with Mk VIII SCUBA in preparation for SEALAB III.

Warrant Officer ROBERT A. BARTH, USN has lived longer under high pressure than any other man in the world. He was a participant in the early U.S. Navy saturation diving experiments which began in 1957 and served as an Aquanaut in SEALABs I and II. In addition to being a qualified first class diver (hard-hat and SCUBA), Barth is a submariner. Since entering the Navy in 1947 he has served in a variety of surface ships and several submarines. (Born Manila 1930; hometown San Diego; married; two children; Legion of Merit for SEALAB I; Navy Commendation Medal for SEALAB II)

Engineman First Class RICHARD C. BIRD, USN entered the Navy in 1956. After attending submarine school he served in several conventional and nuclear-powered submarines, among them the Polaris submarine ETHAN ALLEN. He was assigned to the Submarine Escape Training Tank at New London in 1964, after which he attended diving school and, in 1966, was ordered to the DSSP Technical Office. (Born Newton, New Jersey 1937; hometown Newton; married; two children)

Aviation Ordnanceman First Class RICHARD M. BLACKBURN, USN, entered the Navy in 1957 and received training as a diver and in explosive ordnance disposal and aviation ordnance handling. He subsequently was assigned to the Naval Missile Center at Point Mugu, California, and the Experimental Diving Unit in Washington, D. C. He was ordered to the DSSP Technical Office in 1967. (Born Portland, Oregon 1939; hometown Portland; married; three children)

Lieutenant ROBERT A. BORNHOLDT, USN received a B.S. from Kings Point College in 1961. He entered the Navy the same year and subsequently served in a tank landing ship, and as executive officer of a tug and then a salvage ship. He attended diving school in 1965 and was assigned as operations officer to the DSSP Technical Office in 1967. (Born New York City 1938; hometown Seaford, New York; married)

Lieutenant Commander MARK E. BRADLEY, MC, USN received his B.S. (cum laude) from the University of Notre Dame in 1958 and his M.D. from the University of Maryland in 1962. After interning at the University of Virginia Hospital in Charlottesville, he entered the Navy in 1963. Dr. Bradley attended diving and submarine schools and then served in the nuclear-powered Polaris submarines ROBERT E. LEE and STONEWALL JACKSON, and ashore at Pearl Harbor. He was a research investigator in diving physiology at the University of Pennsylvania School of Medicine before being assigned to the DSSP Technical Office in 1967. (Born Baltimore, Maryland 1936; hometown Brewster, Massachusetts; single; Navy Commendation Medal for physiologic studies of saturation diving at the Navy Experimental Diving Unit in 1968)

Shipfitter First Class FRANK BUSKI, JR., USN entered the Navy in 1950 and served in destroyers until 1954 when he left the service. He re-enlisted in 1961 and subsequently served in a destroyer tender, attended diving and radiography schools, and in 1966 was assigned to the DSSP Technical Office. (Born Phoenixville, Pennsylvania 1933; hometown Phoenixville; married; one child)

WILLIAM J. BUNTON
is a civilian experimental test mechanic at the Naval Undersea Warfare Center (Pasadena, California). He served in the Army from 1950 to 1953, including service in Korea with the 187th Airborne Regimental Combat Team. In 1960 he joined the staff of the Navy Electronics Laboratory (San Diego) and subsequently transferred to the Naval Undersea Warfare Center. Mr. Bunton was an Aquanaut during SEALAB II, serving as photographer on the third team in that ocean floor experiment. (Born Vandergrift, Pennsylvania 1933; hometown Detroit, Michigan; married; five children; Navy Superior Civilian Service Award for SEALAB II)

Lieutenant LAURENCE T. BUSSEY, USN
earned his B.A. in education from Gorham State College (Maine) in 1961. After graduation he attended Navy Officer Candidate School and was commissioned in 1962. After sea duty in a destroyer he qualified as a salvage diver and served as assistant repair officer, ship's superintendant, and diving officer of the repair ship VULCAN. After attending underwater swimmers school and first class diving school he was assigned to the DSSP Technical Office in December 1966. (Born Portland, Maine 1937; hometown Kittery Point, Massachusetts; married; three children)

BERRY L. CANNON
civilian electronic engineer with the Navy Mine Defense Laboratory (Panama City, Florida), served in the Navy from 1953 to 1957. He received his B.S. in electrical engineering from Florida State University in 1962 and joined the staff of the Navy Mine Defense Laboratory the following year. He served as an Aquanaut in the SEALAB II ocean-floor experiment. (Born Red Level, Florida 1935; hometown Panama City, Florida; married; two children)

Commander M. SCOTT CARPENTER, USN
is the U.S. Navy's senior Aquanaut. He received his B.S. from the University of Colorado and entered the Navy in 1949. After flight training he served with a patrol squadron in the Korean War. In 1954 he attended Naval Test Pilot School and subsequently served as a test pilot at the Naval Air Test Center, Patuxent River, Maryland. Carpenter was selected as one of the original seven U.S. Astronauts in 1959 and underwent intensive training with the National Aeronautics and Space Administration. He was backup pilot for John Glenn for America's first orbital flight and flew the second American manned orbital flight in 1962, piloting his spacecraft through three revolutions of the earth. The flight, which reached a maximum of 164 miles, lasted 4 hours 54 minutes. He was an Aquanaut in the SEALAB II experiment, remaining at a depth of 205 feet for a record 30 consecutive days. He was assigned to NASA until August 1967 when he was transferred to the Deep Submergence Systems Project as Assistant for Aquanaut Operations. In addition, he is Deputy On-Scene Commander and Special Assistant for Aquanaut Operations in the SEALAB III experiment. (Born Boulder, Colorado 1925; hometown Boulder, Colorado; married; four children; Legion of Merit for SEALAB II; Distinguished Flying Cross and NASA Distinguished Service Medal for orbital flight)

Petty Officer First Class DEREK J. CLARK, RN
entered the Royal Navy in 1949 and has served in several ships and at a number of shore activities. He has had extensive diving experience and was an instructor at HMS Vernon, the Royal Navy's deep diving establishment at Portsmouth. He was assigned to the DSSP Technical Office in January 1968. (Born Bristol, England 1934; hometown Portsmouth, England; married; five children)

Torpedoman's Mate First Class KENNETH J. CONDA, USN entered the Navy in 1954 and subsequently qualified as a torpedoman and submariner. He served in several submarines,including the nuclear-powered Polaris submarine THEODORE ROOSEVELT. After diver training he participated in the Project GENESIS physiological studies and was an Aquanaut in SEALAB II. During the ocean-floor experiment he helped handle the porpoise "Tuffy." He is currently assigned to the DSSP Technical Office. (Born Phoenix, Michigan 1932; hometown Phoenix, Michigan; married; three children; Navy Commendation Medal for SEALAB II)

RICHARD A. COOPER
is a research oceanographer for the Bureau of Commercial Fisheries, Department of the Interior. He received his B.S. in fisheries from the University of Michigan and earned his M.S. and Ph.D in biological oceanography at the University of Rhode Island's Graduate School of Oceanography. He is currently assigned to the Bureau of Commercial Fisheries Biological Laboratory in Boothbay Harbor, Maine, where he participates in diving operations while researching the distribution, growth, and behavior of lobsters in the Gulf of Maine. (Born Ann Arbor, Michigan, 1936; hometown Ann Arbor, Michigan; married;three children)

GEORGE B. DOWLING
is a civilian research physicist at the Navy Mine Defense Laboratory, Panama City, Florida. He served in the Navy during World War II and received his B.S. degree from Emory College and a M.S. from Florida State University. Mr. Dowling has participated in Navy Mine Defense Laboratory oceanographic expeditions off the coasts of North and Central America, in the Marshall Islands, Bering Sea, and Arctic Ocean. He was an Aquanaut in the SEALAB III experiment. (Born Bradenton, Florida 1926; hometown Panama City, Florida; married; five children)

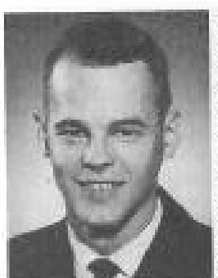
Gunner's Mate First Class WILBUR H. EATON, USN entered the Navy in 1944 and participated in the invasion of Okinawa in 1945. After the war he left the Navy to attend college and then teach social studies and physical education. He re-enlisted in the Navy in 1955, served in a mine hunter,qualified as a diver and in explosive ordnance disposal, and served with the EOD unit at Charleston from 1956 to 1964. He was surface support diver for SEALAB I and an Aquanaut in the SEALAB II ocean-floor experiment. He is currently assigned to the DSSP Technical Office. (Born Omaha Nebraska 1926;hometown Fort Lauderdale, Florida; married; six children)

Lieutenant MATTHEW C. EGGAR, USN
enlisted in the Navy in 1944 and served with the Navy Mobile Construction (Seabee) Battalions during the latter part of the war. Post-war assignments included several ships and diver training. He was commissioned as a limited duty officer (engineering) in 1962 and served subsequently in the salvage ship CURRENT and at the Naval Ammunition Depot in Bangor, Washington. Lieutenant Eggar was assigned to the DSSP Technical Office in 1967. (Born St. Paul, Minnesota 1926; hometown St. Paul Minnesota; married; two children)

Warrant Officer RICHARD A. GARRAHAN, USN
enlisted in the Navy in 1956 and after attending machinery repairman school served successively in two ASW aircraft carriers. He attended diving school in 1959, after which he served in a submarine rescue ship and then at the Navy Experimental Diving Unit in Washington, D. C. At EDU he helped evaluate the Mk V and Mk VI diving equipment and assisted in computing the diving tables for Project GENESIS, SEALAB I and SEALAB II. Upon promotion to warrant officer in 1966 he was assigned to the DSSP Technical Office as assistant engineer officer. (Born Luzerne, Pennsylvania 1936; hometown Luzerne; married; five children)

Lieutenant Commander LEO C. GIBS, USN was graduated from the Naval Academy in 1958. He subsequently served in a destroyer and was material officer for an escort squadron. Following these assignments he attended the Massachusetts Institute of Technology, earning a M.S. in naval architecture and marine engineering, and attended diving school. He then served at the Long Beach Naval Shipyard before being ordered to the Deep Submergence Systems Project Office in Chevy Chase, Maryland. He is designated as an Engineering Duty Officer. (Born Cincinnati, Ohio 1936; hometown Cincinnati, Ohio; single)

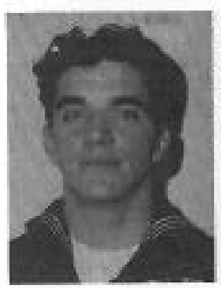
LAWRENCE W. HALLANGER is with the staff of the Naval Civil Engineering Laboratory at Port Hueneme, California, since 1965. He received his B.S. in engineering science from Harvey Mudd College in 1961. He subsequently earned his M.S. and Ph.D in mechanical engineering from the California Institute of Technology in 1962 and 1967, respectively. He is currently in charge of the undersea construction and equipment program for SEALAB III at the Naval Civil Engineering Laboratory. (Born Oakland,California 1939;hometown Oakland, California; married)



Lieutenant Commander DAVID MARTIN HARRELL, USNR is a civilian systems engineer in the Ocean Engineering Branch, Deep Submergence Systems Project. Lieutenant Commander Harrell received his B.S. in aeronautical engineering and his M.S. in electrical engineering from the Georgia Institute of Technology. While on active duty in the Navy from 1959 to 1962 he qualified as a salvage diver and served two years in a submarine rescue ship as first lieutenant and diving officer. He subsequently worked as an aerospace engineer for the Manned Spacecraft Center (Houston, Texas) and as an engineer at the Experimental Diving Unit. He joined the staff of DSSP in July 1966. (Born Jacksonville, Florida 1937; hometown Jacksonville, Florida; married)

Damage Controlman First Class SAMUEL E. HUSS, USN entered the Navy in 1960. He had duty in two amphibious ships, one of which made two deployments to the Western Pacific and operated in the Tonkin Gulf while assigned to the Seventh Fleet. He attended diving school in 1966 after which he was assigned to the DSSP Technical Office. (Born Decatur, Alabama; hometown Grass Valley, California; married; one child)

WALLACE T. JENKINS a civilian oceanographer with the Navy Mine Defense Laboratory (Panama City, Florida), received his B.S. in psychology from Florida State University in 1957. He served in the Navy from 1958 to 1962, when he enrolled in the University of Washington, doing postgraduate work in oceanography. Mr. Jenkins has been associated with the undersea programs of the Navy Mine Defense Laboratory since 1962 and was an Aquanaut in the SEALAB II experiment.



Engineman First Class DUANE N. JENSEN, USN entered the Navy in 1962. After serving three years in a tank landing ship he attended deep sea diving school, after which he served in a salvage ship until being assigned to the DSSP Technical Office in 1967. (Born Harlin, Iowa 1944; hometown Gary, Indiana; unmarried)

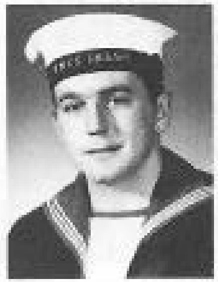
Hospital Corpsman First Class JOHN G. KLECKNER, USN entered the Navy in 1959. After attending Hospital Corps School he received training in the operation of hyperbaric pressure chambers and served at the Navy Air Facility, Naples, Italy, and the clinical laboratory at the Naval Hospital, Portsmouth, Virginia. In 1965 he attended Laboratory School at the Submarine Medical Center. He also underwent diver training prior to being assigned to the DSSP Technical Office in 1967. (Born Pottsville, Pennsylvania 1941; hometown Pottsville, Pennsylvania; married; two children)

Lieutenant CYRIL F. LAFFERTY, RN attended Preston Catholic College and Britannia Royal Navy College before entered active naval service in 1958. He served at sea in an ASW escort and a coastal minesweeper before becoming first lieutenant (executive officer) of the diving trials ship RECLAIM. While in the RECLAIM he participated in the Royal Navy's 600-foot dives in the Mediterranean Sea. He was officer-in-charge of the Plymouth Command's Clearance Diving Team before being assigned to the DSSP Technical Office early in 1968. (Born Leeds, Yorkshire, England 1938; hometown Broadmayne, Dorset, England; married; three children)

Lieutenant-Commander LAWRENCE M. LAFONTAINE, RCN entered the Canadian Navy as a reserve cadet in 1951 while attending Loyola College in Montreal. After officer training he attended diving school and served in destroyer escorts. He subsequently served in shore billets and attended the Royal Canadian Air Force Staff College. He was assigned to the DSSP Technical Office in January 1968. (Born Montreal, 1934; hometown Montreal; married; five children)

Commander PAUL G. LINAWEAVER, JR., USN received his B.A. in zoology from Duke University in 1951 and his M.D. from George Washington University in 1955. He subsequently earned his M.S. in physiology from the University of Pennsylvania. After interning at the Oakland Naval Hospital he was assigned to the Navy Experimental Diving Unit in Washington, D. C., as a research physiologist. Subsequent assignments included duty on Guam and at New London as Director of the Submarine Medical Research Laboratory. While assigned to MRL he made a 60-day submerged patrol in the nuclear-powered Polaris submarine ALEXANDER HAMILTON. During 1967 he served with Harbor Clearance Unit One in Southeast Asia and was project officer for the ADS-IV deep-diving system. Dr. Linaweaver became the senior medical officer of the DSSP Technical Office in December 1967. (Born Washington, D. C. 1929; hometown Monroeville, Alabama; married, five children)

Machinist's Mate First Class FERNANDO LUGO, USN enlisted in the Navy in 1960 and after brief duty in Philadelphia with the mothball fleet he attended machinist's mate school. He then served in guided missile ships before being assigned to the DSSP Technical Office in 1966. During his Aquanaut training Lugo participated in the record-setting 1,025-foot dive conducted at the Navy Experimental Diving Unit. (Born Yuma, Arizona 1942; hometown Fresno, California; married; two children; Navy Commendation Medal for 1,025-foot dive)



Leading Seaman WILLIAM F. LUKEMAN, RCN entered the Canadian Navy in 1958 and after radar plotter's training he served three years in a destroyer escort. While in the ship he qualified as a diver and subsequently underwent diver training. His diving experience includes exercises with the U.S. Navy and aiding in the recovery of a USAF KC-97 tanker aircraft which crashed into the sea off Newfoundland. He was assigned to the DSSP Technical Office in January 1968. (Born Nova Scotia 1940; hometown Sydney, Nova Scotia; married)

Lieutenant JAMES E. McDOLE, USN
is assistant officer-in-charge of the DSSP Technical Office in San Diego. He enlisted in the Navy in 1946, served in several ships, underwent diver training, and attended explosive ordnance disposal school. He was commissioned in 1960 after which he served at the Naval Ordnance Test Station in Pasadena and in additional surface ships, including a tour as executive officer of the salvage ship ESCAPE. McDole was assigned to the DSSP Technical Office in 1967. (Born Ballenger, Texas 1928; hometown Abilene, Texas; married; two children)

Chief Construction Mechanic JAMES M. MELDER, USN
entered the Navy in 1952 and served in a variety of Seabee activities. His overseas duty stations included Alaska, Okinawa, and Taiwan. After attending diving school he was assigned to the DSSP Technical Office in 1967. (Born Shreveport, Louisana 1934; hometown Shreveport; married; one child)

Electrician's Mate First Class JACK W. MOREY, USN
entered the Navy in 1956 and attended electrician and submarine schools. He subsequently served in the nuclear-powered attack submarine SCAMP and a number of other ships. Morey is an explosive ordnance disposal expert in addition to being a qualified diver. He was assigned to the DSSP Technical Office in 1966. (Born Albany, California 1939; hometown Albany, California; married; two children)

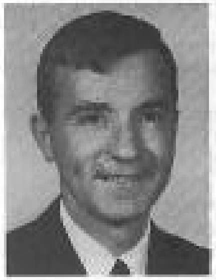
Machinist's Mate Second Class KEITH H. MOORE, USN
entered the Navy in 1960 and after attending second class diver's school he served in repair ships. He subsequently attended machinist's mate, first class, diving, and underwater demolition schools, and served in other surface ships prior to being assigned to the DSSP Technical Office in 1966. (Born Independence, Missouri 1939; hometown Independence; married; two children)

Machinist's Mate Second Class JAY W. MYERS, USN
entered the Navy in 1963. After attending machinist's mate and submarine schools he served in the nuclear-powered Polaris missile submarine THOMAS EDISON. He then attended underwater swimmers school, served in the conventional fleet submarine IREX, and attended diving school before reporting to the DSSP Technical Office in 1967. (Born Buffalo, New York 1944; hometown Buffalo, New York; married)

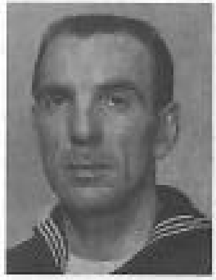
Lieutenant Commander JAMES H. OSBORN, USN
was graduated from the Naval Academy in 1959. After commissioning he was assigned to the Naval Civil Engineer Corps School at Port Hueneme, California, and subsequently attended Rensselar Polytechnic Institute and Texas A&M, earning a Bachelor of Civil Engineering degree from the former and a Master of Civil Engineering from the latter. His assignments have included maintenance officer at the Naval Academy and base plans officer on the staff of Commander, Fleet Air Hawaii. Lieutenant Commander Osborn attended deep sea diving school in 1967 and was assigned to the DSSP Technical Office in September of 1967. (Born El Paso, Texas 1938; hometown El Paso, Texas; married; one child)

Lieutenant (j.g.) ANDRES PRUNA, USNR
is a civilian physical science technician with the Naval Oceanographic Office. He attended the San Alejandro Academy of Fine Arts in Havana from 1957 to 1958, and the National Academy of Fine Arts in New York City during 1960. He worked as a diver on a Dutch ship in the Caribbean during 1959. Late in 1960, Lieutenant Pruna joined Brigade 2506 of Cuban exiles and underwent training in guerrilla warfare and underwater demolition. He was with the Cuban underwater demolition team during the ill-fated Bay of Pigs invasion in 1961. After commanding the surviving exile UDT personnel he was commissioned in the U.S. Naval Reserve in 1963 and served on the staff of Commander, Amphibious Training Command, Atlantic Fleet. He left active service in 1964 and joined the staff of the Naval Oceanographic Office. (Born Havana, Cuba 1940; hometown New York City; married; two children)

Photographer's Mate First Class WILLIAM C.RAMSEY, USN
entered the Navy in 1951. His first sea duty was in a destroyer which made three deployments to the Western Pacific during the Korean War and participated in nuclear tests in the Pacific. He subsequently served in other surface ships, an aircraft squadron, a Seabee battalion, and at the Naval Missile Center, Point Mugu, California. He has been assigned to the Combat Camera Group Naval Air Station North Island, San Diego since 1966. (Born Truckee,California 1933; hometown Oxnard, California; married; two children)



Lieutenant LAWRENCE W. RAYMOND, MC, USN
received his B.S. in civil engineering from Manhattan College in 1956 and his M.S. from Harvard University in 1957. He subsequently attended the Medical College of Cornell University, receiving his M.D. in 1964. Lieutenant Raymond entered the Navy in 1965 and was assigned to the Naval Medical Research Institute in Bethesda, Maryland, where he conducted research in physiological problems of prolonged underwater exposure. He is currently in residency at the Naval Hospital, Bethesda. (Born Buffalo, New York 1935; hometown Binghamton, New York; married)



Machinery Repairman First Class FRANK L. REANDO, USN
entered the Navy in 1956. After duty in an escort carrier he attended machinery repairman school and successively served in three repair ships. He then attended underwater swimmers and deep sea diving schools, and served in submarine rescue and salvage ships before being assigned to the DSSP Technical Office. (Born Potosi, Missouri 1936; hometown San Antonio, Texas; married; four children)

Photographer's Mate First Class JOHN F. REAVES, USN
entered the Navy in 1947 and subsequently served in a number of Navy activities concerned with photography. He provided photographic documentation of the Hydro Iris Upper Air Research Rocket, the Hydro V Missile and the Navy's porpoise research program. He attended SCUBA and first class diver schools and was an Aquanaut during the SEALAB II ocean-floor experiment. He is currently assigned to the Naval Missile Center, Point Mugu, California. (Born Robertsdale, Alabama 1929; hometown Ventura, California; married; two children; Navy Commendation Medal for SEALAB II)

Hospital Corpsman First Class TERREL W. REEDY, USN
entered the Navy in 1959 and has served as a hospital corpsman at several naval bases, hospitals, and in a number of ships. He attended diving school which, coupled with duty in a submarine tender and submarine rescue ship, have given Reedy a comprehensive background in diving and submarine medicine. He is currently assigned to the DSSP Technical Office. (Born Tuscola, Illinois 1941;hometown Villa Grove,Illinois; married; two children)

Mineman Second Class DON C. RISK, USN entered the Navy in 1954 and after attending mine school served in air service squadrons and at sea aboard a seaplane tender. After attending explosive ordnance disposal and undersea weapons schools he was assigned to Underwater Demolition Team (UDT) 21. He has also served in an aircraft carrier, at the naval magazine in Rota, Spain, and at the Navy Mine Defense Laboratory. He has been assigned to the DSSP Technical Office since 1965. During his Aquanaut training Risk participated in the record-setting 1,025-foot saturation dive conducted at the Experimental Diving Unit. (Born Muncie, Indiana 1937; hometown Muncie; married; one child; Navy Commendation Medal for 1,025-foot dive)

N. TERREL ROBINSON is with the Deep Ocean Surveys Division of the Naval Oceanographic Office in Suitland, Maryland. Mr. Robinson received his B.A. in geology from Vanderbuilt University. He was a cartographer for the Coast and Geodetic Survey from 1963 to 1965, when he joined the Naval Oceanographic Office. (Born Atlanta, Georgia 1940;hometown Annapolis, Maryland;married; two children)

Boatswain's Mate First Class IRWIN C. RUDIN, USN entered the Navy in 1951. He subsequently served at the Torpedo Test Range at Piney Point, Maryland, in a destroyer and two destroyer tenders. He attended diving school and was selected for the Man-in-the-Sea Program while serving at the Navy Experimental Diving Unit in Washington, D. C. He is currently assigned to the DSSP Technical Office. (Born Atlanta, Georgia, 1932; hometown Atlanta,Georgia; married; three children)

Chief Builder WILLIAM J. SCHLEIGH, USN entered the Navy in 1953 and served in a number of Seabee billets. His duty assignments have taken him to Newfoundland, Bermuda, Barbados, San Salvador, and Sicily. After attending diving school he was assigned to the DSSP Technical Office in 1967. (Born Philadelphia 1935; hometown Eddington, Pennsylvania; married; three children)

Chief Machinist's Mate DONALD J. SCHMITT, USN entered the Navy in 1955 and served in several destroyer-type ships. After attending diving school he served with the salvage and rescue unit at the Naval Air Station Corpus Christi, Texas,and after additional diver training, was assigned to a fleet tug and repair ship. He was assigned to the DSSP Technical Office in 1967. (Born Tucson, Arizona 1937; hometown Tucson, Arizona; married; three children)

Shipfitter Second Class JOE P. STUBBS, USN entered the Navy in 1954 and subsequently qualified as a diver. He has served in several ships, including two salvage ships. He is currently assigned to the DSSP Technical Office. (Born Martel, Tennessee 1937; hometown Martel,Tennessee; married;three children)

Lieutenant RICHARD R. SUTTON, RAN completed training at the Royal Australian Naval College in 195 and was graduated from the Royal Naval College in England the following year. He subsequently served in several Australian naval ships, qualified as a clearance diver, and served with the RAN clearance diving team. Additionally, he served as an instructor at the Royal Australian Naval College. Lieutenant Sutton was assigned to the DSSP Technical Office in April 1968. (Born Toowoomba, Queensland, Australia 1940; hometown Clontarf Beach, Queensland; single)

Senior Chief Engineman CYRIL J. TUCKFIELD, USN entered the Navy in 1942 and subsequently served in a number of conventional submarines and a submarine tender. Chief Tuckfield began diving in 1948. He made a record 302-foot buoyant ascent from the submarine ARCHERFISH off Key West, Florida, in 1959. The feat, made with Captain George F. Bond, MC, USN, helped establish the feasibility of unaided escape from disabled submarines. He also served as an Aquanaut in the SEALAB II ocean-floor experiment. (Born Shreveport, Louisana 1921; hometown Miami, Florida; married; Legion of Merit for 302-foot ascent from submarine)

Lieutenant Commander JAMES VOROSMARTI, JR., MC, USN received his B.A. from Lafayette College and his M.D. from Jefferson Medical College. He interned at the Naval Hospital in Portsmouth, Virginia, in 1961-1962 after which he attended diving and submarine schools. His sea duty was in the nuclear-powered attack submarine JACK and the nuclear-powered Polaris Submarine JOHN ADAMS. Dr. Vorosmarti served at the Pearl Harbor Submarine Base before being assigned to the DSSP Technical Office in 1966. (Born Palmerton, Pennsylvania 1935; hometown Palmerton; married; two children; Secretary of the Navy Achievement Medal for physiologic studies of saturation dives at experimental Diving Unit in 1968)

RICHARD A. WALLER is a staff scientist with the Bureau of Commercial Fisheries, Department of the Interior. He earned a B.S. and M.S. in biological oceanography at Florida State University. Mr. Waller was selected for the SEALAB III experiment to represent the interest of the Bureau of Commercial Fisheries in studying marine life inhabiting the continental shelves. (Born Jacksonville, Florida 1934; hometown Jacksonville, Florida; married; two children)

Senior Chief Torpedoman PAUL A. WELLS, USN entered the Navy in 1950 and has spent most of his Navy career working with explosive ordnance and in diving. He served as an Aquanaut in the SEALAB III experiment and is now assigned to the DSSP Technical Office. (Born Folcroft, Pennsylvania 1927; hometown Fort Lauderdale, Florida; married; Purple Heart for service in Marine Corps during World War II; Navy Commendation Medal for SEALAB II)

Engineman First Class WILLIAM W. WINTERS, USN entered the Navy in 1957. After two years of shore duty he served in several ships and attended diving school. He has been assigned to the DSSP Technical Office since early 1967. (Born Albany, New York 1940; hometown Colonie, New York; unmarried)

AQUANAUT SELECTION AND TRAINING

All Aquanauts in the SEALAB III experiment are Navy or civilian specialists, highly skilled in a number of fields related to ocean floor work. This underwater work includes biology, ecology, bio-acoustics, physical oceanography, geology, bio-luminescence, construction, salvage, photography, and communications.

Most of the SEALAB III Aquanauts and alternates volunteered for the Man-in-the-Sea program while in other diving assignments in the Navy. These included assignments as ship's divers and with underwater demolition teams (UDT), explosive ordnance disposal (EOD) units, and salvage activities. Other Aquanauts had other Navy or civilian diving experience.

Five British Commonwealth navy divers were invited to participate in SEALAB III as part of a broad U.S. effort to increase international co-operation in the exploration and exploitation of the sea. Invitations to participate in SEALAB III were extended to Australia, Canada, and the United Kingdom because of previous co-operation among them and the United States in diver training, and because all four nations use similar diving equipment and techniques. In addition, use of a common language facilitates operations under the stress conditions of undersea activities. Thus, two divers each from the Royal Navy and Royal Canadian Navy, and one from the Royal Australian Navy have qualified to serve as Aquanauts; three of these men are living and working on the ocean floor during SEALAB III while the two others are surface support divers and alternates.

After an arduous training program, early in 1968 the primary and alternate Aquanauts for SEALAB III were chosen by the staff of the Deep Submergence Systems Project.

Naval School Deep Sea Divers

The U.S. Navymen in SEALAB III are all qualified first class divers, having attended a 26-week diving course at the Naval School Deep Sea Divers in Washington, D. C. (since redesignated Naval School Diving and Salvage). This course qualified the divers in the use of SCUBA gear for depths to 130 feet using compressed air and in the use of "hard hat" diving equipment to depths of 320 feet breathing a helium-oxygen mixture. Training at the school consisted of both classroom work and actual dives, the latter being conducted in Washington's murky Anacostia and Potomac Rivers. The students practiced underwater work and salvage techniques and actually salvaged a small ship which was intentionally sunk and brought to the surface by each class.

The navy divers from Britain, Canada, and Australia who are participating in the SEALAB III experiment have undergone similar diver training previously.

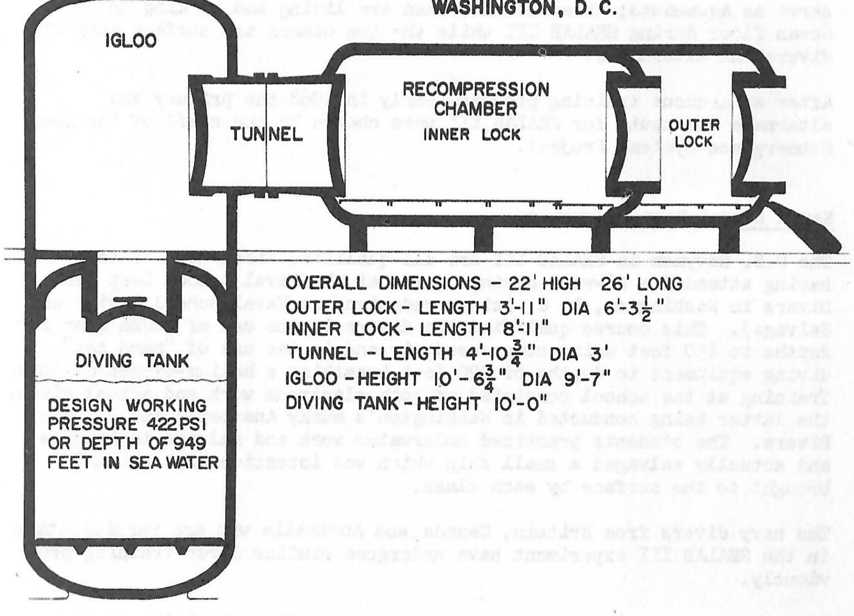
Most SEALAB III Aquanauts then underwent specialized training at the Navy Underwater Swimmers School in Key West, Florida; the Navy Experimental Diving Unit in Washington and the DSSP Technical Office in San Diego.

Navy Experimental Diving Unit

At the Experimental Diving Unit (EDU) the men made "dives" in dry and wet chambers which simulated deep-ocean pressure. Actually, the pressure inside the chambers was the same as they encounter during SEALAB III; many dangers, such as too rapid decompression, were the same as in the open sea. The "dives" at EDU determined if the candidates were psychologically suited for saturation diving. In these dives the men were taken to various simulated depths, eventually spending at least 24 hours at the 600-foot level. They were then returned to surface pressure, undergoing a slow, carefully calculated decompression or reduction of pressure to prevent their contracting the deadly disease known as "bends."

During these EDU chamber dives two Aquanauts, Machinist's Mate First Class Fernando Lugo, USN, and Mineman Second Class Don Risk, USN, reached a simulated depth of 1,025 feet and remained at that depth for 13 minutes before returning to join three companions who were at a simulated depth of 825 feet. The 1,025-foot mark established a new depth record in diving. (The five men also remained at 850 feet for 48 hours during the test, the longest period man had ever remained at that depth.)

U.S. NAVY EXPERIMENTAL DIVING UNIT
WASHINGTON NAVY YARD
WASHINGTON, D. C.



The two pressure chambers at EDU each have an inner lock approximately nine feet long, an outer lock four feet long, and a vertical section with two tandem chambers totalling 20 feet in height. The smaller, outer lock is used to pass in food and equipment--medical personnel in an emergency--to the men in the inner lock and vertical chambers. The vertical chambers, the lower of which can be partially filled with water, are used for work activities and equipment tests.

In addition to the diver and equipment evaluation aspects of the chamber dives, each prospective Navy Aquanaut was taught to operate a saturation diving system similar to the one being used in SEALAB III.

Specialized Training

Certain SEALAB III Aquanauts also received special training in preparation for specific tasks in the experiment's ocean bottom program. For example, Aquanaut photographers installed and maintained a special camera-lights package at the SEALAB III test site as part of their training. They practiced servicing and operating the equipment in the actual environment they are now encountering in the ocean. Hospital corpsmen learned to use special equipment for bio-medical analysis in the SEALAB III environment and to monitor the seafloor habitat's atmosphere.

Additional training was provided to the Aquanauts at the DSSP Technical Office in San Diego. This activity was the "homeport" and primary training facility for the U.S. Aquanauts. Prior to the start of the SEALAB III experiment the men underwent intensive training at the Technical Office including open-sea diving exercises, instruction in the operation of SEALAB III equipment and special tools, and additional practice in safety procedures.

Integration Testing

Groups of the Aquanauts travelled to the San Francisco Bay Naval Shipyard approximately six months before the experiment began to take part in system integration testing. These tests made certain that all of the "pieces fit together"--the surface support ship, the diving system, seafloor habitat, Aquanaut equipment, etc. Each Aquanaut is responsible for knowing his own equipment, such as the Mk VIII SCUBA, wet suit, and equipment related to his bottom work, as well as the multitude of valves, gauges, plugs, outlets, and indicators in the habitat and, to a lesser extent, in the diving system.

About a month before the experiment began the surface support ship ELK RIVER (IX-501) and seafloor habitat were moved to the Long Beach Naval Shipyard for shallow water tests. There the habitat was lowered to a depth of about 45 feet and the entire SEALAB III complex was again connected for integration tests. This was the "dress rehearsal" for SEALAB III. At Long Beach, as at San Francisco, the Aquanauts received additional on-the-job training. Throughout this period the tests the

Aquanauts themselves were undergoing continual physical examinations at nearby naval hospitals and at the DSSP Technical Office.

A few days before the experiment commences, the surface support ship, habitat, support craft, and Aquanauts shift to the test site off San Clemente Island. The Aquanauts then join the support ship personnel and support divers handling and lowering the habitat, rigging umbilical cables between the support ship and seafloor habitat, and between the ship and San Clemente Island. These last-minute activities give the Aquanauts a last-minute look at the status of various components of the SEALAB III complex, and important part of their training. After the habitat is securely emplaced at a depth of some 600 feet and the various cables, lines, and equipment connected, two Aquanauts of the first eight-man team descend to the ocean floor and enter the habitat. After a final check of the habitat's equipment, they declare the habitat ready for their fellow team members. The training ends as that first team enters the habitat; SEALAB III is under way.

PRESS HANDBOOK

APPENDIXES

A.

MAN-IN-THE-SEA PROGRAM

The Man-in-the-Sea phase of the U.S. Navy's Deep Submergence Systems Project has the purpose of developing the technology and equipment necessary to allow man to live and work in the ocean depths. This capability is required if man is to exploit the enormous economic wealth and military potential of the ocean, especially the continental shelf areas. These shelves are generally considered the offshore regions which slope down to between 600 and 1,000 feet, after which there is a steep drop to considerably greater depths.

This underwater area is alien to man: sunlight and voice communications penetrate only a few hundred feet; artificial lighting, if the equipment can withstand the pressure, penetrates the murky darkness only a few feet; the movement of man or vehicle can further reduce visibility by stirring up bottom mud and sediment; the cold is numbing; and there is abundant marine life known to be dangerous to man.

The U.S. Navy's program to penetrate this "Inner Space" began with laboratory experiments using animals and then human beings, exposing them to prolonged high-pressures and artificial atmospheres. From these laboratory tests came the SEALAB experiments, wherein Navy personnel and specially qualified civilians have lived in underwater habitats and worked and explored in the surrounding water. These in situ experiments, backed up by extensive psychological and engineering studies, are now approaching the point where the ability to work on the ocean floor for extended periods of time will be an operational capability of the U.S. Navy.

The problems facing this effort are formidable. Astronaut Edward White became the first American to emerge in Outer Space when he left his space capsule orbiting more than 100 miles above the earth in June of 1965. Two months later the U.S. Navy's SEALAB II experiment placed an underwater habitat for free-swimming Aquanauts at a depth of 205 feet. Some of the Aquanauts made a brief excursion dive to a depth of some 300 feet--less than one-tenth of a mile below the surface of the sea.

This comparison of the Astronaut in Outer Space and the Aquanaut in Inner Space demonstrates the bizarre extremes of these programs and man's severely limited ability to enter the sea although he has used the sea for exploration, commerce, food, and war for more than 5,000 years. This use, until now, has been limited essentially to the surface of the sea and man has not ventured very far into the depths without a protective vehicle to withstand the tremendous external pressure encountered in the abyss.

Until recently, man's maximum working depth in the sea was considered to be 380 feet for 30 minutes with "hard-hat" diving equipment. This depth/time limitation is based on the extreme cold and the accumulation of dissolved gas in the body of a diver, proportional to the depth and duration of his dive.

Diving Physiology

Without proper decompression when returning from depths of the ocean, the diver becomes subject to the painful and sometimes fatal disease known as "bends." This disorder is caused by too sudden a change from high pressure air to ordinary surface pressure. Too rapid a change in pressure will not allow the body to safely eliminate excess gases (such as nitrogen or helium) it has absorbed in the artificial atmosphere at depth. The most common symptoms of decompression sickness are local pains, and to a lesser extent, dizziness, fatigue, shortness of breath, and paralysis. Death can result in severe cases.

Score of laborers working in tunnel construction and divers were killed or maimed by the disease before the French physiologist Paul Bert discovered its causes in the 1870s and advocated gradual decompression or "recompression." This process provided for a gradual return to the surface. The first recompression chamber--which simulated changes in air pressure for treating victims of the "bends"--was installed to aid laborers working on the first Hudson River Tube in New York City in 1893.

As men dived deeper with compressed air, they encountered great difficulties from these gases. Although oxygen is essential to human life, high concentrations can have undesirable effects. To divers the danger from breathing oxygen under pressure is oxygen intoxication, which affects the brain. This intoxication can cause convulsions, which, in turn, can lead to underwater accidents.

Nitrogen narcosis is as dangerous as oxygen poisoning. Under pressure, the nitrogen of compressed air becomes narcotic and interferes with normal mental functioning. The symptoms of this affliction include loss of judgment, a false feeling of well-being, difficulty in performing even minor tasks, and, at great depths, unconsciousness. The nitrogen of compressed air begins to have intoxicating effects at a depth of about 100 feet.

In an effort to solve the problems involved with breathing compressed air in deep-sea diving, the U.S. Navy's Bureau of Construction and Repair, which was responsible for Navy diving operations, and the U.S. Bureau of Mines, which was seeking practical uses for helium, conducted joint experiments with breathing helium-oxygen mixtures under pressure. Animals were used in the early experiments and by 1927 the work had progressed to the point where human subjects could be used.

The Navy's participation in this project was formally designated the U.S. Navy Experimental Diving Unit (EDU) in 1927, and later moved to permanent facilities at the Navy Yard in Washington, D.C. The EDU facility, with its adjacent Deep Sea Divers School, remains the world's principal diving research and training establishment.

The U.S. Navy continued experiments with helium-oxygen gas mixtures for deep-sea diving. In 1938, using a helium-oxygen mix, two Navy divers reached a simulated depth of 531 feet in one of the tanks at EDU.

The experience gained in these dry-land experiments was put to operational use in May of 1939 when the U.S. submarine SQUALUS sank in 243 feet of water off the New England coast. Initial dives at the disaster scene were made with compressed air, but most of the 640 dives employed helium-oxygen mixtures. There was not a single death or serious injury suffered during this intensive deep-sea diving operation. The new technique was proven far superior to compressed-air breathing.

On the basis of data obtained during the SQUALUS dives, the U.S. Navy established 380 feet as the new limit with 30 minutes on the bottom. Without complications, a dive of this depth/duration requires more than three hours decompression, an unfavorable ratio of working time to decompression of 1:6. This remains the U.S. Navy operational limit for "hard-hat" diving.

Saturation Diving

This unfavorable ratio of decompression to bottom time has been overcome with a technique known as "saturation diving." Saturation diving postulates that the diver should be provided with a habitat on the sea floor which is pressurized to the outside water pressure and provided with a suitable breathing gas mixture. After about 24 hours of exposure under pressure all tissues of the diver's body have a gas saturation equivalent to the surrounding atmosphere and the diver is considered to be "saturated." Once he has been saturated, the diver's requirements for decompression are based on depth rather than duration of the dive. Thus, a diver saturated to 300 feet requires the same decompression time (approximately 2-1/2 days) whether his bottom time is <u>one day</u> or <u>one month</u>.

In the saturated diving situation the diver lives in a chamber or habitat that provides an exit directly to the surrounding ocean environment for work and research. After several hours of useful work in the water he returns to the safety and comfort of the underwater habitat. Since there is no appreciable difference between the pressure of the habitat and the outside water, there is no requirement for decompression of a man entering the undersea chamber. Rather, decompression of the saturated diver for his total time spent at depth is accomplished on a single phase when he returns to the surface after days or weeks of useful work on the ocean bottom.

Saturation diving could also be accomplished with the diver returning to the surface in a pressurized "elevator" and living in a pressurized chamber aboard ship. However, the Man-in-the-Sea concept, with the man living on the ocean floor, provides: (1) independence from surface support, (2) less transit time between chamber and work area, and (3) direct observation of the ocean floor from the living chamber.

The capabilities which saturation diving provide for extended ocean-floor operations will enable the Navy to undertake underwater salvage, construction, search, survey, recovery, maintenance, and research tasks heretofore considered impossible for divers.

Project GENESIS

GENESIS was the code name given to the first studies of the effect of saturation diving on man. This project was initiated by Commander George F. Bond,* Medical Corps, USN, in 1957, while he was Assistant Officer-in-Charge of the Naval Medical Research Laboratory at New London, Connecticut.

Dr. Bond had become concerned with the prospect of an eventual world shortage of animal protein while in private medical practice in North Carolina. His concern led him to studies of the nutritional and economic potential of the ocean, an interest which continued after he entered the Navy in 1953 and specialized in submarine medicine.

At the Naval Medical Research Laboratory, Dr. Bond's main work was concerned with submarine escape. This in itself required detailed studies of underwater breathing gases and led him to preliminary work in diving time limitations and advanced breathing gas mixtures. Dr. Bond reasoned that if man were to exploit the underwater wealth of the ocean he would have to enter the underwater world and remain there to explore, observe, build, and harvest.

Project GENESIS began during 1957 on a "spare time" basis. GENESIS was selected as the name for the experiments because through them an important step would be taken toward attaining the "dominion over the sea" promised in the first book of the Bible.

The first phases of Genesis concerned the reactions of laboratory animals to prolonged exposure to high pressure and to various breathing gases. These Phase A and Phase B experiments took several months during 1957-1958, and involved white rats, guinea pigs, squirrel monkeys, and goats. During the first series of tests the animals breathed a mixture of helium and oxygen at one atmosphere to seven atmospheres of pressure--the equivalent of a depth of about 200 feet--for two weeks. The latter tests established that although the test animals could not survive a high pressure of normal air for more than 35 hours, they could tolerate an equivalent exposure to high pressure while breathing a helium-oxygen mixture. The animals lived under these conditions for two weeks without showing any signs of deterioration.

During late 1958 these preliminary studies into saturation diving attracted two other naval officers to the project, Commander Walter F. Mazzone, Medical Service Corps, USN, and Commander Robert D. Workman, Medical Corps, USN.*

*All three officers since promoted to Captain

Commander Mazzone reported to the Medical Research Laboratory as Training Officer with the collateral duty of Project Officer for GENESIS. Although a veteran submariner, he had no previous diving experience and for his new billet, attended the Deep Sea Diving School in Washington, D.C., for instruction in diving. (He was probably the first Navy medical administrative officer to undergo such training.) Commander Workman, a submariner and diver, reported to the Medical Research Laboratory in August 1959 as Assistant Officer-in-Charge.

Studies into saturation diving continued on a "part time" basis. In an effort to obtain the backing for a formal saturation diving program, Dr. Bond submitted "A Proposal for Underwater Research" in which he declared that "new knowledge of inert gas use, and the physiological effects of these gases on man, offers opportunity for development of ecological systems which would permit man, as a free agent, to live and perform useful work to depths of 600 feet, and for periods in excess of 30 days."

After describing the animal experiments, the paper "suggested and requested that the human experimental phase of this...project be approved." And,

> Upon completion of the necessary human experimental work, it is believed that operational use of this established human capability might best be effected through development of both mobile and fixed underwater habitations from which scientists, engineers, and military personnel could be routinely deployed in performance of extended underwater tasks, to a depth of 600 feet.

The paper then went on to describe how existing submarines could be modified to provide an underwater, mobile base for divers and how fixed stations could be established.

The possible uses for a technology developed by these SEALABs would be almost unlimited. Major fields of interest would include marine biology (as the first step toward underwater "farming"), oceanography, deep sea salvage, underwater construction, oil and natural gas exploitation, development of a radiation-free laboratory, and numerous military areas.

The proposed extension of GENESIS to human subjects was not approved.

However, a short time later the Navy's interest in manned space flight called attention to the possible use of a helium-oxygen environment for spacecraft. Additional data on human reactions in a helium-oxygen breathing gas were desired and an extension of GENESIS to provide this data was proposed an approved. Project GENESIS thus became a formal Navy program and work continued at flank speed.

Phase C of GENESIS was the first test involving human beings. Two submarine medical officers, Lieutenants John C. Bull, Jr. and Albert P. Fisher, Jr., and a veteran Navy diver, Chief Quartermaster Robert A.

Barth (now Warrant Officer) were exposed to a helium-oxygen breathing gas at one atmosphere of pressure for six days late in 1962. The atmosphere consisted essentially of 79% helium and 21% oxygen. Throughout the test period the men were under observation and they were checked continuously for visual acuity, color perception, auditory abilities, voice, and psychomotor phenomena. A complete battery of physiological tests were performed daily.

The ability of the men to talk intelligibly to each other in the helium-oxygen atmosphere was impaired. As had long been recognized, the breathing of helium changes the sound of a person's voice, raising its timbre and creating what is called the "Donald Duck" effect. The subjects in Phase C had difficulty understanding each other's speech during the first two days, but by the fourth day they were able to adapt sufficiently for their colleagues to understand them.

The Phase D experiments of GENESIS were conducted in April of 1963 at the U.S. Navy Experimental Diving Unit (EDU) in Washington, D.C. This time the subjects were three petty officers from New London, Barth (again), Chief Hospital Corpsmen Sanders W. Manning and Raymond R. Lavoie. These men lived in a two-section pressure chamber, breathing a helium-oxygen atmosphere of 6% oxygen, 62% helium, and 32% nitrogen for six days.

The chamber at EDU consisted of a "dry" compartment 12 feet long and 6 feet high. This room was linked by a passageway to a cylindrical "wet" room, 10 feet in diameter, and 18 feet deep, and partially filled with water. Periodically the men entered the wet room to swim underwater and do special energy-consuming work. The entire EDU chamber was pressurized to three atmospheres, the equivalent of a depth of about 100 feet. The chamber was equipped with a stove and refrigerator, fans to keep the air circulating at a comfortable temperature, and a toilet. Books, magazines, and games were provided to help the men through the six-day stint.

The Phase E test was conducted in August-September 1963 at the Climate-Altitude Chamber at New London. This cylindrical chamber, nine feet long and about seven feet in diameter, can simulate pressures ranging from a depth of 250 feet to an altitude of 200,000 feet, with controlled temperatures, humidity, sound levels, and light levels.

In this phase of GENESIS, three men--Dr. Bull, Barth, and Manning--lived at a pressure equal to an ocean depth of 200 feet for 12 days. During this experiment the oxygen content of the test atmosphere was reduced to 3.5% (compared to 21% at sea level) with 79.5% helium and 16% nitrogen.

Once again the test subjects were carefully watched and their condition and reactions were monitored. As in all of the GENESIS tests involving human beings, a medical officer and chamber operators were in continued attendance.

After 11 days in the chamber, at a simulated depth of 200 feet, there was a 27-hour decompression period during which the pressure in the chamber was gradually reduced to the one-atmosphere pressure of the surface. At the end of 12 days the chamber's hatch swung open, and the human "guinea pigs" emerged. They had suffered no ill effects from their prolonged "submergence" and had even gained weight.

The successful Phase E tests completed the laboratory phase of the U.S. Navy's Man-in-the-Sea Program.

SEALAB I

The Navy's first underwater experiment was SEALAB I, conducted from July 20 to July 31, 1964, at a depth of 193 feet.

Putting man into the sea is complicated. Instead of small lab facilities, an underwater experiment requires support divers, a shore base, surface craft, seafloor habitat, diving equipment, etc.

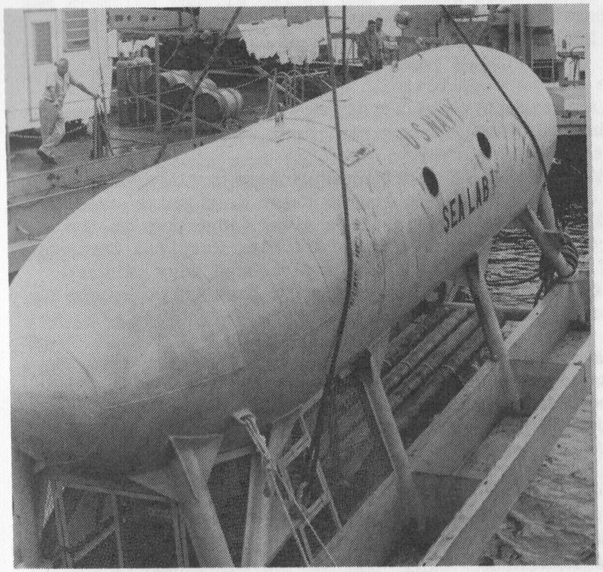
Initial plans for SEALAB I called for four Aquanauts to live on the seafloor at a depth of 200 feet. The Aquanauts--a term which came into being during GENESIS to designate saturation divers who live in the sea--were Chief Quartermaster Barth and Senior Chief Hospital Corpsman Manning, veterans of the GENESIS tests and experienced Navy divers; Gunner's Mate First Class Lester E. Anderson, and Lieutenant Robert E. Thompson, Medical Corps, USN.

The site selected was 26 miles off Bermuda in water 193 feet deep, on a portion of the Plantagenet Bank. Adjacent to the Navy's Argus Island (a man-made structure built for sonar research), the site was in warm clear water, and relatively free of storms.

The SEALAB I habitat was constructed from two floats, welded together to form a cigar-shaped chamber 40 feet long and 10 feet in diameter. Two 12-inch portholes were installed on each side of the chamber. Access to the sea was through two manholes in the bottom of the chamber. No intermediate locks were required because the pressure inside the habitat was the same as that of the surrounding water. End sections of the habitat were fitted to hold water ballast, breathing gas for emergency use, and electrical equipment. Twenty-four feet of "living space" in the center of the habitat was stuffed with bunks, lockers, lab equipment, environment controls, refrigerator, hot plate, oven, food locker, shower, toilet, air conditioning equipment, storage space for SCUBA gear, and, of course, the Aquanauts. An umbilical cable carrying electricity, compressed air and helium for breathing, fresh water, an air-sampling line, and lines for a telephone, electro-writer, and two-channel TV monitoring system would connect the habitat and the support ship. The initial charge of the atmosphere for SEALAB I (80% helium, 16% nitrogen, and 4% oxygen) was pumped into the habitat through the umbilical. Replenishment was accomplished through the stored gas supply.

Surface support for the experiment was provided by the YFNB-12, a large covered lighter. This craft is 260 feet long, 40 feet wide, and capable of lifting large objects. It was fitted with accommodations for a crew of 32 plus 30 scientific personnel or technicians. Also provided was a Submersible Decompression Chamber (SDC) which the Aquanauts used as an underwater elevator. Pressurized to the equivalent of 200 feet, the SDC was also a safety escape chamber and decompression device.

During the experiment the Aquanauts could live in the artifical atmosphere of the habitat without any special breathing apparatus. While outside working or exploring in the open water, they would wear the



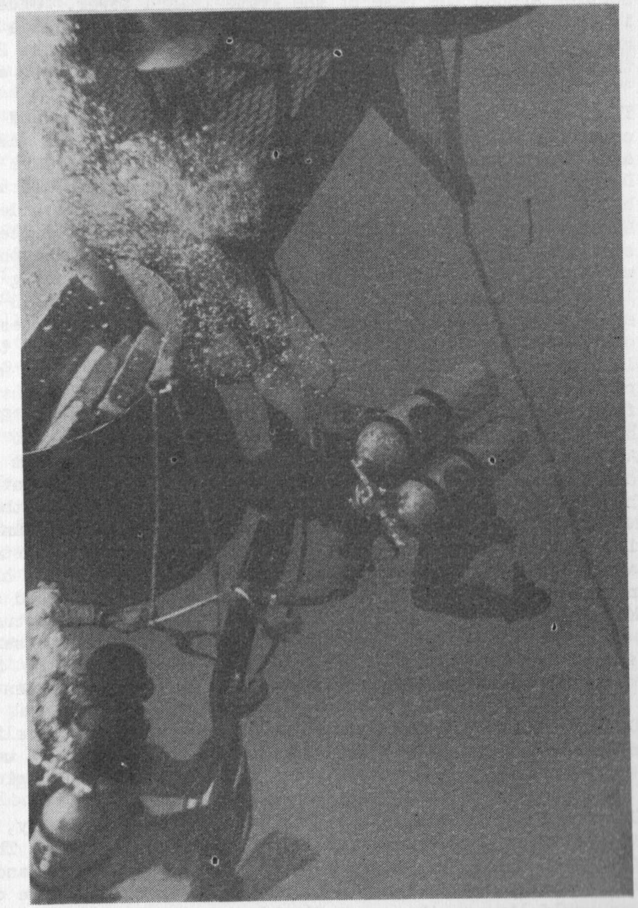
The SEALAB I habitat being prepared.

Navy's standard Mk VI semi-closed circuit breathing apparatus with their breathing gas carried in back tanks. An alternate system was the HOOKAH ARAWAK which provided breathing gas from the habitat through an umbilical cable to the diver. This latter mode gave the diver an unlimited supply of breathing gas but restricted him to a 100-foot radius from the habitat. The Mk VI breathing device provided a 70-minute gas supply.

Preliminary testing of the SEALAB I habitat was conducted at the Navy Mine Defense Laboratory, Panama City, Florida, and in the adjacent Gulf of Mexico. Practice lowerings abd testing of all umbilicals and subsystems were also accomplished prior to the actual seafloor experiment.

On July 18, 1964, the habitat arrived off Argus Island and was attached to the large crane on the tower. Divers removed the habitat floats and it was lowered to a depth of 62 feet, below the rough air-sea interface, to ride out the night. The next morning the crane began lowering the habitat into the sea while a gas mixture of helium and oxygen was pumped into the chamber to prevent flooding through its open bottom hatches. At 1:30 p.m., the habitat settled level on the ocean floor at a depth of 193 feet.

The following morning support SCUBA divers went down to the ocean floor to complete mooring and anchoring the habitat. Dr. Bond and Captain



Surface support divers help rig the SEALAB I habitat.

Mazzone entered the SDC and were lowered to a depth of 160 feet. They swam to the habitat for a final inspection and returned to the surface. Next, the four Aquanauts entered the SDC and were lowered into the sea. At 5:30 p.m. on July 20, they swam into the habitat, formally beginning the SEALAB I experiment.

The following morning the Aquanauts checked out communications and controls and undertook other housekeeping chores. They then donned their SCUBA gear and made their first trip into the undersea world outside of the SEALAB habitat. They swam about the immediate area, observing the physical features and marine life of the ocean bottom and made brief sorties around the base of the Argus Island tower. Underwater visibility was good. When looking up, the Aquanauts could see clearly the hull of the support barge on the ocean surface, almost 200 feet above them. Horizontally their view extended about 150 feet at mid-day.

The men quickly became accustomed to their new home and to the other creatures of the ocean. There was a large amount of marine life in the area which occasionally "stampeded" with the appearance of sharks. Diving the experiment the Aquanauts tested a shark-attraction system, but it failed to attract any sharks. Other projects undertaken by the Aquanauts included placing ultrasonic beacons on the ocean floor, installing current meters, and rigging lights for night photography. It was during a photographic mission that Aquanaut Manning almost lost his life. The accident occurred during the visit to SEALAB I by STAR I, an experimental one-man submersible. The procedure was testing the ability of the Aquanauts to observe the craft's operations and to assist it in landing on a simulated submarine hatch. Manning's job was to help photograph the event. He had taken about 15 feet of movie film on a 50-foot roll when he suddenly began feeling lightheaded. Realizing that his SCUBA was not functioning properly, he swam back to the habitat. Apparently his gas supply had been cut off, causing him to breath his own exhalation. Just as he started to climb up the entranceway to the habitat he lost consciousness. Anderson, on watch in the habitat, heard Manning's SCUBA tanks strike the structure as he fell unconscious. He investigated and snagged Manning's limp body as it started to drift away. Bringing Manning into the habitat, Anderson had him breathing normally within a minute or two. Dr. Thompson returned and examined Manning. Blood vessels in the Aquanaut's eyes had ruptured, turning the white portion red and then black. Kept under close observation, Manning showed no other injuries from his near-fatal accident. It was decided to leave him below as an active Aquanaut. The experiment continued.

During SEALAB I a small pressure chamber was used to deliver newspapers, magazines, food, and other items to the Aquanauts. It was also used to transfer various specimens to the surface for physiological testing.

Other than an initial slowing in pace of their activity, the Aquanauts displayed no physical or psychological abnormalities. They seemed to feel a sense of independence from the support vessel, and carried out their tasks as willingly, if slower, as they would have on the surface. Man could live on the ocean floor!

On July 31, the eleventh day of SEALAB I, the decision was made to terminate the experiment. The hurricane season had arrived and a tropical disturbance was reported 700 miles to the south. In the calm sea, 193 feet below the surface, the Aquanauts went about the chores required to prepare the habitat for return to the surface.

Plans called for the Aquanauts to ride the habitat to the surface, with the habitat serving as their decompression chamber. The crane on Argus Island began the long ascent-lift of the SEALAB I habitat. As the habitat neared the surface rough seas began affecting the chamber, lifting it until the crane cables went slack, and then dropping it--whipping the cables to singing tenseness, and putting great strain on the crane.

As a safety precaution, at 7:32 a.m. on July 31, the four Aquanauts left the habitat at the depth of 81 feet and swam into the SDC. While in the SDC they would have to remain in a vertical position, immobile, cold, and without surface supervision. Finally, at 2:40 p.m. the SDC was raised to the cargo deck of Argus Island, placed in a horizontal position, and the decompression period of 56 hours was completed.

At 8:35 on the morning of August 1 the four Aquanauts stepped out of the SDC and into the sunshine. After press briefings, they boarded a helicopter and were flown to the U.S. Air Force hospital at Bermuda for medical tests and special debriefings. All tests indicated that the men were in good health. Their habitat was raised to the surfaced, buoyed, and eventually returned to the Navy Mine Defense Laboratory for use in subsequent Man-in-the-Sea work.

Analysis of the information gathered during the experiment showed some major problem areas: better engineering was needed in lowering and raising the habitat; humidity inside the habitat had been too high; the helium atmosphere had greatly impeded speech; better umbilical reliability was required; more effective communications were needed; certain equipment failed to function properly in a helium-oxygen environment; and some technique had to be found to reduce the amount of equipment the swimmer had to wear in the water, and don, take off, and store in the habitat.

Despite these problems, SEALAB I was a major success. Never before had men worked and lived in the sea at so great a depth for so long. Although cut short by the impending hurricane, the experiment amassed a large amount of physiological data from instruments and personal experiences.

But to state a record and accomplishments are but to state a challenge for a more amitious experiment in underwater living.

SEALAB II

Within five months of the completion of SEALAB I the Navy established the framework for a second underwater experiment in saturation diving--SEALAB II.

The SEALAB II experiment consisted of three 10-man teams living and working at a depth of 205 feet from August 28 to October 14, 1965, with each team spending 15 days at that depth. An increase in depth was not an objective of SEALAB II. More important was the selection of a dark, cold site, better physiological monitoring, and greater numbers of men working on the bottom. The site selected was on a ledge of the Scripps Marine Canyon near La Jolla, California.

Initial plans called for two teams of ten men with each team spending two weeks on the bottom for a 28-day experiment. However, as the program expanded, plans were changed to provide three 10-man teams. Two men would each be on two teams for a total of 28 men taking part in a 45-day experiment. The number of Aquanauts and the length of SEALAB II were increased to handle additional scientific experiments.

The two Aquanauts who spent 30 days at depth were Commander M. Scott Carpenter, USN, on leave of absence from the National Aeronautics and Space Administration as team leader for the first two teams, and Lieutenant Robert E. Sonnenburg, Medical Corps, USNR, a physician who was on both the first and third teams. Master Chief Torpedoman's Mate Robert C. Sheats, USN, one of the Navy's master divers, was leader of the third team.

The other Aquanauts were drawn primarily from the surface support divers of SEALAB I, for these men were among the most experienced divers in the Navy. Chief Quartermaster Robert A. Barth, who had taken part in the GENESIS and SEALAB I experiments, and ten civilians from Navy activities and the Scripps Institute of Oceanography completed the list of 28 Aquanauts in SEALAB II.

Aquanaut training officially began at the Navy Mine Defense Laboratory in Panama City, Florida, on April 1, 1965, nearly six months before the experiment. Classroom work included diving physiology and physics, detailed study of the Mk VI breathing apparatus, underwater communications, photography, training with swimmer propulsion units, etc. After three months at Panama City, the Aquanauts moved to the Naval Base at Long Beach, California, for check-out and commissioning of their new underwater habitat.

The new SEALAB structure was a built-for-the-purpose habitat, incorporating many of the lessons from SEALAB I. It was 57 feet long and 12 feet in diameter, with "capped" ends and a small "conning tower" which made it resemble a railroad tank car without wheels. It was divided into four areas: The entry area contained the access hatch in the deck, two shower stalls, and swim gear stowage. The laboratory area included communications equipment, test gear, gas monitoring devices, and work

space. The galley came next, with the final area--the living and eating space--containing five double-level bunks, lockers, and a folding table. Eleven large portholes provided maximum viewing area for the Aquanauts to observe their surroundings and fellow Aquanauts in the water.

The habitat's floor was made of cement (for ballast) with heating cables imbedded in the cement. Other ballast for the habitat included water ballast tanks in the overhead and a free-flooding "conning tower." This was the habitat for SEALAB II. The final touches included the addition of a protective anti-shark cage near the entrance hatch and installation of external stowage racks for 24 gas bottles.

The SEALAB II habitat prior to "commissioning."

Appreciating the problems caused by the lack of an adequate surface support ship in SEALAB I, plus the desire to provide an improved system to decompress the divers, a staging vessel used in Polaris missile "pop-up" tests was obtained for use in SEALAB II. This vessel was actually two YC barges, each 110-feet long and 34-feet wide, spaced 22 feet apart and connected by a covered structure to form a U-shaped vessel. Existing facilities in the craft included galley, dining, and storage spaces; electric power generators; winches; air compressors; and a 50-ton capacity crane. For SEALAB II a portion of the missile bay was enclosed to provide a diver ready room and the remainder of the bay was used for installation of a ten-man Deck Decompression Chamber (DDC). This DDC would enable a ten-man team to be brought to the surface in a pressurized Personnel Transfer Capsule (PTC) which would "mate" with the DDC for the continuous decompression aboard the surface support vessel. Two vans were also installed on the support vessel to serve as a command center. Additional communication gear, moor line tensioning devices, breathing gas storage, and other special equipment were brought aboard.

Thus refitted, the craft was renamed BERKONE for Joe Berkich of the Naval Undersea Warfare Center at Pasadena, California, which operated the Navy's underwater test facilities off California, and for Captain Walter Mazzone, the SEALAB II physiological Control Officer.

Connecting the BERKONE and SEALAB II habitat would be a PTC "elevator"; a pressurized dumbwaiter to transfer food, mail, and equipment; and an umbilical cable. While on the bottom the habitat would be provided with electrical power and water through lines from the Scripps Institution pier; the umbilical cable from the support ship would provide breathing gas, communications, and instrumentation lines. The shipboard umbilical would also be a secondary source of electrical power.

The distance from the Naval Shipyard at Long Beach to the SEALAB II site off La Jolla was 92 miles. The habitat was taken in tow at a speed of almost three knots by the Navy salvage ship GEAR and arrived at the site on August 21. The habitat's gas lines were connected to the support barge BERKONE and, on August 26, the habitat submerged beneath the waters off La Jolla. The habitat was held at a depth of 60 feet for an inspection. Some of the sealed ports were developing gas leaks as pressure was being build up inside the habitat. To minimize the gas loss, the habitat was rapidly lowered to the bottom. Upon arrival on the bottom, the structure had a list to port of six degrees and a trim to the stern of six degrees. This position led to the habitat being dubbed the "Tiltin' Hilton" by Aquanauts.

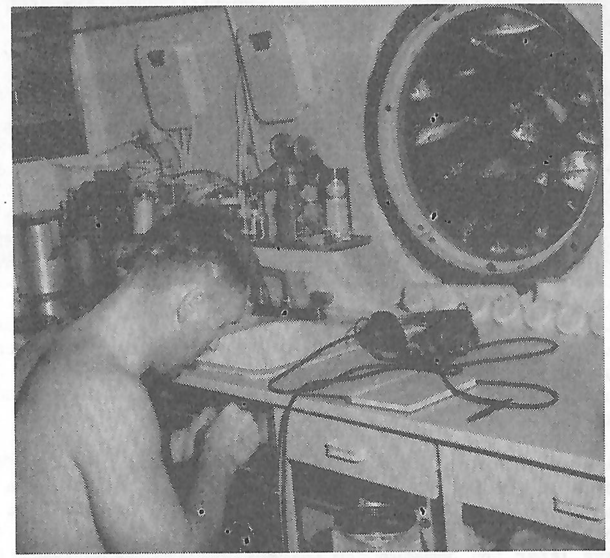
On the morning of August 28, 1965, the Aquanauts of the first team donned their SCUBA gear and plunged over the side of the BERKONE to swim down to their ocean floor abode. Inside the habitat the Aquanauts set up house and established communications with the BERKONE. Equipment which had been lashed down for the tow and submerging of the habitat was set up and tested. Then a radio link was established with the GEMINI space capsule on its orbit of the earth. Aquanaut Scott Carpenter, at 205 feet under the sea, spoke to Astronaut Gordon Cooper, whose space capsule was circling the earth at altitudes from 106 to 217 miles.

Once the seafloor chamber was reasonably habitable the Aquanauts devoted their main efforts to the scientific programs and equipment evaluation. This included erection of a strength test platform and tests of torque wrenches, a current meter, underwater weather station and sound range, visual acuity range, target array, water clarity meter, fish cages, homing beacons, external TV cameras, bioluminescence meter, photo and diving lights, bathythermograph, and other specialized equipment. Daily physiological examinations of the Aquanauts were conducted. Samples of their breath, blood, urine and saliva were sent to the surface in a pressurized dumbwaiter each day for detailed study.

In addition, the daily "housekeeping" chores performed by the Aquanauts included repairing diving lights, adapting equipment to the list and trim of the habitat, replacing leaky valves, cooking, cleaning up, repairing pumps and gauges, and maintaining SCUBA equipment. Before and after each dive, strength and manual dexterity tests were performed in the water. Each evening there were daily activity and mood check lists, and occasionally "brain teasers" and arithmetic tests to determine

possible effect of the high pressure, helium-oxygen atmosphere on higher thought processes.

Excursions into the water outside of the habitat were made with Mk VI SCUBA equipment, with the Aquanauts breathing a helium-oxygen mix carried in back-tanks or provided through an umbilical to the habitat (an improved HOOKAH-ARAWAK system). Initially the HOOKAH-ARAWAK rigs were used as a secondary or backup system to the Mk VI, but more and more emphasis was placed on the hose system as the experiment progres



Aquanaut Berry Cannon repairs helium unscrambler.

The gas mixture breathed by the Aquanauts in SEALAB II consisted of 77% to 79% helium, 18% nitrogen, and 3% to 5% oxygen. Lithium hydroxide was used to remove carbon dioxide from the air and charcoal was used to remove odors.

On the 16th day of the operation, September 12, nine members of Team 1 were brought to the surface in the Personnel Transfer Capsule. The PTC was hoisted aboard the BERKONE and mated directly to the Deck Decompression Chamber, allowing the Aquanauts to enter the DDC without being exposed to surface atmosphere. Nine other Aquanauts descended into the depths to join Scott Carpenter in the habitat, the Aquanaut/Astronaut having remained on the bottom to serve also as leader of Team 2.

During this exchange of personnel Carpenter was stung on the finger by a scorpion fish. The creature's venom caused Carpenter's arm to swell to several times its normal size and provided a real test of the effects of drugs in a pressurized, helium-oxygen atmosphere. Recovery was complete within 24 hours.

The second team of Aquanauts conducted tests with "Tuffy," a porpoise trained to respond to sound signals, to determine whether such an animal could be useful to men in the sea. Initially Tuffy did not respond as expected, probably because of his new surroundings and the noise from the surface support ship. However, he was soon giving excellent performances, making several dives from the surface to 205 feet, delivering mail, tools, and messages. In another test, Tuffy carried a guideline from the habitat to an Aquanaut who was signalling that he was in need of assistance. On his longest dive the air-breathing porpoise stayed below for 4½ minutes.

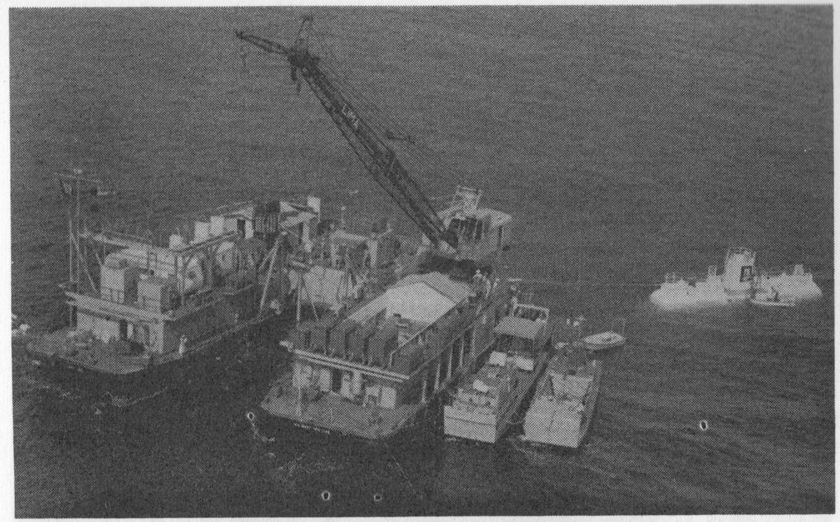
Team 2 also conducted tests of electrically-heated wet suits, powered by batteries (worn by the Aquanauts in lieu of wieghted belts) or by an umbilical from the habitat. The suits generally extended the Aquanauts' endurance from one hour to about two hours in the 50°F water. However, the suits were not totally successful.

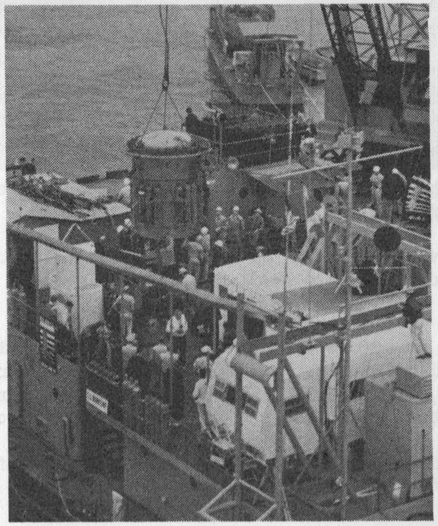
While Team 3 was on the bottom, a radio link was established with the CONSHELF III experiment of Frenchman Jacques-Yves Cousteau, which was being conducted with four men at the depth of 328 feet off Nice, France, using saturation diving techniques. U.S. Aquanauts Robert Sheats and Richard Grigg talked with the CONSHELF Oceanauts Cousteau and Andre Laban. This SEALAB-to-CONSHELF conversation, carried on halfway around the world, presages a time when scientists in seafloor laboratories would compare data and exchange information as they conduct related experiments in the ocean depths.

Finally, the Aquanauts in Team 3 prepared the habitat for return to the surface. On October 10, the last of the Aquanauts came to the surface in the PTC and began decompression. On October 12, the members of Team 3 emerged from the BERKONE's DDC into the earth's atmosphere. Two days later the habitat was raised from the ocean floor and prepared for towing to Long Beach. SEALAB III was complete

Upon return to the surface, each team of Aquanauts required 31 to 35 hours of decompression. Scott Carpenter's 30-day stint required no additional "desaturation." One diver did develop a case of the bends and remained in the decompression chamber for an additional 12 hours. Exhaustive tests of the Aquanauts revealed no immediate, discernible psychological or physical ill effects after the experiment. Changes that were apparent in measured physiological functions were of a mild, transitory nature and returned to pre-dive levels immediately after the experiment. Measurements of work performance revealed some decrease in exertive strength, manual dexterity, and two-hand coordination while in the seafloor environment. But there was no change between pre-dive mental tests and those conducted during the experiment.

SEALAB II was a severe challange to the individual Aquanauts. The water was cold and visibility was poor; the work schedule, requiring long hours of preparation, was often interrupted, delayed or revised;





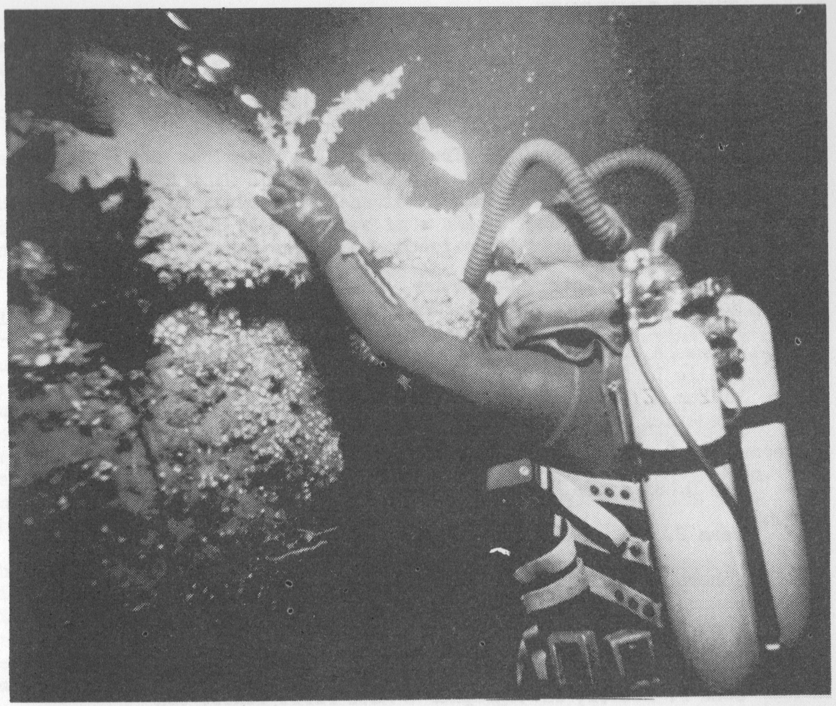
The SEALAB II support vessel BERKONE (top) with habitat on surface at far right; second photo shows Personnel Transfer Capsule being mated with Deck Decompression Chamber in BERKONE.

communications were difficult because of the helium-speech distortion; sleep was difficult because of the work schedule. Life in general was made more difficult due to the high humidity inside the habitat.

Meeting and accepting these challenges only added to the overall success of the SEALAB II experiment. The 28 Navy men and civilians spent more than 450 man-days on the ocean bottom. Not only did these Aquanauts live underwater, but they conducted a multitude of physiological experiments and underwater work tasks in salvage, oceanography, geology and construction. More than 400 man-hours of useful work were conducted outside of the habitat. The experiment proved that:

- Reasonably large groups of men were able to live from 15 to 30 days at a depth of 205 feet, have a degree of autonomy, accomplish useful work, be safely decompressed, and show no adverse physical or psychological effects.
- Excursion or "bounce" dives to three atmospheres below habitat living depths were successful.
- There was a significant degree of diver adaptation to cold water.
- Adequate protection against cold water was obtained for extended periods of time by the use of heated suits. (Swimmers without supplemental heated suits were limited to less than one hour of useful work in waters 47°F to 54°F.)
- Improved tools and techniques for the ocean environment showed promise for the accomplishment of salvage tasks and other undersea work.
- Porpoises can be extremely useful to Man-in-the-Sea operations to depths of 250 feet, and even deeper with training.
- Ocean floor living offers a new and important methodology to scientific, biological and geological investigations of the ocean bottom.
- A great amount of effort went into SEALAB II, involving naval activities, scientific institutions, commercial organizations, and most important, individuals. The reaction of the participants to SEALAB II can best be summed up in the words of one of the Aquanauts:

> That was the hardest I have ever worked in my life. And it is the busiest I have ever been. I would go back right now. I didn't want to come up.



Aquanaut Robert Sheats explores the Scripps Canyon at a depth of 300 feet during the SEALAB II experiment.

SEALAB I AQUANAUTS

Robert E. Thompson, Lieutenant, MC, USN
Lester E. Anderson, Gunner's Mate First Class, USN
Robert A. Barth, Chief Quartermaster, USN
Sanders W. Manning, Chief Hospital Corpsman, USN

SEALAB II AQUANAUTS

Team 1

M. Scott Carpenter, Commander, USN (also Team 2)
Robert E. Sonnenburg, Lieutenant, MC, USNR (also Team 3)
Berry L. Cannon (Navy Mine Defense Laboratory)
Thomas A. Clarke (Scripps Institute of Oceanography)
Billie L. Coffman, Torpedoman's Mate First Class, USN
Wilbur H. Eaton, Gunner's Mate First Class, USN
Frederick J. Johler, Chief Engineman, USN
Earl "A" Murray (Scripps Institute of Oceanography)
Cyril J. Tuckfield, Chief Engineman, USN
Jay D. Skidmore, Chief Photographer's Mate, USN

Team 2

Robert A. Barth, Chief Quartermaster, USN
Howard L. Buckner, Chief Steelworker, USN
Kenneth J. Conda, Torpedoman's Mate First Class, USN
George B. Dowling (Navy Mine Defense Laboratory)
Arthur O. Flechsig (Scripps Institute of Oceanography)
John F. Reaves, Photographer's Mate First Class, USN
William H. Tolbert (Navy Mine Defense Laboratory)
Glen L. Iley, Chief Hospital Corpsman, USN
Wallace T. Jenkins (Navy Mine Defense Laboratory)

Team 3

Robert C. Sheats, Master Chief Torpedoman's Mate, USN
William J. Bunton (Navy Electronics Laboratory)
Charles M. Coggeshall, Chief Gunner's Mate, USN
Richard Grigg (Scripps Institute of Oceanography)
John J. Lyons, Engineman First Class, USN
William D. Meeks, Boatswain's Mate First Class, USN
Lavern R. Meisky, Chief Shipfitter, USN
John M. Wells (Scripps Institute of Oceanography)
Paul A. Wells, Chief Mineman, USN

B.

THE FUTURE OF MAN-IN-THE-SEA

The Navy's operational requirements to provide a capability for extended swimmer operations at continental-shelf depths have led to the current goal of 850 feet for an operational saturation diving system. Studies are now being conducted to determine advanced goals and missions for the Navy's Man-in-the-Sea Program.

Technologies and equipment will undoubtedly be developed to enable man to perform useful work at greater depths unless (1) definite and unsurmountable physiological or behavioral phenomena limit the Aquanaut's ability to go deeper, or (2) there is a clear prediction of persistently unfavorable cost effectiveness in comparison with the other concepts for accomplishing required missions at advanced depths.

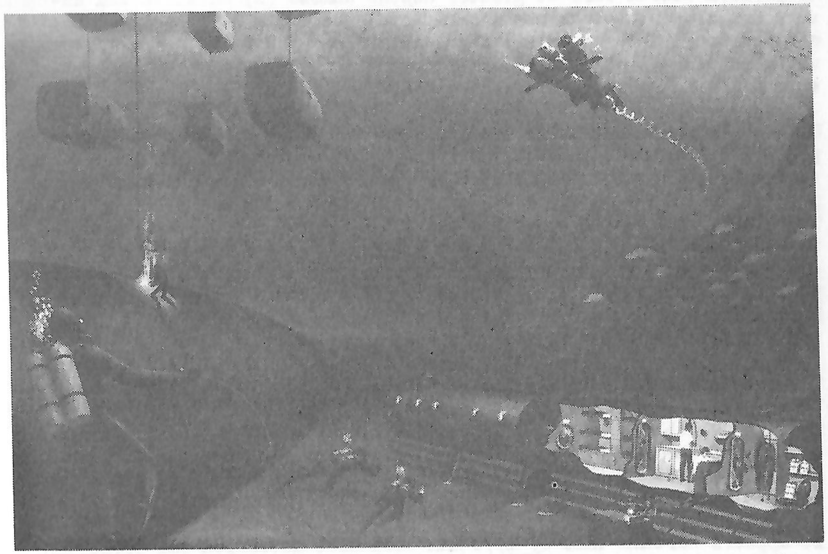
Ultimately, hardware being developed in the Man-in-the-Sea program will produce operational seafloor habitats which are totally independent of surface support once placed on the ocean bottom. This capability will provide for all-weather, even under-ice, operations on the ocean floor. There will also be "semi-mobile" habitats--crawler or submarine-like vehicles--which will enable Aquanauts to range over a relatively wide area of the ocean floor, to pass through a hatch into the ambient water, perform useful work, and return to the habitat without decompression. During the mobile habitat's return to surface atmosphere or its base the entire crew would be decompressed.

The possible applications of an extended-duration Man-in-the-Sea capability tests our imagination. Beyond the large number of military missions which are apparent are the national-interest projects which, because of the Navy's capabilities in saturation diving, will certainly lead to various combinations of Navy, scientific, and industrial organizations becoming engaged in extensive seafloor operations.

It appears certain that by 1970 man will have developed the technology necessary to work at a depth of 1,000 feet. Although most of the world's protein resources, organic and mineral riches of the oceans, are to be found on the continental shelf, it is unlikely that man will be content to stop if he can develop the capability of diving below the 30-atmosphere level.

Below 1,500 feet helium can probably no longer be used as the inert gas in the Aquanaut's breathing mix since it too becomes narcotic at this depth. The only other inert gas which could then be used is hydrogen, since this gas is theoretically less narcotic than any known inert gas. Ironically, a hydrogen-oxygen breathing gas was used in experimental dives to 14 atmospheres some two decades ago by the Swedish engineer Zetterstrom but with fatal results, due to tender error. If such a breathing gas can be developed for practical use the physical properties of hydrogen might also lead to reduced decompression time for saturation diving. (There would be no danger of explosion from the hydrogen in such a breathing gas because of the extremely low oxygen content.)

Beyond these depths some contend that it is possible, although not necessarily probable, that man may dive freely to 10,000 feet and deeper for brief periods. Man swimming at these depths would breathe an oxygenerated liquid, which would be pumped directly into his windpipe and lungs. Although the practicality of man walking the abyssal plains is a matter for discussion, man's traditional drive to discover and explore new worlds will unquestionably take him farther and farther into Inner Space.



Artist's concept of a major Navy salvage operation in the 1970s: saturated divers are salvaging the disabled submarine at left; at right is a seafloor habitat totally independent of surface support once emplaced on the bottom.

C.
SUSTAINED UNDERWATER LIVING EXPERIMENTS

Project	Location	Start	Duration	Depth	Personnel
Cousteau Conshelf 1	Marseille, France	Sept. 1962	7 days	33 ft	2
Cousteau Conshelf 2	Port Sudan, Red Sea	June 1963	30 days	36 ft	5*
U.S. Navy SEALAB I	Bermuda	July 20, 1964	11 days	193 ft	4
U.S. Navy SEALAB II	La Jolla, California	Aug. 28, 1965	45 days	205 ft	Three 10-man teams** (15 days each team)
Cousteau Conshelf	Nice, France	Sept. 22, 1965	22 days	328 ft	4
U.S. Navy SEALAB III	San Clemente Island, Calif.	Oct. 1968	60 days	600 ft	Five 8-man teams (12 days each team)

*Two of these Oceanauts descended to 85 ft for seven days.

**One Aquanaut remained at depth for 30 consecutive days and one for two 15-day periods separated by 15 days. Thus, a total of 28 men participated in the experiment

D.

DEEP SUBMERGENCE SYSTEMS PROJECT

The U.S. Navy's Man-in-the-Sea program is but one phase of an intensive Navy effort to develop the techniques and equipment to operate in the deep depths of the oceans. Although man has used the oceans for more then 5,000 years for food, for exploration, for commerce, for war, and, especially during the past few years, for recreation, his endeavors have been limited to the near-surface of the oceans, to the epidermis of the seas.

Man fishes from surface ships with nets and lines; he raises "sea food"--and comparatively little--in sheltered, shallow, coastal waters. Even his underwater ships, the so-called "submarines" are limited to the near surface with a depth capability measured in hundreds of feet in an ocean which has a maximum depth of some 36,000 feet.

These limitations became painfully obvious when the nuclear-powered submarine THRESHER was lost at sea in April 1963. Although the THRESHER was lost in 8,400 feet of water, there was no means of rescuing survivors even had she come to rest at her "collapse depth," the maximum depth her hull should have remained intact. A surface ship had been in contact with the THRESHER when she was lost, but it still took more than a year to pin-point the location of the submarine's wreckage and recover a single piece of piping.

Soon after the THRESHER was lost the Navy established a Deep Submergence Systems Review Group to analyze naval capabilities in the ocean environment and to recommend changes in Navy operational capabilities. This Review Group generally known by the name of its chairman, Rear Admiral E. C. Stephan, USN (Ret.), former Oceanographer of the Navy, categorized the subjects included under deep submergence capabilities into four areas:

1. Recovery of surviving personnel from disabled submarines
2. Investigation of the ocean bottom and recovery of small objects
3. Recovery of large objects
4. Man-in-the-Sea: enabling man to live and work on the ocean floor

In recovering submarine survivors the Review Group noted that the Navy was dependent upon individual (buoyant) escape from submarines or rescue with the McCann chamber (diving bell). The Review Group reported: "The risks and time required have limited escape training to date so that escape from below 50 feet is only speculative." And, in regard to rescue, that the present rescue chamber system "has a theoretical capability for rescue down to a depth of 850 feet. Considering the rescue chamber limitations and the present deployment of submarines... only a small percentage of today's operations are protected. Adverse weather or strong currents could negate a particular rescue attempt."

The Review Group observed a similar lack of capability for locating small objects on the ocean floor with most of the Navy's search equipment designed to search either large ocean volumes for operating submarines or shallow areas for mines.

The ability to salvage large objects was limited by the work capability of divers (380 feet for 30 minutes maximum), a lack of suitable equipment, a lack of interest, and a lack of qualified personnel.

Finally, the Review Group noted that only scattered efforts to extend the working depth of Man-in-the-Sea were being pursued by the Navy and private interests and that several foreign countries were ahead of the U.S. Navy in this field of underwater work.

The Review Group recommended that the Navy initiate a detailed program to improve its capabilities for deep-sea rescue, search, salvage and diving. These recommendations were submitted in February 1964 and the following June the Navy established a Deep Submergence Systems Project (DSSP) to develop the techniques and equipment required to improve Navy capabilities in the deep ocean environment. In addition to the four areas studied by the Review Group, DSSP was assigned responsibility for the development of a nuclear-powered, ocean engineering and research vehicle, the NR-1.

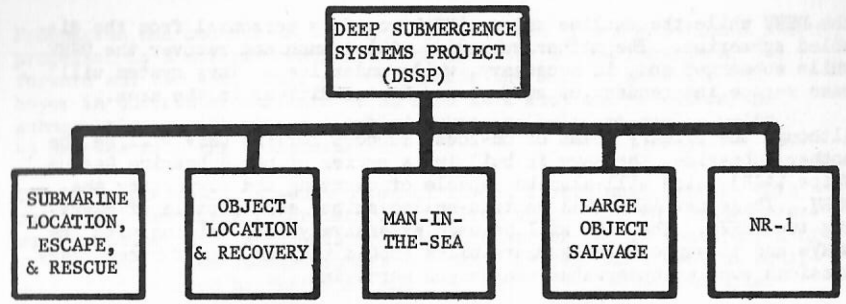
The Deep Submergence Systems Project was initially assigned to the Navy's Special Projects Office (which is responsible for the Polaris and Poseidon missile systems). While DSSP was under the Special Projects Office a basic organization was established, program elements were defined, and operational projects were started.

(As if to further emphasise the need for development of deep-sea capabilities, in January 1966 a U.S. Air Force B-52 bomber and KC-135 tanker aircraft collided over the ocast of Spain with one of the bomber's unarmed hydrogen bombs falling into the sea. A three-month effort was required to locate and recover the "Palomares bomb" from a depth of 2,850 feet. Simultaneously, the war in Vietnam was straining the Navy's limited salvage capabilities as the enemy sunk a number of merchantmen and small combat craft in the approaches to the port of Saigon.)

After operating under the cognizance of Special Projects for almost two years, the Deep Submergence Systems Project was made a separate Navy organization on 9 February 1966. The establishment of DSSP as a separate project was indicative of the importance placed on the Navy's deep submergence efforts. The Project Manager of the Deep Submergence Systems Project reports directly to the Chief of Naval Material who, in turn, reports to the Chief of Naval Operations.

DSSP Program

The Deep Submergence Systems Project has five major programs; (1) Submarine Location, Escape, and Rescue; (2) Object Location and Small Object Recovery; (3) Large Object Salvage System; (4) Man-in-the-Sea, and (5) the Nuclear-Powered, Deep Submergence Research and Ocean Engineering Vehicle NR-1.



Submarine Location, Escape, and Rescue

DSSP is currently developing alerting devices for use in locating a distressed submarine and improving existing individual escape techniques from disabled submarines. The latter effort includes developing a rapid-pressuring escape trunk and individual escape-survival equipment, improving personnel escape training, and experimental testing of open-sea escape to a maximum depth of 850 feet.

The major effort in this program is the development of several Deep Submergence Rescue Vehicles (DSRV) which will be capable of "mating" with a disabled submarine on the ocean floor and removing up to 24 passengers per trip.

DSRV Mission

The Deep Submergence Rescue Vehicle is especially designed to provide a quick-reaction, world-wide, all-weather rescue capability. The DSRVs will be based at three locations close to airfields from which the U.S. Air Force C-141 and C-5 jet cargo aircraft can operate. Upon notification that a submarine is disabled, the DSRV and its support equipment (the required equipment being housed in a mobile van) will be loaded aboard two C-141 or a C-5 and flown to a port near the disabled submarine.

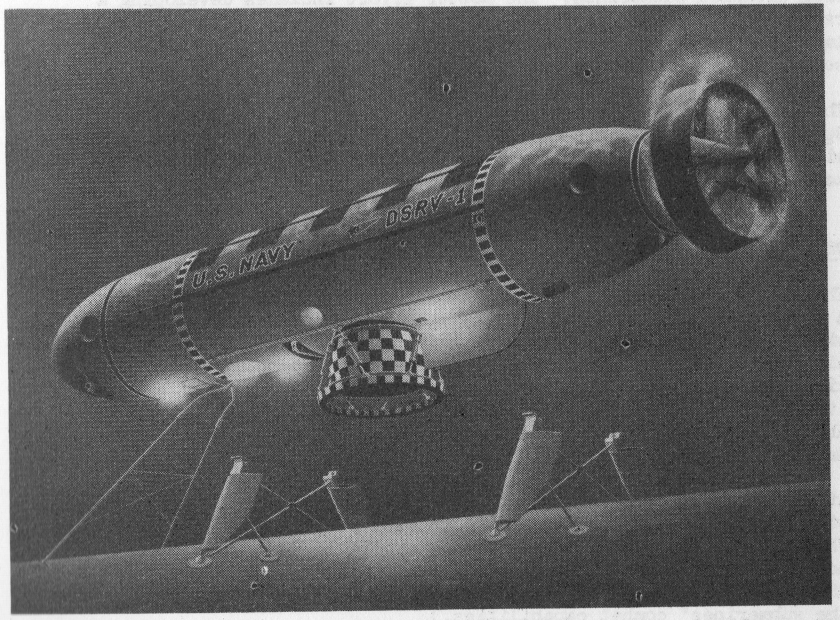
At the remote port the DSRV and certain equipment from the support van will be loaded aboard a "mother" submarine or a surface Submarine Rescue Ship (ASR), whichever is more readily available. The Navy plans to modify a number of nuclear-powered submarines to carry and support the DSRV. (The provision to carry and support a DSRV will not detract from the submarines' combat capabilities.)

The mother submarine, with the DSRV attached to its main deck, will then proceed to the disabled submarine and serve as an underwater base for the DSRV while the smaller submersible transfers personnel from the disabled submarine. The mother submarine will launch and recover the DSRV while submerged and, if necessary, while under ice. Thys system will make rescue independent of surface weather conditions in the area.

Although the primary means of on-scene support for the DSRV will be the mother submarine, the Navy is building a series of new Submarine Rescue Ships (ASR) which will also be capable of carrying and supporting the DSRV. These new ASRs will be twin-hulled ships, each capable of carrying two DSRVs. The ASRs will be used extensively for training with the DSRVs and to support the submersibiles should they be used for secondary missions such as underwater search and surveying.

DSRV Vehicle

The DSRV will be the most advanced deep submergence vehicle in existence with the capability of "hovering" over a disabled submarine and "mating" with the submarine's escape hatch. An elaborate Integrated Control and Display (ICAD) system will enable the DSRV's pilot and co-pilot to use information from sonars, closed-circuit television, and sophisticated navigation devices to perform their intricate mission.



Artist's concept of a Deep Submergence Rescue Vehicle "landing" aboard a "mother" submarine. The DSRV has hooked on a trapeze which will guide the vehicle onto the pylons.

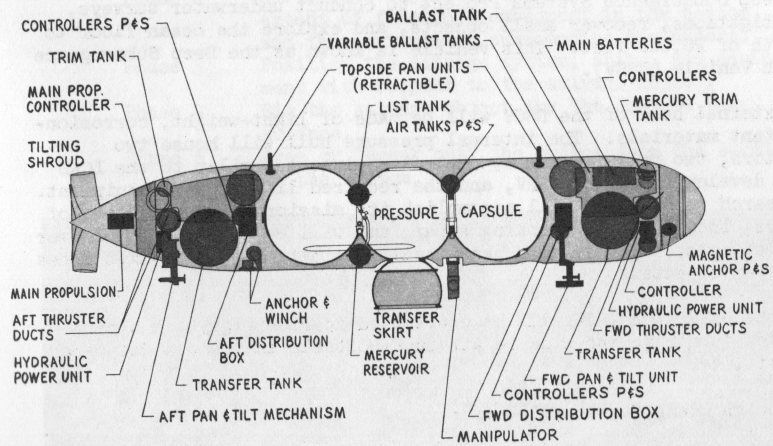
Propulsion and control of the DSRV are achieved by a conventional stern propeller in a movable control shroud and four ducted thrusters, two forward and two aft. This system permits the DSRV to maneuver and hover in underwater currents of as much as 1 knot and to enable the submersible to mate with a disabled submarine lying at angles up to 45 degrees from the horizontal.

The DSRV outer hull is constructed of formed fiberglass. Within this outer hull are three interconnected spheres which form the manned pressure capsule. Each sphere is $7\frac{1}{2}$ feet in diameter and is constructed of HY-140 steel. The forward sphere contains the vehicle's control equipment and is manned by the pilot and co-pilot. The center and after spheres accomodate 24 passengers and a third crewman.

Under the DSRV's center sphere is a hemispherical protrusion or "skirt" which seals over the disabled submarine's hatch. During the mating operation the skirt is pumped dry to form a secure seal and enable personnel to transfer between the DSRV and the submarine

The characteristics of the DSRV are:

Design weight	70,000 lbs.
Overall length	49 ft. 3 in.



This cutaway drawing of the Deep Submergence Rescue Vehicle shows the arrangement of the three pressure spheres. The transfer skirt "mates" to the disabled submarine's rescue hatch; the pan and tilt units, which retract into the vehicle, mount a variety of cameras and lights.

Diameter	8 ft.
Propulsion	Electric motors, batteries
Maximum speed	5 knots
Endurance	3 knots for 12 hours
Operating depth	5,000 ft.
Personnel	Pilot, Co-pilot, mid-sphere, 24 passengers
Life support	24 hours (minimum plus emergency individual life support for 3 hours minimum)

The DSRV-1 is now under construction at the Lockheed Missiles and Space Company in Sunnyvale, California, and is scheduled to be completed early in 1969. A contract has been awarded to Lockheed for a similar DSRV-2. Plans for four additional rescue submersibles are pending.

Object Location and small Object Recovery

More than 80 percent of the ocean lies below the U.S. Navy's current submarine operational capabilities with most of the ocean floor being covered by seas 20,000 feet deep. A submersible is being developed by the Deep Submergence Systems Project to conduct underwater surveys, investigations, recover small objects, and explore the ocean floor to a depth of 20,000 feet. This vehicle is known as the Deep Submergence Search Vehicle (DSSV).

The external hull of the DSSV will be made of light-weight, corrosion-resistant materials. The internal pressure hull will house two operators, two relief crewmen, control equipment similar to the ICAD being developed for the DSRV, and the required life-support equipment. The search submersible will accomplish its missions with a variety of sensors, including side-looking sonar, and will be equipped to recover small objects (the size of a basketball) and attach surface lift lines to larger objects.

Like the DSRV, the DSSV will be configured to ride piggyback aboard a modified submarine and will be air transportable in the C-5 jet cargo aircraft.

The design goals for the DSSV are:

Weight	70,000 lbs.
Overall length	50 ft.
Diameter	11 ft.
Propulsion	Electric motors, fuel cells
Maximum speed	5 knots
Endurance on bottom	3 knots for 30 hours
Operating depth	20,000 ft.
Personnel	2 operators, 2 relief

Plans for the Object Location and Small Object Recovery program

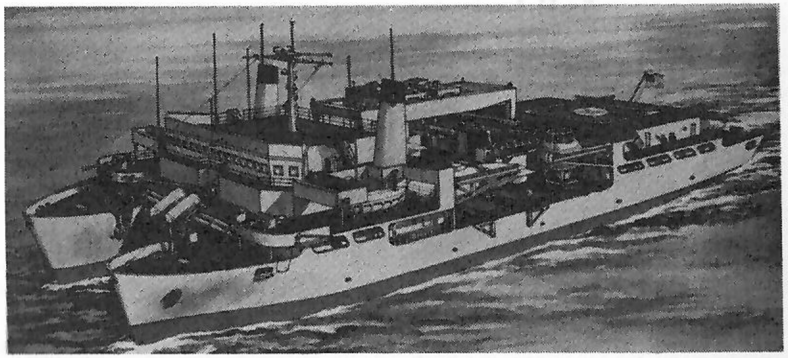
envision two Search and Recovery Forces, one on the U.S. east coast and one on the west coast. Each Force will consist of two DSSVs, one set of Unmanned Instrument Platforms (UIP), a mother submarine, and a surface support ship. The surface support ship may be one of the new twin-hulled Submarine Rescue Ships (ASR).

Large Object Salvage System

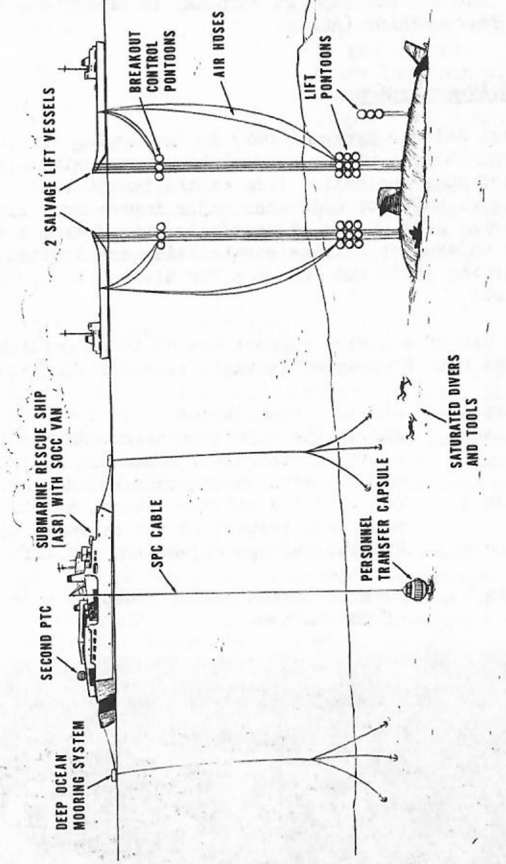
The Large Object Salvage System (LOSS) is developing the capability of recovering large objects with a deadweight of approximately 1,000 tons, including intact sumarine hulls, from depths to 850 feet. Underwater salvage techniques have not undergone major improvement since 1939 when the U.S. submarine SQUALUS was successfully raised from a depth of 243 feet. Present underwater salvage capabilities are limited primarily by the maximum-working depth and duration for divers, i.e., 380 feet for about 30 minutes.

LOSS will make use of a diving support system to accomplish many of the tasks associated with deep-water salvage. These include:

Phase 1	Locate sunken object
Phase 2	Survey the object to ascertain its integrity, extent of flooding, embedment in the bottom, and the environment surrounding the object.
Phase 3	Position the salvage system, ships, and equipment with respect to the salvage object.
Phase 4	Rig the salvage object for the lift to the surface.
Phase 5	Free or "break out" the object from the suction of the bottom.



The new-construction Submarine Rescue Ship (ASR) underway. Note the twin-hull configuration, heavy bridge crane amidships for handling vehicles and helicopter platform.



LARGE OBJECT SALVAGE SYSTEM

Phase 6	Lift the object to the surface. Control must be maintained of the rate of lift as well as the distribution of the lift force over the length of the salvage object to regulate its attitude.
Phase 7	Rig the object for tow and tow it to shoal water.
Phase 8	Final raising of the salvage object and placing it in drydock for repair or other disposition.

Rigging the salvage object for the lift is the most difficult of all salvage tasks and the diver appears to be the most effective means of accomplishing this task. The diver support system is thus a major component of LOSS. The other major systems under LOSS are surface ships and the lifting mechanism.

The nerve center of the salvage operation will be a Salvage Operational Control Center (SOCC) located in a Submarine Rescue Ship (ASR). The SOCC will include computer and display systems to provide the Salvage Master with a dynamic report of the location of lift pontoons, the condition of divers, the amount of break-out force being applied, the condition of ship moors, etc. Sensor devices on the ship's bottom will provide inputs to the SOCC as will gauges in the lift mechanism. The submarine rescue ship will also serve as the surface support ship for the divers and will have decompression chambers, gas supplies, personnel transfer capsules, etc. (In addition to supporting LOSS, these ships will serve as surface support ships for the Deep Submergence Rescue Vehicle.)

LOSS will employ buoyant pontoons in conjunction with winches to lift objects from the sea floor. The pontoons will provide most of the lift force with the winches, two 75-ton capacity winches on each of two lifting barges, providing control as well as lift. The pontoons will have a combined buoyancy of up to 1,000 tons.

A planning concept for an extended depth capability envisions a LOSS system lifting a totally flooded submarine (approximately 5,000 tons deadweight) from the submarine's collapse depth. Extended depth LOSS would use shipboard winches to provide the lift force and manned submersibles to perform the tasks performed by divers in shallower depths. The salvage target would be lifted to a shallow depth and then transported beneath the lift ship to be grounded in about 500 feet of water. The wreck would then be salvaged using the standard LOSS concept.

Nuclear-Powered, Deep Submergence Research and Ocean Engineering Vehicle, NR-1

The fifth program of DSSP is the Nuclear-Powered, Deep Submergence Research and Ocean Engineering Vehcile. Dr. John P. Craven, the Chief Scientist of DSSP, has stated that the NR-1, "initiated without fanfare, may be the most significant innovation in the technology of the sea bottom."

Existing manned underwater research vehicles are limited by the short endurance of their propulsion and auxiliary machinery. For example, the deepest diving craft in existence today, the U.S. Navy's bathyscaph TRIESTE II, has an endurance of five hours at two knots; the planned Deep Submergence Search Vehicle (DSSV) will have an endurance of 30 hours on the ocean bottom. The NR-1 will have an endurance limited only by the amount of food and supplies carried onboard.

With its great depth and endurance capabilities, the NR-1 will be able to perform tasks heretofore only imagined; it will be able to perform detailed studies and mapping of the ocean bottom for commercial and scientific purposes. The NR-1 will be manned by a crew of five plus two scientists. (In conjunction with this multi-purpose capability of the NR-1, it may be made available to agencies other than the Navy.)

The Department of the Navy and the Atomic Energy Commission are jointly developing the NR-1. The Deep Submergence Systems Project has the overall responsibility for the vehicle's development. The Naval Ship Systems Command (formerly Bureau of Ships) is responsible for vehicle design and construction, and the Atomic Energy Commission's Division of Naval Reactors (under Vice Admiral H. G. Rickover, USN-Ret.) is responsible for the design, development, and construction of the NR-1's power plant.

The NR-1 is now under construction at the Electric Boat Division of General Dynamics Corporation, in Groton, Connecticut.

E.

SUPPORTING ACTIVITIES AND CONTRACTORS

Abbey Electronics Corporation
Long Island, New York

Advance Communications, Inc.
Chattsworth, California

Aerogrip Corporation
West Los Angeles, California

Aervalco Company
Rosemead, California

A. M. Castle & Company
Pacific Metals Division
San Francisco, California

AMPCO Metal Inc.
Milwaukee, Wisconsin

Ampex Corporation
Redwood City, California

Associated Aero Science
Laboratories, Inc.
Torrance, California

Avondale Shipyards, Inc.
New Orleans, Louisiana

Benthos, Inc.
North Falmouth, Massachusetts

Bethlehem Steel Corporation
San Francisco, California

Betts Spring Company
San Francisco, California

Birns & Sawyer, Inc.
Los Angeles, California

Boston Insulated Wire & Cable Company
El Segundo, California

Brill Electronics
Oakland, California

Bristol Company
San Francisco, California

Brooks Instrument Division
Hatfield, Pennsylvania

Bureau of Commercial Fisheries
Department of Interior

Bureau of Medicine & Surgery
Department of the Navy

The B/W Controller Corp.
Birmingham, Michigan

B. Welson & Company, Inc.
Hartford, Connecticut

Cal-Pacific Equipment Company
San Francisco, California

Cambridge Systems, Inc.
Newton, Massachusetts

Charles M. Bailey Company, Inc.
Emeryville, California

Circle Seal Inc.
Anaheim, California

Clarostat Manufacturing Company
Dover, New Hampshire

Contromatics Corporation
Rockville, Connecticut

David Clark Company, Inc.
Worcester, Massachusetts

D. G. O'Brien, Inc.
Framingham, Massachusetts

Dorteck, Inc.
Stamford, Connecticut

Dover Corporation
W. C. Norris Division
San Francisco, California

Dupar Dynamics Corporation
Hayward, California

Earle M. Jorgensen
Seattle, Washington

Eastman Kodak Company
Whittier, California

Edgerton Germeshausen & Grier, Inc.
Boston, Massachusetts

Ehrenreich Photo Optical Industries
Garden City, New York

Electric Heater Company
Stamford, Connecticut

Electro Kinetics Corporation
Torrance, California

Electromagnetics Industry, Inc.
Sayville, Long Island, New York

Electro-Oceanics Division
Winsco Instruments & Controls
Santa Monica, California

Electro Optical Systems, Inc.
Pasadena, California

Electro-Voice, Inc.
Buchanan, Michigan

Eric P. Strutt
Newport Beach, California

Esterline Angus Instrument Company
Indianapolis, Indiana

E. T. Skinner Company, Limited
London, England

Exide Industrial Division
Electric Storage Battery Company
San Francisco, California

Fenway, Inc.
Ashland, Massachusetts

Genco Tool & Engineering Company
Silver Spring, Maryland

General Dynamics Corporation
Electric Boat Division
Groton, Connecticut

General Electric
Schenectady, New York

General Instruments Corporation
Thermo Electric Division
Newark, New Jersey

General Radio Company
Mountain View, California

Giannini Scientific Corporation
Santa Ana, California

Global Marine, Inc.
Los Angeles, California

Graybar Electric
San Francisco, California

Grove Valve & Regulator Company
A subsidary of Walwarth
Hazlet, New Jersey

Heinemann Electric Company
Trenton, New Jersey

Hansen Manufacturing Company
Cleveland, Ohio

Harold Beck & Sons, Inc.
Philadelphia, Pennsylvania

Hill Magnetics Products
Manlo Park, California

H. J. Wickert & Company, Inc.
San Francisco, California

Hoffman Corporation
Springfield, Virginia

Hoke, Inc.
Cresskill, New Jersey

Honeywell, Inc.
San Francisco, California

Hydrodynamics, Inc.
Sausalito, California

Hydrodynamics, Inc.
Silver Spring, Maryland

Hydro Products Division
Oceanographic Eng. Company
San Diego, California

J. B. Nottingham & Company, Inc.
New York, New York

J-B-T Instruments, Inc.
New Haven, Connecticut

Jon Hall/Del Dickenson Underwater
Camera Housing Company
Hollywood, California

Kieruiff Electric
Palo Alto, California

Kintec, Inc.
Beverly Hills, California

Kirby-Morgan Corporation
Goleta, California

Lear Siegler, Inc.
Bogen Communications Division
Paramus, New Jersey

Litton Industries
Atherton Division
Cleveland, Ohio

Long Beach Naval Base
Long Beach, California

Long Beach Naval Shipyard
Long Beach, California

Lukens Steel Company
Coatesville, Pennsylvania

Manhattan Marine & Electric Company
New York, New York

Marine Contracting Inc.
Southport, Connecticut

Marotta Valve Corporation
Boonton, New Jersey

Marsh & Marine
Houston, Texas

The Merian Instrument Company
Cleveland, Ohio

Meyers Safety Switch Company
San Francisco, California

Miller Fluid Power Division
Flick-Reedy Corp.
Bensenville, Illinois

Miratel Electronics Company
St. Paul, Minnesota

Mitchell Camera Corporation
Glendale, California

Montgomery Bros.
Burlingame, California

Monsanto Research Corp.
Mound Laboratories
Miamisburg, Ohio

Motorola Communications &
Electronics Inc.
Riverside, California

M. R. Rosenblatt & Sons, Inc.
New York, New York

National Electric Company
San Francisco, California

Naval Applied Science Laboratory
Brooklyn, Massachusetts

Naval Civil Engineering Lab.
Port Hueneme, California

Naval Facilities
Engineering Command
Department of the Navy

Naval Medical Research Institute
Bethesda, Maryland

Naval Missile Center
Point Mugu, California

Naval Oceanographic Office
Suitland, Maryland

Naval Research Laboratory
Washington, D.C.

Naval School Diving & Salvage
Washington, D.C.

Naval Ship Systems Command
Department of the Navy

Naval Undersea Warfare Center
Pasadena, California

Naval Underwater Swimmers School
Key West, Florida

Navy Experimental Diving Unit
Washington, D.C.

Navy Mine Defense Laboratory
Panama City, Florida

Navy Subsistence Office
Washington, D. C.

Northrop Nortronics
A division of Northrop Corporation
Palos Verdes, California

Ocean Design Engineering Corporation
Long Beach, California

Oceanographic Engineering Company
San Diego, California

Ocean Science & Engineering Company
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Office of Naval Research
Washington, D.C.

Pacific Coast Instruments Company
San Francisco, California

Parkway Fabricators
South Amboy, New Jersey

Paul Munroe Hydraulics, Inc.
Burlingame, California

Philadelphia General Hospital
Philadelphia, Pennsylvania

Photo-Sonics, Inc.
Burbank, California

Plug-In Instruments, Inc.
Nashville, Tennessee

Poce Engineering Company
North Hollywood, California

Quantum-Dynamics, Inc.
Tarzana, California

Radio Corporation of America
Pasadena, California

Ralph W. Atkinson Company, Inc.
Los Angeles, California

RCA
San Francisco, California

Relco Products, Inc.
Denver, Colorado

Rotron Pacific Division
Rotron Manufacturing Company,Inc.
Burbank, California

Rowan Controller Company
Westminster, Maryland

Rubatex Corporation
Bedford, Virginia

Samuel Moore & Company
Mantua, Ohio

San Francisco Bay Naval Shipyard
Hunters Point Division
San Francisco, California

Scott Aviation Corporation
Lancaster, New York

Sears, Roebuck & Company
Chicago, Illinois

Simplex Wire & Cable Company
Hydrospace Systems Division
Portsmouth, New Hampshire

Snap Tite Incorporated
Union City, Pennsylvania

Steam Specialties Company
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Stromberg Carlson
Telecommunications Plant
Burlingame, California

Strong Tube Company, Inc.
Richmond, California

Submarine Medical Center
Groton, Connecticut

Suchy Division
Reflectronic Corporation
New York, New York

Supervisor of Salvage
Department of the Navy

Terry Sales Corporation
Riviera Beach, Florida

Thermoelectric Division
General Instrument Corporation
Hicksville, New York

Transducers, Inc.
Santa Fe Springs, California

TRW, Inc.
Columbus, Ohio

Tube Turns
Louisville, Kentucky

Union Carbide Corporation
Linde Division
Los Angeles, California

Uniroyal
Research Center
Wayne, New Jersey

U. S. Divers Company
Santa Ana, California

Vacuum Reflex Ltd.
New Malden, Surrey, England

Varo, Inc.
Product Division
Garland, Texas

Victor Computer Corporation
Business Machines Group
San Francisco, California

Victor Electrowriter Sales
Glendale, California

Viets Engineering Company
Long Beach, California

Voit Rubber Company
Santa Ana, California

Western Gear Corporation
Heavy Machinery Division
Everett, Washington

Western Transformer Company
Oakland, California

Westinghouse Electric Corp.
Marine Division
Sunnyvale, California

Westinghouse Electric Corp.
Underseas Division
Annapolis, Maryland

Yardney Electric Corporation
New York, New York

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SEALAB III GLOSSARY

AQUANAUT	U.S. Navy term to designate "saturation divers" who spend prolonged time at depth in a habitat on the ocean floor; see Saturation Diving
ARS	Navy designation for Salvage Ship
BIBS	Built-In Breathing Systems; emergency breathing equipment in seafloor habitat
BOGEN	Intercom system linking various stations in habitat and the surface support ship
BQC	AN/BQC-1 underwater communications system in seafloor habitat and each Personnel Transfer Capsule (PTC); in this system the human voice is carried by underwater sound waves
CAVE	Consolidated Aquanaut Vital Equipment (integrated system to provide Aquanaut with breathing gas, navigation data, communications, thermal protection, electric power, and decompression computer)
CCG	Combat Camera Group (Pacific Fleet)
CIB	Command Information Bureau
CONSHELF	Continental Shelf; Captain Cousteau's saturation diving experiments
DDC	Deck Decompression Chamber (see DDS)
DDS	Deep Diving System; an integrated surface ship system providing all necessary equipment for a diver to descent to the ocean depths, perform a mission, and return safely to the surface; the Deep Diving System Mark 2 in the support ship ELK RIVER consists of Deck Decompression Chambers, Personnel Transfer Capsules, Main Control Consoles, Strength-Power-Communication Cables, life support equipment, etc.
DSSP	Deep Submergence Systems Project
DSSPO	DSSP Office (Chevy Chase, Maryland)
DSSPTO	DSSP Technical Office (San Diego, California)
(DV)	Navy designation for enlisted man who is a qualified diver; in addition to the man's specialty rating
EDU	Navy Experimental Diving Unit (Washington, D. C.)
EKG	Electrocardiograph

GENESIS — Project conducted by Captain George F. Bond, MC, USN, at shore facilities to test saturation diving concept (1957-1963)

HOOKAH — Underwater breathing apparatus with breathing gas provided to the diver through a hose from the seafloor habitat or from habitat-mounted tanks; named for resemblance to Turkish water pipe

IMC — Integrated Medical and Command vans; mounted on surface support ship ELK RIVER

IX — Navy designation for Miscellaneous Unclassified ship; the ELK RIVER is designated IX-501

LBNSY — Long Beach Naval Shipyard

LOSS — Large Object Salvage System

MAN-IN-THE-SEA — Programs to extend man's underwater work capability, primarily through use of saturation diving techniques (see Saturation Diving); U.S. Navy Man-in-the-Sea Program has the goal of extended work periods on Continental Shelf (850 feet) without surface support

MCC — Main Control Console (see DDS); controls Deck Decompression Chamber

MDL — Navy Mine Defense Laboratory (Panama City, Florida)

Mark 2 — Deep Diving System (see DDS)

Mk VIII — Semi-closed Circuit Underwater Breathing Apparatus

Mk IX — Semi-closed Circuit Underwater Breathing Apparatus

NAVOCEANO — Naval Oceanographic Office

NCEL — Naval Civil Engineering Laboratory (Port Hueneme, California)

NMC — Naval Missile Center (Point Mugu, California)

NMRI — Naval Medical Research Institute (Bethesda, Maryland)

NUWC — Naval Undersea Warfare Center (Pasadena, California); formerly Naval Ordnance Test Station (NOTS)

OINC — Officer-in-Charge

PAO — Public Affairs Office(r)

PM — Project Manager (within Naval Material Command); the Deep Submergence Systems Project is designated PM-11

PQC — AN/PQC-3 underwater diver communications device ("walkie talkie")

PTC — Personnel Transfer Capsule (see DDS); pressurized "elevator" to lower and raise Aquanauts

SATURATION DIVING — Concept in which the diver lives in a chamber (aboard ship or on the seafloor), which is pressurized to the outside water pressure, and provided with a suitable breathing gas in which a lighter inert gas replaces the nitrogen. After about 24 hours of exposure under pressure the tissues of the diver's body will no longer absorb gas from the surrounding atmosphere and the diver is considered to be "saturated." Once he has been saturated his requirements for decompression are based on depth rather than duration of the dive and the decompression time is the same whether the diver's stay at depth is one day or one month.

SCI — San Clemente Island

SCUBA — Semi-closed Circuit Underwater Breathing Apparatus

SEALAB — Sea Laboratory; U.S. Navy open-sea saturation diving experiments

SFBNSY — San Francisco Bay Naval Shipyard

SPC CABLE — Strength-Power-Communications Cable (see DDS); cable used to lower and raise Personnel Transfer Capsules

(SS) — Navy designation for enlisted man who is a qualified submariner; in addition to man's specialty rating

STEP — Submerged Test and Evaluation Platform; the SEALAB I habitat used for research at the Navy Mine Defense Laboratory (Panama City, Florida)

TANK — Diving chamber ashore

TOPSIDE — Slang used by Aquanauts for the surface (i.e., "topside personnel")

UQC — AN/UQC-1 underwater communications system in surface support ship ELK RIVER with human voice carried by sound waves

UUDD — Underwater Upside Down Davit; mounting on habitat for dumbwaiter system to transfer supplies between habitat and surface support ship

YFU — Navy designation for Harbor Utility Craft

NORTHROP CORPORATION'S NORTRONICS DIVISION is proud to be a member of the Navy-industrial team which is undertaking man's most ambitious effort to date to penetrate Inner Space.

As Systems Engineering Support Contractor for the Navy's Deep Submergence Systems Project, Nortronics performs a number of tasks for the SEALAB III. Activities in support of the experiment include: monitoring of the design development and fabrication of the SEALAB system to identify potential problems and recommend solutions; Man-in-the-Sea program evaluation and analysis for Navy management; preparation of interface control drawings for the SEALAB system and deep diving system; preparation of test plans and policy documents; technical review of test procedures; development of a scenario for pre-operation testing; preparing safety certification plans for Aquanaut equipment; and related technical support.

In addition, Nortronics designed and assembled the Integrated Command and Medical vans which serve as the operational and medical command posts for SEALAB III. After SEALAB III these vans will be used ashore and aboard other research ships to support future Man-in-the-Sea activities.

Northrop Nortronics is providing similar support for other activities within the Deep Submergence Systems Project, primarily the Deep Submergence Rescue System and the various surface support ships and submarines involved in DSSP activities.

Other Northrop programs in the area of undersea operations include the Polaris-Poseidon missile submarine check-out equipment, Mk 30 submarine target, anti-submarine tactical evaluation and monitoring systems, command and control display systems for ASW, Mk 46 torpedo gyroscopes, periscope drives for Polaris submarines, gyroscopes for Polaris submarines, AN/BRA-8 submarine-towed buoys, and research in underwater living, Aquanaut protective clothing, and underwater hull protection.

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'Colonies at sea in 20 years'

By PEARCE WRIGHT, Science Correspondent

The first move to colonize the sea, with men living and working on floating islands, will occur within the next 20 years, Dr. William A. Nierenberg, director of the Scripps Institution of Oceanography at California University, said in London yesterday.

He was one of four speakers at a conference to celebrate the centenary of the scientific publication Nature who reviewed some of the most rapidly developing frontiers of science. The others were Professor F. Hoyle, Cambridge, Dr. F. H. C. Crick, laboratory of molecular biology, Cambridge, and Professor D. S. Lehrman, institute of animal behaviour, Rutgers University, United States.

Dr. Nierenberg considered the implications of developing the mineral wealth of the seas and exploiting the ocean spaces for both civil and military purposes.

He said the surface of the ocean would show great changes Large islands would be constructed to float almost motionlessly in all sea and wind conditions. They would range from 200ft. squares to mile-long airports, and would serve as research stations, factories, early warning sites, tactical and strategic bases, and even simply as hotels.

He said that throughout history war at sea had been largely mastery of one of the major sea routes and economic control of these routes. What was important was manifest dominance of the oceans, or what was commonly known as gunboat diplomacy. Until recently this mastery of the oceans belonged to the United States but we now recognized the emergence of the U.S.S.R. as a naval power that had effectively begun to challenge the United States Navy as a diplomatic force.

What was different today was the effects of new technology. The most important was the Polaris weapon system which had converted the ocean into a strategic reserve.

Although the submarine had been an important military factor since the First World War, it was hardly to be considered a true submersible unit until the advent of nuclear propulsion. We were moving steadily to where operationss at or near the bottom of the ocean would become both a civilian and military commonplace.

In the world of tomorrow the structures will play a fundamental role in the use of the oceans. Dr. Nierenberg maintains that overseas military bases are an increasing diplomatic problem and that the west is in a deteriorating position from both internal and external pressures. In addition, floating airports are far less vulnerable to low-cost attacks and an effort to "get them" would expose an enemy to an even more costly retaliation.

To complete the picture, Dr. Nierenberg says, permanent buoy fields will cover large areas of the oceans for both military and civilian needs. These will carry the instruments for measuring all the factors for jobs such as long-range weather forecasting and monitoring traffic in the ocean.

Summing up, he believes that in 20 years the oceans will have become sparsely inhabited, but rather uniformly on the surface and in depth. One difficulty with this development is that of ownership or lack of it and the complication that can arise in the absence of effective law.

Dr. Nierenberg mentioned the deep drilling programme of the Scripps Institution, in which oil was found in the Gulf of Mexico but beyond the Continental shelf. There was no law to govern who might have the right of ownership to minerals discovered in such a situation.