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NOTS TP 4130

NOTS PARTICIPATION IN SEALAB II PROJECT

by

E. P. Carpenter

Underwater Ordnance Department

ABSTRACT. For the SEALAB II project, the U. S. Naval Ordnance Test Station was assigned responsibility for all surface operational support. The underwater site was selected in cooperation with the Scripps Institution of Oceanography. A staging area was established at the Long Beach Naval Shipyard and a staging vessel was provided and modified to meet the needs of the program. Complete system integration and checkout were performed. All necessary operational support, personnel, equipment, and material were supplied.

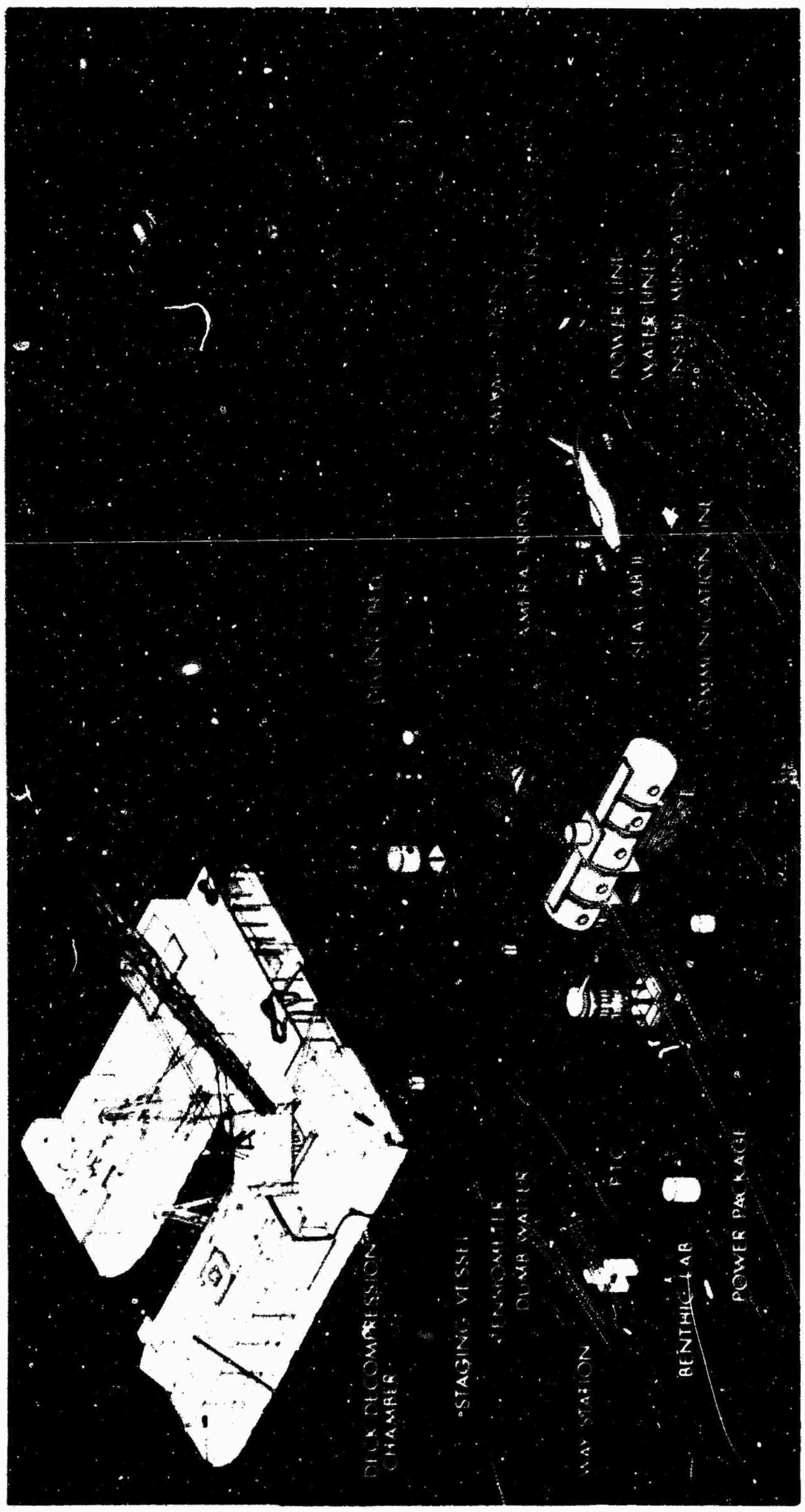
U. S. NAVAL ORDNANCE TEST STATION

China Lake, California September 1966

CONTENTS

GLOSSARY

BNSY	Boston Naval Shipyard
DDC	Deck decompression chamber
LBNSY	Long Beach Naval Shipyard
MDL	Mine Defense Laboratory
MPL	Marine Physical Laboratory, Scripps Institution of Oceanography
NEL	Navy Electronics Laboratory
NOTS	Naval Ordnance Test Station
ONR	Office of Naval Research
SFBNSY(HP)	San Francisco Bay Naval Shipyard, Hunters Point Division
PTC	Personnel transport capsule
SIO	Scripps Institution of Oceanography
SMC	Submarine Medical Center
SPO	Special Projects Office



FRONTISPIECE. SEALAB II Installation at La Jolla, Calif.

INTRODUCTION

The SEALAB II project was designed to test the ability of men to perform saturated diving for extended periods of time and to accomplish useful work at a nominal depth of 200 feet. Facilities provided to accomplish this experiment consisted of a 10-man habitat, called SEALAB II, placed on the ocean floor, and a surface support vessel moored above the habitat on which were located a 10-man decompression chamber, a personnel transport capsule, and the control station for the experiment. A site for SEALAB II operations was selected at a point about 3,000 feet west of the end of the pier at Scripps Institution of Oceanography, La Jolla, Calif. Electrical power and fresh water were supplied through lines from the shore with alternate sources from the support vessel.

Three teams of aquanauts, rotating every two weeks, inhabited the SEALAB. Cmdr. Scott Carpenter, in command of the aquanauts, stayed down 30 consecutive days; Dr. Robert E. Sonnenberg, the medical officer, spent 30 days under water in two 15-day periods.

Figures 1 and 2 show the site and general project layout, respectively. A chronological history of major events is given in Appendix A. The Polaris Pop-Up staging vessel called the Berkone[1] with certain modifications was utilized as the SEALAB surface support craft.

BACKGROUND

One of the Specific Operational Requirements (SOR 46-19) of the Navy's Deep Submergence Systems Program (DSSP), titled "Man-in-the-Sea," has for its objective the development of a capability to place men on the continental shelf (depths to 600 feet) for extended periods of time to accomplish useful work.

SEALAB I, an Office of Naval Research (ONR) program in progress during DSSP planning, was incorporated as part of the DSSP "Man-in-the-Sea" investigation. The SEALAB I experiment had been conducted during the summer of 1964 at Plantagenet Bank near Bermuda and had consisted of lowering a habitat housing four men to a depth of 193 feet for a period of 11 days.

SEALAB I results indicated that the concept of extended saturation dives is feasible and that additional testing of a more sophisticated

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[1] The staging vessel became known as the Berkone during the SEALAB II project, a designation derived from Berkich and Mazone, the names of two people stationed aboard.

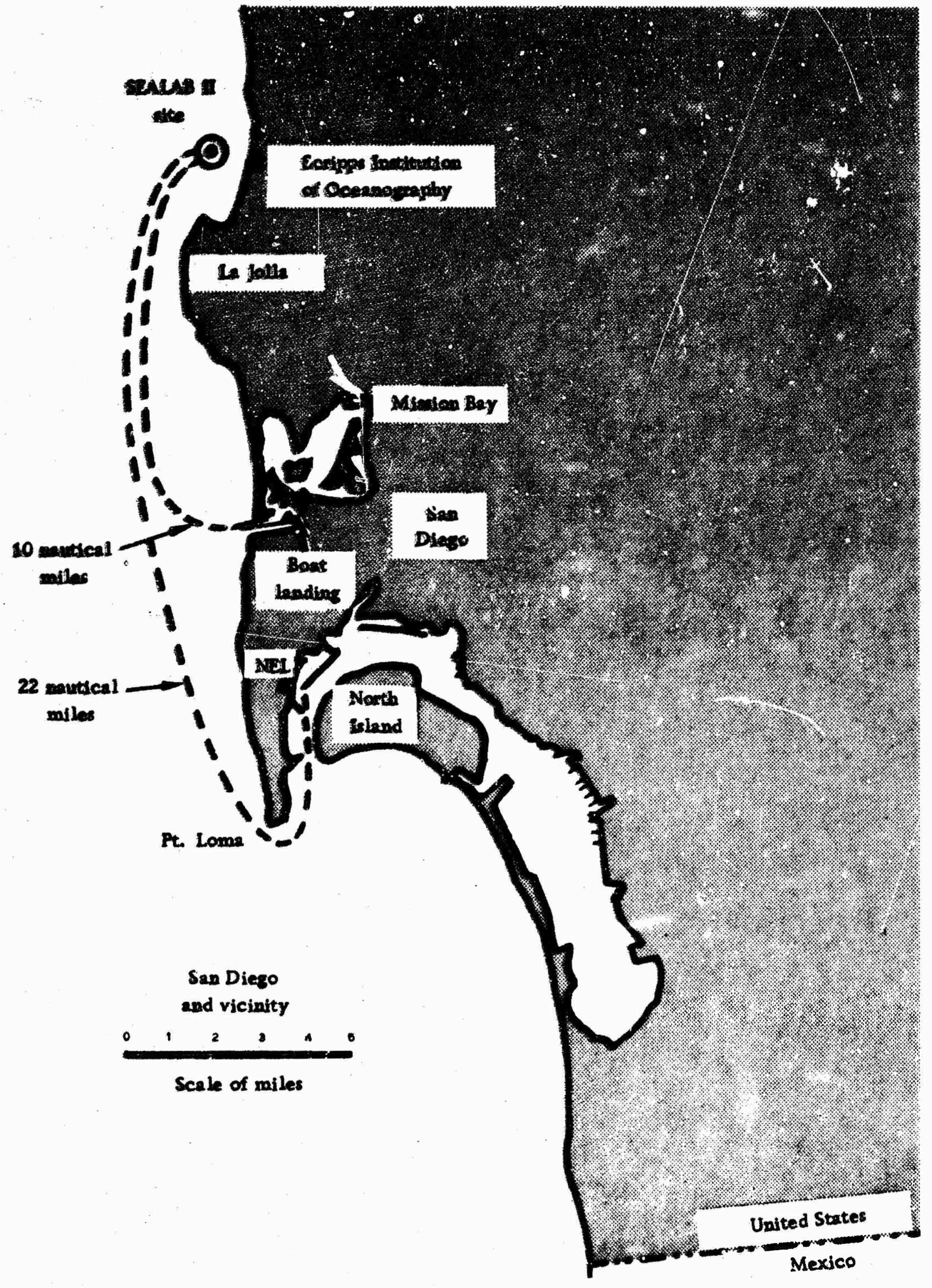


FIG. 1. SEALAB II Site.

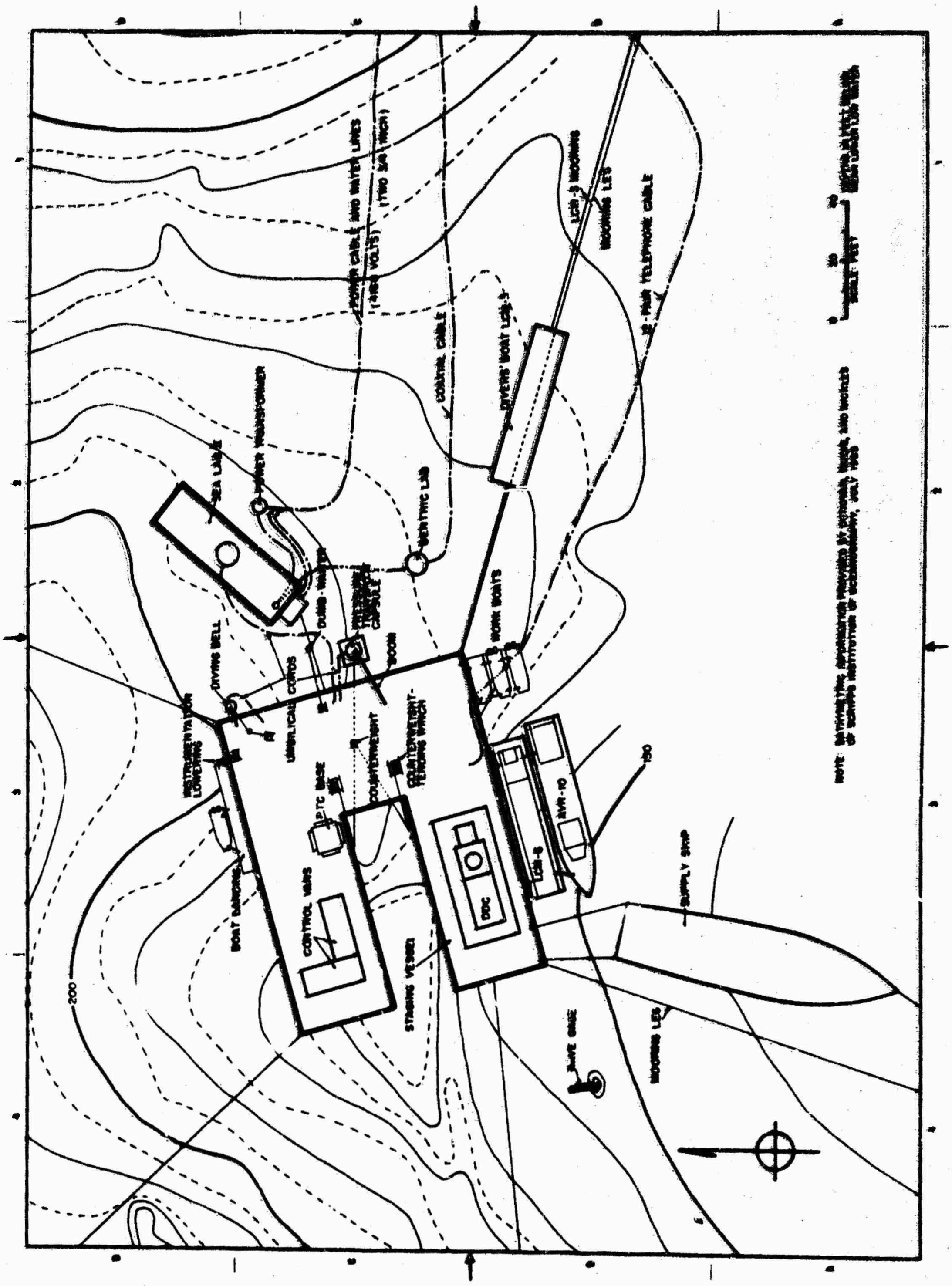


FIG. 2. SEALAB II Operational Configuration, La Jolla, Calif.

nature should be undertaken. Accordingly, in February 1965, the Special Projects Office (SPO), Bureau of Naval Weapons, made initial plans to conduct the SEALAB II experiment.

Various agencies were assigned responsibilities. ONR was designated program manager. The Mine Defense Laboratory (MDL) was assigned the responsibility of preparing engineering design specifications for the habitat. The San Francisco Bay Naval Shipyard, Hunters Point Division (SFBNSY, HP) was to design and construct the habitat. The Naval Ordnance Test Station (NOTS) was given the responsibility for surface support, system integration and checkout, and site installation. ONR took the responsibility for the decompression complex consisting of a 10-man deck decompression chamber (DDC) and a personnel transport capsule (PTC). The DDC and PTC were designed and built by the Dixie Mfg. Co., Inc., Baltimore, Md., and were installed on the surface support craft provided by NOTS. Scripps Institution of Oceanography (SIO) was given the responsibility for supplying power and fresh water from shore to SEALAB II and for providing the instrumentation complex, called the Benthic Lab, by which SEALAB II data would be collected and recorded.

PROJECT OBJECTIVES

Basic SEALAB II objectives, not necessarily in order of priority, were as follows:

1. To further study the physiological and psychological characteristics of man in a sea environment for prolonged periods of time.

2. To determine man's capability of doing useful underwater work, both physical and mental, and to study the magnitude and nature of the degrading effects of the environmental parameters, including pressure, temperature, visibility, viscosity, etc.

3. To develop processes, techniques, procedures, and hardware for underwater living and working.

4. To approach a step nearer the objectives of placing men on any part of the continental shelf.

ORGANIZATION PLAN

To organize and coordinate the efforts of the people and agencies contributing to the SEALAB II project, the ONR program manager established two general disciplines. One was in force during the planning, design, construction, and preparation stages and the other applied during the operational period; both are shown as organizational charts in Fig. 3 and 4, respectively. The NOTS organization for the operational phase is shown in Fig. 5.

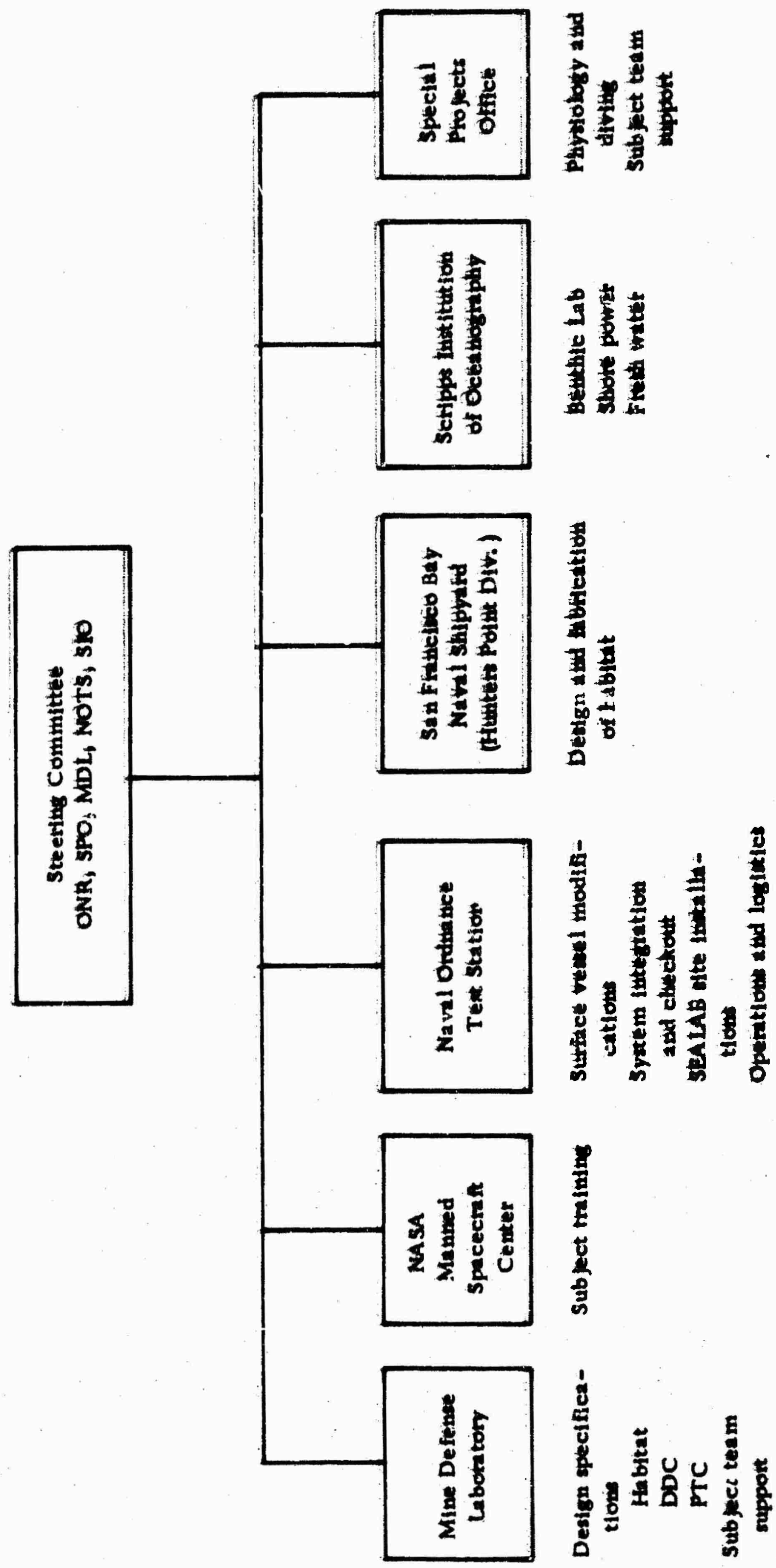


FIG. 3. Planning and Preparations Phase Organizational Chart.

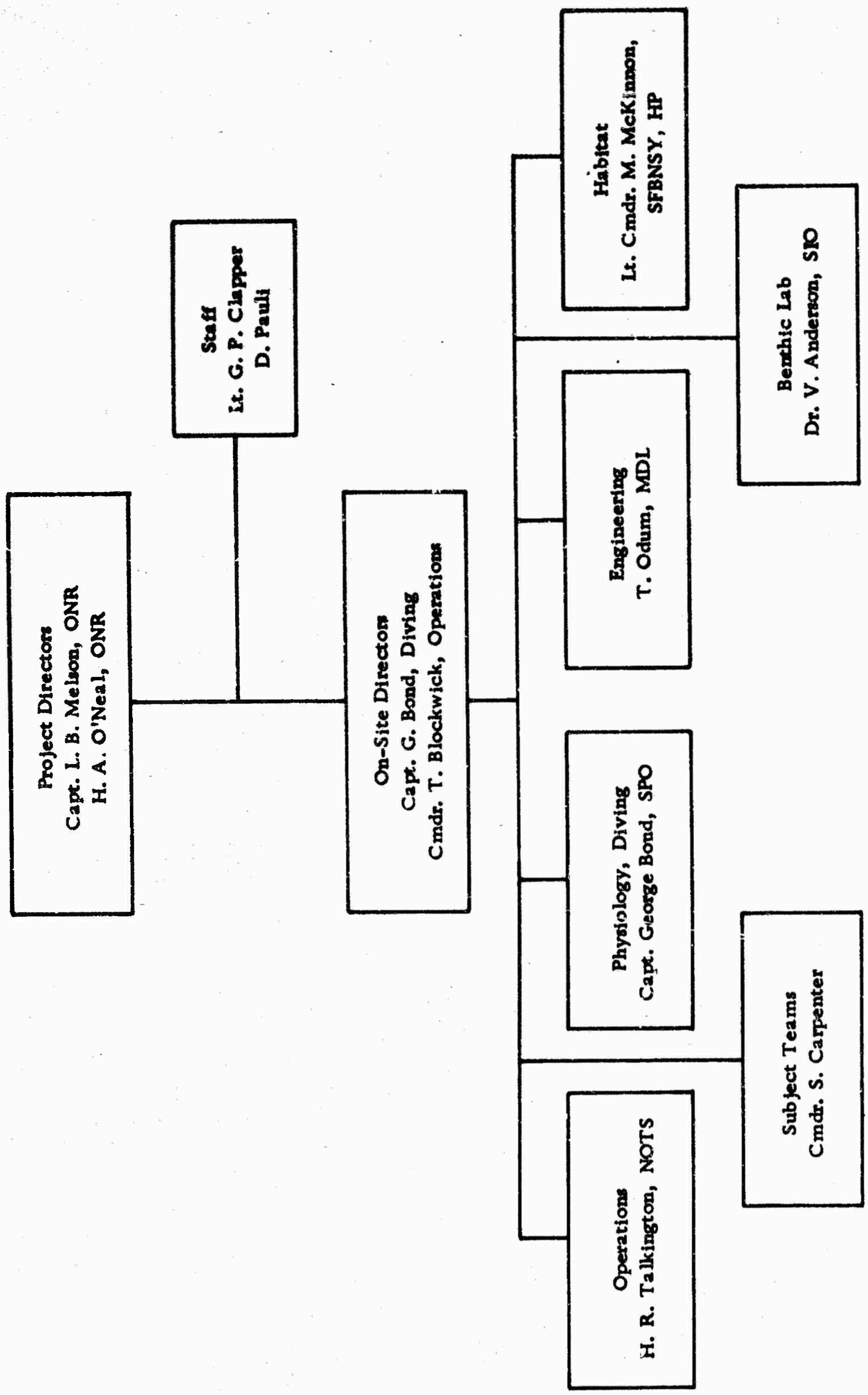


FIG. 4. Operational Phase Organizational Chart.

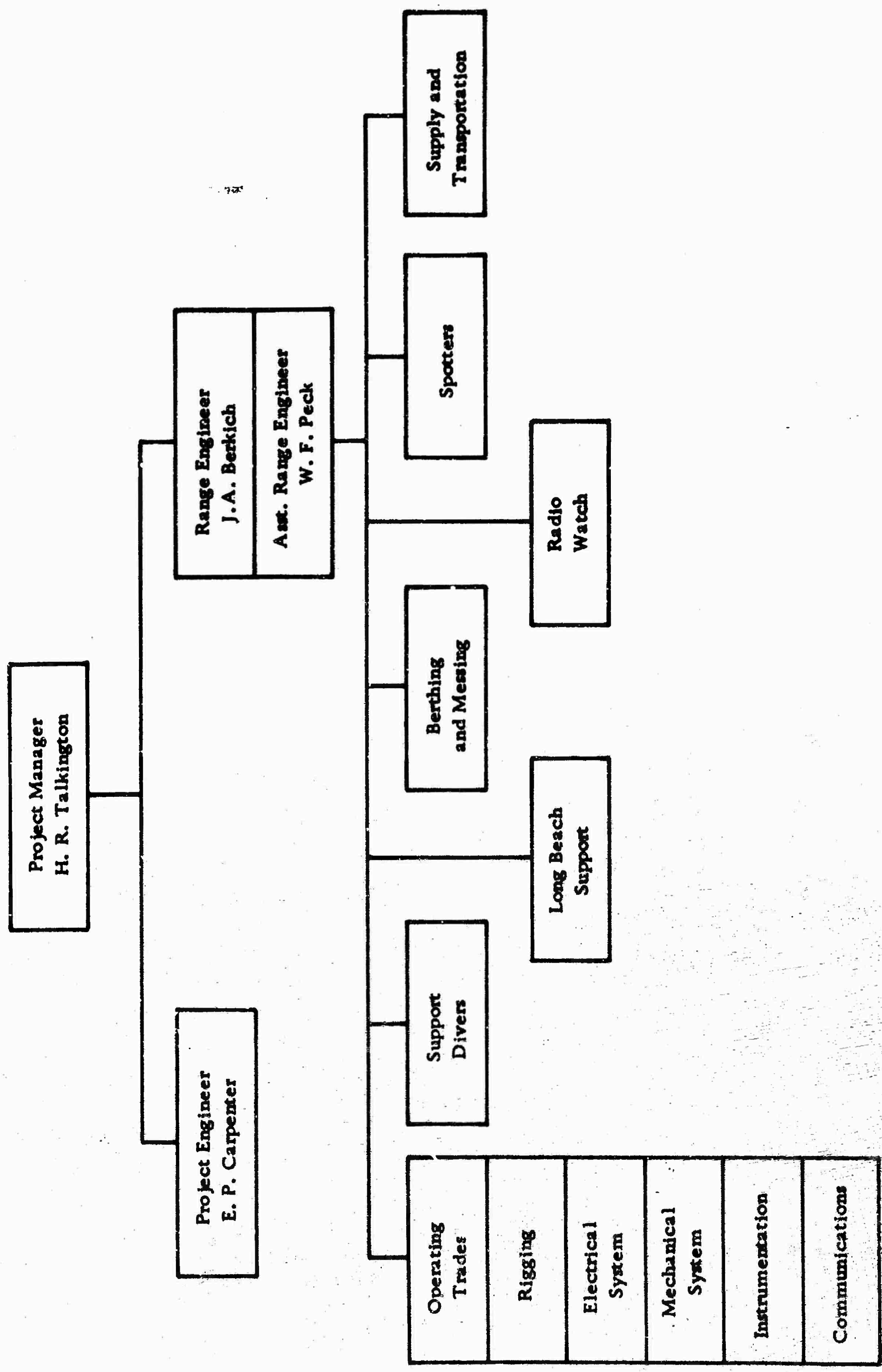


FIG. 5. NOTS Organizational Chart for SEALAB II Operational Phase.

Principal key personnel assigned to the SEALAB II project were

Director, Naval Applications Group	Capt. L. B. Melson ONR, Washington
Director, Project SEALAB II	H. A. O'Neal ONR, Washington
Deputy on-scene commander	Cmdr. T. N. Blockwick Boston Naval Shipyard, Boston, Mass.
Physiology and diving SPO project officer	Capt. George Bond, MC Special Projects Office, Bureau of Naval Weapons, Washington
Surface vessel modifications and SEALAB II operation	H. R. Talkington NOTS, Pasadena, Calif.
Engineering Surface Support Vessel	G. Abbot Long Beach Naval Shipyard, Long Beach, Calif.
Engineering and Diving Equipment	T. Odum Mine Defense Laboratory, Panama City, Fla.
SEALAB II Construction	Lt. Cmdr. M. McKinnon San Francisco Bay Naval Ship- yard, Hunters Point Division, San Francisco
Administration and Staff Consultant	D. Pauli ONR, Washington
Atmosphere Control Officer	Capt. W. Mazzone (MSC) U. S. Naval Submarine Medical Center, New London, Conn.
SEALAB II Design	L. S. Jue San Francisco Bay Naval Ship- yard, Hunters Point Division, San Francisco
Benthic Laboratory	Dr. V. Anderson Scripps Institution of Oceanography, Marine Physical Laboratory, La Jolla, Calif.

Subject Teams	Cmdr. Scott Carpenter National Aeronautics and Space Agency, Manned Spacecraft Center, Houston, Tex.
Staff	Lt. G. P. Clapper ONR, Washington

PROGRAM PLANNING

In the summer of 1964, NOTS was called upon by SPO to provide assistance in the preparation of the Technical Development Plan (TDP) for the DSSP, which includes the SOR for "Man-in-the-Sea." The drafts of this TDP that were written and submitted to SPO were subsequently used for the present TDP. A proposal for the operation of SEALAB II, as part of the Man-in-the Sea program, was also submitted to SPO, recommending the use of the Polaris Pop-Up staging vessel, with modification for use as the surface support craft, and a method for lowering SEALAB II to the ocean floor.

With the assignment to NOTS of the responsibility for system integration and checkout and on-site surface support, planning was begun with the Long Beach Naval Shipyard (LBNSY) for the necessary modifications to the Berkone, and with others for the site surveys, supporting function contracts, and equipment procurement.

SITE SURVEY AND SELECTION

Several considerations were involved in the selection of the SEALAB site. Cold water and reduced visibility were sought, to represent more nearly the world's oceans than did the ideal conditions at Plantagenet Bank during SEALAB I operations. Areas of oceanographic interest in proximity to existing shore-based support facilities were also desired.

After the program management selected the undersea Scripps Canyon area at La Jolla, Calif., consideration was given to other requirements:

1. Water depth between 200 and 250 feet
2. A site as near the lip of the underwater canyon as practicable
3. Areas sufficiently broad and flat for the emplacement of the SEALAB and its related components (the power transformer, the Benthic Lab, and the PTC) and also for the planned salvage operations and other routines to be performed by the aquanauts
4. Anchor-holding capacity in the surrounding area sufficient for adequate mooring of the Berkone
5. If possible, no necessity for the utility and communication lines from Scripps Pier to span the canyon

The Marine Physical Laboratory (MPL) at Scripps made a bathymetric chart of the La Jolla area based on an acoustic locating system for horizontal control and on echo soundings for depth information, enabling the selection of a tentative site on the south side of Scripps Canyon at a depth of 210 feet. A more detailed MPL survey of this tentative site used spotters on shore for horizontal control and lead-line soundings for depth information. This chart (Fig. 6) is the one used in the SEALAB operations.

The NOTS CURV (cable-controlled underwater research vehicle) and the NOTS YFU-53, with its underwater frame mounting TV, lights, and cameras, were used to make a visual inspection and to take bottom photographs. A silty, sandy bottom and some rock outcrop near the edge of the canyon were disclosed.

Three anchor pull tests were conducted on the north side of the canyon, using the U. S. S. Cocopa (ATF-101) with an 8,000-pound anchor. The holding force of the anchor was found to be seven times its own weight in two of the pulls and ten times its weight in the third.

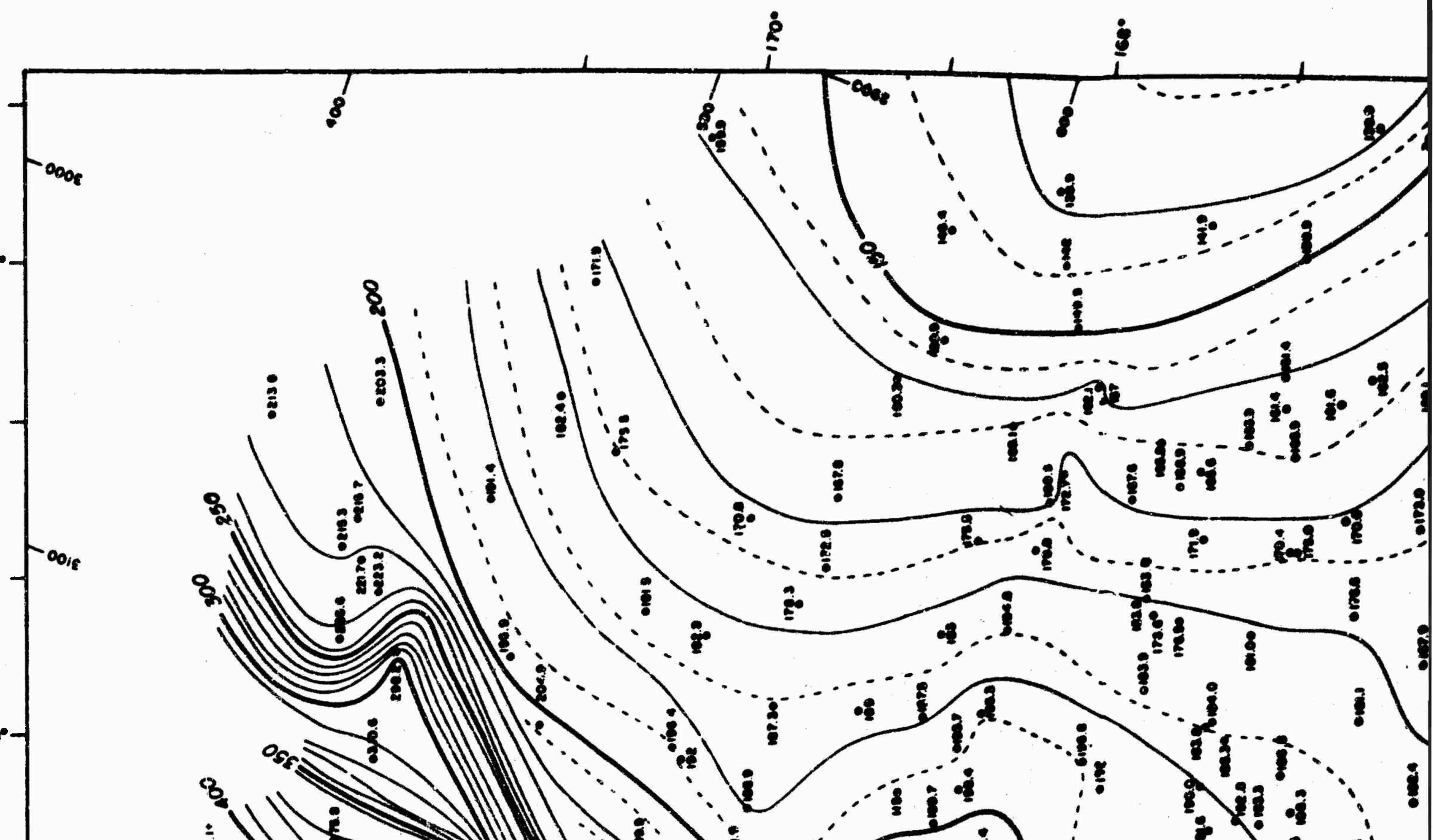
Bottom samples were not easy to secure. In the core-sampling attempts, a 2-inch gravity-type corer, weighted with several hundred pounds of lead, had difficulty penetrating the bottom, and after many tries, yielded one core about 4 inches long and another about 2 inches long. Grab-type samples were procured from the bottom and from both sides of the canyon. Analysis of the samples and the two cores showed a uniformly silty, sandy bottom and indicated that a bearing pressure of 300 lb/ft^2 could safely be used in the design of the SEALAB footings.

LONG BEACH STAGING AREA AND SYSTEM INTEGRATION

Personnel of the Long Beach Naval Shipyard (LBNSY), working to specifications provided by NOTS, designed, fabricated, and installed the Berkone modifications and provided other items pertaining to preparation of the SEALAB system for on-site operations. These modifications are discussed under Support Vessel and are detailed in Appendix B.

Building 139 in the shipyard, a facility that had been used in the Polaris Pop-Up program, was established as a staging area for the accumulation of materials and for system integration and checkout. Building 504, in the Long Beach Naval Station, was made available as headquarters for the aquanauts and for classroom training.

While the Berkone was undergoing modifications at LBNSY, other project components were prepared elsewhere and shipped, between mid-July and mid-August, to the staging area. System integration and checkout consisted of final assembly of subcomponents, including modifications where necessary, and testing of components for circuitry,



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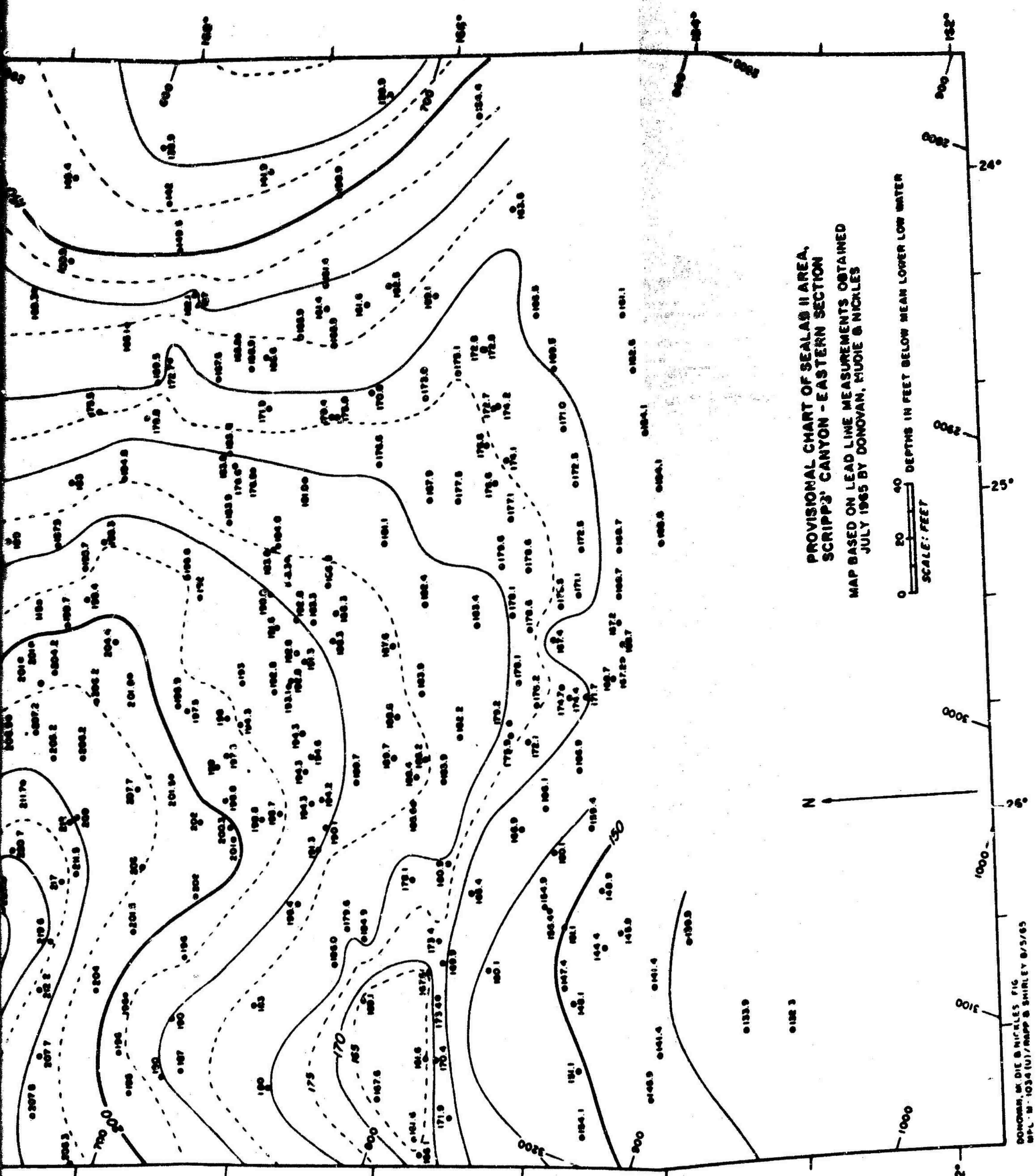


FIG. 6. SEALAB II Site Bathymetry.

strength, and desired function. As integration of the components progressed, the various systems and subsystems were further tested. These procedures are summarized in Appendix C.

The success of the integration and checkout was the result of the cooperative efforts of the Naval Submarine Medical Center (SMC), New London, Conn., ONR, MDL, SIO, SFBNSY(HP), LBNSY, SPO, NOTS, and the three teams of SEALAB subjects, or aquanauts.

SEALAB MODIFICATIONS AND CHECKOUT

The SEALAB (Fig. 7) was shipped from SFBNSY(HP) to LBSNY aboard a YC barge, which was berthed alongside the Berkone. Originally, it was to undergo only final outfitting and trim tests, but some modifications to the gas manifolding and the umbilical cable were found necessary.

The gas hoses of the umbilical cable, which had become kinked during shipment of SEALAB, blistered badly when pressure was applied. NOTS procured new hoses and the umbilical gas supply lines were completely replaced.

While the umbilical package was open for replacement of the gas hoses, an electrical power cable was added for underwater photo lights, and two cables were added for Life magazine's three cameras and flash equipment inside SEALAB.

Each of the cables going into SEALAB had to be potted to prevent the atmosphere of SEALAB from "hosing up" the cable. Each wire in the cable was stripped back about 6 inches, and potting compound was impregnated between each strand of the stranded conductors. A connector was then attached and the assembly made waterproof with self-vulcanizing rubber tape. Once SEALAB was on the bottom, this assembly was passed up through the Benthic cable trunk by the aquanauts and connected to the camera control unit.

Additions and modifications inside SEALAB II were carried out while the umbilical cable was being replaced. A Krassberg oxygen sensor was installed and connected to the oxygen system. This device is preset to the partial pressure of oxygen desired in the atmosphere and, once set, acts as both an alarm if the level falls too low and as a regulator, automatically adding oxygen to the atmosphere when necessary.

An Electro-Writer for reproducing handwriting was installed and speakers with independent volume controls were placed in the laboratory and berthing areas. These speakers were driven from an AM/FM tuner on the Berkone.

Various medical equipment from SMC was installed and connected to the instrumentation patch panel where necessary.

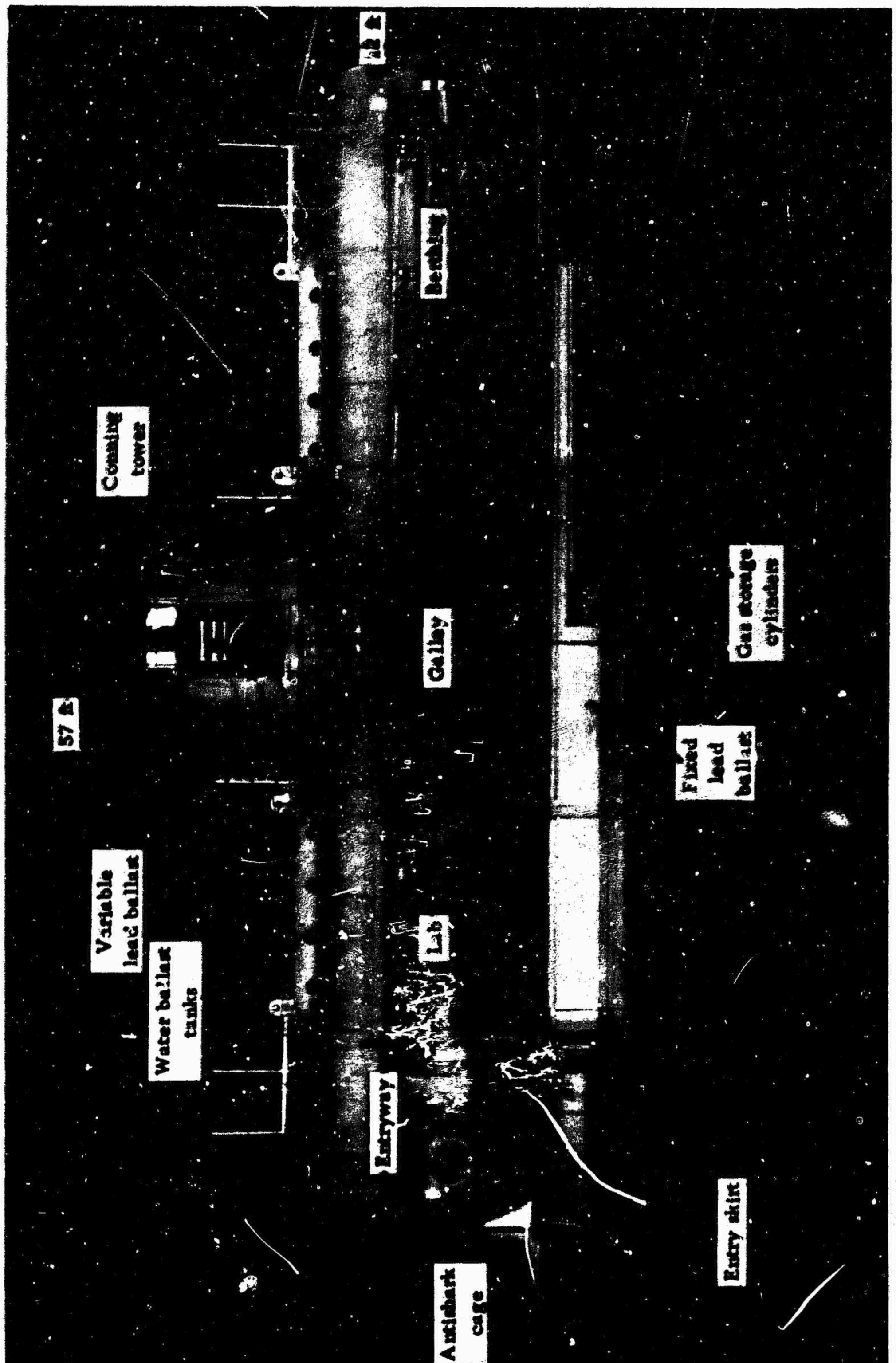


FIG. 7. Plastic Scale Model of SEALAB II.

While still on its shipping barge, the SEALAB was towed to San Diego where MPL instrumentation and TV installations were made and checked out with the MPL Benthic Lab.

Twenty four 9-inch-by-20-foot long gas storage bottles were procured and installed in racks on the outside of SEALAB II to supply helium and oxygen for the habitat. The gases were manifolded to the atmosphere control panel inside SEALAB.

The concrete floor in SEALAB II was covered with wall-to-wall carpeting for the comfort of the occupants.

After all modifications were complete and a complete systems check had been performed, SEALAB II was sealed and pressurized to 5 psi. All electrical and gas systems were checked for correct operation. In two valves, debris had lodged, scoring the valve seats and causing leakage. These valves were replaced and the SEALAB II was ready for trim tests. The German crane at LBNSY lowered SEALAB II into the water, and lead ballast was adjusted in the ballast trays until the proper trim was achieved. The water ballast tanks were also cycled to check the operation of the flood and vent systems. (Figure 13 on page 30 shows the SEALAB II ballasting system and gives displacement and buoyancy information.)

SUPPORT VESSEL

The Berkone, originally built for the Polaris Pop-Up tests conducted by NOTS at its San Clemente Island Test Range, was used as the SEALAB II surface support vessel. This craft consists of two 110-by-34-foot YC barges, spaced about 22 feet apart and connected by a covered structure at one end. A rigid U-shaped platform about 110 by 90 feet around an open well is thus provided.

As configured for the Pop-Up Tests, the Berkone's basic structure consisted of the open well with an underwater hinged platform for launcher-loading operations, an open bay on the port barge for missile handling, and the necessary machinery, equipment, storage spaces, galley, and dining areas. Machinery and equipment included three AC generators with a total capacity of 460 kw, two 15,000-pound line pull winches, one high-pressure air compressor, one low-pressure air compressor, and a 100-ton Lima crane restricted to a 50-ton working load as mounted on the Berkone.

To adapt this vessel for SEALAB II use, the underwater hinged platform was removed and a portion of the missile bay was roofed over, providing an enclosed space for the divers' ready room with showers, head facilities, and racks for breathing equipment and wet-suit drying. The 10-man deck decompression chamber (DDC) was installed in the open portion of the bay area, and fitted with a canvas cover that could be removed for PTC/DDC mating operations. The space immediately aft of the divers' ready room was fitted out with benches, equipment, plumbing, and power as required to overhaul, repair, and fill the Mk VI equipment, which is a self-contained, semi-closed-cycle breathing apparatus containing a mixture of helium and oxygen.

Two vans, with a connecting enclosure on the 01 level, were installed for the SEALAB Control Center, which housed communications control, atmosphere control, and the medical center. Communications equipment procured by NOTS, plus a helium voice unscrambler borrowed from the Naval Applied Science Laboratory, was installed, and the necessary circuitry for the operation of all equipment was provided. The atmosphere and medical equipment were supplied by SPO and SMC.

Other equipment required on the Berkone included a counterweight system for lowering and raising the SEALAB and the personnel transport capsule, a dumbwaiter for transporting both dry and wet items between the Berkone and the SEALAB, a diving bell for transporting divers to air-breathing depths, a method of attaching the mooring lines to the Berkone using 1 1/4-inch Carpenter stoppers, a tension-measuring and recording system for the mooring lines, a gas storage and distribution system, terminal connections for the umbilical lines and communications at the divers' platform, exterior and interior communications, and berthing accommodations for 40 people.

The generators, air compressors, crane, and other pieces of machinery were used without modification. The Berkone, as used for SEALAB II operations, is shown in Fig. 8.

OPERATIONAL SUPPORT SYSTEMS

DUMBWAITER

During SEALAB II operations, the Berkone was positioned with its fantail almost directly above the anti-shark cage of SEALAB. A 1/2-inch wire rope was attached to the cage and brought up to a sheave on the 01 level of the Berkone, passed over a second sheave and back into the water to a 500-pound counterweight that kept the line taut and allowed for wave and tide motions. To transport supplies between the surface and the SEALAB, a weighted container was loose-shackled to the taut wire and lowered and raised with a 1/4-inch wire on an air-driven winch. Supplies that needed to be kept dry were put in a pressure container that could be vented in either direction to equalize its internal pressure before being opened. An expanded metal cage was provided for transporting items that could get wet, or they were shackled directly to the taut wire for lowering or raising.

Getting the supplied items into the SEALAB was complicated. It was necessary for one of the aquanauts to suit up, go out of the shark cage, and bring the container inside of the cage to a point where it could be hoisted up through the access hatch by a block and tackle. In the future, this system should be designed to operate without the necessity of putting a man into the water outside of SEALAB.

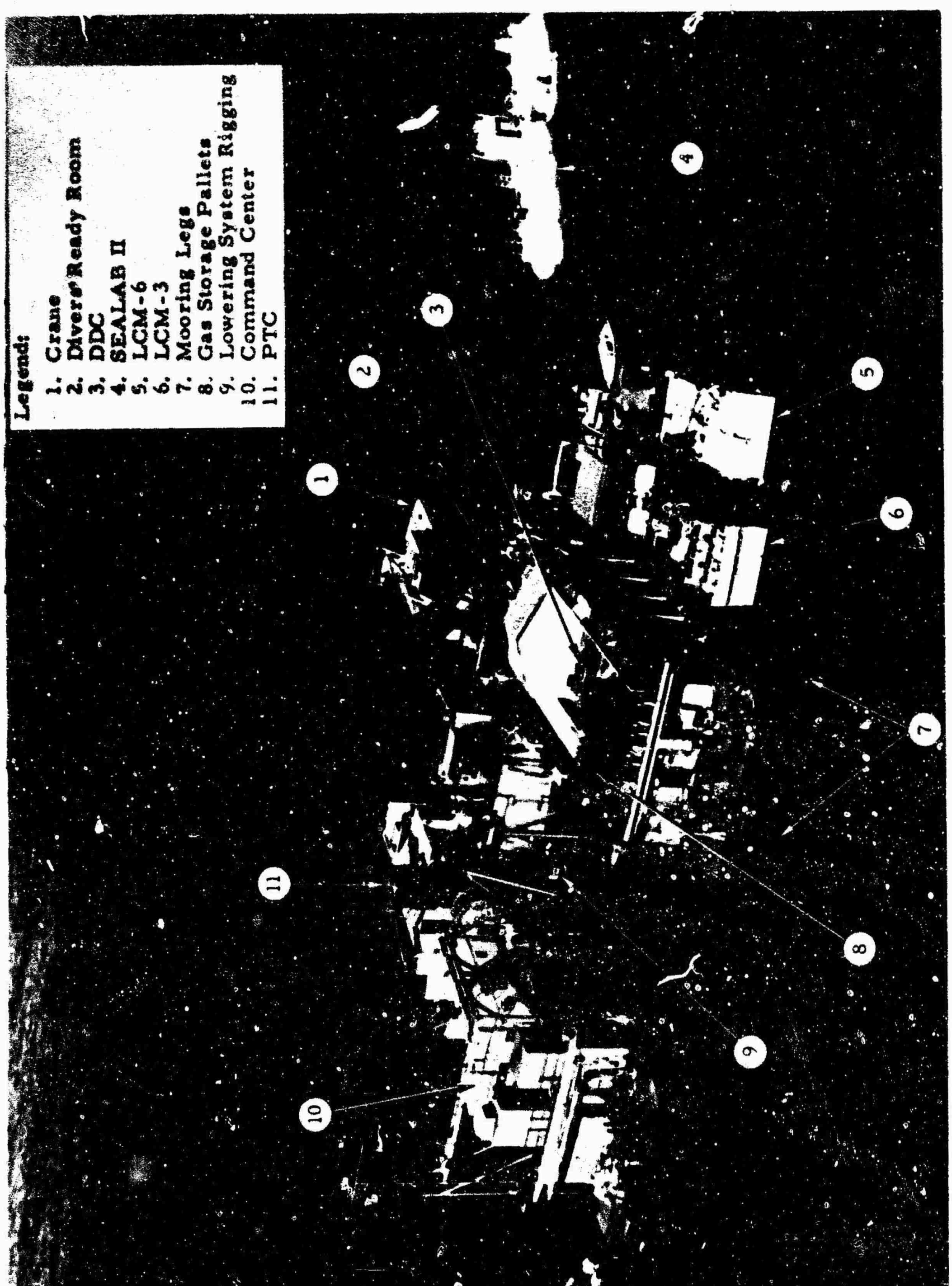


FIG. 8. SEALAB II Primary Surface Support Vessel, the Berkone.

MOORING

The Berkone used a five-point mooring system, each leg of which consisted of a 13,000-pound anchor, three shots of 2-inch chain, a 10,000-pound steel clump, and 1 1/4-inch wire rope running to the Berkone. A crown wire from the anchor to a 5-foot-diameter spherical buoy on the surface and a similar wire from the clump to a spud buoy facilitated the installation and removal of the moor. The spud buoys also served as auxiliary moors for surface vessels. A Miller swivel at each clump allowed the 1 1/4-inch leg wire to rotate under tension.

At the Berkone, each leg was secured with two Carpenter stoppers, one as a backup to the other, with enough spare wire to allow the vessel to shift 100 feet for final positioning, if necessary.

The moor functioned satisfactorily. Only when a supply ship or other vessel was moored to the Berkone, exerting an outside force upon it, was the movement within the moor on the order of 5 to 20 feet, which was well within the limits of the operating conditions.

To monitor the conditions of the moor, a strain-gage system for checking dynamic loads on each of the mooring lines was installed. NOTS contracted with the David Taylor Model Basin to manufacture five strain gages with a maximum tension of 200,000 pounds each. One was placed in each of the five mooring lines on the outboard Carpenter stopper, and the outputs were amplified and recorded on a Sanborn recorder. Nominal readings of 10,000 pounds per line were recorded throughout the operation. A maximum tension of about 55,000 pounds was observed in one leg. Although there was no way of calibrating the gages against a static load, it is felt that accuracies were on the order of 10% of the dynamic recordings.

In addition to the five-point moor, an auxiliary moor was installed that consisted of a 13,000-pound anchor, three shots of 2-inch chain, a 10,000-pound steel clump, and a 2-inch chain to a peg-top buoy on the surface. This buoy was used by the USNS Gear during SEALAB lowering and raising operations.

GAS STORAGE AND DISTRIBUTION

About 300,000 cubic feet of gas was used for SEALAB II operations, the major part consisting of helium, oxygen, and a helium-oxygen mixture. Approximately half of this gas was purchased in bulk and delivered from the vendor's tube trailer directly to SEALAB receivers—the SEALAB interior, the DDC, and the twenty-four 1,300-cubic-foot bottles mounted on the SEALAB. The remainder of the gas, mostly the helium-oxygen mixture, was delivered in "towner" pallets, each pallet consisting of thirty 200-cubic-foot bottles manifolded together. Nine towner pallets were stored on board the Berkone at all times, making a total capacity of 54,000 cubic feet of gas available. Empty pallets were continually replaced with full ones. A high-pressure piping system was provided to deliver the gas from the pallets to the points of use as needed—the DDC, PTC, Mk VI filling area, and the SEALAB.

During the third team's stay on the bottom, a hose was run to the SEALAB from the Mk VI shop on the Berkone to charge the Mk VI bottles in SEALAB instead of bringing them up for refilling.

DIVING BELL

A diving bell, about 3 feet in diameter, with a self-contained oxygen supply and an umbilical cord supplying air, communications, and power, was provided for transporting aquanauts and surface-support divers. In submerging, an aquanaut could breathe in the bell until the depth limit for air was reached. At that point, he would convert to his Mk VI mixed-gas apparatus and swim to the SEALAB. A surface-support diver could also use the bell for the required decompression stops on his way to the surface.

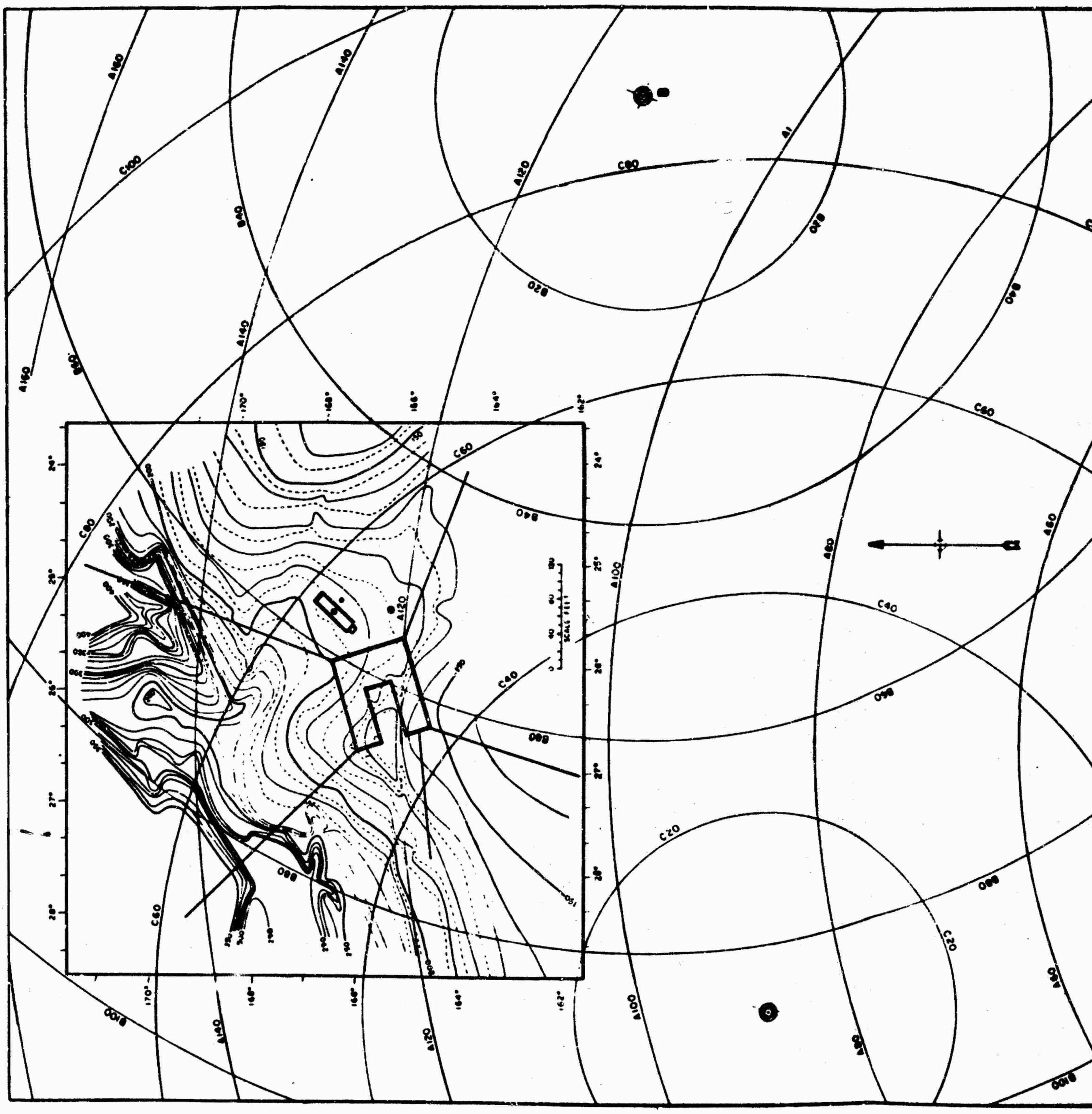
POSITION CONTROL

Position control of all SEALAB components was maintained chiefly by two spotters occupying the surveyed positions on shore that Scripps used for control in making the bathymetric chart of the operating site. Accuracies of about 2 feet could be obtained.

Also available was a second system developed by SIO for their bathymetric survey, which operated on an acoustic principle of position determination. It consisted of three hydrophones at known positions on the ocean bottom near the site (Fig. 9) that were pulsed from the end of the Scripps Pier by a signal generated on the Berkone and transmitted by wire to the pier. The signal was synchronized with the operation of a precision recorder, so that the pulses of the bottom-mounted hydrophones, picked up by a hydrophone suspended from the Berkone, could be recorded and the position of the receiving hydrophone plotted from the elapsed time information from any two bottom hydrophones. This acoustic position-control system has an advantage over visual sighting by being operable in bad weather, but its accuracy is perhaps one order of magnitude lower.

COUNTERWEIGHT LOWERING SYSTEM

For safety in lowering and raising the SEALAB or the personnel transport capsule from the Berkone, the relative motion of the two vessels must be considered. Wave action could cause 10 feet of relative motion during a wave half-period of about 5 seconds. The counterweighted system devised by NOTS (Fig. 10) had the effect of maintaining a nearly constant line tension during lowering operations and thus preventing tension fluctuations which otherwise could have varied between zero (free fall through the water) and a point so high the line could fail completely. Static characteristics of the counterweight system for SEALAB II are shown in Fig. 11.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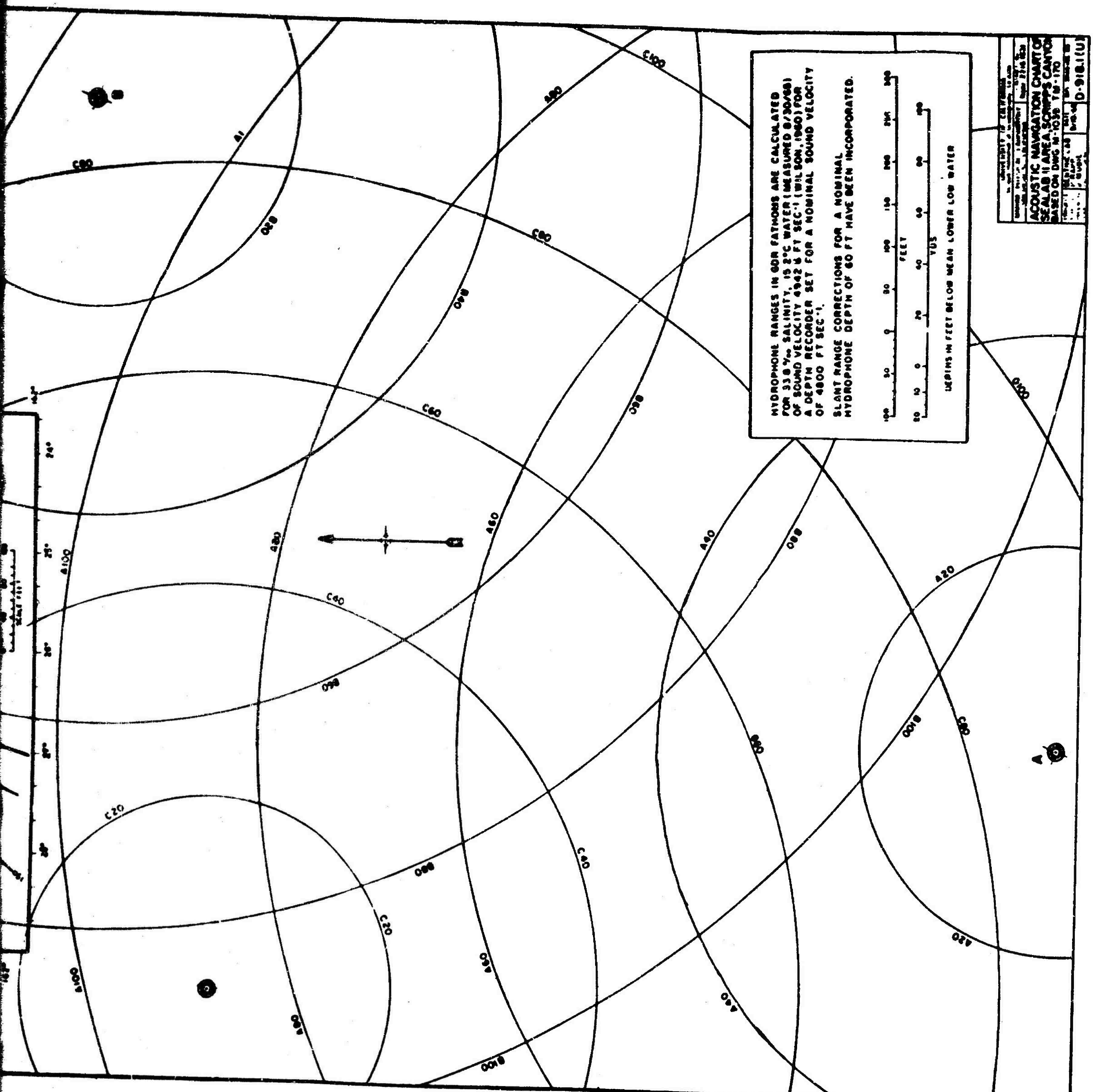


[FI]G. 9. Acoustic Navigation Chart of SEALAB II Area, Scripps Canyon.

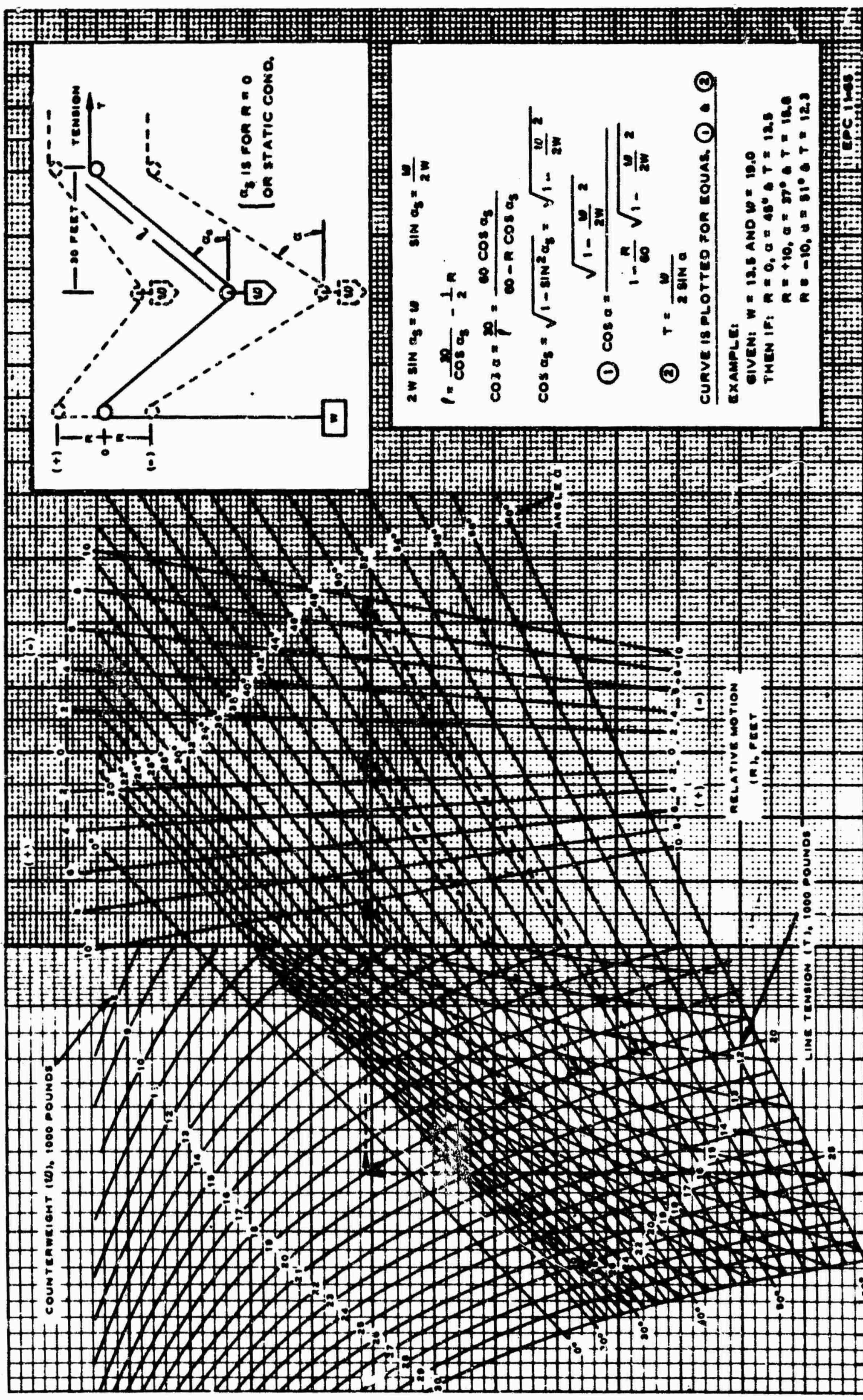


FIG. 11. Static Characteristics of Counterweight Lowering System.

Properly operated, the system automatically and smoothly loads and unloads itself when bottom or surface is reached. A wide range of loads can be handled without change in the size of the counterweight. Theoretically, shock loads on the line would not occur in the load range between zero and infinity. Actually, in the low load range (0 to 500 pounds) and at the Berkone's natural pitch period, the response of the counterweight did not match that of the vessel because of its own inertia. Operation in this load range (0 to 500 pounds) was required on occasion to maintain a slight tension on the line when the PTC was sitting on the bottom prior to lift-off. This requirement was met by placing a small auxiliary counterweight on the lowering line, as shown in sequence 3 of Fig. 10, and by removing the influence of the main counterweight from the system. Both the main and the auxiliary counterweight systems functioned well in all respects.

DECOMPRESSION COMPLEX

Emergence from the SEALAB was accomplished by bringing 10 men at a time to the surface in the personnel transport capsule at a pressure equivalent to bottom pressure and transferring them, under pressure, to the deck decompression chamber through a mating hatch. Operation of the decompression chamber was under the direction of Capt. Mazzone of SMC. Decompression took place at the rate of 6 ft/hr along a straight line function.

DECK DECOMPRESSION CHAMBER

When the DDC was received from the Dixie Mfg. Co., Baltimore, it was installed on the port side of the Berkone on a preprepared foundation and assembled and attached its prefabricated work platform. For heating and cooling, hot and cold water were connected and an additional water heater was installed to augment the Berkone's equipment.

To light the interior of the DDC, external lights were installed over the view ports at the top; internal lights were prohibited by the critical fire hazard during a high-oxygen decompression cycle. Gas and air were brought to the DDC from the helium and oxygen pallets and from the Berkone's compressor room; the piping was selected and placed according to SMC specifications. During the installation of an externally driven CO_2 scrubber, it was found that a babbit brushing was required around the drive shaft from the external motor to assure free-running operation and the maintenance of pressure inside the chamber.

Although the DDC was equipped with an intercom system, the outdoor public-address-system speakers were unusable and were replaced with 8-ohm paper-cone speakers. Music was also made available to the occupants of the DDC.

A need for additional working platforms around the mating hatch became apparent after operations began. Platforms were built and extensions of the yoke bolt shafts were also provided to facilitate cranking during the PTC mating process.

PERSONNEL TRANSPORT CAPSULE

The PTC (Fig.12), also delivered from the Dixie Mfg. Co., was water-buoyancy tested and the lead ballast adjusted to meet design specifications. To facilitate mating of the capsule to the PTC ballast tray, the base was modified by the addition of four aligning pins that engage the funnel on the capsule portion.

Operation of the escapement mechanism was tested both in air and in water. As received, its performance was not adequate, but after the bearings were reworked and other adjustments were made, the mechanism was satisfactory for use by the occupants to control their ascent without assistance from topside.

A PTC umbilical cord was not included in the design specifications. Because the need became apparent during checkout tests, an umbilical package consisting of a helium-oxygen line, a low-pressure (400-psi) air line, a 117-v AC cable, and a hard-wire communication cable was provided.

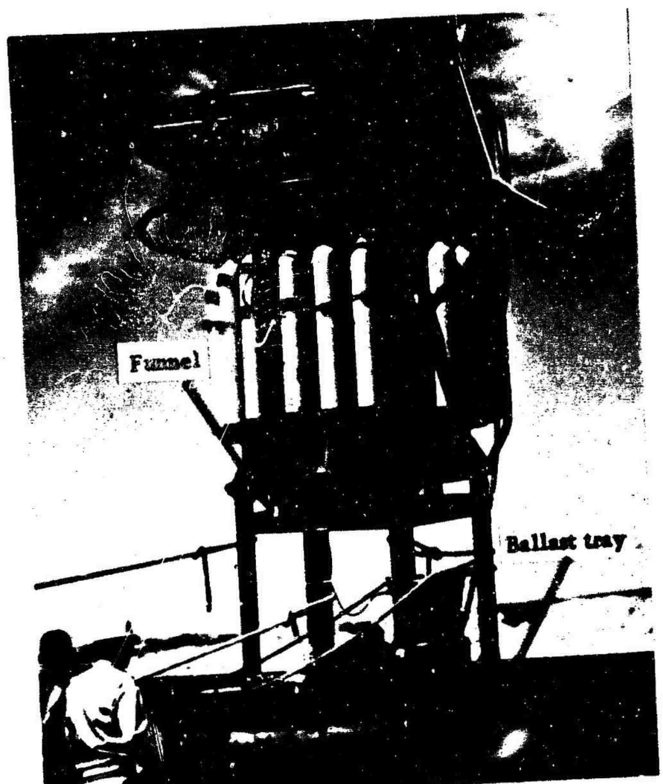


FIG. 12. Personnel Transport Capsule.

Power for the PTC lighting system and the CO_2 scrubber was supplied by the Berkone's 117-v AC generator; the 400-psi air supply was available for the operation of the escapement mechanism on the PTC ballast tray; and the helium-oxygen line brought the breathing mixture to the PTC.

The all-important self-contained life-support capability of the PTC was enhanced by the fabrication of a submersible battery pack. This battery supplied 28-v DC at 300 amp-hr to an internally mounted DC-to-117-v AC inverter so that the CO_2 scrubber could be driven for 8 to 10 continuous hours in the event of a surface power failure. For operation of the external battery pack by PTC occupants, three electrical circuits were passed through connectors in a 1-inch steel flange installed over one of the PTC view ports. With these improvements, all the umbilical-cord systems except lighting were self-contained in the PTC.

Other installations for the PTC included 18 externally mounted, 200-cu-ft gas-storage bottles for self-contained emergency atmosphere control, and guard rails and an expanded metal cover to protect vulnerable outside fittings.

An emergency acoustic communications system was also installed but did not prove dependable.

COMMAND CENTER

Vans were used on the Berkone to house the SEALAB II central command, including atmosphere control, habitat communications, and medical lab facilities. A 24-hour watch was maintained in the area by Capt. Bond (the principal investigator), Capt. Mazzone, and other SMC personnel.

Atmosphere Control

Specifications for an atmosphere control van were supplied to NOTS by SMC. The important features were incorporated, but some adaptations were made in order to combine it with the communications center (described below) in two halves of an existing 25-by-7-foot house trailer. Gas-sampling lines from the SEALAB, the PTC, and the DDC were connected to the trailer, and carrier gases were procured and installed as required. A Krassberg sensor readout to indicate the partial pressure of oxygen in the SEALAB was incorporated. An air-conditioning system was installed.

Habitat Communications

The communications and instrument complex in the trailer was constructed as nearly as possible to the layout specified by SMC. The complex contained most of the equipment necessary for communicating with the SEALAB. The equipment is listed in detail under Communications, below.

MEDICAL LABORATORY

According to specifications of SMC, a medical laboratory was installed in a van on board the Berkone. The 12-by-7-foot van, installed on the 01 level of the vessel and connected to the atmosphere-control van by a breezeway, was equipped with cabinets, refrigerator, work benches, sink, air conditioning, and an intercommunication system.

COMMUNICATION SYSTEMS

HABITAT

The voice communications between the Berkone and the habitat were passed by a helium voice unscrambler and a Bogen intercom via hard wire through the habitat's umbilical cable. A third channel was provided for the Victor Electro-Writer, which is a handwriting-duplicating device.

The principal acoustic voice channel to and from the SEALAB was the Navy's submarine voice communication system AN/BQC. An Aqua-Sonics acoustic voice system was also provided but gave unsatisfactory results.

Other communications equipment on the Berkone included a tape recorder, a TV control consolette, a phone patch, an FM tuner, and two TV tuners.

During the checkout of SEALAB II, the communications and instrumentation to the habitat were thoroughly checked. All systems were found to be satisfactory and, for the most part, remained satisfactory throughout the project.

PERSONNEL TRANSPORT CAPSULE

The primary system of communication for the PTC was an open-ended microphone in the PTC to an intercom amplifier on the Berkone. A secondary acoustic system was used as a backup, but proved unsatisfactory.

INTERNAL COMMUNICATIONS

A 12-channel internal communications system was installed on the Berkone, connecting all of the primary and normally manned operating stations. In addition, an intercom voice system was provided for communication between the DDC control station and personnel inside the chamber. A slave station of this DDC intercom system was installed at the atmosphere-control center to permit monitoring at that point.

TELEPHONE

All local and long-distance telephone requirements were met by three dial telephones on board the Berkone that were connected to shore facilities by underwater cable, and by one magneto-type, two-terminal circuit directly to the Public Information Office (PIO) on shore. It was through this telephone communication cable that Cmdr. Scott Carpenter talked to astronaut Maj. Gordon Cooper in the Gemini 5 space capsule during an 8-day outer-space orbit. The output of the helium voice unscrambler was connected through the cable to a NASA-leased communications circuit on shore, then to the space radio communications facilities at Antigua Island, British West Indies.

RADIO

One HF, three UHF, and five VHF channels installed aboard the Berkone provided radio communication for administrative and logistic functions. These channels also provided communications for the various support craft, Scripps Institution of Oceanography, Mission Bay Aquatic Control Center, and portable and mobile units on shore. Through a relay station on San Clemente Island, the range of the radio communications was also extended to include the Island, Long Beach, and Pasadena.

A remote-control console in the Range Engineer's office on the Berkone monitored all channels and transmitted on three of them. Remote speakers were also installed in the SEALAB communications control center.

An amateur radio transceiver was made available to the project personnel for after-hours entertainment purposes by the Hallicrafters Corp.

All radio communication equipment was maintained by a duty technician to assure reliable service on a 24-hour basis.

INSTRUMENTATION, TV, AND PHOTOGRAPHY

Instrumentation and TV signals were transmitted (some on a time-shared basis) through the SEALAB umbilical line for:

1. Closed-circuit TV for viewing the SEALAB interior
2. The Krassberg sensor for oxygen analyzing and partial pressure
3. The Wedge Spirometer for photographing the subjects' breathing functions on an oscilloscope readout
4. The electrocardiograph series, one of the time-shared functions
5. The leveling sensor unit, important for checking the pitch and roll of the SEALAB during raising and lowering procedures
6. FM music and commercial TV programs for aquanauts' entertainment

Because the TV cameras inside SEALAB II gave poor images, they were replaced by Oceanographic Engineering Corp. cameras, which gave good results but went out of focus after operating for a time. Apparently, the helium atmosphere leaked past the seal in the pressure housing, affecting certain presumably pressure-sensitive electronic components. After the TV cameras were mounted outside in the water, to look in through the viewing ports and thus avoid the helium leakage, they worked very well.

Although not specifically assigned the responsibility of photographic and TV coverage, material contributions in this field, particularly in the underwater area, were made by NOTS.

For underwater photography and TV coverage, a tripod frame previously developed for underwater work was used. On a remotely operated pan-and-tilt platform mounted on the tripod were placed two motion-picture cameras, a still camera, a TV camera, two 1,000-watt incandescent lights, and a strobe light, all remotely operated from the Berkone. The Berkone crane could place the tripod on the bottom at any point within its 100-foot reach. This equipment was used to document some of the salvage operations and other activity outside the SEALAB. Additional underwater coverage was obtained by hand-held, diver-photographer-operated equipment.

Topside documentary coverage consisting of both movies and stills was also obtained by NOTS photographers.

Specific equipment used by the NOTS photographers consisted of:

Underwater, Hand-Held	
Movie Camera	Bell & Howell K-70, 16-mm × 100 feet, housed in a Sampson Hall case
Light	Birns and Sawyer 1,000-watt unit
Still Camera	Nikonos/Calypso, 35-mm × 36 exposures
Light	Edgerton strobe unit, 50-watt-second
Light Meter	Weston Masters II in Plexiglas housing
Underwater, Tripod-Mounted	
Movie Cameras	Milliken, 6-mm × 200 feet, with wide angle, Model DBM-4 lens, at 24 fps
	Milliken, 6-mm × 400 feet, with telephoto lens, at 24 fps
Light	Birns and Sawyer 1,000-watt unit
Still Camera	Edgerton, 35-mm × 100 feet, 35-mm lens, one exposure every 10 seconds, 500-exposure capacity
Light	Edgerton strobe unit, 200-watt-second
TV Camera	Oceanographic Engineering Corp.

Topside, General Documentary

Movie Camera	Bell & Howell, Model 270, 16-mm × 100 feet
Still Camera	Nikon, 35-mm × 36 exposures, 28-mm lens

It is estimated that 25,000 feet of 16-mm exposures, 4,000 feet of 35-mm exposures, and two hundred and ten 4-by-5 cut-film exposures were made during the project period.

OPERATIONAL AND SAFETY PROCEDURES

In the preparations for project operations and installations, a series of procedures and safety bills were written to cover every phase of activity to be conducted. These procedures were used as a guide during operations but were modified as necessary when unforeseen conditions became apparent.

SEALAB HANDLING

The primary restriction imposed on all handling operations of SEALAB II was that at no time could it be allowed to come in physical contact with any dock or floating vessel. This restriction was imposed because of the vulnerability of its many exposed fittings, valves, external gas storage bottles, etc.

SURFACE HANDLING

Because of its weight (about 200 tons), SEALAB II could be lifted only by the big crane at San Francisco and the German crane at Long Beach. It was barged from San Francisco to Long Beach, where it was placed in the water and towed "wet" to the test site at La Jolla.

Eight lifting pad eyes on the top of SEALAB were provided by SFBNSY (HP) during construction for lifting it out of the water. Four of these pad eyes were used for lowering and raising SEALAB in the water.

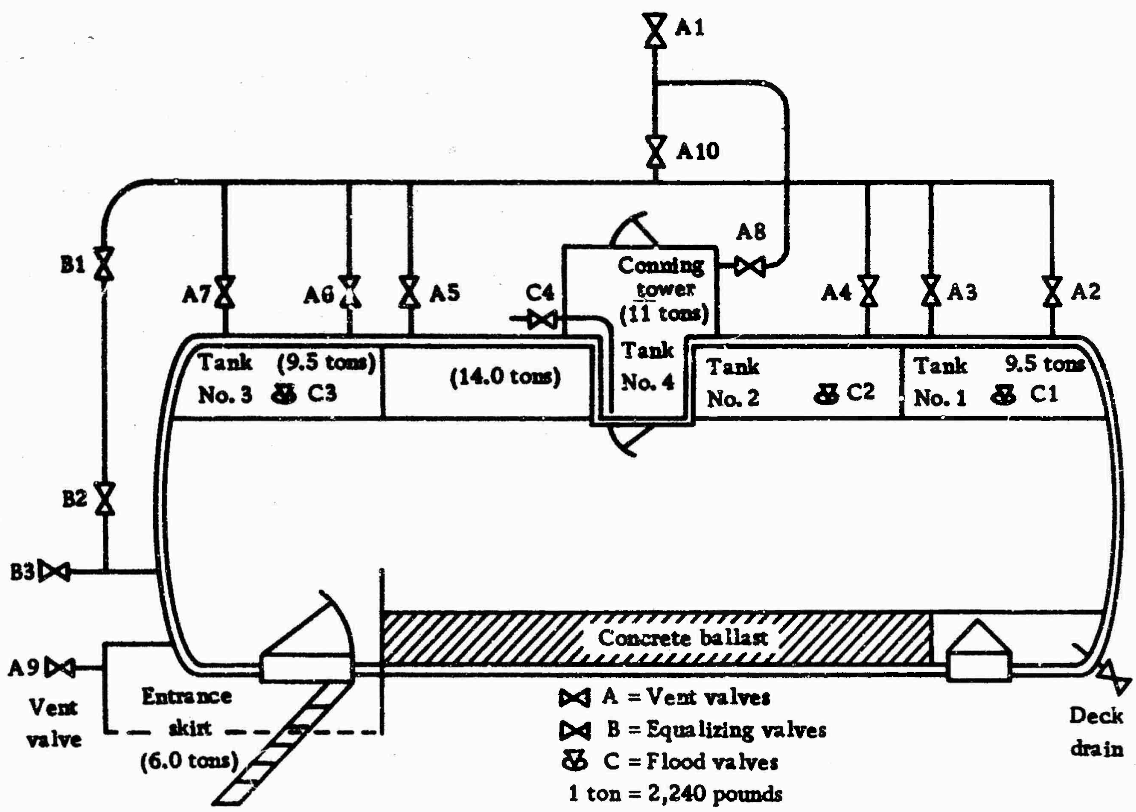
Towing of SEALAB from LBNSY to La Jolla and back was accomplished by the USNS Gear. The towing line was attached to a length of chain which, in turn, was passed through a closed chock on the SEALAB bow, and from there to one of the lifting eyes. No towing bridle, as such, was required. Towing was accomplished, with SEALAB bow forward (entryway and shark cage aft), at a speed of about 5 knots. No particular towing stability problems were encountered. The SEALAB was trimmed level and drew about 15 feet of water. Only the conning tower and less than 2 feet of the cylinder were above the surface. The towing vessel's captain recommended that SEALAB be towed no faster than 5 knots and that the stern be trimmed down slightly to prevent the bow from submerging while underway.

During tow, the SEALAB was pressurized to about 15 psi, with an exterior alarm on the conning tower to indicate loss of internal pressure. For safety, a shallow water route was followed.

Upon arrival at the test site, the SEALAB was placed in a temporary two-point moor between the auxiliary moor and the spud buoy on leg No. 2 of the Berkone moor. The Gear moored itself fore and aft between the spuds on legs 1 and 2 of the Berkone moor and ran a third mooring line from its starboard beam to the auxiliary moor. The SEALAB was then brought into a position between the Gear and a point about 40 feet aft of and parallel to the Berkone's fantail. Lines were run from the bow and stern of SEALAB to both the Berkone and the Gear, thus placing it in a four-point moor. In this position, the lowering wire from the Berkone was attached to the lowering sling on the SEALAB, and the prescribed procedure for flooding ballast tanks commenced (Fig. 13). When tanks 1 and 3 were flooded, the SEALAB waterline was on the conning tower at a point which indicated that, when the conning tower was flooded, the SEALAB would be approximately 10,000 pounds negatively buoyant. The conning tower, which is ballast tank No. 4, was then flooded, allowing the SEALAB to sink. The tending lines to the Gear were held taut to prevent the SEALAB from drifting into the Berkone. When the SEALAB had gone deep enough to clear the vessel, the tending lines were slacked off to allow it to hang on the lowering line directly below the vessel. The SEALAB was then lowered to the bottom, the tag lines to the Gear being used to prevent rotation and to make final orientation for touchdown.

LOWERING

To eliminate the necessity for equalizing internal pressure as the SEALAB was lowered or raised, the SEALAB design called for preliminary pressurization with helium. During this process, three of the viewing-port pressure covers developed leaks, but no correction was made at the time, since it was known that the differential pressure, and consequently the flow, would be reduced at depth and that the port vents would be closed completely when the SEALAB reached the bottom. However, the SEALAB came to rest with a 10-degree bow-up pitch and a 10-degree roll to port. After divers had closed the vents, preparations were made to lift the SEALAB, rotate it slightly with the Gear's tag lines, and settle it back in a more level spot. The capping of the port vents brought the internal differential pressure directly to bear on the Plexiglas of those ports that had leaky pressure covers, and a limitation was thus placed on the height to which the SEALAB could be raised without reduction in the internal pressure, which might unseat the main access hatch. Because of the pressure differential limitation, the SEALAB could not be raised high enough for reorientation. Further attempts toward better orientation were abandoned, ballast tank No. 2 was flooded, and entry preparations went forward with the SEALAB sloping 6 degrees fore and aft and athwartships, a condition that could be tolerated, although the aquanauts found it somewhat annoying.



		Tons
Submerged displacement		209
Fixed ballast:		
Concrete		29
Lead		31
Variable ballast:		
Lead		5
Water		33
Tank No. 1	9.5	
Tank No. 2	14.0	
Tank No. 3	9.5	
Entrance skirt		6

	Weight, tons	Buoyancy, tons
1. SEALAB on surface 1 ft 8 in. freeboard	183	
Flood tanks 1 and 2	+19	
Charge living compartment and Tank No. 2 with gas		
2. SEALAB ready for lowering (hanging on conning tower)	202	+7
Flood conning tower	+11	
Lower to bottom		
3. SEALAB during lowering operation	213	-4
Set SEALAB on ocean floor		
Flood Tank No. 2	+14	
4. SEALAB sitting on legs	227	-18
Blow skirt with helium	-6	
Open 48-in. access hatch		
5. SEALAB placed and ready for occupancy	221	-12

FIG. 13. Venting and Flooding System and Displacement and Buoyancy Information. (Supplied by San Francisco Bay Naval Shipyard, Hunters Point Division, for optimum ballast condition.)

RAISING

Difficulties due to increased weight of the SEALAB were encountered at the close of the experiment when attempts were made to raise the habitat to the surface. Because of the 6-degree slope at which it was resting, it was impossible to blow ballast tank No. 2 completely free of water. Another weight factor was the amount of additional gear accumulated by the aquanauts. There was also the possibility of bottom breakout resistance having built up over the 45-day operating period. The lifting force required to raise the SEALAB from the ocean bottom was more than twice that of its negative buoyancy when it was lowered (10,000 pounds). A lifting force of from 20,000 to 30,000 pounds applied for more than an hour was not sufficient to raise the habitat.

Water was then blown out of ballast tanks No. 1 and No. 3, a process which resulted in lightening the weight to the point where SEALAB could be raised with a tension of 20,000 pounds. It was impossible, however, to empty these tanks symmetrically, and the resulting imbalance was such that the SEALAB arrived at the surface at an angle of about 40 degrees bow up.

After the conning tower was blown and the SEALAB was leveled with an assist from the crane, all water remaining in the ballast tanks was removed and the vessel was prepared for tow back to LBNSY.

PTC HANDLING

The original plan had been to use the Berkone's crane to lower and raise the PTC in the water, but wave action caused such heavy loading that the counterweight system was employed. It proved to be satisfactory. The aquanauts reported that they experienced no sensation of acceleration or other movement during descent or ascent.

After the PTC had been raised to the surface, it was transferred to the crane, lifted out of the water, set on the 01 level, and its ballast tray was removed. The crane then moved the pressurized capsule to the mating hatch on the DDC. Four tag lines used on the PTC during the swinging operation were replaced by four sets of block and tackle for better control during the mating operation.

BENTHIC LAB AND POWER-UNIT INSTALLATION

The Benthic Lab and the power transformer units, built by MPL of SIO, each housed in cylinders about 5 feet in diameter and 6 feet high, were placed on the bottom by use of the Berkone's crane. An LCU, provided by the Navy Electronics Laboratory (NEL), San Diego, laid electrical cables and two 3/4-inch plastic pipes for fresh water from these units to the end of Scripps Pier. Shore power was brought out at 4,160 volts to the transformer unit, where it was stepped down to 440 volts. Transformers inside the SEALAB stepped the 440 volts down to 208/110 volts for the house circuits. The power unit was used as an anchoring point for attachment of the two fresh-water pipes. The aquanauts ran flexible hoses from the SEALAB to connect to the pipes terminating at the power unit.

MANPOWER

Manpower for the principal surface-support functions was provided by contract and military personnel. Contract personnel were employed for the operation of the Berkone; for messing, berthing, and housekeeping; for spotting for Berkone position-keeping; for photographic coverage; and for electronic equipment installation maintenance. Military personnel provided the surface diving support, operated the auxiliary surface craft, and stood watch on the Berkone.

About 40 civilian personnel and 40 military personnel were involved in the above functions. In addition, the aquanauts not actually in SEALAB and other military divers performed surface functions relating directly to the support of the SEALAB aquanauts. Two 12-hour shifts were established for all surface operations. Most of the operating personnel were quartered ashore but berthing for up to 40 people was provided aboard the Berkone. About 80 people were aboard during the day.

SURFACE SUPPORT CREWS

A Westinghouse contract crew of about 30 men, including rigger and maintenance personnel, operated the Berkone, performed the handling of SEALAB and the PTC, as well as the operation and maintenance of all shipboard machinery.

Communications, instrumentation, TV, and other electronic equipment was maintained by three contract technicians, two from Photo-Sonics and one from RCA.

A Photo-Sonics photographer operated and maintained the NOTS photo equipment, including the remotely operated tripod with film and TV equipment for underwater coverage.

Two spotters were based at surveyed shore stations to maintain surveillance of the position of the Berkone.

Messing, berthing, and general housekeeping services on board the Berkone were provided on contract by the Merman Co. of San Diego, with 11 people employed for this purpose.

SURFACE SUPPORT DIVERS

Several groups of divers provided surface support to the project, and all the aquanauts not actually in the SEALAB were available for surface-support tasks.

An underwater demolition team from the U. S. Naval Amphibious Base, Coronado, operated from their LCU moored near the Berkone. These divers were equipped with Mk VI gear and were responsible for providing, operating, and maintaining underwater vehicles for the aquanauts' use.

Operating from the NOTS diving boat (LCM-3) moored adjacent to the Berkone was a team of NOTS divers consisting of three officers and 20 men, from which a 24-hour duty crew was available. Equipped for scuba (air) and deep-sea (air) diving, they assisted the Gear in laying and inspecting the Berkone moor at La Jolla and in placing the Berkone in the moor. More than 1,000 man-minutes of diving time were logged for 30 scuba dives. One deep-sea dive, lasting an hour and 48 minutes, was made to check the bottom contour at the SEALAB resting site.

AUXILIARY SURFACE CRAFT

In addition to the Berkone, other vessels, some belonging to NOTS and some to fleet units, were required to support the SEALAB II operations. The NOTS boats used were as follows:

1. The AVR-10, a 63-foot wood-hull boat used for personnel transport between the site and the Port Control boat landing in Mission Bay (see page 34). This 12-mile run required 50 minutes each way, and six round trips per day were normally scheduled.

2. The LCM-6, a 55-foot unmodified landing craft used for transporting supplies and equipment from the NEL waterfront to the site. This was about a 25-mile run, one way, and trips were scheduled as needed.

3. The LCM-3, a 55-foot landing craft with an enclosure and other modifications needed for use as a divers' boat. This boat was moored to the Berkone during the entire operating period and used by the surface-support divers.

4. Five 18-foot work boats with outboard motors used primarily by the riggers and for transporting blood and urine samples to Scripps Pier.

Other support craft utilized during the operations included:

1. The LCU-45, the LUCY, operated by NEL for laying cable between the Berkone and Scripps Pier and for transporting the Scripps power transformer unit to the site.

2. The LCU-539 from the Amphibious Training Command, San Diego, which provided underwater swimmer vehicles and surface-support divers.

3. The Oconostoga, a Scripps boat, which transported the Benthic Lab to the site.

4. Several YTM tugs from the Eleventh Naval District, used to assist in placing the Berkone in its moor.

5. An LCU from the Amphibious Base, which transported the Linde Co.'s helium tube trailer to the site for the initial charge of helium in the SEALAB and the deck decompression chamber.

6. The USNS Gear, the primary project support ship, which placed the moor for the Berkone, towed the Berkone and SEALAB from Long Beach to the site and back, placed the Berkone in the moor, tended the SEALAB during lowering operations, and removed the moor upon completion of operations.

7. A YO from the Eleventh Naval District for diesel oil replenishment, making one trip per week to the Berkone.

LOGISTICS

Logistics involved in the SEALAB II project consisted of:

1. Personnel transport from site to shore
2. Material transport from LBNSY to the site
3. Material transport between the Berkone and the SEALAB
4. Medical samples transport from the Berkone to the Scripps Laboratory
5. Provision of meals on the Berkone
6. Provision of berthing accommodations on the Berkone
7. Diesel oil replenishment on the Berkone and support craft
8. Fresh-water replenishment on the Berkone

TRANSPORTATION

To transport personnel to and from the SEALAB site, arrangements were made with the city of San Diego to let the AVR-10 into Mission Bay and use the excellent protected landing at the Port Control office. Ample parking facilities, a waiting room, head facilities, and public telephone were made available. It is estimated that the AVR-10 covered about 9,000 miles in personnel runs between the Berkone and Mission Bay.

The Scripps Pier, although unsuitable for personnel transport because of its susceptibility to the swell and surf of the open sea, was used for passing over medical samples from outboard-motor work boats.

The NEL crane and waterfront facilities at Point Loma were used in the transportation of heavy equipment and supplies by the LCM-6, which traveled between 1,500 and 2,000 miles in making its runs to the SEALAB site. Truck runs from Los Angeles were scheduled as needed to deliver material to the NEL waterfront.

BERTHING AND MESSING

Minimal galley facilities and about 40 bunks were installed on the Berkone as part of the SEALAB modifications. A contract was let for the preparation and serving of meals and for housekeeping. Each day, about 35 breakfasts, 80 lunches, and 40 dinners were served (a total of nearly 10,000 meals for the total project operation).

DIESEL OIL AND FRESH WATER

The Berkone generators were run full-time to provide power to the Berkone and standby power to the SEALAB. An average of 4,000 gallons of diesel oil per week were delivered by a YO in a weekly run from San Diego to supply the generator, crane, and support boats. Water was supplied to the SEALAB through 2 3/4-inch plastic pipes (laid by Scripps) from the ends of Scripps Pier. Extension lines were run from the SEALAB to the Berkone and, during the night when SEALAB's demand dropped off, the Berkone fresh-water tanks were filled. Approximately 9,500 gallons of fresh water were used per week on the Berkone.

CONCLUSIONS AND RECOMMENDATIONS

The Naval Ordnance Test Station's mission in connection with the SEALAB II project was carried out, it is believed, in a satisfactory manner. A site was selected, a staging area was established, surface-support vessels were supplied and manned, operational systems were integrated and checked out. Materials, equipment, and personnel were provided as needed throughout the experiment.

SEALAB II operations showed, however, a need for some improvements in future Man-in-the-Sea experiments. The following are suggested:

1. A method for leveling the habitat to compensate for bottom slopes
2. A remotely controlled ballast flood and vent system capable of operation at the steep angles of SEALAB roll and pitch
3. Provision of shore power to the surface-support vessel to eliminate noise and generation of carbon monoxide
4. A method of retrieving the dumbwaiter container without physically entering the water
5. More cold storage area in the habitat to reduce the number of dumbwaiter transfers
6. An improved above-water PTC-handling system
7. Greater sophistication in communications to the habitat, especially in the area of helium speech unscrambling

It may be found, in the application of the Man-in-the-Sea concept to salvaging or other types of manned operations, that an independent underwater power supply will be required.

The SEALAB II operations achieved a significant advance in the art of handling large objects with high mass and drag in a water column from a floating support. The counterweighted lowering system used for lowering and raising the SEALAB II and the PTC completely eliminated all adverse heaving effects of the sea.

Appendix A
CHRONOLOGY OF EVENTS

Date, 1965	Event
13 Jan	Scripps Canyon area selected for SEALAB II site by SPO
21 - 22 Jan	First SEALAB II planning meeting at MDL
28 Jan	NOTS' responsibilities defined by SPO 1. Emplace, operate, and remove experiment 2. Provide logistic support at site 3. Prepare operational procedures and safety bills for surface operations including lowering and raising procedures for SEALAB II 4. Provide direction for LBNSY in the conversion of the Pop-Up staging vessel (Berkone) for use with SEALAB II 5. Install instrumentation on the Berkone 6. Perform system integration and checkout of the complete SEALAB II experiment prior to placement on site
3 Feb	SEALAB II Steering Group established: Capt. L. B. Melson — ONR Capt. G. F. Bond — SPO Mr. Sid Hersh — SPO Mr. T. Odum — MDL Mr. H. Talkington — NOTS Cmdr. M. McKinnon — SFBNSY(HP) SIO Representative
8 Feb	Contract for operation of the Berkone let and first three contractor personnel report aboard for planning and preparation
26 Feb	Anchor pull test made at site
1 Mar	TV site survey made with YFU-53
16 Mar	NOTS formally accepts responsibilities in SEALAB II project as defined 28 Jan
17 - 18 Mar	TV site survey made using CURV
4 - 5 May	TV site survey made using YFU-53
18 June	All specifications for Berkone modifications submitted to LBNSY

Date, 1965	Event
9 July	SEALAB II arrives at LBNSY from San Francisco
14 July	USNS Gear installs four legs of Berkone moor
16 July	USNS Gear installs fifth leg of Berkone moor
16 July	Atmosphere and medical equipment arrives at LBNSY for installation on Berkone
23 July	SEALAB II christened at LBNSY
29 July	Krassberg sensors and Arawacs (divers' "hookah" pumps) arrive at LBNSY
3 Aug	SEALAB II approved by Certification Board
4 Aug	PTC arrives at LBNSY
4 Aug	Galley on Berkone functional
17 Aug	SEALAB II trim test at LBNSY
18 Aug	Berkone, AVR-10, and NOTS diving boat LCM-3 arrive at La Jolla
19 Aug	SEALAB II departs LBNSY 2135 hours, in tow to La Jolla
21 Aug	SEALAB II arrives at La Jolla 0730 hours
23 Aug	SEALAB II, PTC, and DDC all certified for use
26 Aug	SEALAB II placed on bottom at 205 feet
28 Aug	First aquanaut team enters SEALAB II
28 Aug	Cmdr. Scott Carpenter speaks to GT-5 astronaut Gordon Cooper from SEALAB II at 2326 hours
31 Aug	Benthic Lab installed
12 Sept	First team comes up; second team goes down
12 Sept	Cmdr. Scott Carpenter stung on finger by a sculpin
13 Sept	Dolphin Tuffy arrives at site
22 Sept	Local sea lion, Sam (later called Samantha) begins her training under direction of aquanaut
26 Sept	Second team comes up; third team goes down
26 Sept	President Lyndon B. Johnson calls Team 2 in the DDC by telephone and talks to Cmdr. Scott Carpenter
1 Oct	Aquanauts Sheats and Grigg in SEALAB II talked by telephone to Jacques Cousteau's oceanauts, Andre Leban and Phillipe Cousteau, in Conshelf 3 habitat at a depth of 99 meters at Cap Ferrat in the Mediterranean Sea
5 Oct	First excursion dives made to 300 feet

Date	Event
10 Oct	Third team brought to surface to terminate operations
11 Oct	SEALAB II raised to surface
12 Oct	Final SEALAB II press conference
13 Oct	*Berkone* departs La Jolla for Long Beach

Appendix B

SUMMARY OF STAGING-VESSEL MODIFICATIONS

Item	Agency Specifying Requirement[a]	Design Agency[a]	Agency Performing Work[a]
Removal of Underwater Platform	NOTS	.....	LBNSY
Divers' Ready Room	SMC-MDL	NOTS-LBNSY	LBNSY
DLC Installation	ONR-MDL	NOTS-LBNSY	NOTS-LBNSY-MDL
PTC Foundation (01 level)	ONR-MDL	NOTS-LBNSY	LBNSY
Mk VI Shop	SMC-MDL	NOTS	LBNSY
SEALAB Command Center	SPO-SMC-MDL	NOTS	NOTS-LBNSY
Gas Storage	SPO-SMC-MDL	NOTS	NOTS
Umbilical Terminals and Cableway	NOTS	NOTS	LBNSY
Dumbwaiter	MDL	NOTS	LBNSY
Lowering System	NOTS	NOTS-LBNSY	LBNSY
Diving Bell	SPO-NOTS	NOTS	NOTS
Mooring Leg Attachment	BNSY	BNSY	BNSY-LBNSY
Mooring-Line Tension Systems	BNSY	DTMB	DTMB-NOTS
Communications (Interior and Radio) and Wiring	MDL-NOTS	NOTS	NOTS-LBNSY
Galley Activation	NOTS	NOTS	LBNSY
Berthing and Ventilation	NOTS	NOTS-LBNSY	LBNSY
Storage	MDL-NOTS	NOTS	LBNSY
Acoustic Positioning System	NOTS	NOTS-SIO	NOTS-SIO
Water Heaters and Plumbing	NOTS	NOTS-LBNSY	LBNSY

[a] Accurate listing of responsibilities is difficult because of overlapping contributions.

Appendix C

SYSTEM MODIFICATIONS, INTEGRATION, AND CHECKOUT

Item	Reason
SEALAB II Habitat	
1. Replace all gas hoses in umbilical cord	Original ones kinked and unusable
2. Add three electrical cables to umbilical cord	One for mobile photo unit lights One for *Life* Magazine camera and flash control One for *Life* as standby
3. Install Krassberg oxygen sensor and control unit	Final outfitting
4. Install Electro-Writer transceiver	Final outfitting
5. Install speakers with volume controls in lab and berthing areas	Final outfitting
6. Install Wedge Spirometer and various other pieces of equipment from SMC	Final outfitting
7. MPL instrumentation and TV installations and checkout with Benthic Lab at San Diego	Final outfitting and marriage of SEALAB to Benthic Lab
8. Install twenty-four 9-inch-by-20-foot gas storage bottles with manifolding in racks on outside of SEALAB, for helium and oxygen supply	Final outfitting
9. Install carpet on SEALAB floor	Subject comfort
10. Replace two faulty valves in gas lines	Dirty and scored valve seats
11. Conduct trim test	Adjust lead ballast and check operation of flood and vent systems

Item	Reason
Deck Decompression Chamber (DDC)	
1. Install on foundation on port side of staging vessel	Normal system assembly
2. Install prefabricated working platform	Normal system assembly
3. Connect plumbing for hot and cold water	Normal system assembly
4. Install external lights over view ports	Normal system assembly
5. Install externally driven CO_2 scrubber	Normal system assembly
6. Replace internal speakers	Speakers provided with DDC were incompatible with sound system
7. Provide music circuit to DDC interior	Subject entertainment
8. Connect high-pressure piping for gas supply	Normal system assembly
9. Provide additional working platforms around mating hatch	Insufficient space on the prefabricated platform
10. Extend shafts of both mating yoke bolts	To permit cranking in full turn from safe position rather than in half-turns from awkward position
Personnel Transport Chamber (PTC)	
1. Install four aligning pins on ballast tray	To facilitate mating of capsule to ballast tray by engaging funnels on capsule
2. Conduct water-buoyancy test	Adjust lead ballast to meet design specifications
3. Provide life-support umbilical cord consisting of gas supply line, low-pressure air line (400 psi), 117-v power, and a communication cable	For safety and improved operational procedures
4. Provide self-contained life-support capability including CO_2 scrubber and breathing-gas supply	Normal system assembly

Item	Reason
Personnel Transport Chamber (PTC) Cont'd.	
5. Provide submersible battery pack and DC-to-117-v AC inverter	For self-contained power for operation of CO_2 scrubber
6. Install acoustic communications system	For emergency use
7. Install guard rails and expanded metal covering	To protect exposed fittings from damage by lifting sling or other source
8. Install eighteen 200-cu-ft gas bottles with manifolding on outside of PTC	Normal system assembly
9. Rework bearings and make adjustments on escapement mechanism	As received with PTC, mechanism did not perform satisfactorily
10. Remove port and install 1-in. steel flange with three electrical connectors	For internal control of external equipment
Atmosphere Control Center	
1. Install 25-by-7-foot house trailer on 01 level of staging vessel	Normal system assembly
2. Connect and check out gas-sampling lines from SEALAB, PTC, and DDC	Normal system assembly
3. Install carrier-gas supplies for gas-analysis equipment	Normal system assembly
4. Install Krassberg sensor readout	Normal system assembly
5. Install two intercom systems	One to staging vessel, general One to DDC control station
6. Install miscellaneous additional items including spirometer readout and other instruments	Normal system assembly
7. Install fresh-water plumbing, sink, benches, power, lights, air-conditioner, etc.	Normal system assembly

Item	Reason
Communication and Instrumentation Center	
1. Install and check out a. Helium speech unscrambler b. Tape recorder c. TV control consolette d. Intercom units (2) e. Electro-Writer f. Phone patch g. FM tuner h. TV tuners (2) i. SEALAB patch panel j. Patch panel k. Speakers (2) l. MPL intercom to Benthic Lab control m. Aqua Sonics acoustic communications system n. Remote radio speakers (2)	Normal system assembly
2. Install benches, power, lights, etc., utilizing one end of house trailer provided for atmosphere control center	Normal system assembly
Medical Lab	
1. Install 12-by-7-foot trailer on 01 level of staging vessel	Normal system assembly
2. Construct connecting enclosure between Medical Lab trailer and atmosphere control center trailer	Normal system assembly to enlarge Medical Lab area and make a single unit for the SEALAB command center
3. Install cabinet, benches, plumbing, sink, power, lights, air-conditioning, refrigerator, and intercom	Normal system assembly
Counterweight Lowering System	
1. Conduct operational test using dummy load	To demonstrate principle of operation and to gain operator experience prior to lowering SEALAB

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13. ABSTRACT

For the SEALAB II project, the U. S. Naval Ordnance Test Station was assigned responsibility for all surface operational support. The underwater site was selected in cooperation with the Scripps Institution of Oceanography. A staging area was established at the Long Beach Naval Shipyard and a staging vessel was provided and modified to meet the needs of the program. Complete system integration and checkout were performed. All necessary operational support, personnel, equipment, and material were supplied.

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