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NAVY

OCEAN FACILITIES PROGRAM

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Knowledge of the oceans is more
than a matter of curiosity.
Our very survival may hinge
upon it.

John F. Kennedy
March 1961

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This report presents a brief history and description of the Ocean Engineering & Construction Project Office.

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INTRODUCTION

The Naval Facilities Engineering Command is the oldest of the Navy's material systems commands. Established as the Bureau of Yards and Docks in August 1843, its mission – to maintain Navy yards and docks – was later expanded to include all public works of the naval establishment. When the Navy Department was reorganized in 1966, the Bureau of Yards and Docks became the Naval Facilities Engineering Command.

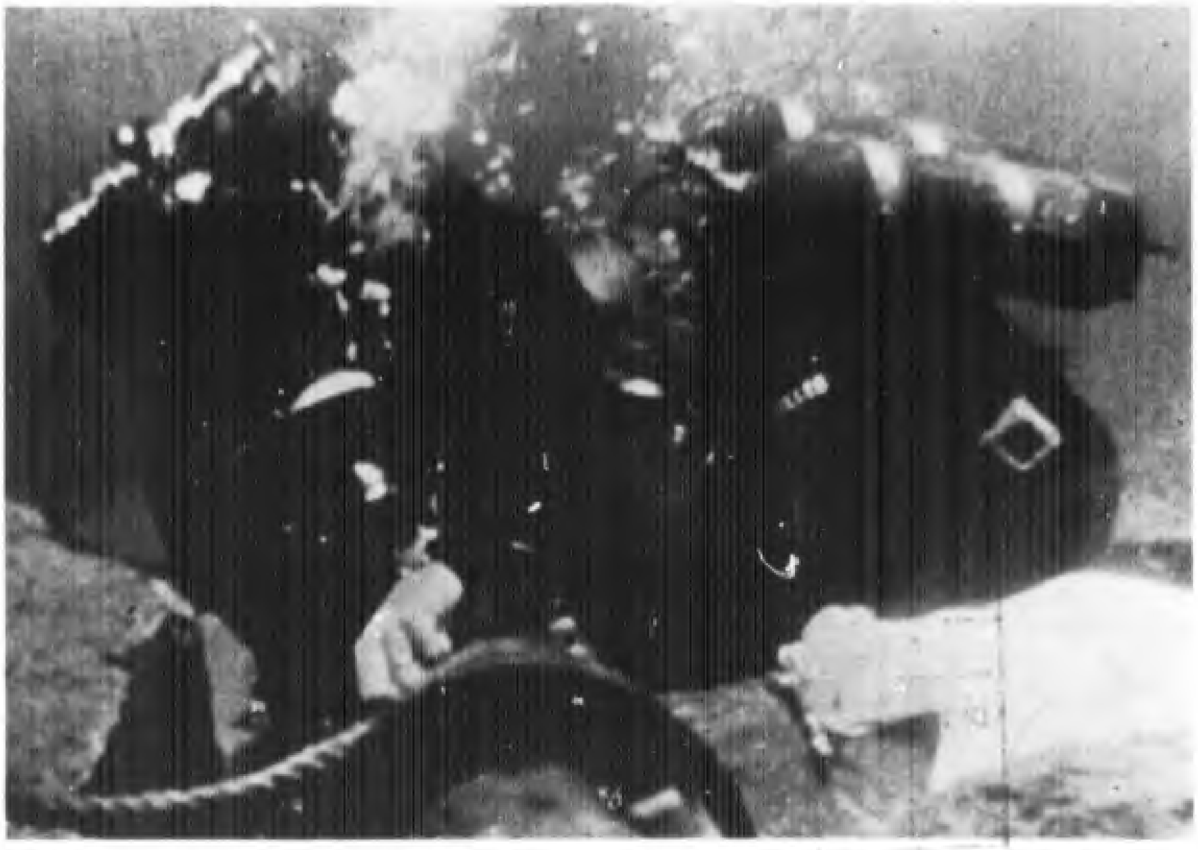
Historically, the Naval Facilities Engineering Command has given technical and engineering support to shore-based U.S. naval operating forces. In 1969, however, by instruction from the Office of the Chief of Naval Material, the Command was assigned the responsibility of supporting the operating forces in ocean facilities engineering and construction.

This decision by Naval Material to take construction offshore was a result of the Fleet's need for a responsive underwater construction resource. Underwater construction is the ability to work in the ocean's environment, an environment that can be friendly or hostile, calm or violent. It is within this environment that the Naval Facilities Engineering Command is chartered to develop the engineering, design, and construction of ocean structures in support of the Fleet at minimum life-cycle cost, using military and/or contractual construction forces.

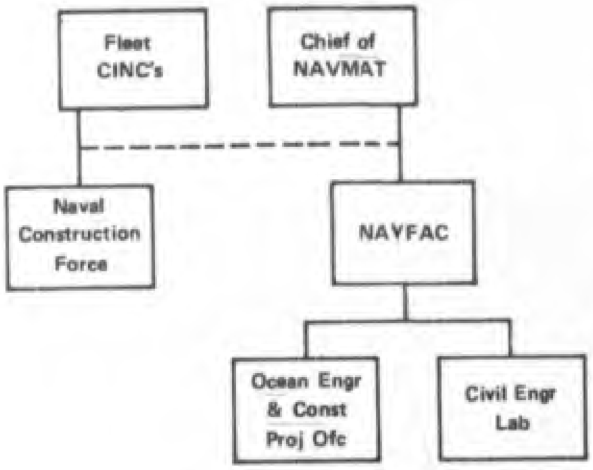
To accomplish this new underwater construction discipline, the Ocean Facilities Program was established by the Naval Facilities Engineering Command and the Naval Construction Force in 1970. During the following years, their operations have reached into ocean regions around the world.

The Naval Construction Force, and its two Underwater Construction Teams, one on the East Coast and one on the West, are the Fleets' underwater construction arms. As Fleet assets, their operations come directly under the Commander in Chief of the Atlantic or the Pacific Fleet. These small, tight, and mobile units of professionals consist of Navy Civil Engineer Corps officers and enlisted men who have been trained in deep sea diving and Basic and Advanced Underwater Construction Technician courses. This training provides the Naval Construction Force with highly proficient divers who are also skilled in underwater welding, drilling, split pipe assemblage, inspection, and related underwater subjects, as well as in surface assistance and supervision.

A Navy diver uses a hydraulically-operated rock drill.



Divers coordinate their work in applying split pipe to an underwater cab



Assisting the Naval Construction Force and the Naval Facilities Engineering Command are ocean engineers, scientists, and technicians from the Civil Engineering Laboratory and the Ocean Engineering and Construction Project Office.

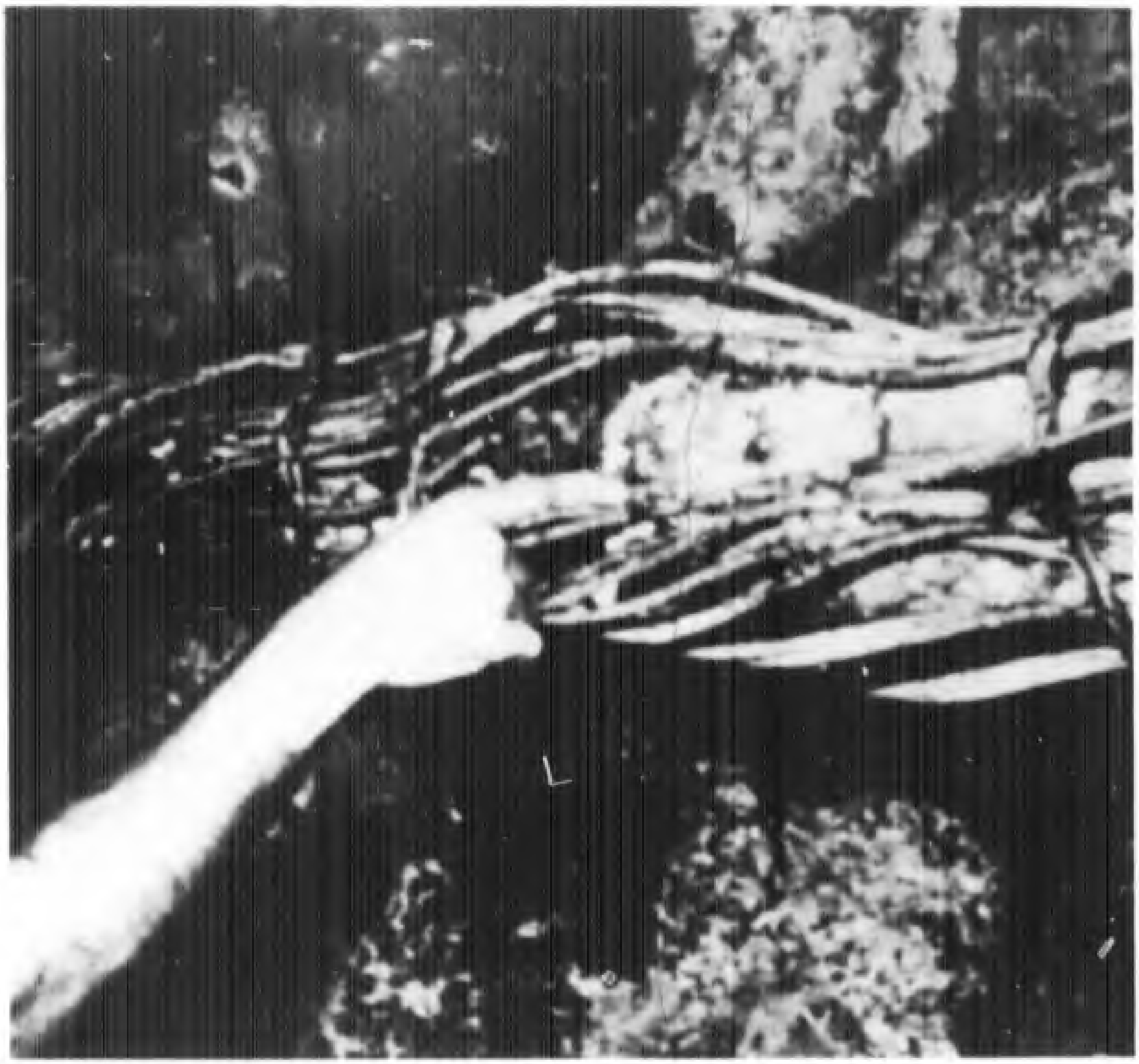
The Ocean Engineering and Construction Project Office was established in 1971 at the Chesapeake Division, Naval Facilities Engineering Command, to provide the necessary services worldwide for ocean facility engineering and construction needs. This office is staffed with a complement of naval and civilian ocean engineers responsible for the technical management and execution of this program.

The Civil Engineering Laboratory's work on ocean engineering has made significant contributions to the Navy's overall effectiveness in and under the sea. Long regarded as a leader in undersea facilities and engineering hardware systems, the Laboratory is the principal research, development, test, and evaluation center for shore and seafloor facilities.

As the tempo and pace of underwater technology accelerates, the talents and skills of the Civil Engineering and Construction Project Office have blended into a capability that is responsive to the Fleet or to any underwater construction need. In the pages that follow, past and future projects utilizing ocean construction skills and disciplines are highlighted and equipment is illustrated.

INSPECTIONS

The Naval Facilities Engineering Command has responsibility for around-the-world inspection of piers, wharves, quays, moorings, and underwater utilities of Public Works Offices. The underwater inspections include taking soil samples, photographing underwater facilities, analyzing structural conditions, and inspecting completed repair work. The information from these inspections is used in construction and repair contract specifications and in quality control. This underwater inspection responsibility also includes examination, on a regular basis, of past and on-going underwater construction projects and the Fleet's undersea surveillance systems.



A diver inspects damaged cable splice.

SITE SURVEYS

Ocean construction engineers make site surveys to determine whether an assigned construction project is technically possible. They gather core borings and bottom soil samples to determine the stability of the ocean floor to support underwater structures. They make precise navigational positionings to mark offshore site locations or, using submersible vehicles such as the ALVIN, which can dive to depths of 12,000 feet, they survey and document the sea bottom topography in the vicinity of an underwater structure's site.

They also survey underwater depths using tethered cameras, such as SNOOPY, without having to conduct manned dives to gather data.

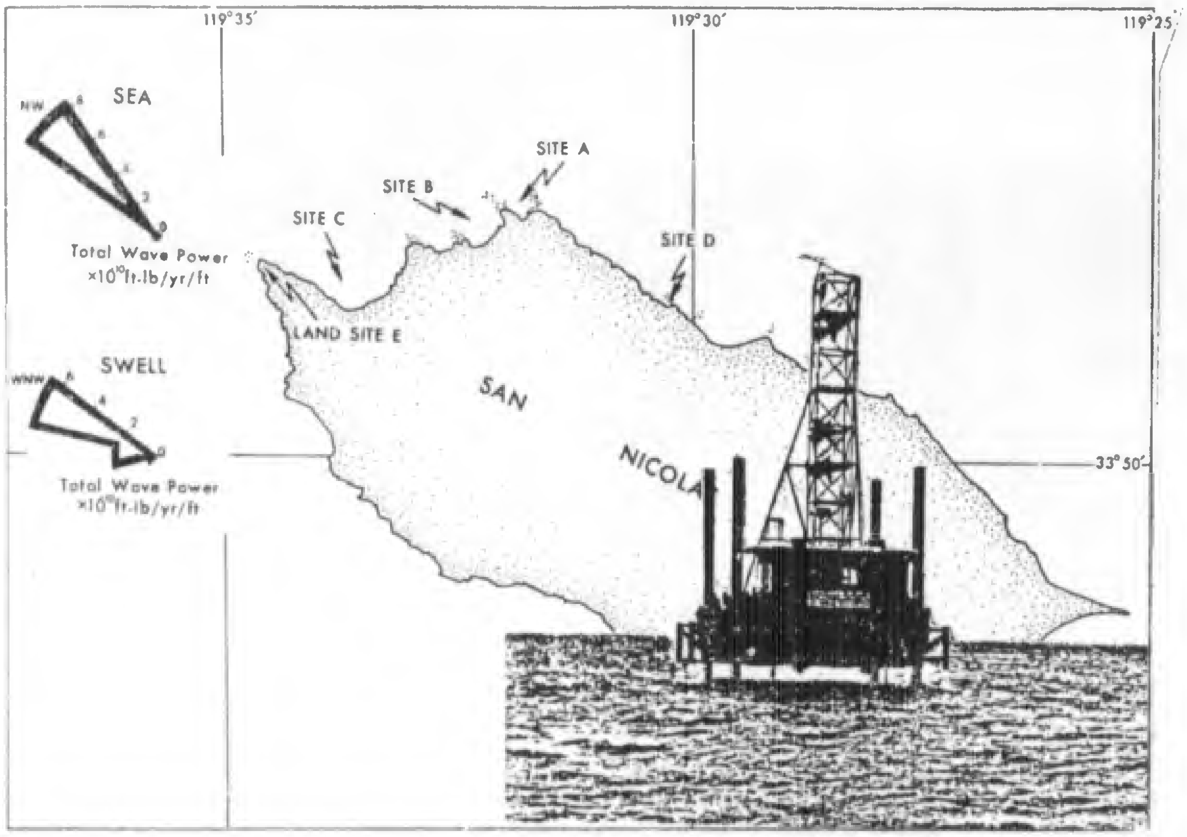
A Naval ocean engineer enters ALVIN before diving to 3,600 feet.

Surveying a project site with the aid of a theodolite.

SNOOPY is a remote-controlled, underwater surveying camera.

FEASIBILITY STUDIES

The practical side of underwater construction is never overlooked. Feasibility studies are part of the "package" whenever an underwater construction project is undertaken. Is it practical? Is it economical? These are questions which feasibility studies answer and which ocean engineers must know before undertaking a project. Navy ocean engineers study the morphology, geology, and physical processes of the beach and nearshore environment to determine the feasibility of an underwater project.



At San Nicolas Island, California, five sites were selected to install a jack-up barge that contained meteorological instrumentation. Studies proved the land site to be the most practical.

UNDERWATER EQUIPMENT AND TOOLS

The Naval Facilities Engineering Command designed and constructed an ocean construction platform to assist the Naval Construction Force with its ocean engineering.

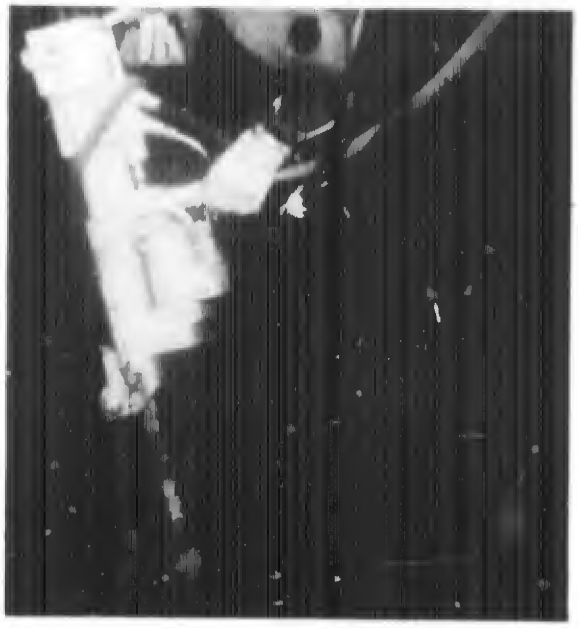
The Ocean Construction Equipment Pool provides the Naval Construction Force with the equipment required to perform responsive, efficient, and safe ocean construction. At selected sites on the east and west coasts, specialized underwater construction equipment and facility components are kept in ready-to-use condition for use by the Naval Construction Force, other naval activities, or government agencies. The equipment ranges from bolts for split pipe connections to the Navy's versatile, new ocean construction platform, the SEACON.

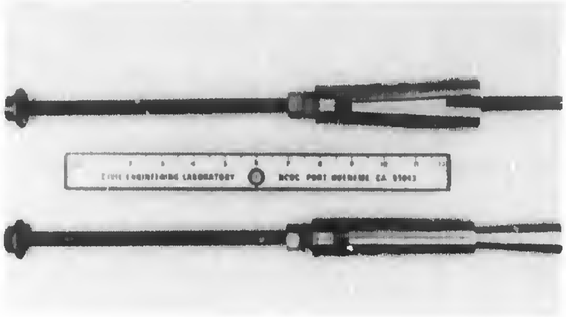
The SEACON (an acronym standing for "sea construction") is used for cable and pipe laying, underwater repair, diver support, material transport, and the installation and recovery of large objects. The vessel's structure is of welded steel, longitudinally framed, 260 feet long with a 48-foot beam. The deck, which is of superior strength, is configured to receive roll on/roll off equipment. The SEACON's large open deck area allows equipment to be rigged in different ways, depending on whether the work involves handling heavy loads, cable laying, or diver construction support. Its unique centerwell provides a protected area for the launch and recovery of objects and for diver access. The SEACON is normally towed from its homeport to the construction site. However, the platform can self-maneuver in shallow or deep water and can position-hold in up to sea state 3.

Other new tools which are being provided to the Naval Construction Force are:

- A commercially available concrete breaker, which can operate as a drill capable of providing 4-inch diameter holes in granite, rock, and coral.

- A hydraulically-operated drill that allows divers to retrieve 3-inch diameter by 3½-inch long cores from seafloor concrete, rock, and coral. ▶

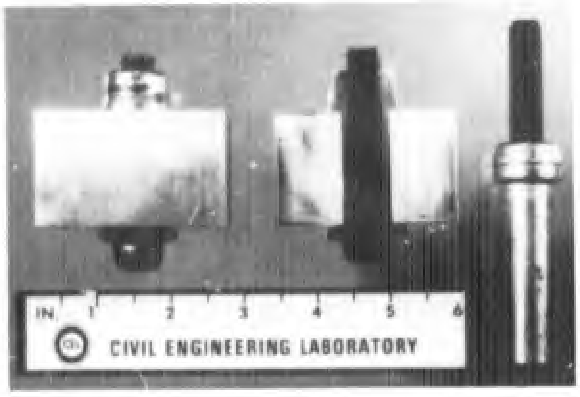


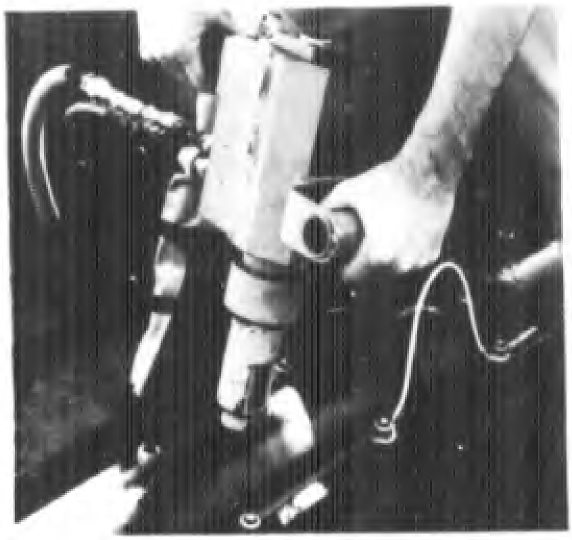


- ◀ A titanium bolt, with a vertical pullout strength of 6,000 to 12,000 pounds, useful for anchoring boats and immobilizing underwater cables.

- ◀ A screw-operated, pliers-type nut splitter, modified to handle stainless steel nuts on split pipe, making the removal of damaged nuts from bolts easier during an underwater operation.

- A one-piece, blind, rivet-type fastener for holding split pipe sections together, and a hydraulic tool for installing them underwater. ► ▼





- A hydraulically-operated, scissors-type cutter, being developed to sever wood pilings at the mud line. Tests indicate that a 12-inch diameter pile can be cut in 1 minute. ►

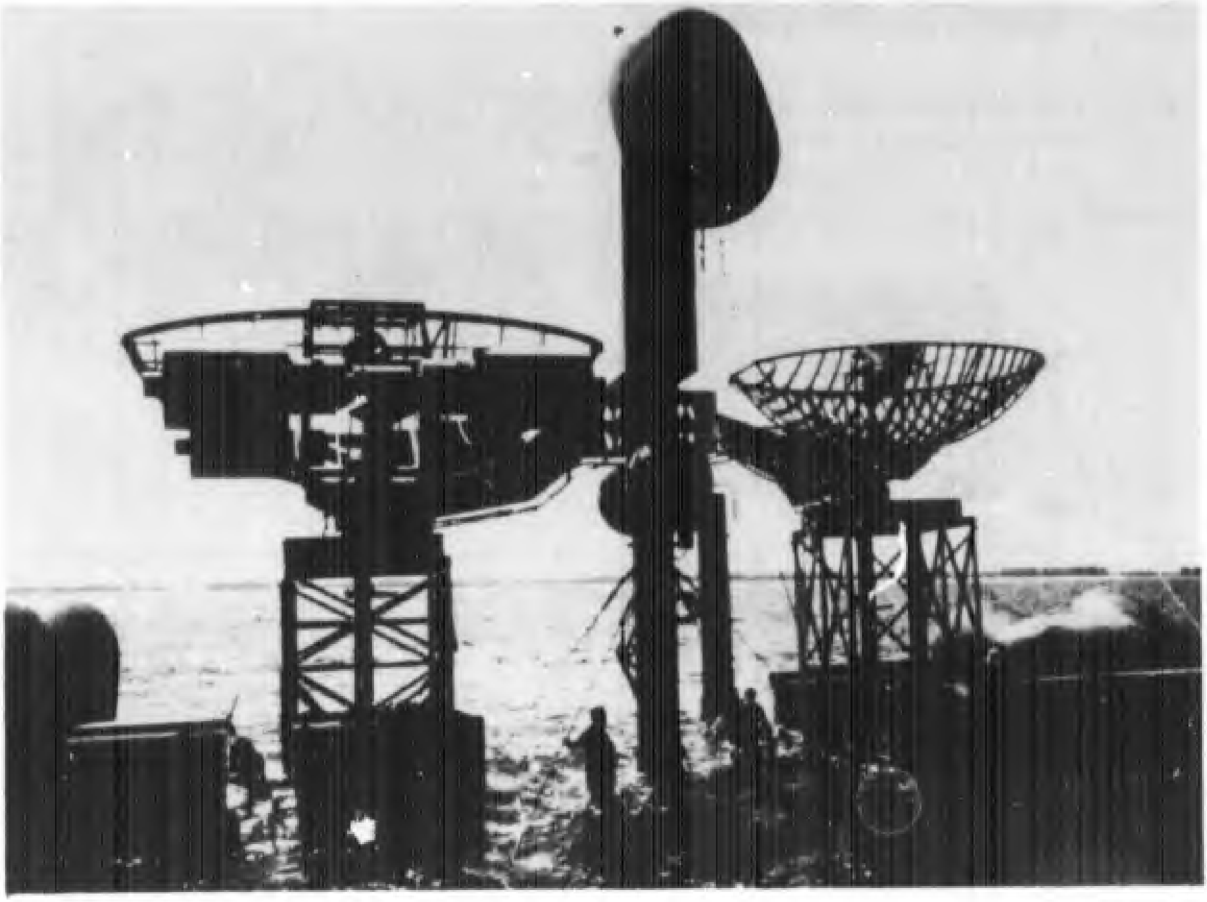
- A portable, diver-held band saw, which ◄ can cut through 3½ inches of double-armored underwater cable in approximately 1 minute.

Because of these new developments in underwater construction equipment and tools, underwater assignments can be done more rapidly and efficiently. Tasks which were previously considered to be infeasible can now be undertaken, and hazards to divers have been decreased.

PROJECTS

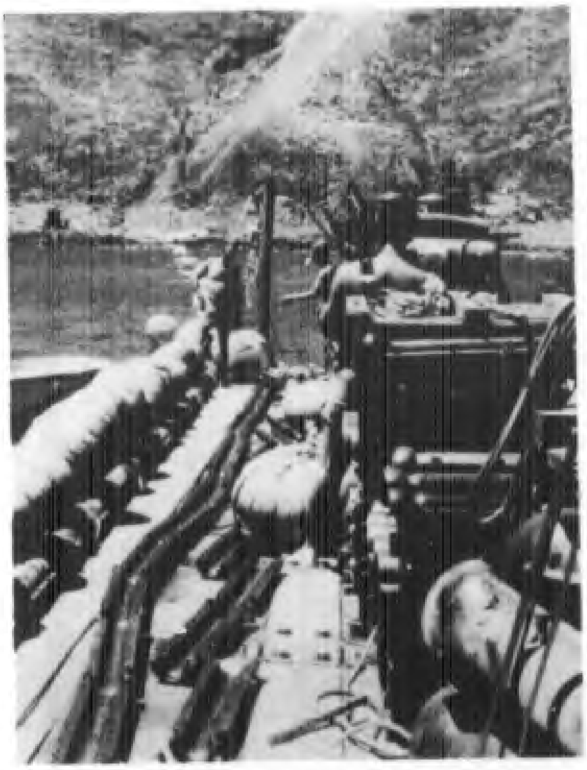
TEKTITE I was a joint U.S. Navy-National Aeronautics and Space Administration-Department of Interior project developed to sustain and measure the work performance of aquanaut scientists on the ocean floor for a period of 60 days. Naval Facilities Engineering Command ocean engineers designed, developed, and installed the system that was used to install the habitat and support facilities.

A massive, acoustic, research antenna array was assembled, installed, tested, and recovered from 1,400 feet of water. The purpose was to measure the array's acoustic properties and to determine the effect of seawater on the structure. After cabling the structure to a shore-based control van, the 40,000-pound antenna array was installed. Its enormous weight required that the barge holding the array be submerged nearly 20 feet in order for the structure to float free and sink to the bottom. The array was retrieved by actuating an explosive device which severed the sea cables at the array's base.



Barge holding the submerged acoustic antenna array.

Four, double-armored electrical cables were laid from a cable ship to a shore laboratory. An innovative cable installation technique was used to stabilize and protect the cables against the damaging effect of a 40-foot winter surf. First, an amphibious causeway was anchored with rock bolts to the basalt seafloor in a four-point moor just outside the surf zone. Cable was then pulled from the cable ship over the amphibious causeway where the split pipe was applied. Floats were attached to the cable, the cable deployed, the floats cut, and the cable deposited on the seafloor. As a safeguard against the severe surf, holes were drilled in the ocean bottom on each side of the encased cable, and U-shaped rods were installed in the holes with hydraulic cement. The installation exceeded its 5-year design life.



Applying split pipe to cable on the amphibious causeway.

Overboarding a deep-water sonar structure.

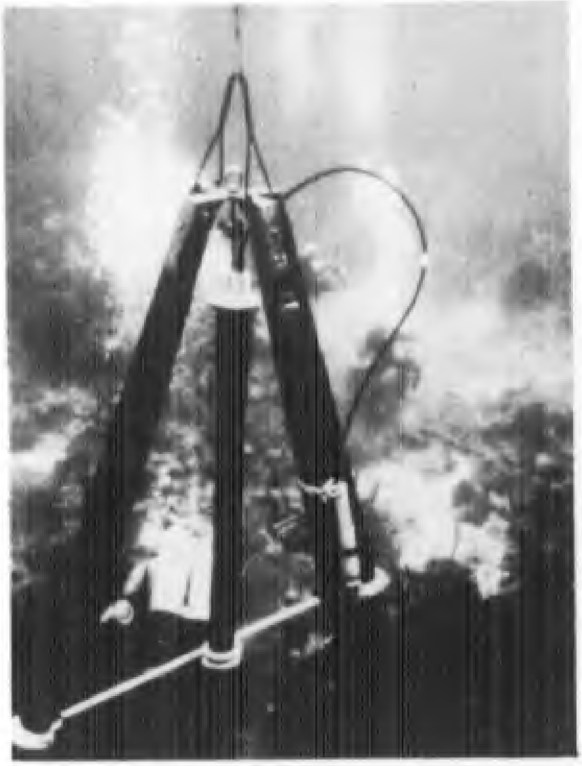
An underwater communication system, with cabling to the shore station, was designed and installed at San Clemente Island in the Pacific and Vieques Island in the Atlantic. This system, known as the Fleet Operational Range Accuracy Check Site, is a deep-water sonar structure. A test implantment, the system was later used at the Atlantic Fleet Weapons Training Facility, St. Croix, during its underwater range expansion.

Cable being secured from a cable ship offshore.

◀ A new cable installation technique was developed that reduced the installation time and cost. First, a small landing craft pulled the cable shoreward from the cable ship. Float balloons were attached to the cable for ease of handling. When the beach end of the cable was pulled ashore, normal procedure would have dictated cutting the balloons and letting the cable sink. At this point, divers would have had to work underwater to bolt on the protective split pipe sections, difficult, time-consuming work. Instead, a landing craft pulled the cable onshore where a construction team bolted the split pipe on the cable with comparative speed and ease. When the cable was fully encased in the iron pipe, the cable ship pulled the cable out to sea, divers removed the float balloons, and the cable descended to its planned position on the ocean floor.

In response to the Atlantic Fleet's need for an advance base, a sewer outfall was installed at LaMaddelena, Sardinia. The nearshore environment had sharply-edged, steep slopes, providing little staging room. This environmental liability was overcome by assembling the polyethylene pipeline parallel to the shore's coastline, bending the pipe seaward at a 90-degree angle, and hauling the line out to sea. The pipeline was then flooded and eased down to its seafloor location. Careful planning and engineering made this an 8-hour operation.

As part of a research and development project to expand the state-of-the-art in the use of various types of subsurface instrumented structures, five sensitive array systems were installed. The array structures' environmental sensitivity could measure minute variations in the earth's magnetic field. Two deep-water arrays were placed in 2,500 feet of water. Shallow-water arrays were seabottomed at 90 and 100 feet, and were positioned and oriented to magnetic north by divers. The fifth array was a highly-sensitive cryogenic magnetometer, the first such array to be placed in the ocean. After implantment, cable from each array was run ashore to instrumentation hookup points. Here, the cable ends were spliced into the shore's circuitry. All array systems were successfully retrieved.



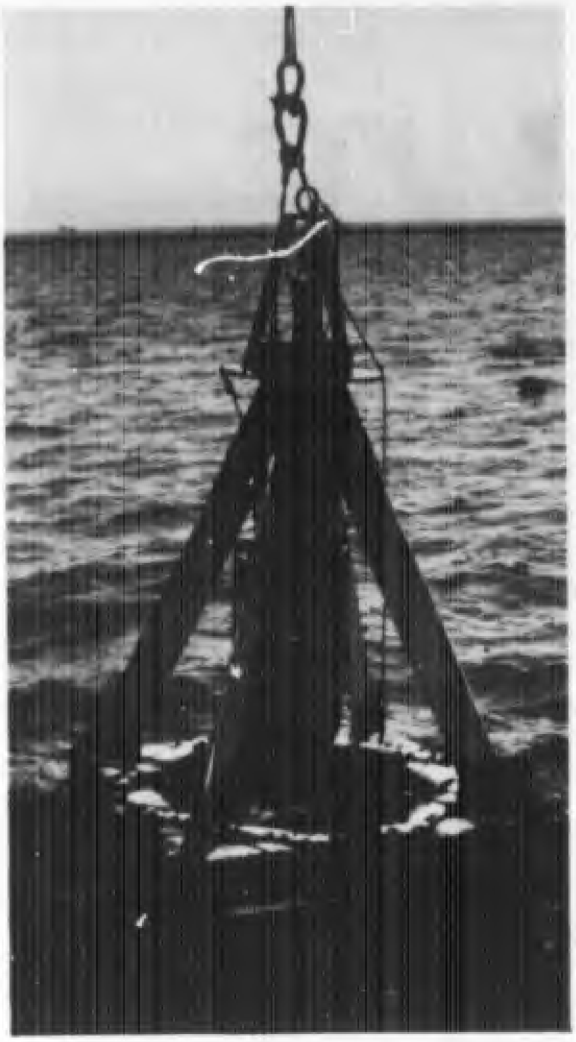
A typical magnetometer array structure being inspected by divers.

Divers overboarding from a small craft to investigate cable damage at the Azores underwater range.

Of the six major cables at an underwater acoustic range, one, which runs roughly parallel to the shore along a depth contour of 110 to 120 feet, had a suspension in excess of 120 feet. This freedom of movement allowed the cable to sway, rub over rock pinnacles, and wear through. An underwater construction team located and repaired the faulty cable section, restoring the range to its full operational status.

At Diego Garcia Island in the Indian Ocean, an underwater construction team installed two 2,500-foot pipelines to carry petroleum oil and lubricants from tankers moored offshore to the island. The team also constructed and installed a permanent mooring system for the tankers. Propellant-actuated embedment anchors were used as the primary holding power for the mooring system.

This was the first use of these anchors in a fleet mooring, and they proved to be a cost-effective solution to a difficult facility problem. These anchors were ideal for the hard coral seafloor found in the atoll's lagoon, where conventional drag-type anchors were ineffective. The anchor's projectile assemblies were launched downward by propellant gases at a pressure of up to 35,000 pounds, achieving peak velocities that exceeded 400 feet per second. The anchor flukes penetrated more than 30 feet into the coral seafloor, and were proof-tested to 150,000 pounds of pull. This successful embedment anchor installation added another valuable technique to the Navy's capability to install mooring systems quickly in environments where less than optimal bottom conditions exist.

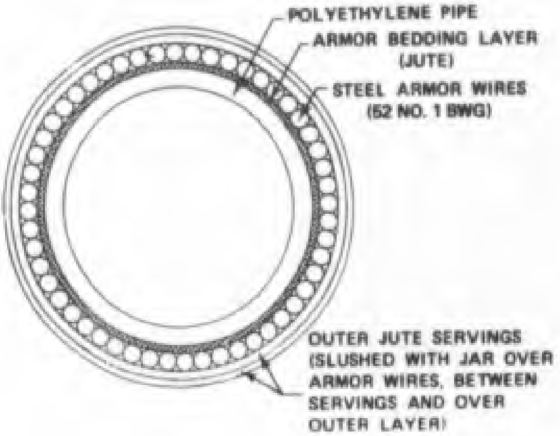


A propellant anchor, in its support structure, being overboarded to the sea bottom in preparation for firing.

Naval Facilities Engineering Command ocean engineers developed a unique liquid transfer facility, designed and constructed as a solution for a sewer outfall at the Naval Facility, Centerville Beach, California. The beach in this area has a dynamic surf zone and a rugged shore terrain that prevented the cost-effective installation of ordinary pipeline materials. To overcome these conditions, the ocean engineers selected a 4-inch inner diameter, high-density, polyethylene pipe protected by helically-wrapped, steel armor wires, and having jute and tar coverings. The steel armor provided abrasion-resistance and sufficient in-water weight for the pipe to be buried by natural surf action.

The pipeline was installed in two sections, one 3,000 feet offshore which extended from the beach to a water depth of 50 feet, and the other 1,000 feet onshore which connected the sewage treatment plant to the offshore line.

The use of plastic pipe for liquid transfer is not new, but use of such pipe in the ocean has been limited by its lack of abrasion-resistance and durability. The use of helically-wound armor-wire provided abrasion resistance, weight, strength, and resistance to pipe collapse, and expanded its usefulness for future ocean facility requirements.



The Naval Facilities Engineering Command was assigned responsibilities for assisting the U.S. Coast Guard in its lighthouse electrification program by providing underwater power cable to lighthouses. Wolf Trap and Smith Point Lighthouses in the Chesapeake Bay, Virginia, and Smith Island and Cape Flattery Lighthouses on the Strait of Juan de Fuca off the northwestern shore of the state of Washington are examples of the Command's installation of submarine power cable for the Coast Guard.

The repair, upgrade, and expansion of a major underwater tracking range was a milestone in the Naval Facilities Engineering Command's ocean engineering capability.

The Underwater Tracking Range is used by the Fleet to test and evaluate its surface and subsurface vessels and weapons systems. One of the range's main characteristics is its ability to track and to monitor sound with precisely located and sensitive underwater structures. Lightning damage and underwater structure component failure had caused a loss of the range's full tracking and monitoring ability.

When alerted to the tracking range's degradation, the Naval Facilities Engineering Command's ocean engineers designed and installed a new lightning protection system. Next, they designed new underwater tracking array structures and a new submarine warning and communication system. The tracking array structures were 4,000 pounds lighter than the old ones, and could be folded in half for ease of transportation and deployment.

New surface and subsurface ocean construction equipments were used for the first time during the project. From the windows of a manned submersible, built to withstand water depth of 12,000 feet, ocean engineers photographed the sea bottom and the exact position of the underwater structures which were to be retrieved. The construction operation took place from the deck of the SEACON, the Navy's first platform designed for ocean construction. The damaged arrays, some of them weighing 12,000 pounds, were retrieved from depths of 3,000 to 3,600 feet. With the aid of the SEACON, this unusually intricate operation resulted in the satisfactory recovery of the damaged arrays and in the installation of the new underwater sonar structures and their sea-to-shore cable. This work represented the largest underwater construction repair effort undertaken by the Command to date.

A typical underwater structure, or array, extended to its full length, being overboarded.

The Barking Sands Underwater Range Expansion project answered the Pacific Fleet's need to enlarge the Barking Sands Tactical Underwater Range at the Pacific Missile Range Facility, Kauai, Hawaii. The enlargement was required to provide sufficient water depth in which to conduct fullscale weapons tests, shipboard training exercises, and major Fleet tactical training evaluations. First, ocean engineers installed the inshore portions of the range's cable. This work was followed by the installation of two cables with hydrophone and submarine communication and electromagnetic navigational equipment, and by the stabilization of three previously-laid cables. This project represented the first opportunity for the Naval Facilities Engineering Command to provide a quick-response support to the Navy's Pacific underwater ranges.

The Naval Facilities Engineering Command successfully expanded the Underwater Test Range at Fort Lauderdale, Florida, by making a complete in-water installation of cable. The ocean construction platform, SEACON, was used to lay in excess of 72 miles of new cable.

The SQUAW is a 134-foot-long submarine hull which the Navy uses as a sonar target for training exercises. Previous moorings of this subsurface structure in 3,500 feet of water have failed at the hull's connection points. Now, the Naval Facilities Engineering Command has been assigned the responsibility for designing a concept which will moor the sonar target in 1,000 fathoms of water.

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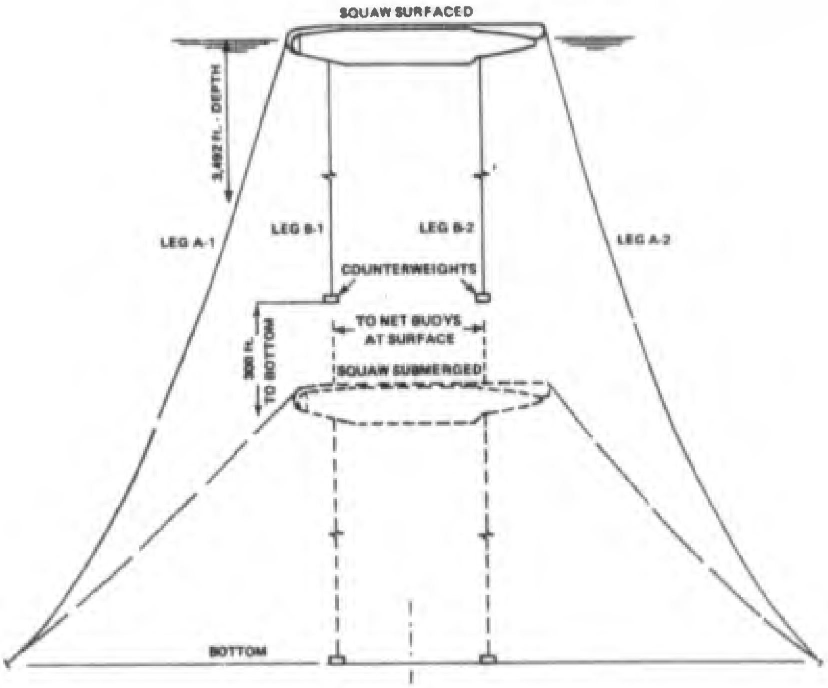
Artist's concept showing the design configuration for the SQUAW mooring.



Thirty miles offshore of Kitty Hawk, North Carolina, four ocean towers were constructed by the Naval Facilities Engineering Command to serve as part of the Air Combat Maneuvering Range.

The range, which serves as an air combat training range, encompasses an approximate 30-mile circle capable of tracking aircraft from 50 to 60,000 feet in the air, and requires strategically-positioned instrumentation towers to make it work. When the pilot fires his weapon system, his missiles are electronically-simulated, with the electronic data transmitted through the towers to high-speed, shore-based computers. The computers process the data from the aircraft and the towers, and compute aircraft positions and altitudes, interaircraft values, safety, and hit or miss results.

The towers' instrumentation—solar screen, navigational lights, and electronic package—is affixed to the upper deck of the two-decked superstructure.

The superstructure, which is above water, has triangular-shaped upper and lower decks supported by 75-foot high vertical columns. The 100-foot jacket rests on the seabed and extends to just above the water's surface. The jacket's three equilaterally-spaced steel legs slope outward and are laced together with braces to transfer and withstand the vertical and lateral loads that the tower may encounter during its 20-year design life. Each tubular leg of the jacket is pinned to the ocean floor with steel pilings driven 250 feet downward into the Continental Shelf.

The installation of each tower, made during the "weather window" of July and August, was similar. Each site had been marked earlier with marker buoys. A derrick barge, the cargo barge with the unassembled tower, and the two tugs assisted. First, the crane on the derrick barge swung over and picked up the jacket, which weighed approximately 200 tons. This was the heaviest lift in the installation operation. When the jacket was raised free of the barge, it was lowered into the water until it floated just over the water's surface. Divers released flood valves and water flowed into the bottom of each jacket leg. With the derrick barge in control, the jacket reoriented itself to an upright position and was set down adjacent to the site's marker buoy. The jacket was then pinned to the ocean floor by pilings. The stabbing cones of the superstructure were placed into the tops of the three piles, an operation equivalent to threading three needles at the same time. When the installation was completed, divers inspected each welding.

Today, because of instrumented Air Combat Maneuvering Ranges such as this one, pilot proficiency will increase. This range is a visible example of the Navy's ability to use ocean engineering to enhance Fleet readiness and to insure national defense.

▲ *Swinging the jacket around the stern of the derrick barge.*

Lowering the jacket in place. ▶

One of the four instrumented Air Combat Maneuvering Range towers.

ADVANCED CONCEPTS

The Naval Facilities Engineering Command is actively engaged in both the present and future of underwater construction. This kind of advanced thinking requires studies carried on over enough time so that experiments can be made to test new ideas and new equipment.

For example, the Command is supporting the evaluation of a new fiber as the strength member in ropes and cables. This fiber has a strength approaching that of steel, yet is as flexible and easy to handle as polyester. The fiber is considered to be of value in underwater construction work because it is corrosion-resistant and has a strength-to-weight ratio 20 times higher than steel in water. The experimental program, consisting of laboratory and at-sea tests of various rope and cable construction has demonstrated the feasiblity of this material for a broad range of underwater construction applications.

The Navy continues to have a requirement for a deep-water, fixed array structure which will expand the tracking and magnetic measurement capabilities of the Fleet. To meet this need, the concept of array rigidity and a 5-year life span are being introduced into the structure's conceptual development. Implantment of such a structure will substantially enlarge the measurement capability of underwater tracking ranges.

To design foundations and anchors for seafloor installations, the engineering parameters of sea bottom sediments must be known. Bottom samples taken by oceanographic corers are continually being tested in the Seafloor Soils Laboratory for strength and other characteristics.

Studies also continue in the area of developing effective engineering methods to analyze the dynamic response of three-dimensional, moored cable structures deployed in the ocean. The dynamic behavior of cables and cable structures involves two problem areas: strumming, which is the small displacement, high-frequency vibration of cables due to vortex shedding; and the large displacement and relatively low-frequency motions caused by time-varying environmental loads during implantment and recovery, or while in-situ.

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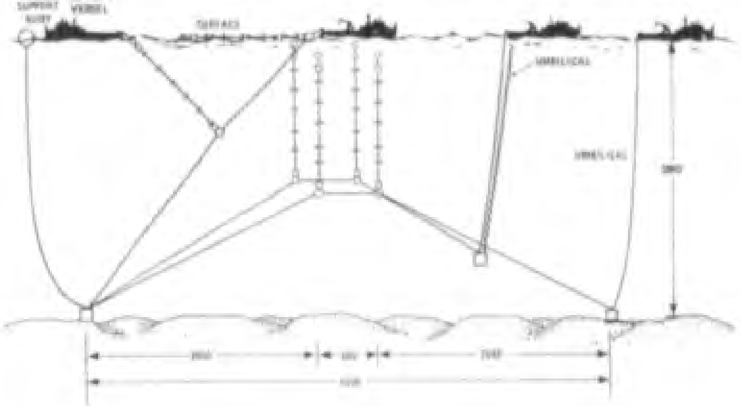
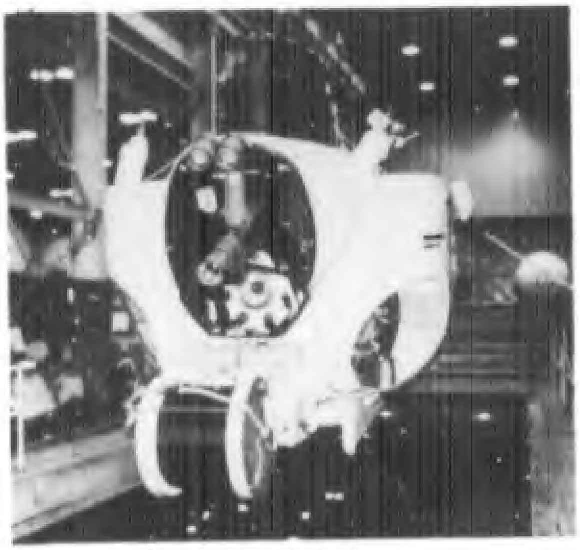
IMPLANTMENT APPROACH
FOR SEMI-FIXED ARRAY

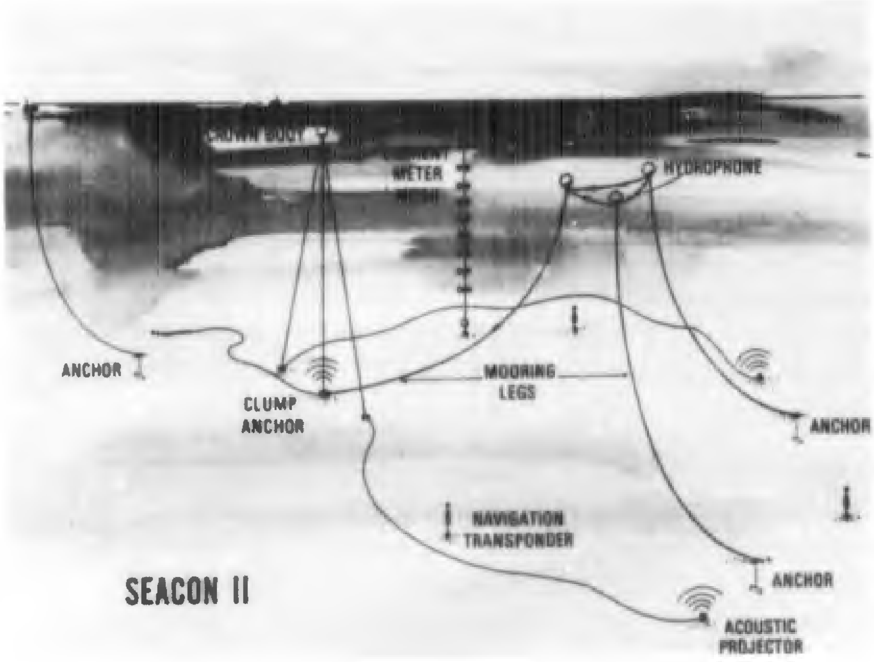


SEACON I was a highly successful "first" in the use of concrete in the sea. This 70,000-pound, unmanned, hollow, concrete structure containing instrumentation was emplaced on the seafloor off Santa Barbara, California, where it operated for 11 months at a depth of 600 feet. Since this successful experiment, research on concrete, considered to be the major underwater building material of the future, continues. Long-term ocean tests of 66-inch outside diameter concrete spheres placed on the seafloor at depths between 2,000 and 5,000 feet are being carried out. Yearly inspections of the spheres are made in submersibles, similar to the Navy's TURTLE.



The Navy's submersible, TURTLE.

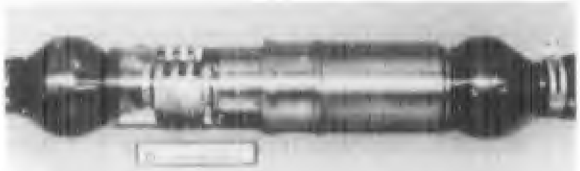
SEACON II was a three-legged cable structure, ½-mile high and more than a mile wide, which was built to gather data for evaluating cable structure design techniques. It had a 1,000-foot wide, triangular-shaped aperture, which was tethered 500 feet below the ocean surface by three, 4,000-foot-long mooring legs. Some of the cables contained electrical conductors for transmission of power and electrical signals between distant points on the structure. After more than a year and a half in the water, the structure maintained nearly complete mechanical and electrical integrity while collecting a substantial amount of position data.



SEACON II

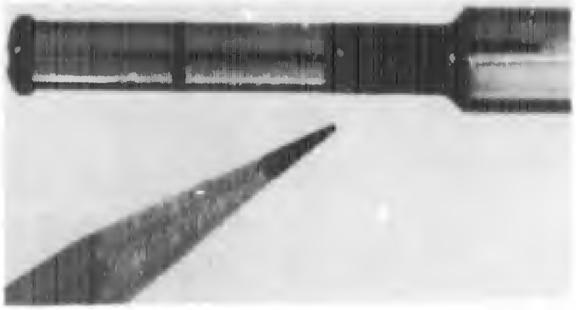
To protect its offshore assets, the Chief of Naval Operations has given the Naval Facilities Engineering Command the responsibility of developing the concept for a system to protect Trident submarines from covert underwater attack while they are at a refit facility.

The development of underwater or "wet" connectors for both parallel and coaxial electromechanical cables continues. Connectors are being designed to provide power and signals for fixed sea-floor facilities and for submersible vehicle applications. The connectors operate at up to 6,000 volts and carry up to 2,000 amperes. They are capable of being actuated either remotely, by manipulators or by divers, and they will function at all ocean depths. The primary connector program at present is the developing of a wet connector compatible with underwater communication cable. Mating requires that the two halves be pushed together. Unmating takes a simple squeeze motion on a compensating bladder by a manipulator or similar tool. The mechanical and electrical portions connect and disconnect simultaneously.



LENGTH (MATED)	22 in
MAX OD	5 in
SQUEEZE RING OD	4 in
WEIGHT IN AIR	53 lb

The need to make precise measurement of deep-ocean, low-velocity currents in order to understand the environmental effects on undersea structures has increased. To satisfy this requirement, a small, reliable, deep-ocean current measurement sensor is being developed. The sensor can measure current speed and direction accurately in all directions. For remote data collection, as many as 40 of these sensors may be placed in line in the system's deployment cable, which may be as long as 20,000 feet.



The Naval Facilities Engineering Command will continue to develop and maintain for the Navy and its Naval Construction Force the capability to meet current and future requirements for underwater construction. The Command's past experience in shallow and deep water ocean engineering, its reliable assemblage of underwater construction equipment, and its development of advanced underwater systems have made the Ocean Facilities Program an asset valuable to the Fleet.

Responding to Needs

For information call

Ocean Facilities Program Office (PC-2)
Naval Facilities Engineering Command
200 Stovall Street
Alexandria, Virginia 22332

(202) 325-0505, AUTOVON 221-0505

Ocean Engineering and Construction Project Office (FPO-1)
Chesapeake Division
Naval Facilities Engineering Command
Washington Navy Yard
Washington, D.C. 20374

(202) 433-3881, AUTOVON 288-3881

Officer In Charge
Civil Engineering Laboratory (L-40)
Naval Construction Battalion Center
Port Hueneme, Ca. 93043

(805) 982-5420, AUTOVON 360-5420

DEPARTMENT OF THE NAVY
UNITED STATES OF AMERICA