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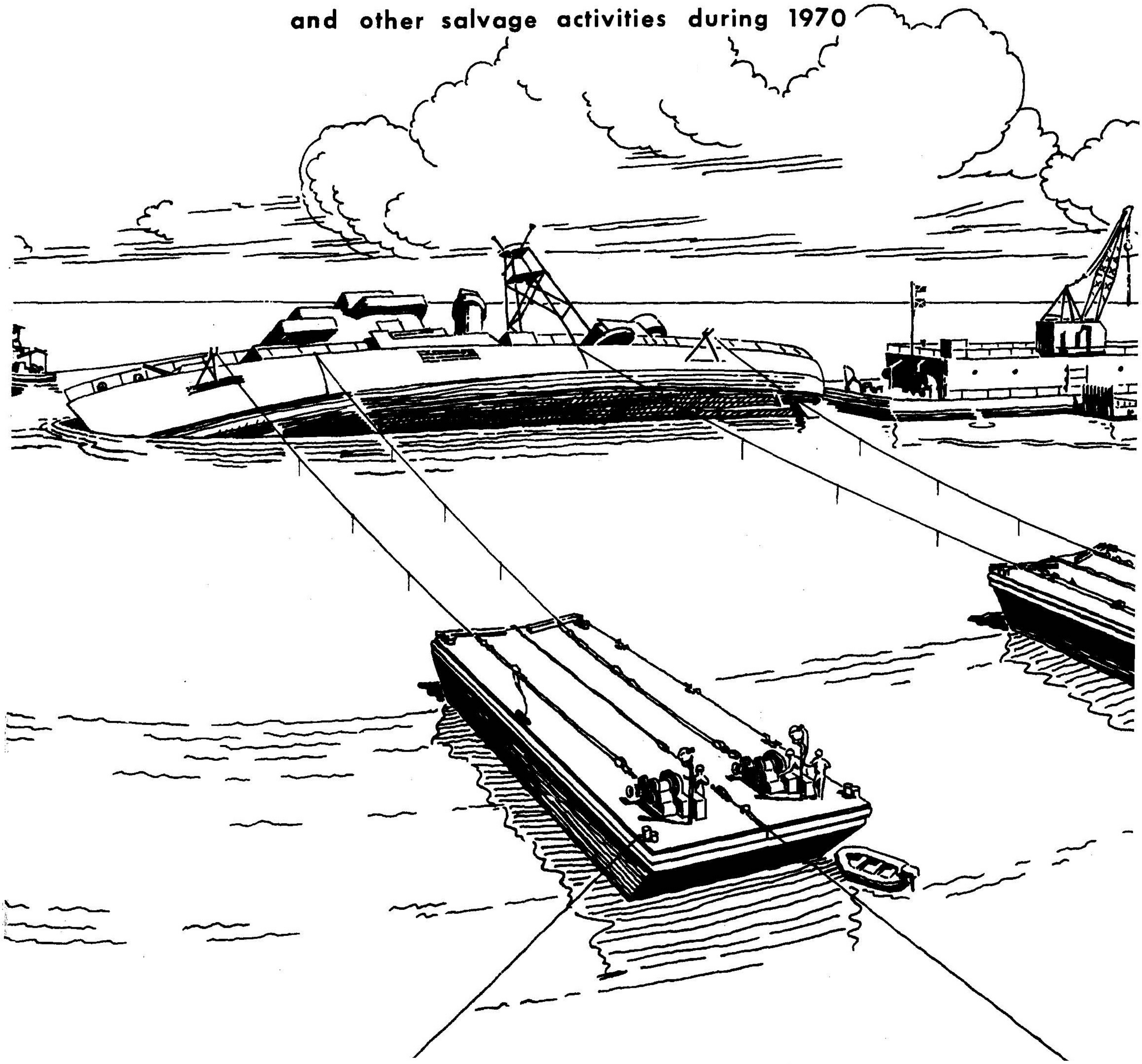
SALVOPS 70

A review of significant salvage operations conducted by U.S. Navy salvage forces and other salvage activities during 1970



Department of the Navy
Naval Ship Systems Command
Washington, D.C.

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FOREWORD

Marine salvage is an ancient art, as old as man's use of the sea. As evidenced in this review of 1971 operations, modern salvage forces of the U.S. Navy employ a formidable array of techniques and equipment, unknown and unimagined by their forebears. Yet the salvor's job remains today as tough and demanding as when he first ventured into the ocean's depths. Perhaps more so. Applications of science and technology have not changed the basic nature of the salvor's work. They have simply increased his capabilities, giving him the tools to tackle assignments of ever increasing difficulty and complexity.

This review covers a wide variety of salvage cases in operational settings ranging from the Azores to the Great Salt Lake to the South China Sea. The diversity of these cases amply illustrates an enduring principle: each salvage operation is unique in some respects. No salvage planner faces precisely the same problem. The seas and weather do not permit it; they always combine their vast elemental forces in different ways to confront the salvor with a new set of operating conditions for each assignment. Moreover, these conditions are almost certain to change as the operation progresses. Assurance of the routine and predictable is a luxury denied the salvor. Indeed, the only certainty is that he will encounter the unexpected.

On the other hand, the articles in this review illustrate another corollary principle: many salvage operations have much in common. One always resembles others in some key aspects. This characteristic is the basis for developing and applying our salvage doctrine and equipment. They are the products of past experience in previous operations and the expectation that similar situations will arise in the future. Planning a new operation is a process of recognizing similarities in the projected conditions with those of other operations. It is his awareness of such similarities that enables the salvor to select the tools and techniques to attempt the job at hand.

Thus we should study a salvage case from two points of view, the common and the unique. First, we seek to learn how the operation resembles other operations. To what extent did the operating conditions, as the salvors understood them, permit the application of known and familiar procedures? How well were they applied and how did their application influence the outcome of the job? In what ways did the operation confirm the adequacy of doctrine and equipment or point the way toward needed improvements?

Secondly, we wish to determine how the salvage force coped with the unknown and unexpected. What conditions did it encounter that were novel and strange? How did it react to such conditions? In what ways can the case advance our knowledge of the salvage art? Are there parallels of such conditions elsewhere in salvage annals that the force possibly failed to recognize at the time? Can we generalize from this experience to others, known or postulated? What is the probability of such conditions occurring again? Does the reaction of the salvage force provide any basis for extending the scope of our salvage doctrine?

I commend this dual approach to the study of salvage cases to the readers of this review. The articles herein constitute a valuable addition to our professional literature. An appreciation of what has been done in the past is a prerequisite to an understanding of what can be done in the future and how best to go about it. This documentation of 1971 operations provides a unique opportunity for U.S. Navy salvors to learn from our mutual experiences, experiences both familiar and novel, all of them contributing to the advancement of the salvor's art.

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ABSTRACT

This is an annual report of the Supervisor of Salvage, U.S. Navy, reviewing significant salvage operations conducted during 1971. The report focuses on operations of U.S. Navy salvage forces and those of contractor salvors working under Navy auspices. It provides detailed treatment of the salvage and disposal of the USS REGULUS; the implantment of the Azores Fixed Acoustical Range; and the raising of a submarine hulk in a major training exercise, SUBSALVEX 71. The work of Harbor Clearance Unit One in its final year of operational employment in Vietnam is also given extensive coverage. Operations to locate and recover six different downed aircraft are described, with emphasis on two especially difficult cases involving U.S. Air Force aircraft downed in Lake Michigan and Great Salt Lake, Utah, respectively. Navy assistance in freeing the civilian ketch, ATOM, from Assateague Island, Virginia is the subject of a short article as is a commercial salvage case, the raising of the barge, BOOTH, in the Gulf of Mexico, which highlights the application of the Pressurized Sphere Injector (PSI) technique.

CONTENTS

SALVAGE EFFORTS AND DISPOSAL

OF

USS REGULUS (AF 57)

OFF HONG KONG

Force of Typhoon Rose drove ship aground on rocky shore of Kau Yi Chau Island off Hong Kong Harbor in August 1971. Damage was too severe to permit retraction and salvage. After decommissioning, Supervisor of Salvage arranged for contractor salvors to dispose of hulk.

USS REGULUS (AF 57) AGROUND OFF HONG KONG HARBOR

SALVAGE EFFORTS AND DISPOSAL OF USS REGULUS (AF 57) OFF HONG KONG

INTRODUCTION

The refrigerated stores ship, USS REGULUS (AF 57) was driven aground on Kau Yi Chau Island off Hong Kong Harbor on 17 August 1971 by Typhoon Rose. Salvage operations, which included off-loading of equipment, fuel, ammunition, stores and debris and surveying the damage were conducted by the U.S. Navy, Task Unit 73.4.2. During these operations it was determined that the cost of repairs and alterations required was disproportionate to the value of the ship. On 10 September REGULUS was decommissioned and turned over to the Supervisor of Salvage Representative for final disposition; Task Unit 73.4.2 was deactivated.

The Supervisor of Salvage tasked Murphy Pacific Marine Salvage Company with the demolition and disposal of the ex-REGULUS. Murphy Pacific, in turn, subcontracted with Fuji Marden & Company, a Hong Kong shipbreaking firm. Disposal operations began on 19 September and included cutting the upper hull structure, removal of steel, lightening the vessel for buoyancy and rigging ground tackle, pumps, compressors and beach gear for refloating. The vessel was finally freed from Kau Yi Chau Island in two sections, the forward on 24 January 1972 and the after on 3 February 1972, and towed to the Fuji Marden yards at Junk Bay, Kowloon.

LOSS OF THE REGULUS

Grounding on Kau Yi Chau Island

The USS REGULUS (AF 57) was driven aground on 17 August 1971 on the southwestern tip of Kau Yi Chau Island off Hong Kong Harbor. The refrigerated stores ship was leaving Hong Kong when warning was received that Typhoon Rose had shifted course and was heading in the direction of Hong Kong. The REGULUS steamed to the northeast, with a pilot, to anchor in the port typhoon shelter offshore from the New Territories mainland section of Hong Kong. Numerous other ships were anchored in the sheltered bay as the typhoon approached.

The full force of the storm struck shortly after midnight. According to the Commanding Officer of the REGULUS, the ship was anchored on both anchors and steaming ahead up to 9 knots but it had dragged anchors about 1.5 miles when it grounded.

The REGULUS was caught on the sharp rocks at the base of Kau Yi Chau Island. The ship had come to rest on a hard sand and rock bottom, down by the stern, on a heading of 060°T with a 9.25-degree starboard list. Its location was at Latitude 22°16.9'N, Longitude 114°04.4'E.

Initial Activities

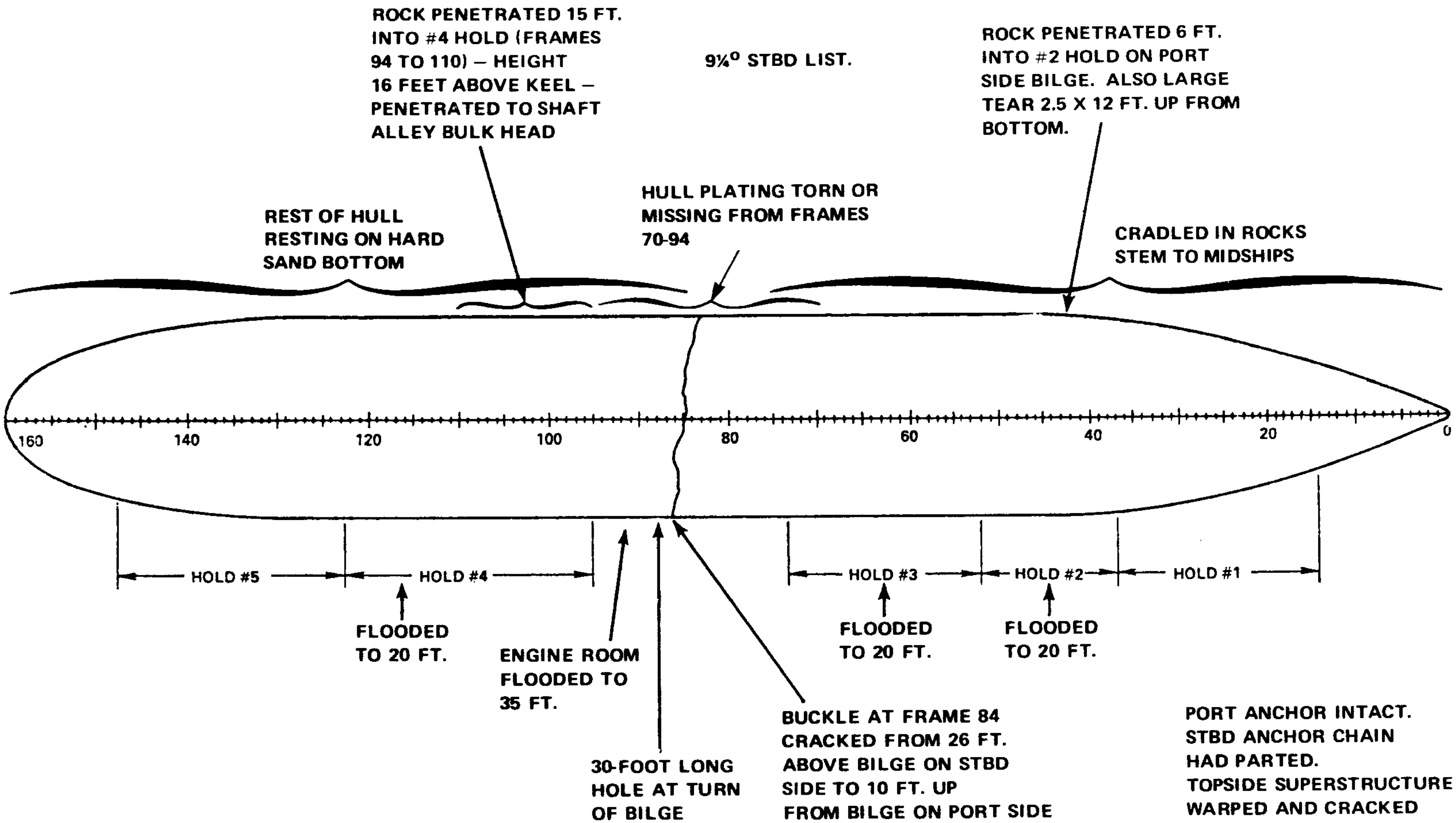
At the time of the grounding, the REGULUS requested assistance from the USS WESTCHESTER COUNTY (LST 1167) which was acting as station ship. The USS SAFEGUARD (ARS 25), the USS CURRENT (ARS 22) and the USS ABNAKI (ATF 96) were ordered to proceed at once to Hong Kong to conduct salvage operations. The USS CURRENT was diverted en route and replaced by the USS GRASP (ARS 24). The first task, undertaken on 17 August, was to evacuate the REGULUS crew to the WESTCHESTER COUNTY. Some personal effects were also transferred. A security detachment remained aboard the grounded ship.

Task Unit 73.4.2 was activated at noon on 18 August. The unit was comprised of the WESTCHESTER COUNTY, SAFEGUARD, ABNAKI and GRASP. Later, on 31 August, the USS WHITFIELD COUNTY (LST 1168) replaced the WESTCHESTER COUNTY. With the arrival of the ABNAKI and the SAFEGUARD on 19 August, salvage operations got underway and continued until Task Unit 73.4.2 was deactivated on 10 September when the REGULUS was decommissioned and turned over to the Supervisor of Salvage Representative (SUPSALVREP) for final disposition.

Initial Damage Estimates

The initial estimates of damage indicated that the ship was hard aground, buckled all the way through at frame 85 with a possible hole under the bow. The engine room was flooded to 35 feet. Numbers two, three and four holds were flooded to 20 feet. The superstructure was warped and cracked, and extensive miscellaneous topside damage had been experienced. There was a 9.25-degree starboard list.

Surveys of damage were made almost daily and these surveys progressively revealed the extensive nature of the damage. By 21 August it was determined that the ship was cradled in rocks from stem to midships with the remainder of the hull resting on hard sand bottom. It was aground its full length at high tide and approximately 4000 tons aground at the highest tide of 8 feet. The buckle at frame 84 was cracked from approximately 26 feet above the bilge on the starboard side around to 10 feet up from the bilge on the port side. Although the bottom could not be seen, the crack appeared to go completely across. There was a hole 30 feet long in the port side of the ship at the turn of the bilge.



Daily diver surveys conducted during the salvage phase revealed extensive damage to the ship and led to the decision to sell the hull on an "as is, where is" basis.

KEY FINDINGS IN UNDERWATER DAMAGE SURVEYS

SALVAGE OPERATIONS, 17 AUGUST – 10 SEPTEMBER 1971

Salvage operations were conducted by U.S. Navy salvage forces (Task Unit 73.4.2) from 17 August to 10 September when REGULUS was decommissioned and Task Unit 73.4.2 deactivated. Removal of all salvageable equipment was completed on 5 September, but backloading of salvage gear continued until the 10th.

With the REGULUS' crew safely evacuated to the WESTCHESTER COUNTY on 17 August and the activation of Task Unit 73.4.2 on 18 August, the salvage force focused its efforts on the removal of equipment and related salvage tasks. Operations included off-loading of sensitive material, personal effects, stores, equipment and fuel; preventing oil pollution and spraying dispersant chemicals on limited oil slicks; surveying the damage to the REGULUS; and removing any debris which could generate hydrogen sulfide gas as it decomposed.

Off-Loading and Removal Operations

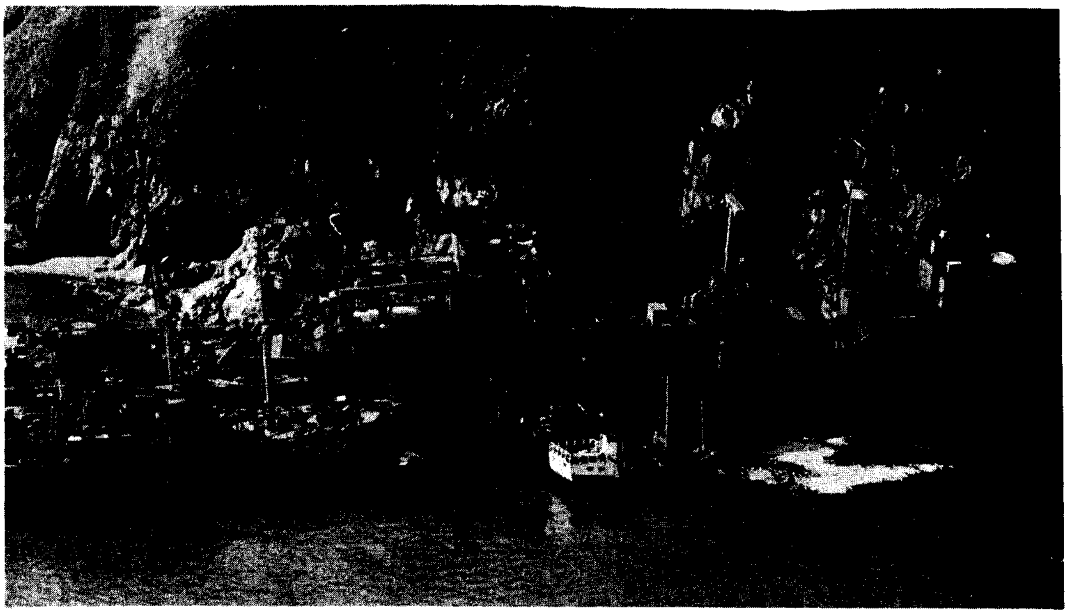
The major task undertaken by the salvage force was the off-loading of stores and equipment. Items removed during this period included classified material and controlled medicinals, forward masts, guns, winch deck house, forecastle, search lights, chain falls, tools, fans and general stores material. By 23 August all 2000 rounds of 3-inch ammunition were off-loaded as were crypto gear, money, small arms and pyrotechnics. REGULUS' four boats were removed on 23 and 24 August.

Number three hold was completely empty by 25 August and number one hold by 26 August. On 31 August, swells forced termination of removal operations except for some topside weight. During the cutting of the superstructure on the night of 31 August – 1 September, several superstructure bulkheads split, apparently as a result of shifting torsional stresses in the hull. To preclude any unexpected large movements, SAFEGUARD provided a portable winch to the after section of the ship and GRASP ran preventer wires from both sections and pulled them tight with winches.

By 5 September all salvageable equipment had been removed. The total topside weight removed was estimated to be over 300 tons. On 9 September, USS ABNAKI departed Hong Kong, followed by the GRASP and WHITFIELD COUNTY on the 10th. The SAFEGUARD remained to provide support and security until arrangements could be made for a contractor to assume responsibility for disposal of the hulk. Task Unit 73.4.2 was deactivated.

From 17 August to 10 September Task Unit 73.4.2 removed all salvageable equipment. Over 300 tons of topside weight were removed including REGULUS' four boats, the forward masts, search lights, winches and controlled equipage.

OFF-LOADING AND REMOVAL OPERATIONS ABOARD REGULUS



USS SAFEGUARD arrived at the salvage site on 19 August. The ARS conducted pumping operations and assisted in off-loading.

USS SAFEGUARD (ARS 25) ARRIVES TO ASSIST STRICKEN REGULUS

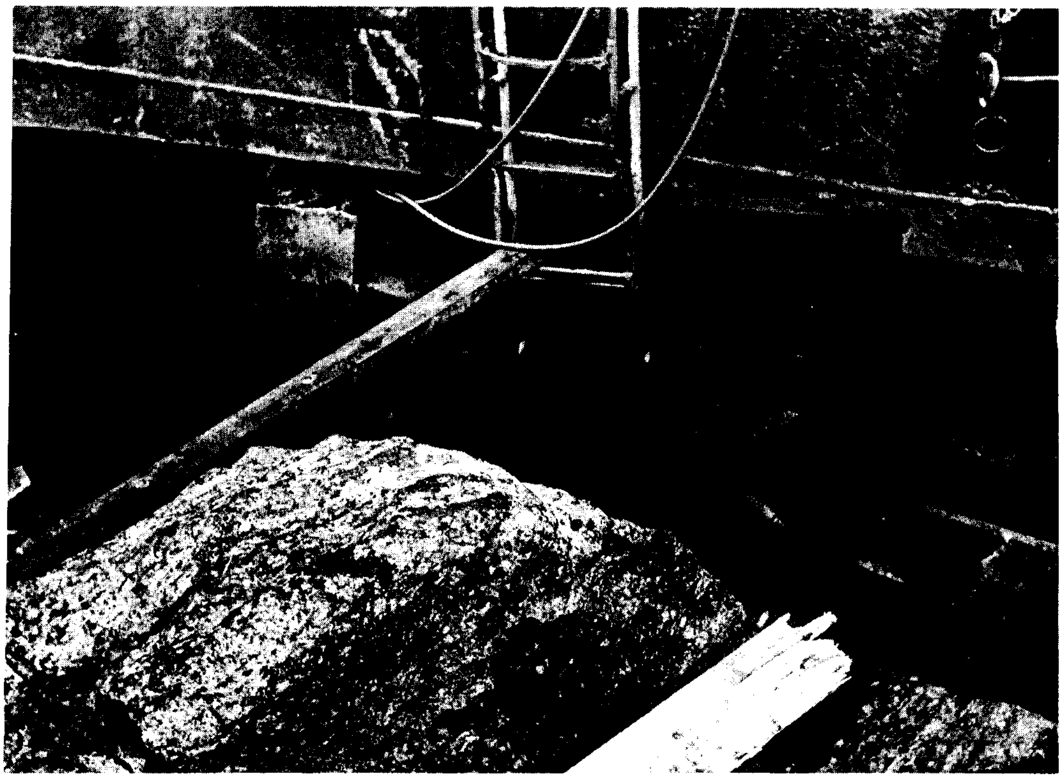
Pumping Operations

Pumping operations began on 19 August when a low-pressure air compressor, oil pumps, hoses, and related tools were obtained from the Shell Oil Company by the SAFEGUARD and a Shell Oil Company barge was moored alongside the REGULUS. During the next few days, additional oil pumps, air compressors, barges and an oil skimmer were obtained from the Shell Oil Company, the Mobil Oil Company, and the Peninsula Oil Company to facilitate fuel and oil removal. On 20 August off-loading of fuel started, one tank at a time, with salt water ballasting as each tank was emptied. Chemical dispersants were sprayed on small quantities of oil that were escaping periodically due to swell action at low tide.

By 22 August, 30,000 gallons of Navy special fuel oil (NSFO) had been off-loaded, leaving the settling tanks empty. In addition, 8 feet of oil was stripped from the engine room, number two hold, and the remaining accessible tanks. By 27 August numbers one and three holds were pumped dry, although some pumping was continued in number three hold because of minor leakage. Numbers two and four holds remained partly flooded. Pumping operations continued throughout the period of salvage activities.

the rock penetrated inboard to the shaft alley bulkhead; however, additional investigations on 26 August showed that, although the shaft alley was flooded, the flooding had not been caused by the rock in number four hold since the common bulkhead was intact. In addition, all fuel oil tanks except 6-122-1 and 6-122-2 and the settling tanks were found either to be holed or suspect.

These diver surveys revealed the extensive nature of the damage. On 4 September it was determined that the cost of repairs and alterations required were disproportionate to the value of the ship and it was recommended that the REGULUS be decommissioned and the hull sold.



At number four hold a rock 32 feet wide had penetrated through the bottom and side of the vessel from frames 95 through 105. It extended 24 feet into the hold to the shaft alley bulkhead and stood 18 feet above the base line.

ROCK PENETRATION INTO HULL OF REGULUS

Plans and Preparations for Extracting REGULUS

Initial plans had called for an athwartship retraction of the REGULUS. Soundings indicated water of 5 to 6 fathoms from about 090°R to 180°R. This idea was abandoned, however, because the rocks cradling the ship were found to extend around the keel back to about number two hold on the starboard side. A second plan was to pull the ship off in the direction of 150°R to 160°R, thereby avoiding the rocks on the starboard side. Target dates were set at 4, 5, and 6 September for attempts to retract the REGULUS. However, it was decided that estimates should be made of the cost of repairs to restore the REGULUS by a team of estimators from the Ship Repair Facility, Yokosuka before beginning the retraction attempts.

On 23 August it was determined that it was not feasible to extract the ship intact in its present condition at this time due to the size of the rock in number four hold and the extent of the tear at frame 84. Investigations at local shipyards into strengthening the hull showed that it would cost $100,000 for hull strengthening material and take about 50 days to install, if strengthening members could be moved into place, which was doubtful. Alternatives to the retraction of the REGULUS being considered at this point were to sever the hull at frame 84 and refloat the two sections separately or to sell the hull to a commercial salvage company for scrap with guaranteed immediate removal. The former alternative was chosen and cutting operations were planned to begin early on 25 August.

Cutting operations scheduled to begin 25 August were deferred, however, pending receipt of additional information. Estimators from the Ship Repair Facility established a preliminary figure for repairs of the REGULUS at a total of $4,306,400. This estimate was based upon 98,000 man days of labor and 8 months overhaul time at Yokosuka; the total also included an allocation of $700,000 for materials.

Recommendations for Decommissioning REGULUS

On 27 August it was recommended that the REGULUS be decommissioned at the earliest opportunity. This was followed on 28 August by a request that a board of inspection and survey be established to determine the suitability of the REGULUS for further service in the U.S. Navy. On 31 August it was recommended that the REGULUS be sold to a ship breaker on an "as is, where is" basis after Navy usable equipment had been removed. The terms of the sale would include the setting of a time limit for removal of the ship. On 1 September it was requested that a local subboard of investigation and survey be convened to conduct a survey of the REGULUS. Administrative procedures for the decommissioning of REGULUS were also promulgated on 1 September.

On 4 September a board from the Navy Ship Repair Facility, Yokosuka conducted the inspection and survey of the REGULUS. It found that the REGULUS was unfit for further service because the material condition of the ship was such that the cost of repairs and alterations required was disproportionate to the value of the ship. The board recommended that the REGULUS be stricken from the Naval Register, that all usable equipment be removed from the ship prior to disposal, and that the hull be sold on an "as is, where is" basis.

On 7 September, the Chief of Naval Operations authorized the decommissioning of the USS REGULUS, effective 10 September, and directed that the ship be disposed of in accordance with existing law and in a manner most advantageous to the government. Accordingly, plans were made to decommission the REGULUS on the morning of 10 September and to turn the ship over to the Supervisor of Salvage Representative (SUPSALVREP) for final disposition. On 10 September the REGULUS was decommissioned and the hull turned over to the SUPSALVREP.

DISPOSAL OPERATIONS, 11 SEPTEMBER 1971 – 11 MARCH 1972

Administrative Arrangements

The decommissioning of the REGULUS and the deactivation of Task Unit 73.4.2 on 10 September 1971 ended the salvage operations phase of the REGULUS conducted directly by the U.S. Navy, more specifically by units of the United States Pacific Fleet. The next phase of operations was conducted by a commercial salvage company under contract with the Supervisor of Salvage, U.S. Navy. This phase of the operations involved the scrapping and removal of the hull of the ex-REGULUS after useful equipment had been removed.

The disposal operations phase began on 19 September 1971 when a representative of Murphy Pacific Marine Salvage Company, Emeryville, California and a representative of Fuji Marden & Company, a Hong Kong shipbuilding firm, took over the responsibility for the ex-REGULUS. Murphy Pacific had been tasked by the Supervisor of Salvage to conduct salvage clearance operations on the REGULUS' hulk, including demolition and disposal of the wreckage in compliance with the conditions and requirements of the Marine Department of the Government of Hong Kong. Murphy Pacific, as authorized by the Supervisor of Salvage, subcontracted the task to Fuji Marden & Company. Although it was intended that the disposal operations would be completed by 11 December 1971, disruptions and setbacks caused delays. Finally, on 11 March 1972 disposal operations on the ex-REGULUS were terminated with the successful removal of the hulk from the wreck site.

Initial Disposal Operations, 19 September – 8 October 1971

When the Murphy Pacific representative boarded the vessel on 19 September, he found it visibly down by the stern an additional 1.5 feet and listing about 0.7 degree more to starboard. These shifts were caused by flooding in the after section, through the second deck passageways. He closed the watertight doors to stop the flooding aft and rigged 3-inch pumps to bring the flooding under control from frames 122 to 135. A pump and security watch were set for the night.

Further examination, including a dive under the vessel, revealed that from frame 122 to stern port the vessel was resting on sand bottom with scouring apparent aft of frame 125. Since positive buoyant forces were obviously supporting a major portion of the weight aft and were providing considerable stability, it was considered important to maintain sufficient buoyancy aft to prevent further settling and listing to starboard as well as to reduce the possibility of submerging the main deck or assuming a more drastic change in attitude. Accordingly, additional pumps were ordered rigged to dewater completely all spaces from frames 137 to 147 down through the third deck.

During the first week of the Murphy Pacific/Fuji Marden operations, work barges were brought alongside, cutting and removal of high topside weight was started, a 150-ton lift rig was brought alongside, and both masts and stack were removed. Also during this week, the first of a series of major disruptions occurred when a fire was started in number three hold by an oxyacetylene torch. Although the crew brought the fire under control, the Hong Kong Harbor Fire Department finished extinguishing the fire, and work had to be suspended temporarily.

Despite delays for fire fighting, flood control, and Typhoon Della, cutting of super and upper hull structure proceeded well. Combustibles were removed from the holds and engine room. However, on 8 October, Typhoon Elaine passed through the area, causing additional damage to the wreck and changes in the planned disposal operations.

Effects of Typhoon Elaine, 9–16 October 1971

Damage from Typhoon Elaine was extensive. A hull girder was completely severed at frame 85 and separated an average of 2 feet from the main deck to the normal waterline. The stern was hogged down approximately 3 degrees and canted 1.8 degrees to port. The after section was listing about 10.5 degrees to starboard and was offset, shifting about 20 inches to starboard at main deck level. The remaining 01 deck structure at frame 85 and forward starboard was crushed upward by pressure related to the difference in list of forward and aft sections. There was no indication of additional damage to numbers one and three holds. The after steering and adjacent spaces were completely flooded to half of the third deck level. The after magazine spaces were dry. All pumps and other major equipment remained lashed to the main deck positions but required drying out. Minor pieces of cutting equipment and tools were lost overboard.

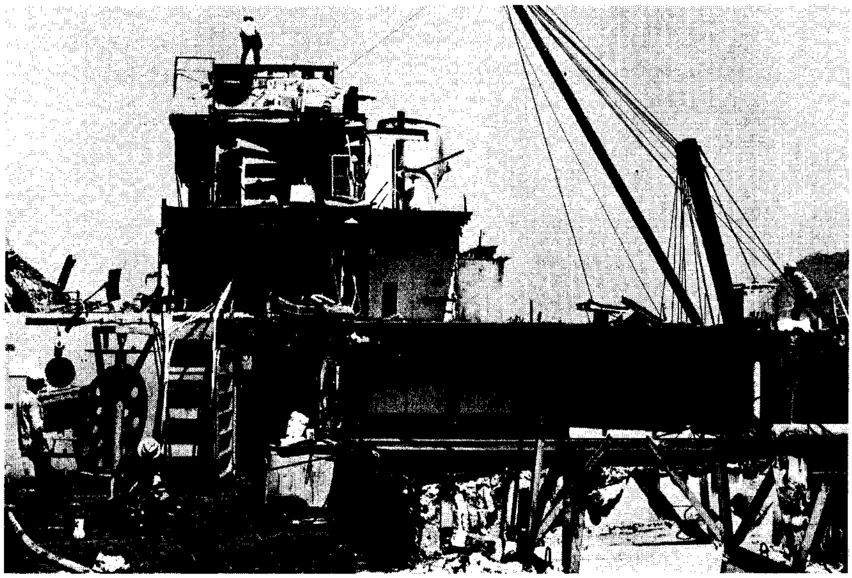
The plan for immediate remedial action included the following: to leave the forward section ballasted until ready for refloating; to install several 3-inch turnbuckles and equivalent chain diagonally across the break in the hull girder and set up with even strain for a spring effect to allow for continued flexing and hopefully to prevent the hull sections from drawing farther apart until ready for refloating. Cleaning and cutting operations were to be resumed as weather permitted in the most expedient manner feasible. Action would be taken as necessary to hold the ship stable and upright in keeping with the objective of complete removal of the vessel from her sunken position.

An underwater inspection of the hull from starboard frame 85 to stern revealed that the break in the hull at frame 85 was about 2 feet at the waterline widening to 7 feet at the turn of the bilge. The bilge keel was crumpled and broken away from the bilge strake from frame 85 to frame 98. The after section was settled more firmly into the sand and rock bottom more than 6 feet in some areas. One large rock penetrated the hull plating from frame 135 to frame 136 creating an additional hole. The ex-REGULUS appeared to have gained stability from settling and from the resultant grounding force aft, but there was some apprehension about her remaining upright during another storm such as Elaine. The weather improved, however, and by the end of the fourth week of operations, work was progressing well.

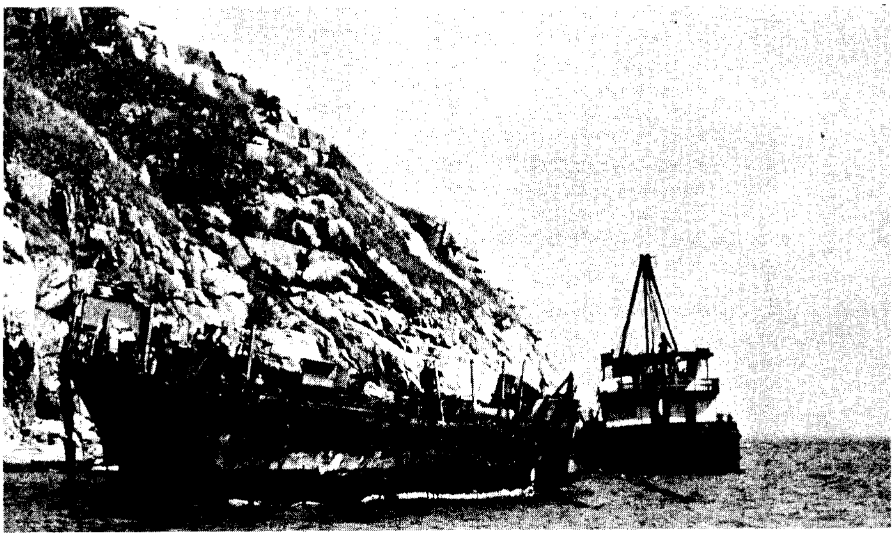
Cutting and Removal of Machinery and Superstructure, 17 October – 10 November 1971

During this period efforts concentrated on cutting and removing machinery and superstructure and rigging beach gear for refloating attempts. The Hong Kong Marine Department agreed to the proposed plan for refloating the vessel in two sections and towing the sections to Fuji Marden yards via the outside channel. The plan included an alternative of beaching the sections nearby at a location more suitable for breaking up the vessel completely.

By the end of October the forward section of the vessel had been cut completely to the second deck from the bow to frame 72 starboard side; the main machinery space had been cut to just above the waterline from frame 80 to frame 95; diving operations had been undertaken to seal off reefer spaces; removal of citrus cargo from number four hold and residual Navy special fuel oil was progressing; and construction of a water-tight bulkhead from scrap steel materials had been started around the immediate vicinity of the major rock penetration in the hull.



Stern section with most of topside weight removed. Helicopter platform has been removed; stanchions supporting platform remain in place.



During the 3-month period from mid-September to mid-December all of the superstructure was cut away and removed.

REMOVAL OF ex-REGULUS SUPERSTRUCTURE

Cutting and removal operations did not occur without setbacks. On 22 October a fire started in number one hold and flashed through between the deck sections of numbers one, two and three holds pushed by strong northeasterly winds. The fire was brought under control by the Harbor Fire Department and continued to smolder for several days. Another typhoon, Typhoon Hester, also hampered steel removal operations but it subsided on 24 October having caused only minor damage and no equipment loss. On 4 November the Hong Kong Marine Department ordered that all operations on the ex-REGULUS be suspended pending a meeting with the Harbor Board. This suspension was attributed to a tightening up in enforcement of harbor regulations following a disastrous restaurant vessel fire which resulted in 40 deaths and extensive damage. The results of the meeting, held the next day, 5 November, were that diving and rigging could continue but all future hot work areas had to be approved prior to commencement of any welding and cutting.

Attempts to Refloat the ex-REGULUS, 11 November – 31 December 1971

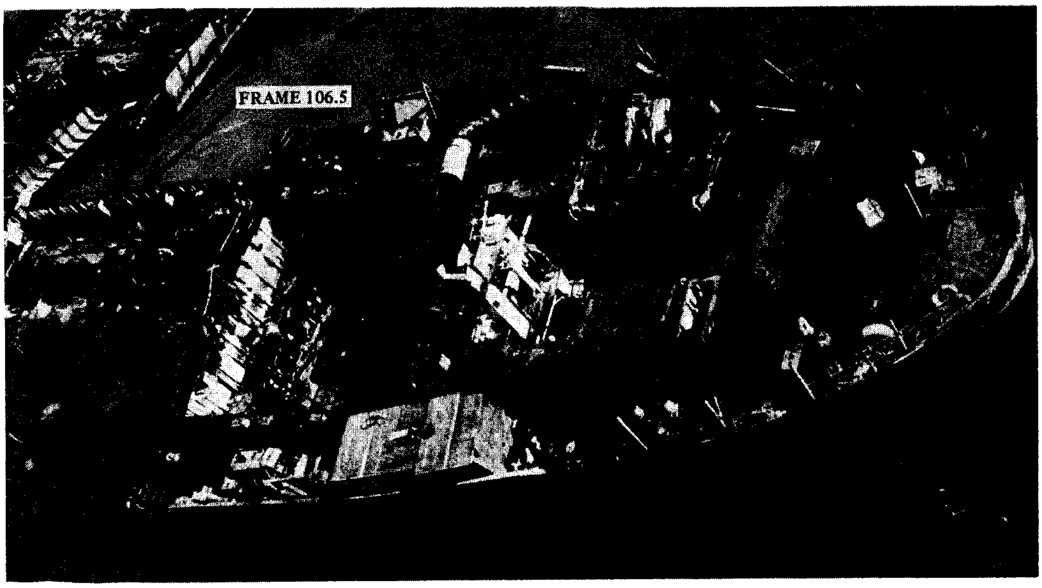
Primary efforts during the middle of November focused on the rigging of ground tackle, pumps, and compressors for refloating attempts during high tides in the period 20–22 November. After three sets of Chinese beach gear had been rigged on the after section and additional water removed, the forward end of the aft section came afloat. It was reflooded to hold the vessel firm until all preparations for the refloating phase were ready.

During the high tide cycle major pulling and pumping efforts were made. The after section of the vessel floated and appeared to move freely, but even with four sets of beach gear, efforts to pivot the vessel into deeper water were unsuccessful. At high tide late on 22 November, a maximum pull with four sets of beach gear pivoted the stern to starboard nearly one degree, but because of rock penetration in the shaft alley and engine room the basic attitude and position remained unchanged.

The latter part of November was devoted to implementation of revisions of the salvage plan to lighten the vessel to achieve sufficient buoyancy to float free of the rock penetrations. The additional measures included removal of machinery from frames 85 to 95, evaluation of rock penetrations and removal if necessary, cutting and removal of steel to second deck level, removal of residual cargo from frames 95 to 122, and possible rigging of two additional sets of beach gear. The Hong Kong Marine Department granted permission for continued cutting in the forward section of the vessel, which was firmly ballasted for the cutting and removal operations.

Throughout December cutting of steel and removal of debris continued, along with the rigging of additional beach gear. Progress was delayed somewhat as workers became reluctant to cut in the more inaccessible areas as they penetrated deeper into the ship. The vessel continued to gain freeboard. Steel removal from the after section was 90 percent completed by 11 December with the removal of heavy deck plate and machinery. The draft of the after section was decreased approximately 3 feet. With removal of additional debris at frame 85 starboard, divers found the rock penetration to be 10 feet high by 18 feet in diameter penetrating into both the forward and the after sections. A clam shell dredge was brought alongside starboard to reduce the sand and shell buildup.

By the end of December, six sets of beach gear were in place, four Chinese and two U.S., pulling and pumping in coordination with the incoming tides. On 29 December, a 1600-horsepower tug was used. On 30 December, while beach gear and a tug were being used for pulling, the stern section of the vessel came free of the major rock penetration on the port side from frame 95 to frame 104. The new attitude assumed was a 1.2-degree list to port, 85-ton ground reaction at frame 95 starboard and minor involvement of the main machinery space. The draft was 28 feet 6 inches aft and forward.* It was secured with a



Transverse cutting of frame 106.5 was required in order for the stern section to regain flotation. The stern section had taken on a 14-degree port list when frame 95 port side moved into a trench off Kau Yi Chau Island.

LOCATION OF FRAME 106.5

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*Draft reports for 16 August, prior to grounding, recorded the draft forward as 16 feet 6 inches, and aft as 21 feet for a mean draft of 18 feet 9 inches and displacement of 9400 tons.

4-point moor, two wire and two chain, and one restraining chain between the forward and after sections starboard. During this pull, the section from frame 95 to frame 106 sustained such structural damage as to be of no further practical use for buoyancy.

In view of the above development, it was decided to remove all the wrecked structure forward of number four hatch by severing the vessel transversely at frame 106.5. By taking advantage of the athwartship in line doors and hatches, it was estimated that the cutting task could be accomplished in 14 to 21 days.

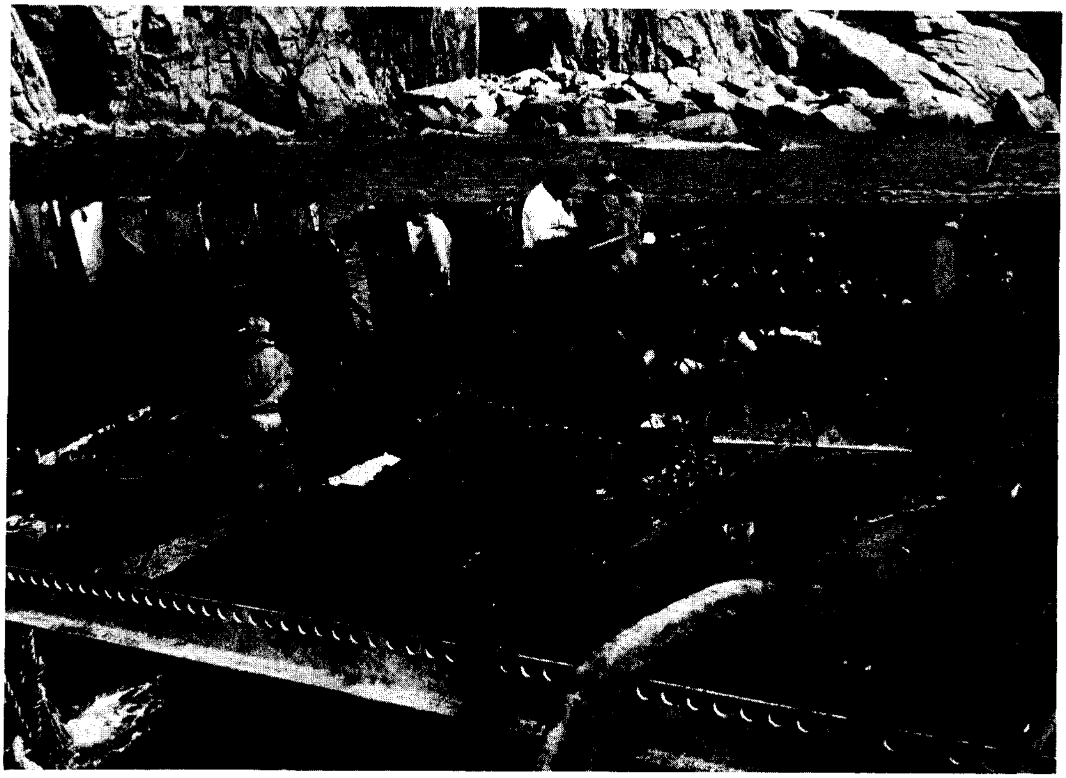
The weight of the section from frame 95 to 106.5 was estimated to be 110 tons. The remaining aft section would then displace an estimated 1240 tons for towing, and the center of buoyancy would shift to frame 131. The draft would be 27 feet 6 inches aft and 26 feet 3 inches forward.

At the same time as the cutting at frame 106.5 was being accomplished, the forward peak tank would be cut off at frame 14 to facilitate pivoting the forward section to starboard in order to clear the rocks off the starboard bow. This would remove 49 tons, and the remaining forward section would displace 781 tons.

Transverse Cutting at Frame 106.5, 1–29 January 1972

The after section was pulled around to 75 degrees, breaking loose virtually everything between the engine room and frame 95. At this time the after section took on a 14-degree port list caused by frame 95 port side moving into a trench. Weather conditions and heavy swells caused the stern section to shift further to the starboard. On 3 January, divers inspected the port side and confirmed that that portion was working deeper in the trench scoured by the ship's previous position and dredge action. As the port list increased slowly during the day, the vessel was rotated again to the starboard using a tug and beach gear in order to find more favorable position. The position of the after section relative to the forward section was 105 degrees. Pumps and beach gear were continued through the night because of heavy swells and high tides. Cutting operations continued on 4 January but the beach gear could not be worked because of continued heavy rain.

By 7 January the after section floated free of the bottom at high tide from frame 110 aft. Two sets of beach gear with one restraining chain to the forward section were in place on the after section. Divers continued cutting frame 106.5, number four hold, to sever the vessel transversely. The Chinese beach gear was moved to the forward portion of the vessel in preparation for refloating that section as soon as possible without interference from the operations aft.



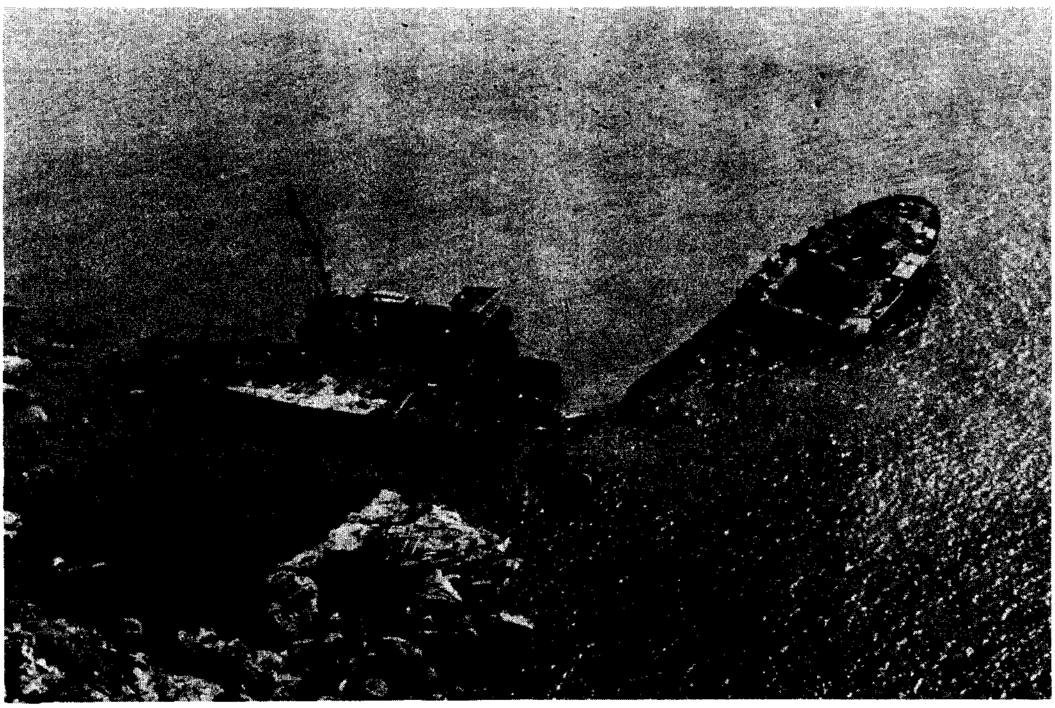
Diver prepares to leave diving station to conduct cutting operations. The stern section served as a diving station for transverse cutting of the hull at frame 106.5.

TRANSVERSE CUTTING OF FRAME 106.5

On 9 January the access to the shaft alley and the double bottom tanks was severed on the third deck, number four hold. Also in this area severing was started on the main shaft and longitudinal piping and structure. It was estimated that about 150 linear feet had been cut to date with about 450 feet remaining. The after section's position relative to the forward section was 95 degrees with two sets of beach gear rigged and one restraining chain attached to the forward section. It was floating free from frame 110 aft. Beach gear and pumps were rigged to the forward section but underwater cutting of the peak tank at frame 14 had not yet been completed.

By 20 January, transverse cutting at the after section at frame 106.5 was approximately 60 percent complete. Cutting of the forward peak tank at frame 14 had been completed, and the tank appeared to have fallen free of the remainder of the forward section. At 2330 on 20 January, the forward end of the bow section was pulled approximately 10 feet to starboard using one leg of beach gear and a 1200-horsepower tug. Pulling operations then stalled because of involvement with rock penetration, machinery space debris, and insufficient line pull. It was decided not to pull the forward section any further until the aft section could be freed and additional beach gear moved to the forward section. However, work continued to improve the buoyancy and stability of the forward section. Numbers one and three holds were dewatered.

On 22 January, during unusual high tides and heavy swells, the after portion of the bow section came completely free of all involvement with rocks and machinery space debris at frame 85. This portion was rotated approximately 25 degrees to the starboard, floating freely from a pivot point at about frame 31, where ground reaction and rock penetration still seemed likely. The pull was made with two sets of Chinese beach gear, one of which failed early in the refloating attempt.



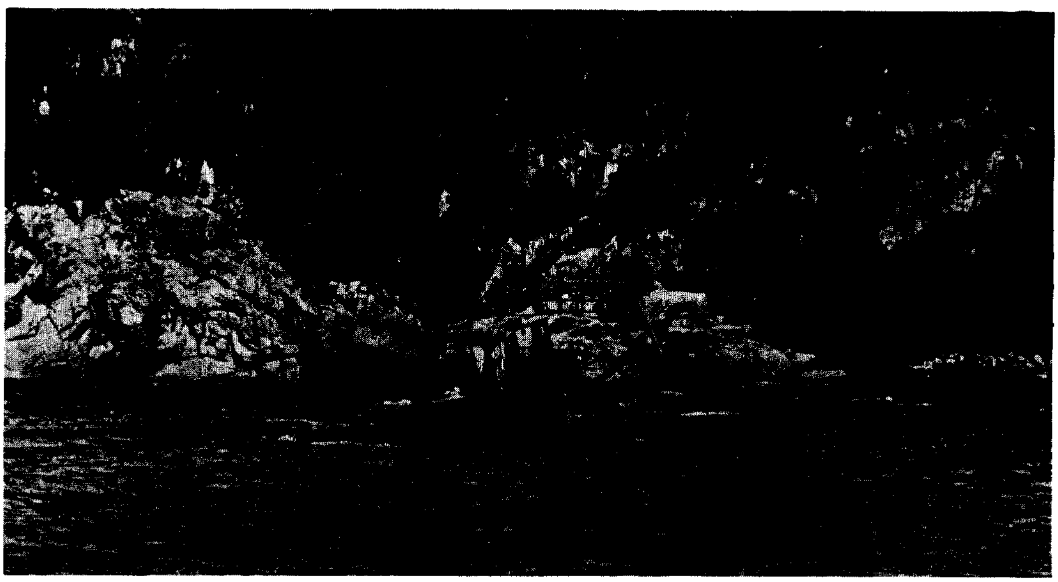
The ex-REGULUS, stripped of all its superstructure and topside weight, lies in two sections. The bow section was finally pulled free from the rocks on 24 January and the stern section on 3 February.

BOW AND STERN SECTIONS OF ex-REGULUS ON KAU YI CHAU ISLAND

On 24 January the forward section was pulled from the rocks of Kau Yi Chau Island. Two sets of Chinese beach gear and a 1600-horsepower tug were used. The forward section was held in a 3-point moor until 25 January when it was towed to Sin Kau Island and beached on a sloping sand shelf. Transverse cutting of the after section at frame 106.5 was estimated to be approximately 75 percent complete.

Preparing and Towing the Bow and Stern Sections, 30 January – 6 March 1972

Transverse cutting was completed by early February and the after section floated free from the cut. The draft was 22 feet 6 inches aft and 25 feet 9 inches forward, the list less than 1 percent. The after section was initially moored on Kau Yi Chau Island with two legs of beach gear and a restraining chain. Marine Department surveyors inspected it there during the afternoon of 4 February. On 5 February the after section was towed from Kau Yi Chau Island to Sin Kau Island where final preparations would be made for towing it to Fuji Marden yards at Junk Bay, Kowloon. Preparations continued on the forward section, beached at Sin Kau Island, for towing it to Junk Bay. Concurrently, divers continued



By mid-February 1972 only a portion of the vessel, frames 96 to 106, remained on the island. Divers continued cutting operations on this portion while awaiting a 150-ton crane to remove remaining scrap.

REMAINING SCRAP AT KAU YI CHAU ISLAND

cutting operations on the portion of the vessel, frames 96 to 106, which remained at Kau Yi Chau Island. This work would enable a local 150-ton crane to remove the remainder of the scrap.

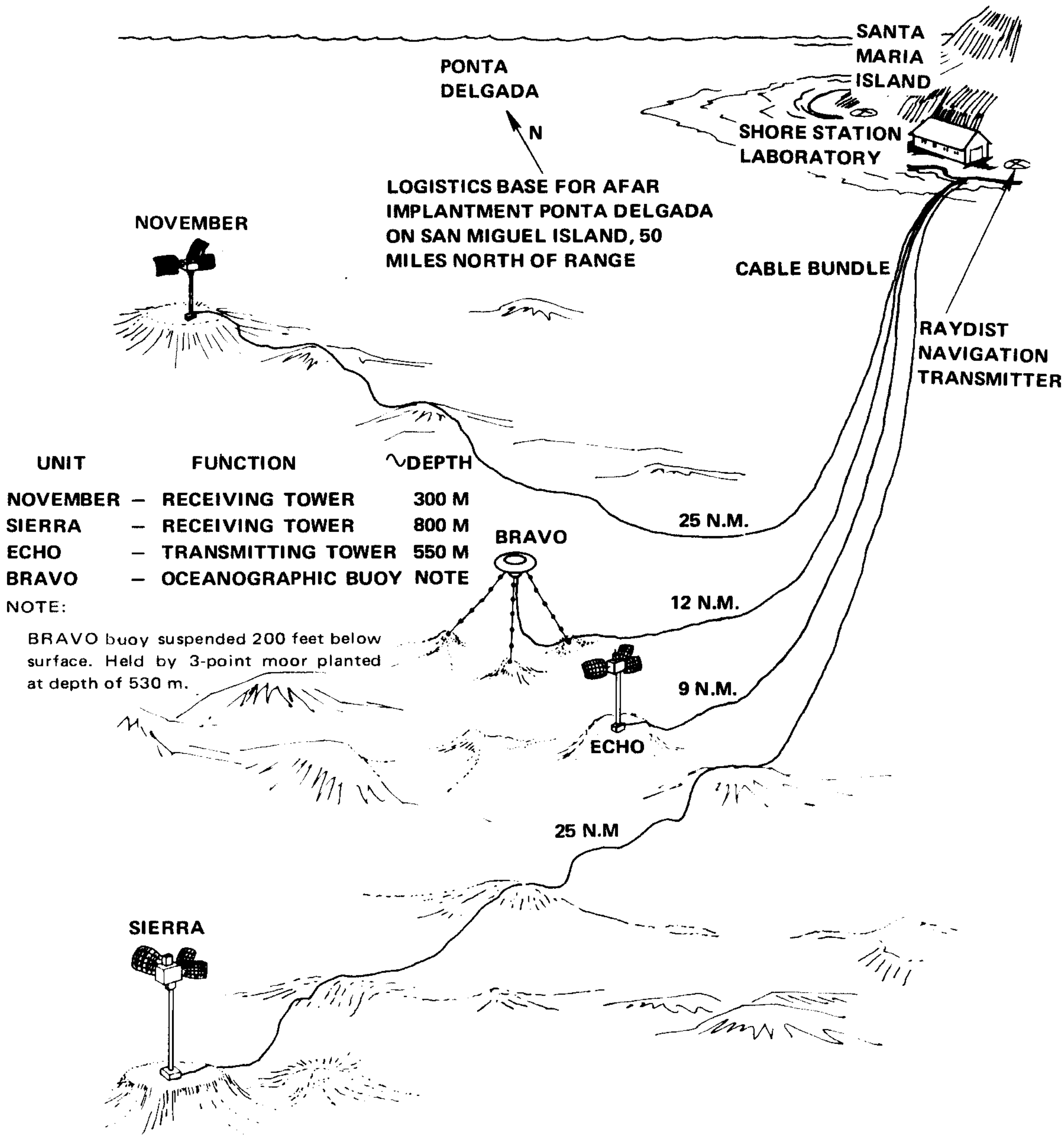
On 18 February the after section was towed to Junk Bay. It was followed by the forward section. Delays were experienced in obtaining a 150-ton crane because of breakdowns and scheduling. The removal of the remainder of scrap from Kau Yi Chau Island was deferred, pending the crane's availability. On 1 June 1972 a representative of Murphy Pacific personally inspected the stranding site of the ex-REGULUS and could find no evidence of the wreck.

PARTICIPATION OF U.S. NAVY FORCES

IN

AZORES FIXED ACOUSTICAL RANGE (AFAR)

1971 OPERATIONS



Purpose of AFAR range is to obtain scientific and ocean engineering information concerning acoustic parameters in the ocean environment. Range is sponsored by eight NATO nations with U.S. and France the principal participants.

AZORES FIXED ACOUSTICAL RANGE (AFAR)

PARTICIPATION OF U.S. NAVY FORCES IN AZORES FIXED ACOUSTICAL RANGE (AFAR) 1971 OPERATIONS

INTRODUCTION

The Azores Fixed Acoustical Range (AFAR or AFAR range) is a deep water acoustical system planted at a depth of about 3000 feet off the island of Santa Maria in the Azores. It consists of an underwater transmitter tower, ECHO; two underwater receiving towers, NOVEMBER and SIERRA; one subsurface ocean environment measuring buoy, BRAVO; and a laboratory on the island of Santa Maria. Electrical cables connect these components.

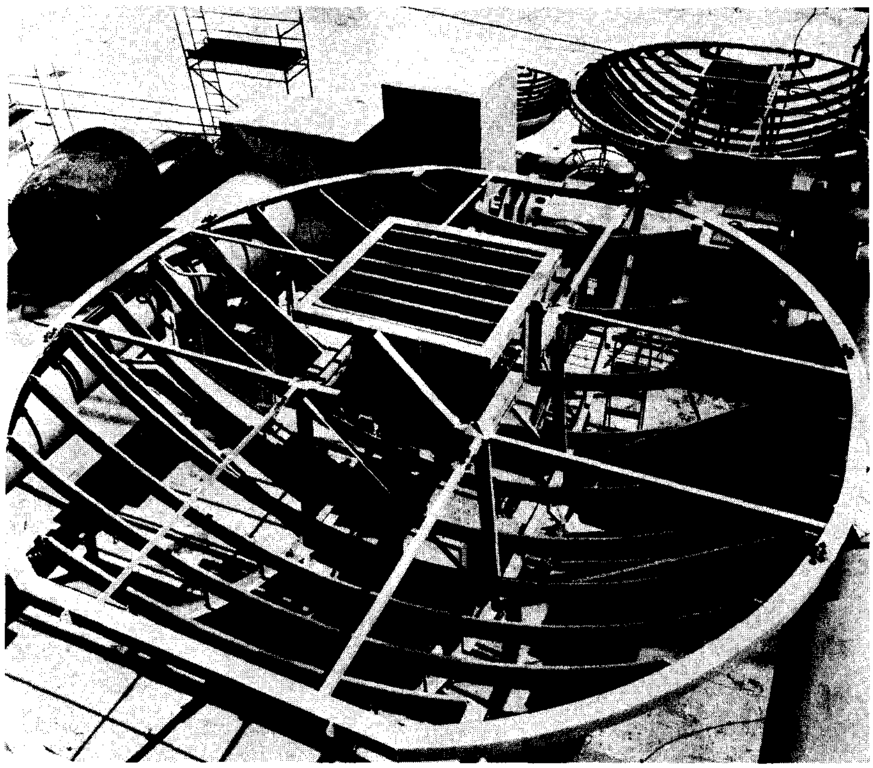
The AFAR range is sponsored in varying degrees by eight NATO nations, with the United States and France being responsible for range installation. Initial implantment operations conducted out of Ponta Delgada, San Miguel during the summer of 1970 did not result in a usable facility. Consequently, AFAR operations were conducted during the summer of 1971 in order to complete establishment of the range. Three major tasks were involved in these 1971 operations: to retrieve, repair, and reimplant ECHO tower; to implant BRAVO buoy; and to repair the receiving cables on NOVEMBER and SIERRA towers.

Two United States vessels, USS KIOWA and USNS NAUBUC, contributed significantly to the accomplishment of the three major tasks. KIOWA and NAUBUC worked closely together to implant BRAVO buoy. NAUBUC also functioned as the mother ship for the Cable Controlled Underwater Research Vehicle (CURV III). CURV attached special fittings to ECHO tower to enable it to be lifted. The research vehicle also located underwater cables and prepared them for retrieval. This article highlights U.S. operations which, of course, were only part of the combined efforts of the NATO participants. Operations of the other nations are covered only as necessary for an understanding of the overall operations.

COMPONENTS OF THE AFAR RANGE

Acoustic Antennas

The acoustic antennas mounted on the towers are the heart of the AFAR range. The first broadband directive antennas built for deep ocean implantment, they range in size from 12 to 22 feet in diameter. The antennas are novel in several engineering aspects: band widths, lightness, and the pressure compensation system. They are also the first antennas to be mechanically steerable in both planes.



This close-up was taken at Ponta Delgada while ECHO tower was being repaired during the summer of 1971 prior to final implantment.

ANTENNAS OF ECHO TOWER

Antenna Towers

The towers which support the acoustic antennas are 100 feet high. When assembled, each antenna tower is 120 feet long and 40 feet wide. Each weighs 72 tons in the air, 6 tons in the water, and has a dynamic mass in water equivalent to 120 tons. Each tower has a lifting eye for attaching the lowering cable used during implantment.

BRAVO Buoy

The subsurface ocean environment measuring buoy, BRAVO, is 13 feet in diameter, 13 feet high, and weighs 5000 pounds in the air. Built by the United States at the Naval Underwater Systems Center (NUSC), New London, Connecticut, the buoy, with an electronics package attached, was designed to be moored 200 feet below the surface in 2200-2300 feet of water in a 3-point moor using 18,000-pound cast iron anchors.

Cables to Shore Stations

A laboratory built on the island of Santa Maria serves as a shore monitoring station. This station is connected to the towers and buoy by cables. A naval construction unit of the U.S. Atlantic Fleet, with the help of a NUSC laboratory team, outfitted the shore laboratory, installed the overland cable runs, and implanted the surf cables.

Three types of cable are used in the Azores range: buoy cables, transmitter cables, and receiver cables. The transmitter and receiver cables were built in the United Kingdom and the buoy cable was supplied by the United States. These cables connect the towers and the buoy to the laboratory on Santa Maria Island.

PLANNING THE 1971 AFAR OPERATIONS

Plans for the 1971 AFAR operations were based on the status of the AFAR range following the 1970 implantment effort. As a result of this effort, NOVEMBER and SIERRA towers were accurately located and in good condition but their electrical cables had developed faults after laying. ECHO tower was lying on the bottom about 0.5 miles east-southeast of its chosen site and hidden from the range area behind a hill. BRAVO buoy had not been implanted because of problems encountered with the deep water, 3-point moor resulting in the loss of all three mooring legs. The buoy, itself, was undamaged and was returned to NUSC following the 1970 operations.

The basic planning technique was to identify critical tasks, develop detailed procedures for accomplishing each task, and assign definite responsibilities for implementing the procedures. As a result of this approach, planning for the 1971 AFAR operations centered on three major tasks:

1. Recover, repair, and reimplant ECHO tower.
2. Implant BRAVO buoy.
3. Repair the receiver cables.

NUSC and the Office of the Supervisor of Salvage (SUPSALV) were the two principal United States agencies responsible for developing detailed plans to accomplish these tasks. Working closely together, NUSC and SUPSALV developed procedures for implanting BRAVO buoy and for conducting the underwater work necessary to recover, repair, and reimplant ECHO tower and to repair the receiver cables. SUPSALV made arrangements with the Naval Undersea Research and Development Center (NURDC), San Diego, California for use of the Cable Controlled Underwater Research Vehicle (CURV). SUPSALV and NUSC also worked closely together in designing a cable grabber, pyranol torch cutter, and special shackle; these tools were to be used by CURV in accomplishing her underwater tasks.

SPECIAL EQUIPMENT DEVELOPED FOR CURV OPERATIONS

SUPSALV designed and procured three critical items of special equipment for the 1971 AFAR operations. The first item was a cable lifting mechanism called a "cable grabber." During operations, the cable grabber was positioned over the cable and then locked onto the cable. With the cable thus firmly gripped, it was ready to be lifted. The second item was the pyranol torch cutter used by CURV to cut the 2.5-inch double armor cable. This equipment was tested in San Diego in May during CURV personnel training.

The third critical item was the special shackle, developed by SUPSALV, which CURV inserted into ECHO's lifting eye. The special shackle consisted of a spring-loaded shackle

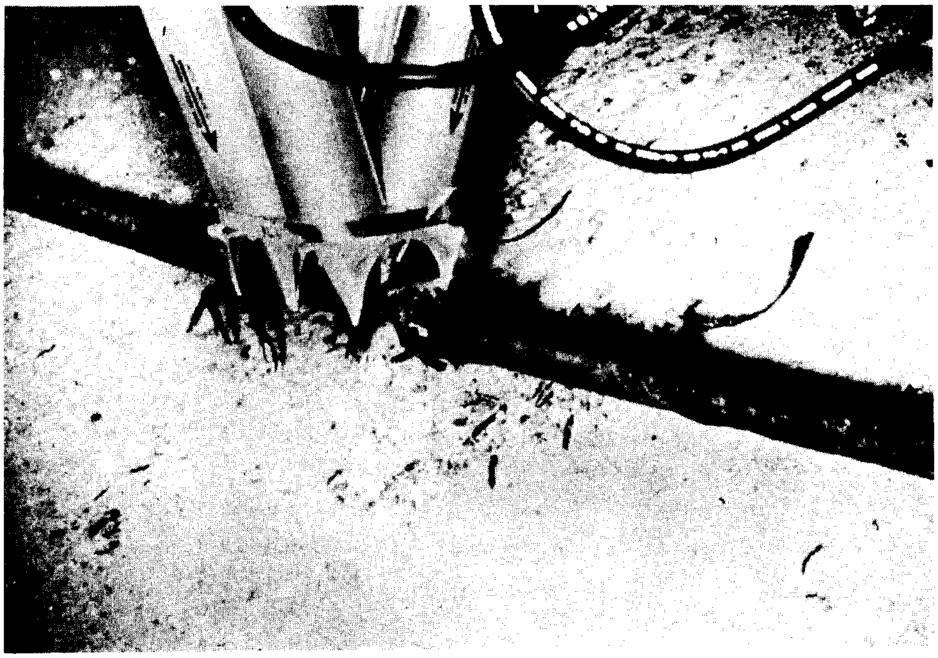
The cable grabber's jaws are closed, clamping the device to the cable. The cable is thereby ready for lift to the surface.

CABLE LIFTING DEVICE, "CABLE GRABBER"

pin, held open by an explosive bolt that was fired electrically from the surface through CURV's electrical/mechanical tether. The shackle was fitted with a triangular equalizer plate with a hole in each corner to which a line could be attached.

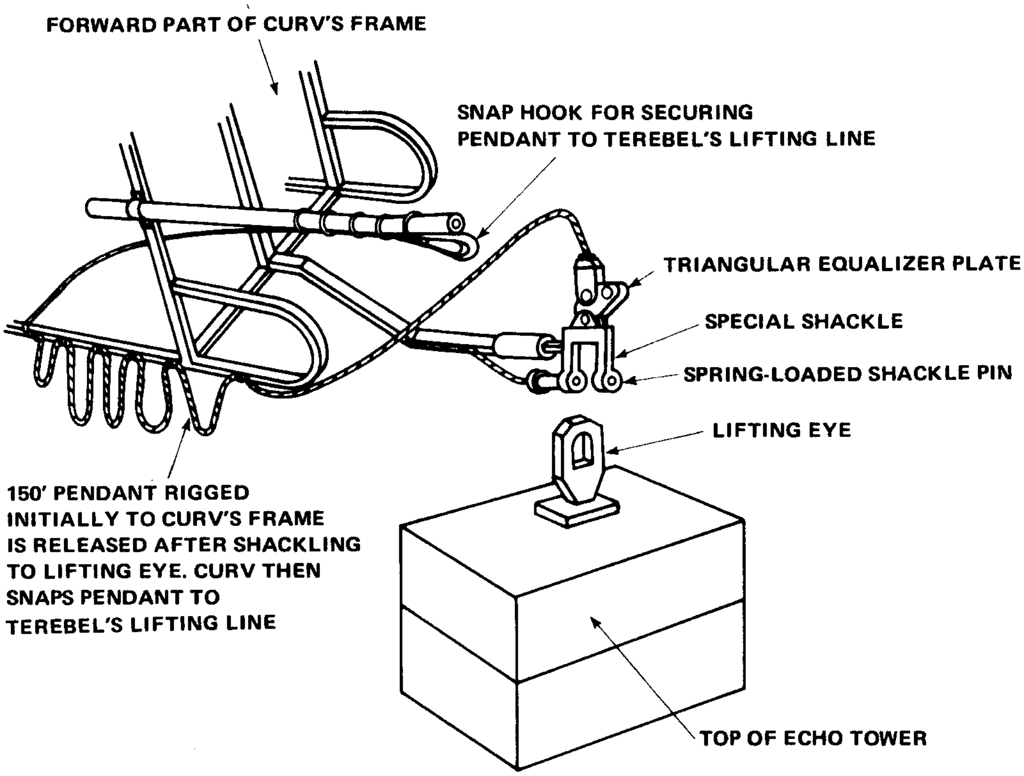
Because CURV could not exert enough force to prevent the lowering line from twisting during descent, the original plan of joining the lowering line and the shackle at the surface by a 150-foot pendant was altered. Provisions were made to attach both ends of the buoyant pendant to CURV's manipulator. The shackle would be attached to the release mechanism and the other end fitted with a snap hook lashed to the side. Since the maximum horizontal transverse CURV could make from beneath NAUBUC was 1200 feet, the spacing between TEREBEL and NAUBUC during the hookup of the buoyant pendant was limited to that distance.

The procedure, as it was developed, called for CURV to descend, attach the shackle, and then release it. A 6-inch 2 in 1 Sampson nylon braided line 120 feet long would be attached to the shackle. A snap hook would be attached at the other end of the nylon line.



CURV with pyranol torch attached severs cable on the ocean floor.

PYRANOL TORCH FOR UNDERWATER CUTTING OF AFAR RANGE CABLES



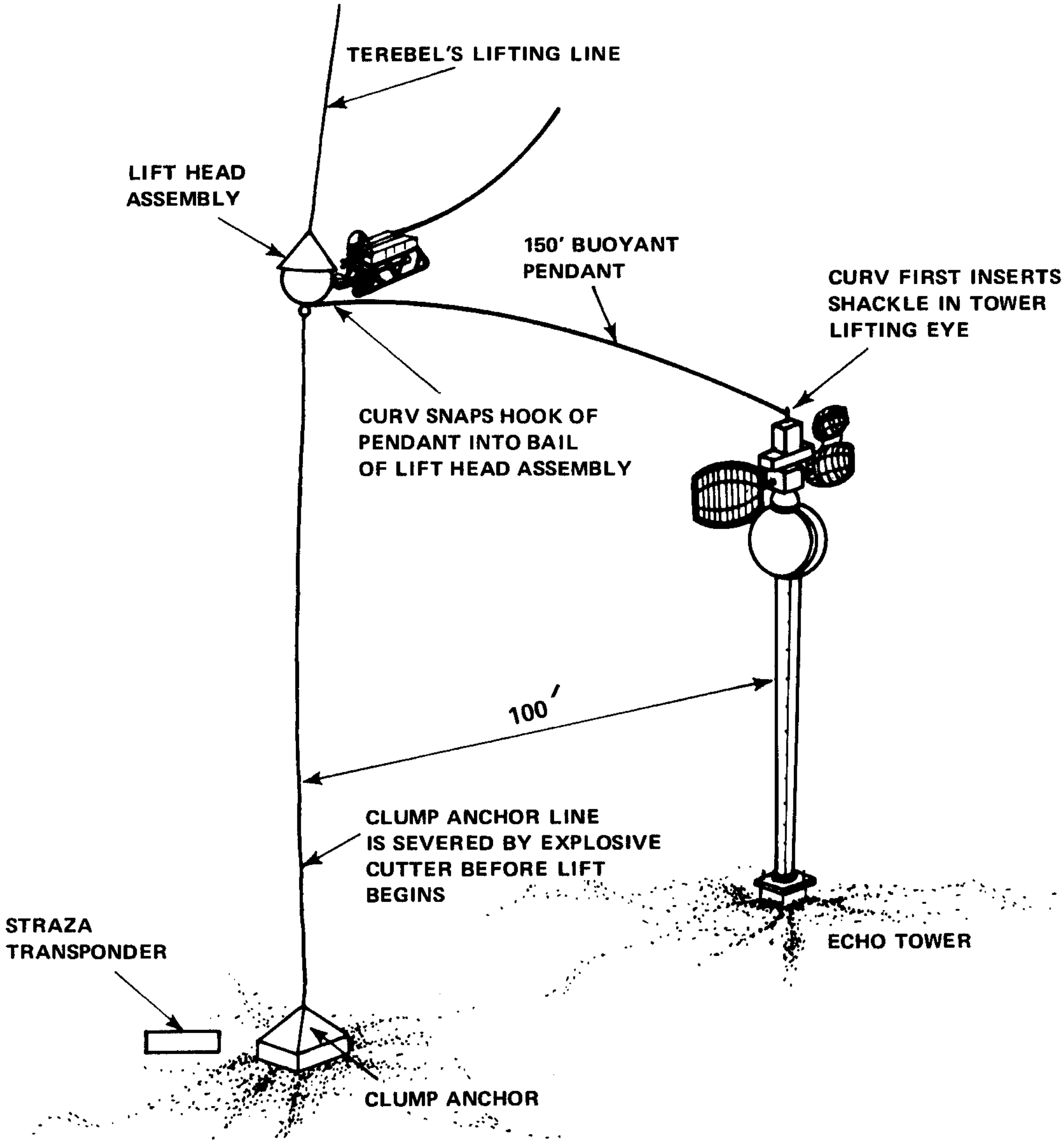
CURV attaches shackle. Explosive bolt, fired electrically from surface through CURV's tethers, drives home the shackle pin. Mechanism in CURV's manipulator assembly releases shackle.

SPECIAL SHACKLE DESIGNED BY SUPSALV FOR INSERTION INTO ECHO TOWER'S LIFTING EYE

CURV would then swim to the TEREBEL line and snap the hook onto the cable bale beneath the armor termination device, the only centerline attachment point available. After tension had been applied, CURV would then inspect the shackle.

THE 1971 AFAR TASK FORCE

The 1971 AFAR task force consisted of six vessels from three nations. From France came the lowering ship, TEREBEL, the cable repair ship, MARCEL BAYARD, and the transport ship, FRANCOIS BLANC. HELGOLAND, a high seas tug, came from West Germany. From the United States came the USS KIOWA, a high seas tug and the USNS NAUBUC, a cable laying and salvage support vessel with CURV III.



CURV connects one end of pendant to ECHO tower lifting eye, then uses snap hook to connect other end to TEREBEL's lifting line. Task force had planned originally to secure pendant to lifting line on the surface. It adopted this procedure to keep lines from fouling.

CURV SECURES ECHO TOWER TO TEREBEL'S LIFTING LINE

Lowering Ship, TEREBEL

The French lowering ship TEREBEL is equipped with a dynamic suspension system for lowering massive loads and a computer-controlled thruster for holding her position. For the 1971 operations it was planned to use a double pulley on TEREBEL as the key means of raising ECHO tower from a depth of 2000 feet. With this approach the tower could be brought under the TEREBEL easily on a simple and relatively light line thus enabling the larger lowering line to be more easily connected. The United States-France interface for raising the tower would be at the special shackle installed in ECHO's lifting eye by CURV.

Cable Layer, MARCEL BAYARD

Assigned cable laying and cable-related tasks was the French cable layer, MARCEL BAYARD, which had been deployed to the Azores in February 1971 to retrieve cables laid during the 1970 AFAR operations. These receiver cables, retrieved near the shore end and near NOVEMBER and SIERRA towers, were sent to New London, Connecticut for evaluation by NUSC. For the 1971 summer operations, MARCEL BAYARD transported NOVEMBER and SIERRA receiving cable from England, recovered the old cables, and laid new ones.

Berthing Ship, FRANCOIS BLANC

The French ship FRANCOIS BLANC provided at sea berthing for French personnel and for 15 United States personnel during the 1971 AFAR operations. As a berthing ship or "hotel," FRANCOIS BLANC accompanied the TEREBEL, HELGOLAND, and KIOWA in their ECHO tower work. This work included raising the tower, preparing it for tow to Ponta Delgada for repair, and reimplantment, and involved at-sea operations lasting several days.

FRANCOIS BLANC also served as the transport ship for transporting the derricks and their related material from France and assisted in their assembly and disassembly. France, with the responsibility for lifting ECHO tower from the water to the pier at Ponta Delgada, had decided that erecting temporary derricks would be most efficient. On 17 July these derricks lifted ECHO tower from the water without incident.

Diving Platform, HELGOLAND

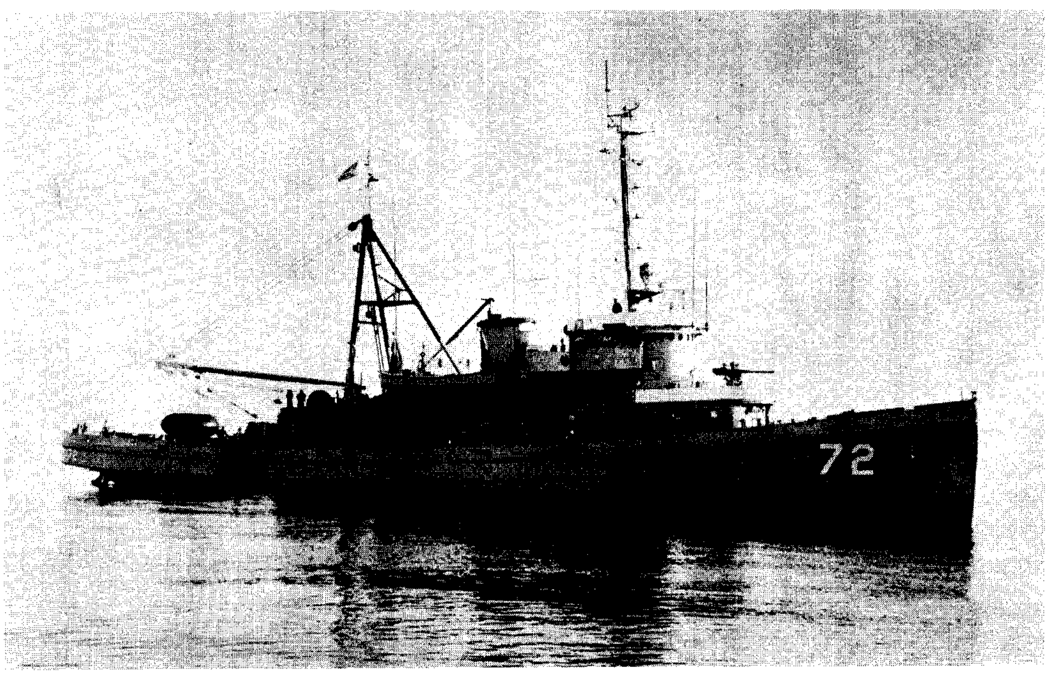
A high seas tug from West Germany, HELGOLAND is equipped with a team of naval divers, a double decompression chamber, and a diving doctor. For the 1971 operations, HELGOLAND towed TEREBEL to and from Ponta Delgada and as a diving support platform, assisted in the retrieval, towing, and reimplantment of ECHO tower.

High Seas Tug, USS KIOWA (ATF-72)

USS KIOWA, a high seas tug which could tow, handle diving equipment, and provide berthing, communications, and a machine shop was used by the United States for the AFAR operations. KIOWA towed the NAUBUC, provided communication services for AFAR units, transported BRAVO buoy to the implantment site, and assisted in ECHO tower's lifting operations and some of the cable retrieval work.

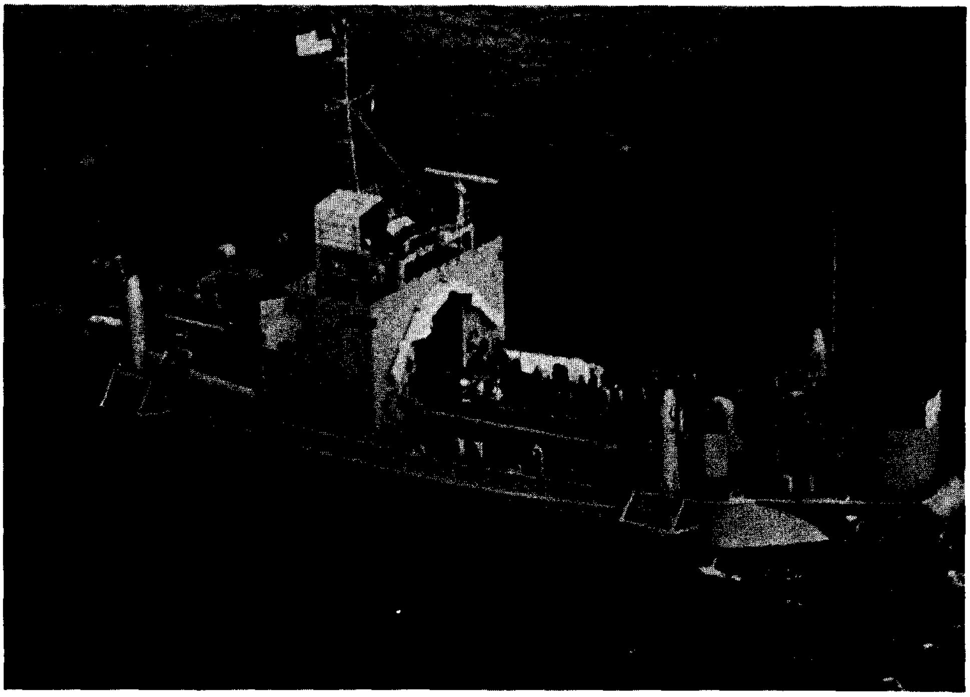
Salvage Tender, USNS NAUBUC (YRST-4)

The USNS NAUBUC was assigned to the 1971 AFAR project because her maneuvering, station-keeping, and cable handling capabilities make her one of the U.S. Navy's most useful ships for underwater cable work. NAUBUC is a self-propelled salvage craft tender with four 1225 HP diesel-driven thrusters, each of which is fully rotatable through 360



USS KIOWA towed NAUBUC between Connecticut and the Azores, assisted in the raising of ECHO tower, and transported BRAVO buoy (on fantail in photo above) to the implantment site.

USS KIOWA (ATF-72); HIGH SEAS TUG OF U.S. ATLANTIC FLEET



A converted net tender, NAUBUC has a dynamic positioning capability. The versatile salvage vessel was used as support platform for CURV, participated in BRAVO buoy implantment, and in cable work on the three antenna towers of AFAR range.

USNS NAUBUC (YRST-4), CABLE LAYING AND SALVAGE SUPPORT VESSEL

degrees and individually speed controlled. The thrusters are located on the port and starboard sides, two forward and two aft, and extend 21 feet below the ship's water line. The thrusters theoretically permit the ship to follow a predetermined track very precisely. The ship's dynamic positioning control system enables the propulsion equipment to be operated in several different modes, manual, semiautomatic or fully automatic. It is possible for NAUBUC to hold an exact position in 25-knot winds and state 5 seas. NAUBUC can turn in her own length, travel broadside at 3 knots, or spin on one spot rapidly enough to "dump" her own gyro.

During April and May 1971, in preparation for AFAR operations, NAUBUC conducted intensive underway training in Long Island Sound and practiced close-in maneuvering at the piers in New London. Training focused on the positioning, handling, and navigation of the ship under varying operational conditions and cable-laying operations.

CURV III (Cable Controlled Underwater Research Vehicle)

CURV is an unmanned vehicle with a 7000-foot depth capability. It can descend and ascend at a speed of 30 feet per minute. Transit speed underwater is about 3 knots when the vehicle is not in its search mode. The basic vehicle consists of an open aluminum rectangular frame to which support systems can be readily added to modify the vehicle for a particular task. Other components include the control cable, control console in a portable van, power supply and conversion equipment and surface handling equipment. Syntactic foam blocks attached at the top of the frame produce a slight positive buoyancy.

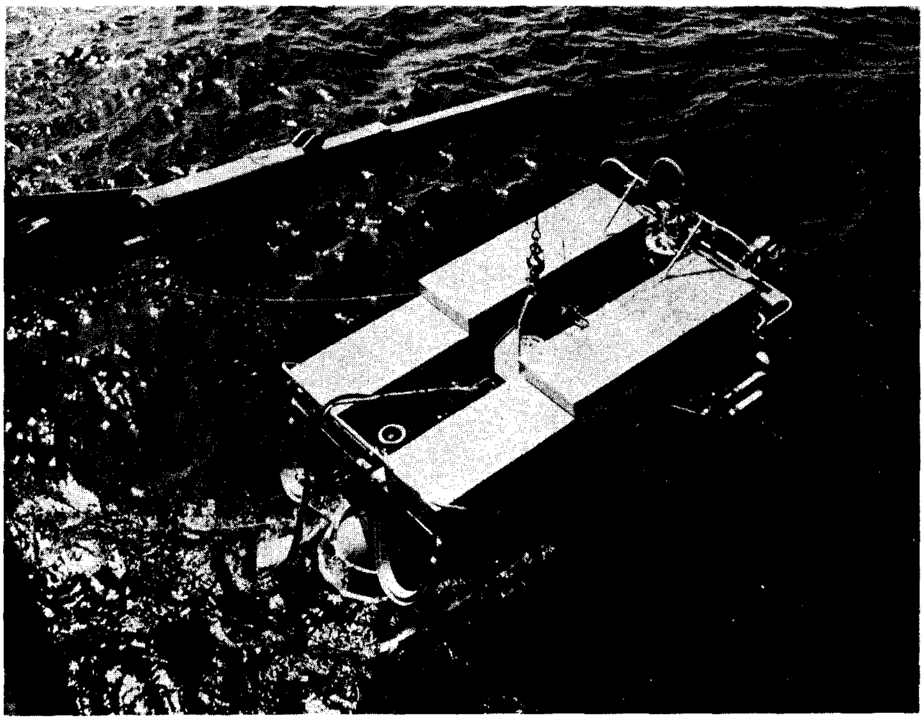
The support systems are mounted on the frame. They include optics, sonar, propulsion, hydraulics, compass, and tool assembly. Equipment includes active and passive sonar, two closed-circuit television cameras, a 35 mm camera, underwater lights, three 10-horsepower propulsion motors, and an electro-hydraulic command system. The control systems for CURV are all contained in a 10 x 10 x 20 foot closed van aboard the mother ship where the operator receives the information which determines the CURV's underwater location and its relative attitude, position, etc. The operator can then maneuver the CURV into the desired position to perform the desired task.

The general location of the worksite is initially established by surface navigation systems such as RAYDIST, radar, or LORAC. While the surface support ship keeps station at the worksite, CURV is launched and maneuvered to the bottom. Handling equipment ideally includes a 19-foot articulating crane capable of 5000-pound lifts for deploying and retrieving the vehicle, a hydraulic traction winch, and a davit and block for handling the nylon line and main cable. Once CURV is on the ocean bottom, a sonar search for the worksite is begun. Bottom time is limited only by the endurance of the topside personnel in the control van topside.

A sonar target is dropped from the support platform prior to deploying CURV. The vehicle is then deployed into the water and lowered to the bottom. CURV uses its CTFM sonar to close on the target and establishes its first search position on the bottom at the target location. The CURV's sonar has a 300-foot range, providing a sweep circle of 600-foot diameter from one search position. The vehicle sits on the bottom, pinpointing all targets in a 120-degree sector. Control personnel topside then turn it 60 degrees to begin a new sector, repeating the maneuver until the full 360 degrees have been covered, locating all likely targets.

Control personnel then maneuver the CURV vehicle to investigate the targets located on the sonar sweeps, using the television screen to help identify and classify the targets as they appear. This part of the maneuver is very exacting when hunting a small object. Almost every object appearing on the sonar screen must be checked out with the television system to ensure that the real target is not overlooked. After completing its initial circle, the vehicle is maneuvered back to its original search position, closing again on the sonar target. It is then deployed to a new search position, using its active sonar and compass to mark range and bearing from the first position. The search pattern is then repeated. The sonar identifies new targets; the television system investigates the targets; and then the CURV establishes a new search circle. This technique of overlapping successive search circles has a high probability of locating the target object if it is, indeed, located in the area of the search datum point. If it is not found, then the search continues by deploying the vehicle to a new base point.

Using a tool assembly that projects forward from the bow, CURV can do useful underwater work. Various types of tools and lifting devices, as required for a particular task,



Vehicle's manipulator tool assembly for underwater work projects forward from bow, upper right in photo. Blocks of solid syntactic foam arrayed on frame provide positive buoyancy, assisting propulsion system in controlling vehicle underwater.

LAUNCHING CURV VEHICLE FROM NAUBUC'S DECK

can be mounted on the assembly. At various times during the AFAR operation, the cable grabber, pyranol torch cutter, and specially designed shackle were each mounted on the assembly to perform their designated tasks.

Functioning of NAUBUC/CURV Team

NAUBUC and CURV worked together very efficiently during the AFAR operation. NAUBUC's dynamic positioning capability enabled CURV to check as much as 1.5 miles of cable in a single run and also facilitated CURV's underwater work in the task of locating ECHO tower and preparing it for lift to the surface.

Other underwater tasks performed by NAUBUC and CURV together included surveying bottom areas for laying cable; finding and identifying previously laid cable; placing the specially designed pyranol "torches" against selected cables and cutting them to permit lifts; placing the special cable grabbers on various cables in a locked position so that the cable could be raised to the surface; and providing means for the special cable splicing teams to do their work aboard the NAUBUC. Each of these tasks was successfully accomplished by the NAUBUC/CURV team, thus making a decisive contribution to the success of the 1971 AFAR implantment operations.

CONDUCT OF 1971 AFAR OPERATIONS

Initial Activities, 18-25 June

The USS KIOWA, with USNS NAUBUC in tow, arrived in Ponta Delgada, San Miguel, Azores on 19 June. CURV had arrived the previous day and was ready for placing on NAUBUC as rapidly as deck space became available.

The first operational task for the NAUBUC/CURV team was to inspect the ECHO tower site. On 23 June CURV was launched for the first time from NAUBUC's deck. However, CURV was unable to locate ECHO tower because NAUBUC had not been placed at the correct site. At a new site on 24 June, CURV located the tower and inspected its base. CURV was then maneuvered up to the top of the 120-foot tower for a close-in look at the lifting eye.

In order for the tower to be lifted later for repairs, it was necessary that the lifting eye be clear to receive the specially designed shackle that CURV would attach later. Although the eye was clear enough at the top, a couple of wire rope pendants passed through it at the bottom and these were attached to a deflated salvage pontoon. These pendants were later burned free by CURV. After CURV was clear of the tower, a STRAZA transponder string was dropped to establish an underwater/surface position reference to aid in locating the tower later.

Inspecting NOVEMBER Tower and BRAVO Buoy Shore Cables, 26-27 June

On 26 June CURV inspected NOVEMBER tower and its cable. Using the pyranol torch cutter, CURV cut the large (2.8-inch diameter) armored cable at the specified position. The location of the cable on the bottom was then marked with a sonar reflector for later acquisition by CURV during the cable recovery phase.

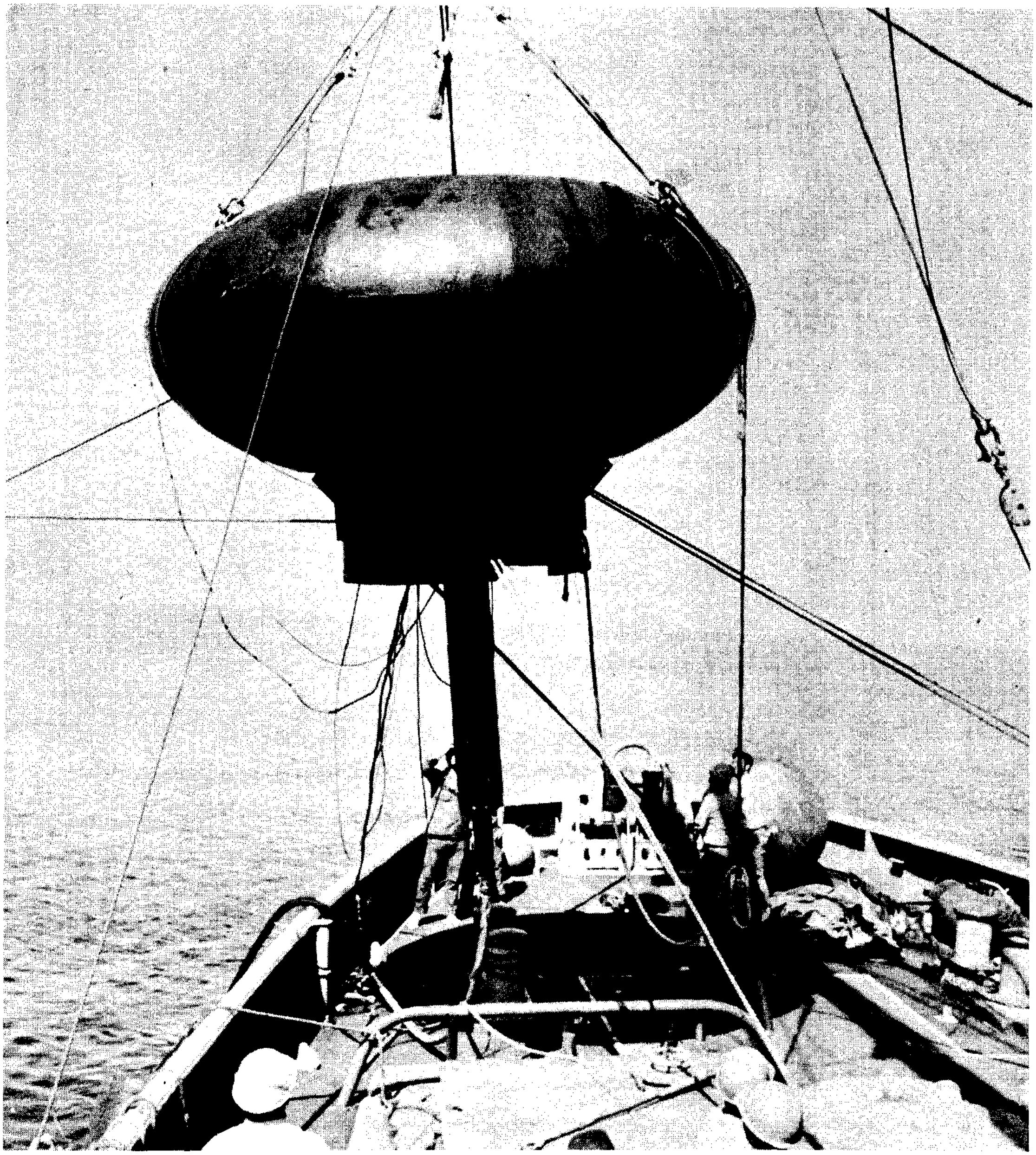
CURV inspected the shore end of the BRAVO cable on 27 June for most of the distance to the steep submarine cliff near the island. Part way up the cliff, CURV began to lose power and became dead in the water. The trouble was found to be caused by condensation from the van air conditioner dripping into the control board circuits. NAUBUC returned to Ponta Delgada.

First Attempt to Implant BRAVO Buoy, 28 June - 3 July

NAUBUC spent 2 days in port loading materials for implanting BRAVO buoy; the buoy itself was transported to the implantment area by KIOWA. CURV equipment was unloaded since it was not required for the buoy implantment operation. Equipment loaded aboard NAUBUC was stored in reverse order of need. Items that would be used first during the operation were stored in the most readily accessible areas. Thus, the first thing stored in NAUBUC's cable tank was the crown/lowering line with eye for mooring leg #3. Next, and on the same level, was buoy leg #3 with the buoy end on top. Next was stored the crown/lowering line with eye and buoy leg for mooring leg #2, again with the buoy end on top. This was followed by the same equipment for leg #1, also with buoy end on top. Also stored were 24-foot pendants for shackling into the top end of each crown line when deployed.

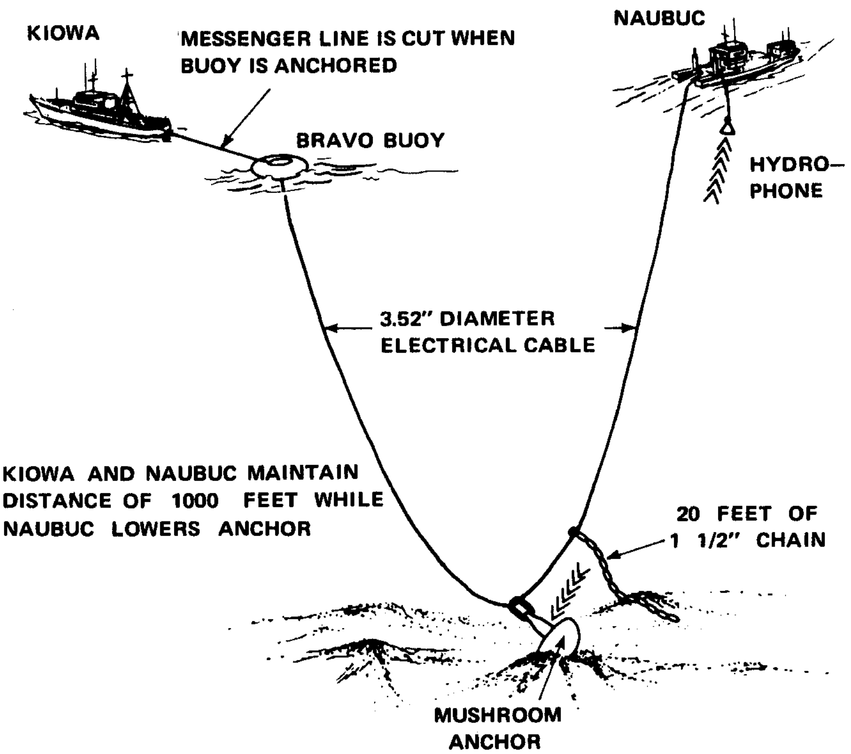
Other equipment was also stored on the NAUBUC, including a 1-inch line with free access for lowering the top end of the crown line over the stern for attaching to the crown buoy, an 8.4-ton pontoon, and on deck, 2-inch shackles for shackling the lowering line onto the 18,000-pound clump anchors. On top of the buoy legs and crown lines, the BRAVO cable was loaded with the shore end on the bottom and the buoy end free on top.

By 2000 on 29 June, nearly 8 miles of jute-covered, armored cable for the environmental buoy had been stowed in the NAUBUC's cable tank. The cable loading operation had taken almost 16 hours because of the distance between the storage bin and ship (about



BRAVO, oceanographic buoy for underwater environmental measurements, is 13 feet in diamater and weighs 5000 pounds in the air. KIOWA, NAUBUC, and CURV teamed up to implant the huge buoy in 1971 AFAR operations.

BRAVO BUOY ON FANTAIL OF KIOWA



NAUBUC first passes cable end to KIOWA for connection to BRAVO buoy. KIOWA then launches buoy. NAUBUC pays out cable and attaches anchor. NAUBUC then bottoms anchor and lays cable to shore station.

PROCEDURE FOR IMPLANTING CABLE FOR BRAVO BUOY

100 feet), the great amount of friction from the tarred jute on all sliding surfaces, and the rigidity of this type of cable. A Kellams grip was placed 2035 feet from the bitter end of the cable, last into the tank.

NAUBUC then deployed for the buoy implantment area off Santa Maria. Four British cable splicers were on board and they immediately began preparing the cable termination to be connected into BRAVO buoy.

On 1 July at 0430 buoy implantment operations began. KIOWA took position 200 feet abeam and hauled in the buoyed off cable termination as NAUBUC payed out the cable. When the cable was on board, KIOWA attempted to connect it into the large buoy on her fantail. This task took 2 hours to accomplish because the connection required extensive grinding before it would fit.

When the connection had finally been made, KIOWA hoisted the large buoy with cable end attached over her side, unhooked it, and stood clear. NAUBUC towed the buoy to the implant position; KIOWA payed out the cable and attached the mushroom anchor and shot of chain at the Kellams grip, 2035 feet from the end. Continuing to pay out cable while holding position, NAUBUC bottomed the anchor.

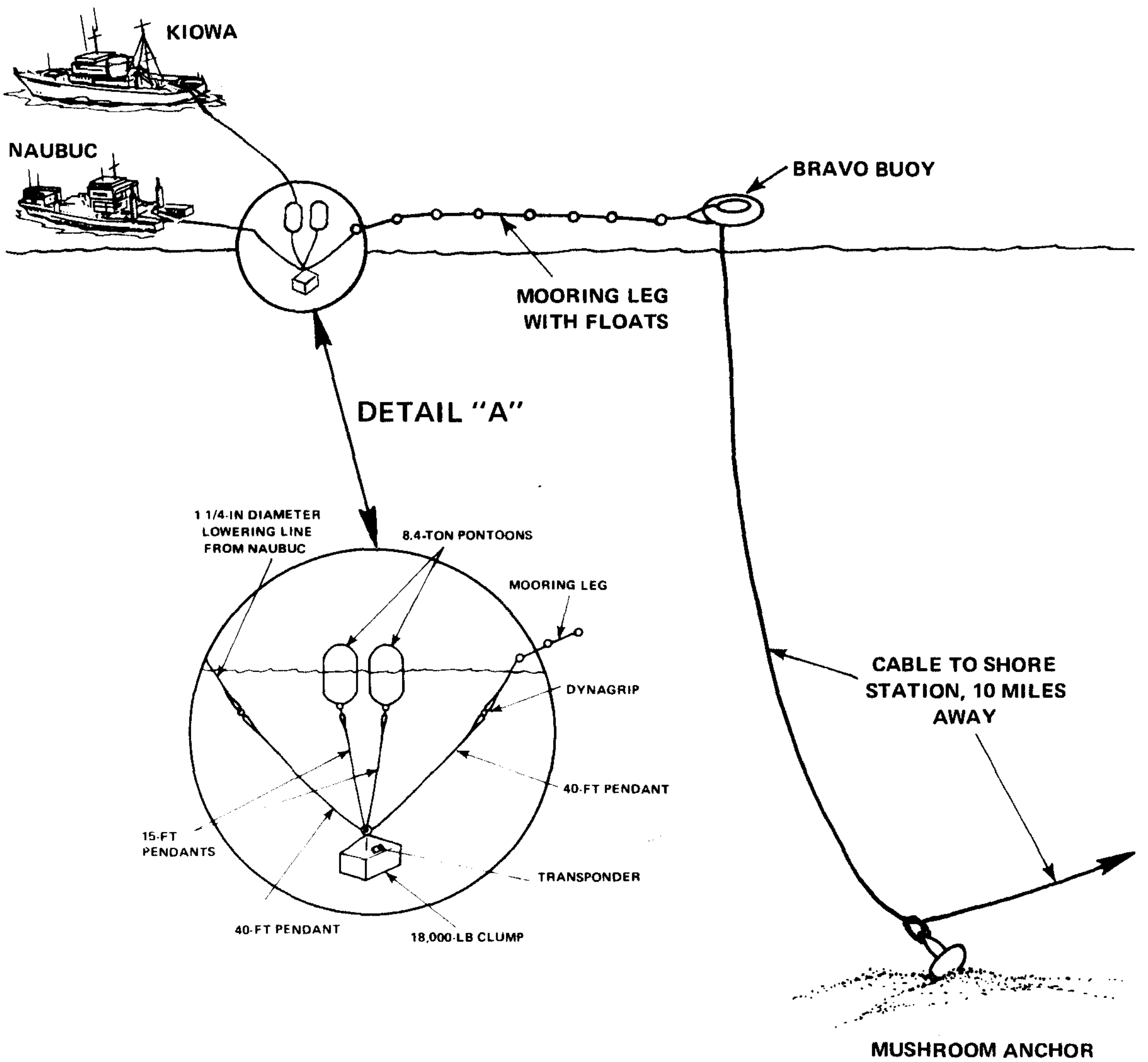
NAUBUC then moved away, along the track toward the shore station, laying cable as she went. The 8 miles of cable were payed out at over 200 feet per minute and the ship moved ahead at about 3 knots, keeping the tension on the cable at about 5000 pounds. By 1615 on 1 July NAUBUC had completed this part of the task, with the lowering of the end to the bottom on a length of 1-inch braided nylon which was then shackled onto a spherical steel buoy (54-inch diameter).

The next task was to place the three mooring legs of the buoy. On 2 July work began at 0430 with the final rigging of the foam flotation units on the buoy end of leg #1. The ship was positioned 100 yards from the buoy and on the correct heading for this leg. After divers connected the leg to the buoy, this cable leg was payed out and foam floats were clamped on every 25 feet.

When the entire leg was out and floating, KIOWA ranged alongside and received the "clump end" of the leg from NAUBUC to shackle into the 18,000-pound clump rigged on her rail. KIOWA also received the clump end of the wire lowering line which was already rove through the cable machine. When KIOWA launched the two 8.4-ton salvage pontoons with the clump suspended from them, NAUBUC picked up on the 1 1/4-inch wire and positioned the clump at the stern chute, ready for lowering. KIOWA moved clear and NAUBUC moved into position and lowered the clump in about 12 minutes.

The cable machinery performed quite satisfactorily (12,000-pound machine lowering an 18,000-pound clump) and was even able to stop lowering without any creeping of the 1-inch wire. The small "kluge" brake, made by NUSC for an external means of stopping the wire from slipping, was used. The clump was planted exactly on target, according to NUSC representatives who were providing the navigation information. This leg was planted by 1350.

Buoy leg #2 was rigged during the afternoon and evening of 2 July but was not planted because of insufficient light. It was buoyed off at 2130. Planting began at 0430 the next morning. First, the "clump end" which had been buoyed off the night before had to be retrieved. As the NAUBUC was maneuvering close in to retrieve the floating leg #2, the leg was caught in the #3 thruster. The thruster was immediately secured and divers cleared the line in a few minutes. KIOWA ranged alongside and transferred the 18,000-pound clump on the lowering wire to the NAUBUC.



NAUBUC first passes mooring leg to KIOWA where it is attached to 18,000-pound clump. KIOWA then lowers whole assembly (Detail "A") over the side. NAUBUC takes up slack on lowering line and swimmers remove pontoons. NAUBUC then places clump on bottom at proper location using RAYDIST navigation fix.

PROCEDURE FOR RIGGING AND LOWERING BRAVO BUOY MOORING LEGS

With KIOWA clear, NAUBUC began maneuvering to get leg #2 onto the proper azimuth. It required nearly 2 hours to tow the buoy leg around to the correct position for lowering because of the long string of floats attached to it and the distance it had drifted out of position during the night. At 1112 NAUBUC began lowering the clump anchor and 19 minutes later it was at the bottom, in 2300 feet of water, within 100 feet of the selected spot, a satisfactory position.

Rigging for buoy leg #3 began immediately and was ready for attachment to the buoy at 1500. As the divers attached this leg to the buoy, the electronic instrumentation package and attached cable suspended inside the buoy, suddenly carried away and fell to the ocean floor. The welded lugs securing the package had sheared off. There was nothing to do but retrieve leg #3 on board NAUBUC, secure this implantment effort, and return to Ponta Delgada.

In Port For Repairs, 4-7 July

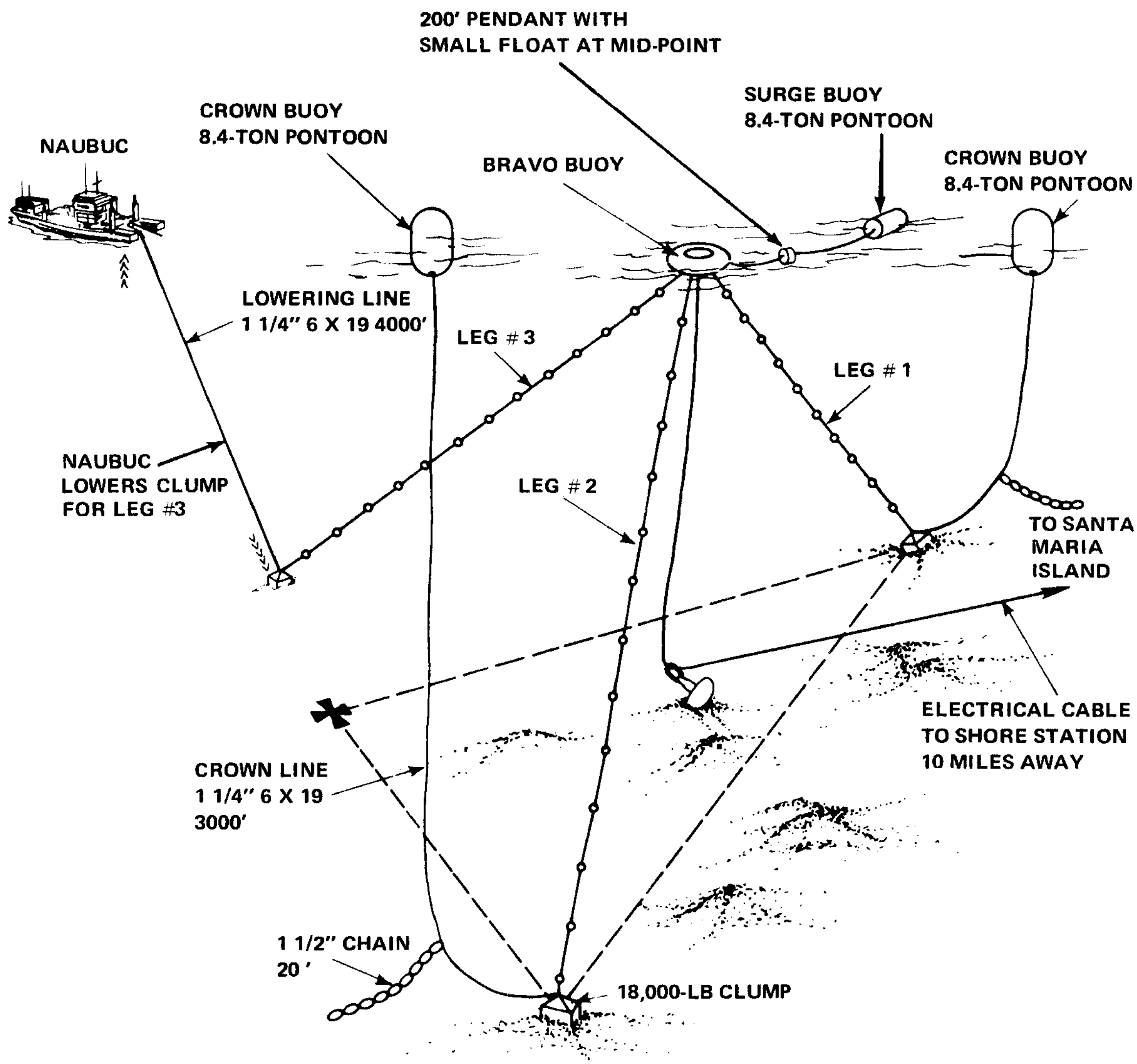
During the time NAUBUC was in port, the problem with #3 main engine was determined to be a timing maladjustment between the left and right cylinder banks caused by a nearly disconnected flexible coupling on the injection pump drive assembly. Most of the bolts in the coupling had sheared and excessive play had torn most of the steel shims. A similar condition was found to be developing on #4 main engine, but it had not yet progressed far enough to cause poor engine operation.

Immediate contacts were made for a local machine shop to supply new bolts and shims for the ship's crew to make temporary repairs. A cablegram was sent to Murphy Pacific Marine Salvage Company, requesting four complete dive assemblies, since no spares of this type were carried on board. In addition, a failure occurred on the drive shaft for the blower on the ship's #2 service generator while in port. This was temporarily repaired by machinists aboard the West German tug, HELGOLAND. NAUBUC has no machine shop equipment or space.

On 6 July CURV was back on board the NAUBUC. Because it had surfaced "dead" on 27 June and was not needed during the buoy implantment operations, it had remained at Ponta Delgada, being completely overhauled, reassembled and tested. Now it was fully operational again.

ECHO Tower Rehearsal Operations, 7-11 July

With preparations for the ECHO tower retrieval operation completed, NAUBUC and CURV, along with KIOWA, HELGOLAND, TEREBEL, and FRANCOIS BLANC left port and steamed to a site about 13 miles southwest of Ponta Delgada which had been selected as



BRAVO buoy is on surface with cable and first two mooring legs laid. NAUBUC lowers clump for leg #3 to bottom, pulling BRAVO buoy underwater. NAUBUC then tows the clump until surge buoy is watching, indicating that BRAVO buoy is at 200-foot depth.

PROCEDURE FOR IMPLANTING THIRD MOORING LEG OF BRAVO BUOY

the location for the ECHO tower rehearsal operation. It had been decided that a rehearsal was necessary in order to familiarize the task force with the equipment and procedures for recovering ECHO tower.

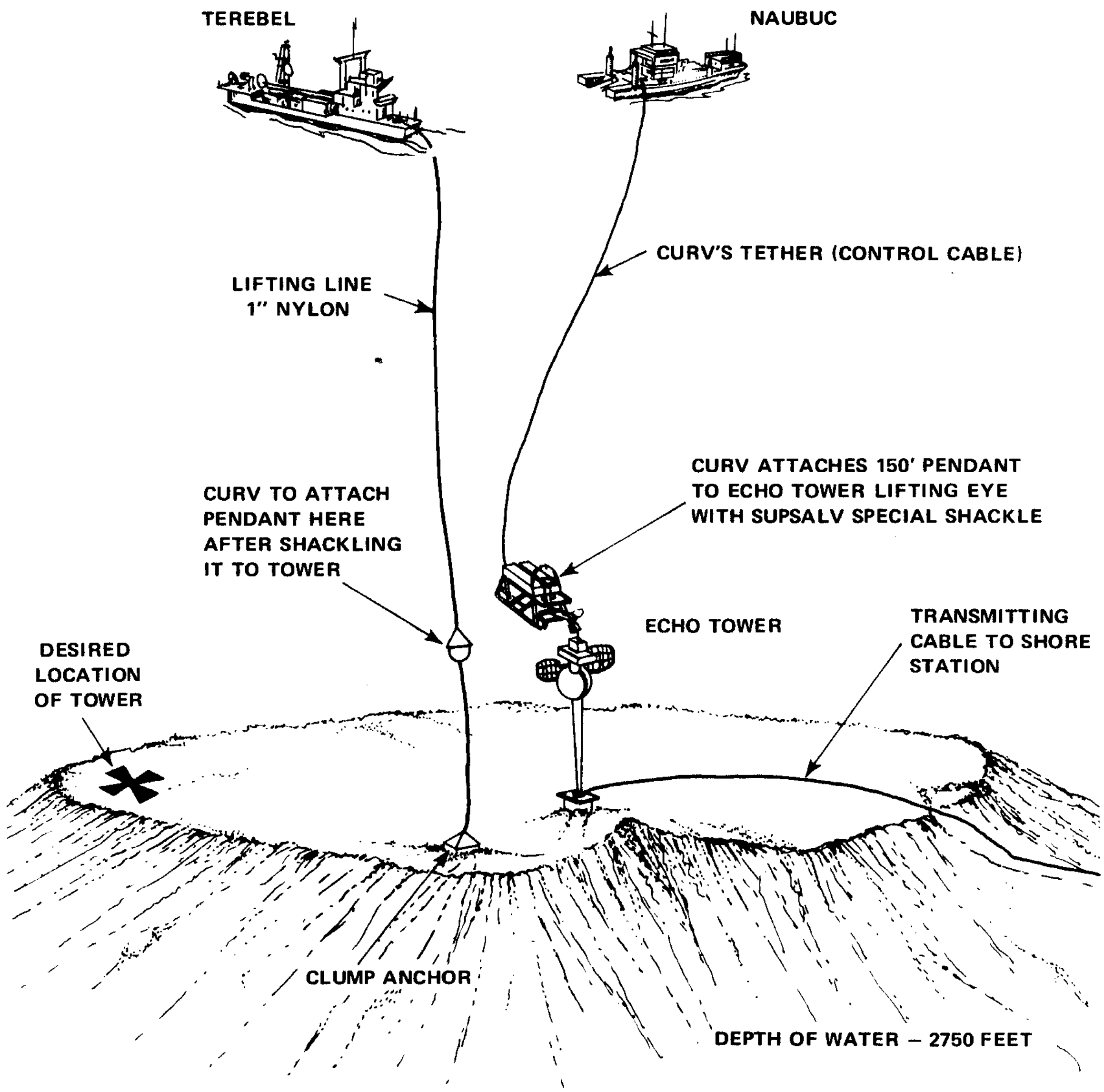
Simulating ECHO tower during this rehearsal was a spare lifting eye which had been modified at the New London Laboratory, NUSC to make it identical to ECHO tower's lifting eye. A mounting platform was also constructed to support the eye in the proper attitude off the bottom so CURV could approach it. This structure, or practice tower, had been shipped from NUSC to the Naval Underwater Research and Development Center, San Diego, California where it was rigged with lines to simulate the ECHO tower eye. The structure was 8 feet tall, had a water weight of 2500 pounds, and contained a 22-inch diameter steel sphere near its upper end that served as a sonar target.

After arriving at the selected site, NAUBUC surveyed the bottom for a level area to plant the practice tower. When the position was determined, NAUBUC took station and the tower was lowered on a 1-inch braided nylon line with an acoustic release at the tower end. When the tower was bottomed, the release was actuated acoustically and the lowering line retrieved.

NAUBUC began station-keeping near the tower to enable CURV to reach it, but CURV could not be launched safely because of 30-knot winds and over 5-foot seas that were prevailing at this time. The weather did not improve during the next several hours so operations were suspended and all ships returned to Ponta Delgada.

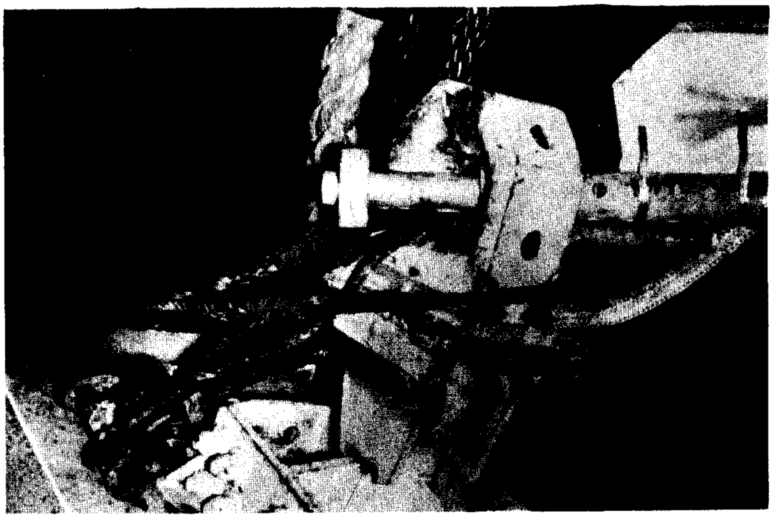
Early on 11 July the ships were underway again and steamed to the test tower site. The wind was down to 10 knots and the seas about 2 feet with a minor ground swell. NAUBUC took station over the tower and launched CURV at 0900. At 1015, CURV was positioned on the bottom, 15 yards from the test tower. TEREBEL was then maneuvered into position 300 yards abeam of NAUBUC. TEREBEL lowered the line with clump anchor and lift head assembly.

When CURV acquired the clump on its sonar, the TEREBEL was coached to "walk" the clump slowly toward the tower until it was planted just 25 yards away. CURV immediately maneuvered the special shackle into the lift eye of the tower. The snap hook was then carried to the lift head assembly on the lift line and snapped into the bail. CURV swam clear while TEREBEL maneuvered over the tower and lifted it to just under the surface. From there it was rerigged to be supported by a salvage pontoon, cast free from TEREBEL and taken by HELGOLAND and lifted to its deck. CURV was retrieved on board NAUBUC and the test exercise was completed.

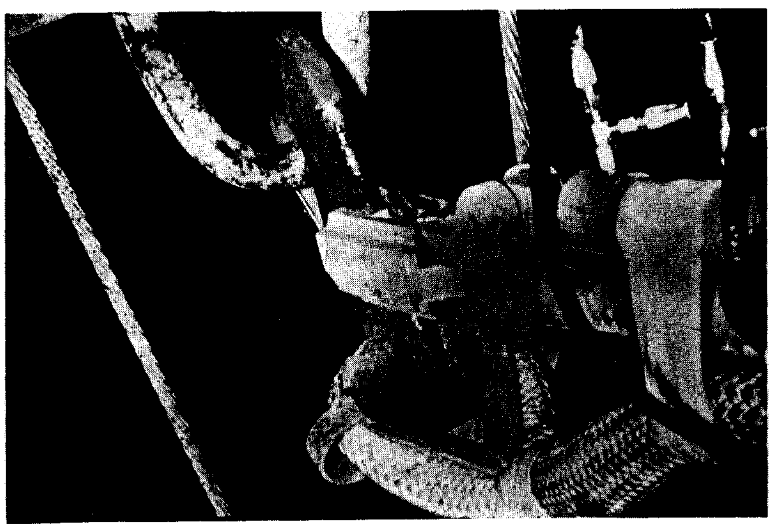


After CURV acquires clump on its sonar, NAUBUC coaches TEREBEL in "walking" clump to within 25 yards of tower base. CURV shackles one end of pendant to tower lifting eye and the other into TEREBEL's lifting line. The transmitting cable is cut and TEREBEL proceeds with the lift.

NAUBUC/CURV TEAM ASSISTS TEREBEL IN RAISING ECHO TOWER



Special shackle inserted by CURV into ECHO tower lifting eye. Nylon pendant is attached to shackle, snap hook on opposite end of pendant.



CURV attaches snap hook to TEREBEL's lifting line, linking tower and lift ship.

UNDERWATER CONNECTIONS MADE BY CURV FOR RAISING OF ECHO TOWER BY TEREBEL

Raising ECHO Tower, 12 July

The task force steamed overnight to the ECHO tower site. CURV was launched at 0935 on 12 July and took position on the bottom, 15 yards from the tower base, at a depth of 1750 feet. TEREBEL was stationed 300 yards abeam of NAUBUC to lower the lift line.

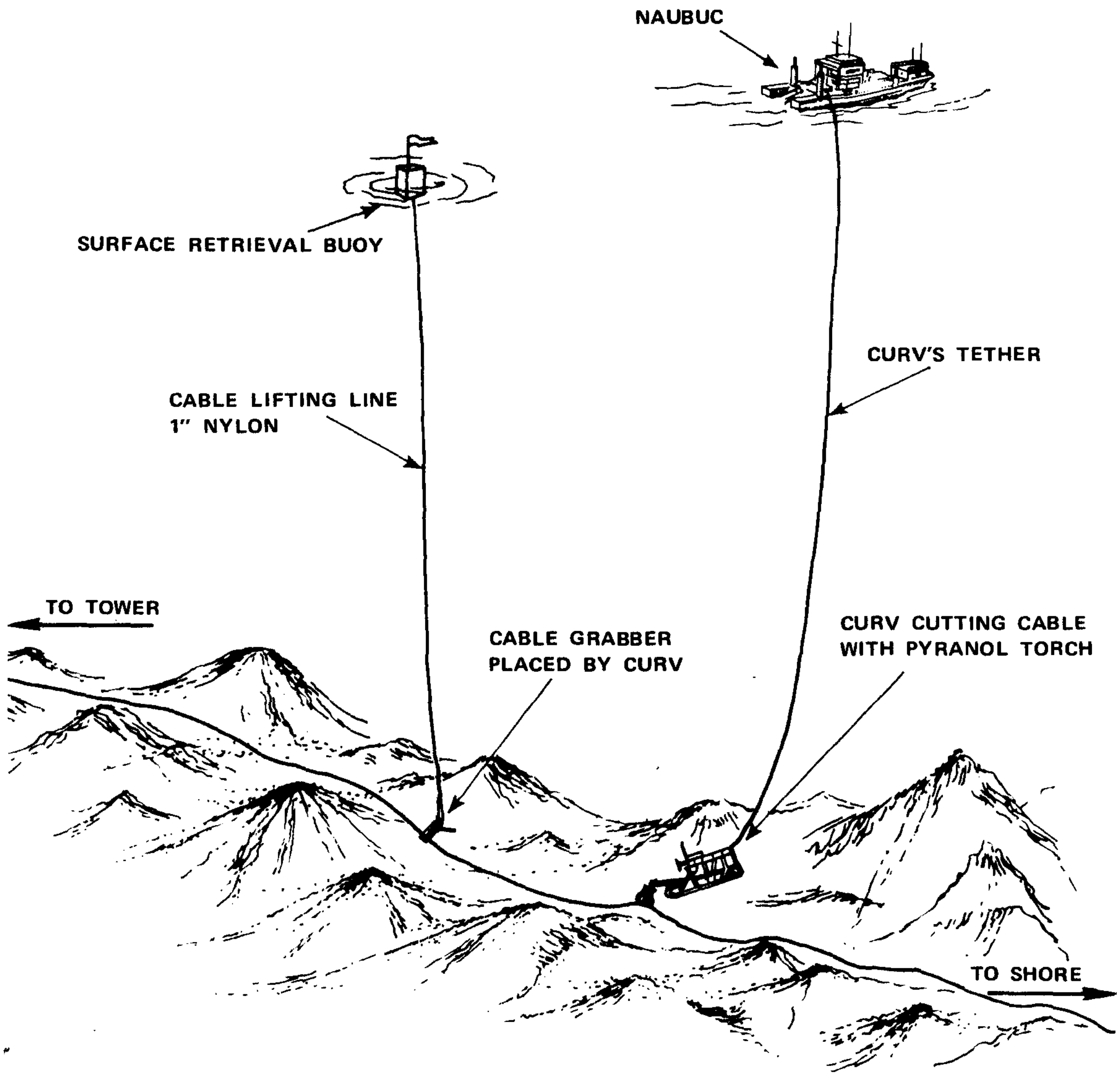
The operation was a repeat of the practice run the day before and all went smoothly. By 1430 CURV had placed the special shackle in the lift eye of the 120-foot tower and the snap hook engaged in the lift head bail. CURV then swam clear. A turn of CURV's umbilical cable was found to be around the lifting line from TEREBEL, but could not be readily located for clearing. Therefore, the tower was lifted carefully as CURV's cable was retrieved. Near the surface CURV was able to clear itself and was taken aboard at 1745. TEREBEL continued lifting the tower and rigging it for towing to Ponta Delgada with the help of HELGOLAND and various diving teams.

NAUBUC/CURV Operations, 13-17 July

On 13 July, as the other ships continued to prepare ECHO tower for towing, NAUBUC and KIOWA left to buoy off and attach a tag line to the shore end of the NOVEMBER tower cable for later lifting by the cable repair ship, MARCEL BAYARD. Despite an 0530 starting time, a series of minor delays occurred throughout the morning, frustrating the work attempts. CURV's first dive was aborted when the mechanism to trigger the cable grabber operated prematurely and the vehicle had to be retrieved on board and rerigged. Next, the motor whaleboat on KIOWA developed a transmission fluid leak. This delayed the tending operation of the 1-inch nylon buoy line with which CURV was to descend. Finally, NAUBUC delayed operations when the solenoid valve on the clutch to #2 thruster "hung up," and the clutch could not be disengaged in normal fashion.

CURV was finally launched at 1230. It swam to the bottom and placed the grabber on the shore end of the NOVEMBER cable. The line was then buoyed off with a 48-inch steel buoy. An evening dive, conducted from 1630 to 2010, surveyed the bottom in the specific area of the planned cable track.

NAUBUC and CURV then proceeded to the site of the BRAVO buoy cable splice. At 0600 on 14 July CURV descended to cut the cable, laid in 1970, and bring its shore end to the surface. This end was to be spliced to the end of the length that NAUBUC had laid on 1 July from the buoy to the shore. Two dives were required to cut the cable and then a third dive to place the cable grabber on the end running to the island. The cable was then buoyed off for raising later. Three British cable splicers arrived on board to prepare for the next splicing task.



CURV's cable cutting operations were similar for all three towers. In each case, CURV clamped the cable grabber to the cable, thus securing the lifting line and buoy to the cable, and then cut the cable on the shore side. Later this buoyed-off cable stub was picked up by MARCEL BAYARD, and new cable from the shore spliced to it.

NAUBUC/CURV TEAM CUTS AND BUOYS OFF AFAR ANTENNA TOWER ELECTRICAL CABLES

On 15 July the "old" BRAVO shore cable was spliced to the "new" BRAVO sea cable (single co-ax-single armor) by the British splicing team. By 1615 the bight was lowered over the stern and cast free.

NAUBUC and KIOWA then steamed to the BRAVO buoy site for further work on BRAVO buoy. Work on BRAVO buoy had been suspended on 3 July when the electronics package inside the buoy fell to the ocean bottom. CURV was launched at 1915 and retrieved 5 hours later; little had been accomplished.

During the morning of 16 July, CURV made a 2-hour dive attempt to place the grabber on the BRAVO buoy cable. However, CURV became fouled in the nylon line and had to be cleared by a swimmer near the surface before it could be brought aboard. Because of the strong current running on the bottom, the complicated rigging and vessel positioning required, and the ground swell developing, other methods by which CURV could place the grabber on the cable were considered. Ultimately, it was decided that all such alternatives would only introduce greater risks of loss or damage to the vehicle and this cable recovery effort should be rescheduled for better sea conditions.

Divers began rigging the BRAVO buoy for pick-up by KIOWA and return to port for reworking before final implantment. By 1848 they had finished their work; BRAVO buoy was retrieved and once again on KIOWA's fantail. NAUBUC and KIOWA then steamed for Ponta Delgada.

In Port, 17-19 July

On 17 July ECHO tower arrived in Ponta Delgada for repairs, after a tow of about 50 miles, without incident. NAUBUC arrived in Ponta Delgada the same day to assist TEREBEL in maneuvering ECHO tower in the harbor.

Large stiff-leg cranes or derricks had been installed by the French to lift ECHO tower in and out of the water. TEREBEL towed the tower into the harbor and maneuvered the tower under the cranes where it could be engaged. NAUBUC supported TEREBEL in this effort, placing three 500-pound anchors to hold the tower in position for lifting and rigging necessary lines. During the next 2 days, NAUBUC remained in port loading the STRAZA sonar transponder strings which were to be used as a grid for the ECHO tower implant.

Disabling NOVEMBER and SIERRA Tower Pingers, 20-21 July

On 19 July, while ECHO tower was being reconditioned and KIOWA remained in port reworking BRAVO buoy, NAUBUC left Ponta Delgada for the NOVEMBER tower site to

On 17 July, NAUBUC (shown in photo) assisted in positioning ECHO tower (in water). NAUBUC also planted anchors to hold tower in position under the cranes for subsequent lift to pier.

ECHO TOWER ARRIVES IN PONTA DELGADA

disable the NOVEMBER tower pinger. The pinger unit was installed on the tower when it was implanted during the summer of 1970 with the intent that it would assist during implant and then "go dead" after 5 days. However, the pinger was still active after a year. It had to be disabled so as not to produce a sound which would interfere with the range acoustics.

During the morning of 20 July NAUBUC arrived on station at the NOVEMBER tower site and CURV was launched. Because the pyranol torch failed to burn, CURV had to mechanically tear the pinger loose in order to bring it to the surface. Since MARCEL BAYARD had completed the NOVEMBER tower cable work, NOVEMBER tower was now operational.

On 21 July, NAUBUC proceeded to the SIERRA tower site to disable the SIERRA tower pinger which was, as the NOVEMBER tower pinger had been, still active after a year. CURV was launched and located the pinger. CURV fired a torch on the pinger, but once again found it had to physically tear it free from the tower before the pinger became quiet. Meanwhile MARCEL BAYARD had spliced a 2-mile stub onto the SIERRA shore cable.

Planting STRAZA Sonar Grid, 22 July

NAUBUC and CURV planted a STRAZA sonar grid on 22 July at the ECHO tower site. The purpose of the grid was to establish an underwater/surface position reference to mark ECHO tower's position, thereby assisting TEREBEL and FRANCOIS BLANC in locating the exact site for reimplantment.

It had been originally planned to use CURV to locate the transponders accurately underwater. However, it was too late in the day to dive CURV and a free fall method was substituted. The four transponder strings were rigged on NAUBUC's deck and then lowered over the stern, just above the surface. NAUBUC then maneuvered into position. Each string was released to free fall to the bottom. Presumably some accuracy in bottom placement was sacrificed. However, it was a simpler and more efficient method than using CURV and it proved to be adequate in the subsequent implantment of ECHO tower.

BRAVO Cable Operations, 21-26 July

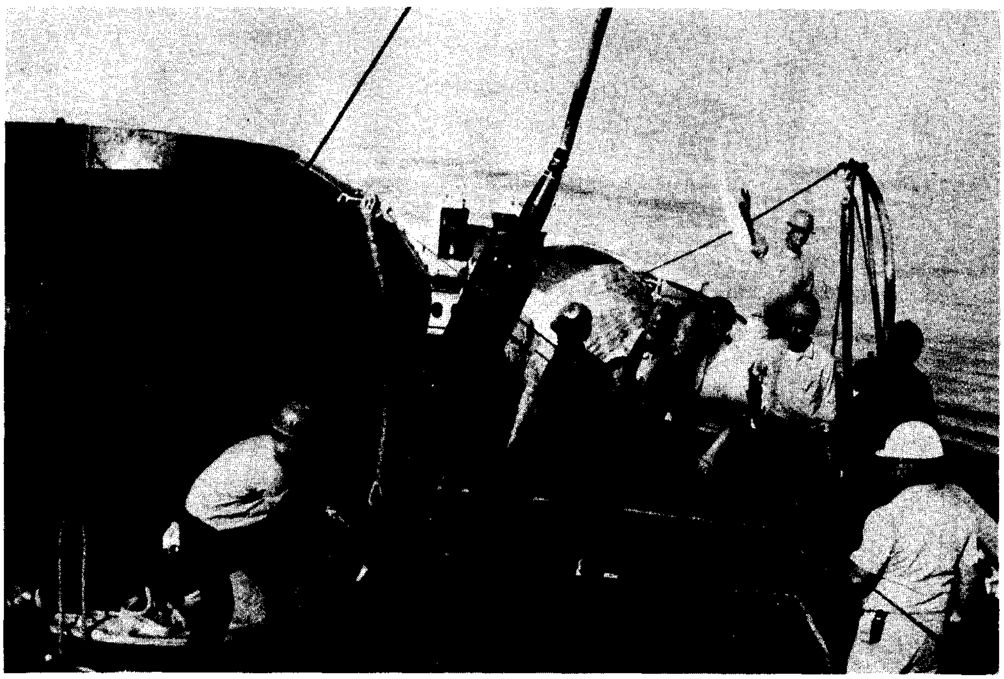
On 21 July NAUBUC again attempted to recover the end of BRAVO buoy cable with CURV. CURV was launched late in the afternoon. Poor navigational information placed NAUBUC incorrectly, thus preventing CURV from reaching the cable promptly. Thus all of the daylight hours were spent in useless searching too far from position. Before this dive ended, CURV's cable had been fouled in the #1 thruster, the nylon lift line had also been fouled there and badly snarled, and CURV had very nearly been set down onto the BRAVO buoy leg previously planted.

KIOWA completed BRAVO buoy rework at Ponta Delgada and brought the buoy back to the implantment site in the AFAR range. NAUBUC was waiting at the site. The next few days were spent in making preparations for the reimplantment effort, doing maintenance and installing new parts on the equipment.

On 25 July NAUBUC launched CURV with the purpose of attaching the cable grabber to the BRAVO cable. Within minutes of reaching the bottom, 2080 feet down, CURV found the cable termination package and placed the grabber firmly on the cable. CURV had taken the 1-inch braided nylon attached to the grabber down with it, married to its own cable with masking tape. On previous attempts this line has been tended off, not very successfully, by a small boat. On this occasion, after the cable grabber was placed on the cable at the dynagrip, the nylon lift line was tended over NAUBUC's stern and CURV began to maneuver clear of the bottom. However, it appeared that CURV was fouled in the lift line and could not clear itself.

The only thing left to do was to take a good strain on the lift line and try to recover everything at once. This was begun; suddenly the nylon lift line went slack. When the end came aboard, the grabber was still attached, but the cable had somehow pulled out of the jaws. It is unknown why the cable was lost during lifting operations. It was decided to begin another cable recovery effort early the next day.

CURV was launched at 0545 on 26 July. By 0732 it had located the cable and the grabber had been firmly attached near, but not on, the dynagrip. Difficulty was then encountered in retrieving CURV. After 2 hours, CURV was finally raised near the surface where a swimmer could see the turn of the cable around the lift line and guide it clear. Once



Electronics package and cable safely aboard, KIOWA detaches spherical buoy (background) and prepares package and cable for attachment to BRAVO buoy, on right.

KIOWA RECEIVES ELECTRONICS PACKAGE AND CABLE FOR BRAVO BUOY

the vehicle was safely aboard, the lift line was run through the cable machinery and slowly picked up. At 1135 the cable itself came on deck firmly held by the grabber. It was stoppered off and the British team of splicers immediately began preparing the splice into the new electronics package. This was completed by 1900. Armor wires and the dynagrip were then placed over the splice by NUSC personnel. This task was completed at 2200. The cable end was buoyed off with a salvage pontoon. Work was secured at 2400 on 26 July with everything in readiness for the lowering attempt the next day.

Successful Implantments, 27 July

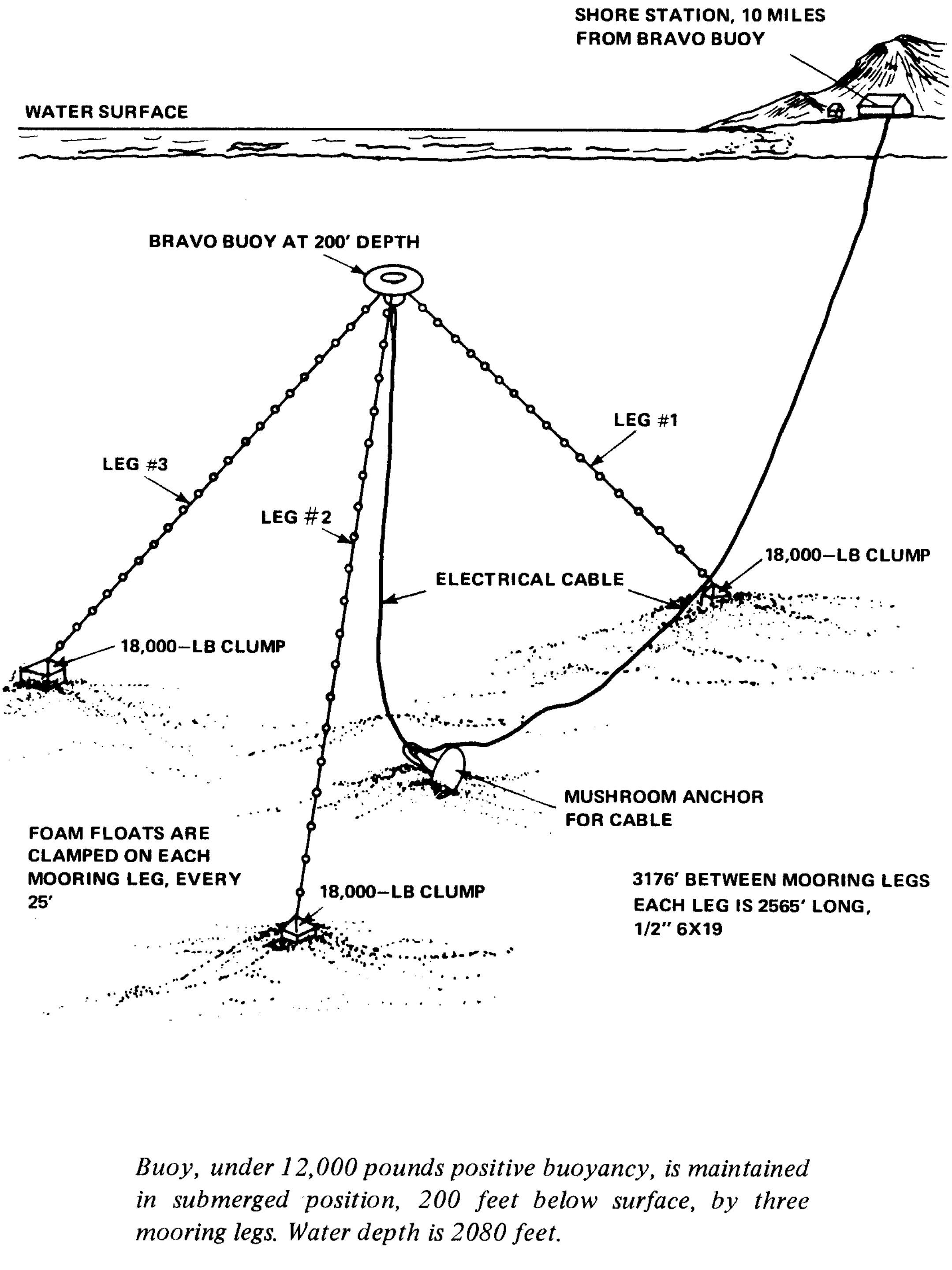
ECHO tower was implanted without incident on 26 July. Neither NAUBUC nor CURV were directly involved in the lowering operation. However, NAUBUC brought CURV to the site early on 27 July for an underwater inspection of the tower in its new position. CURV was launched at 0108. CURV completed the inspection, working at a depth of 2150 feet, and was back aboard by 0300. After subsequent calibration maneuvers by NAUBUC, the NAUBUC/CURV team returned to the BRAVO buoy site to support the final implantment operation.

Despite additional difficulties, BRAVO buoy was finally implanted on 27 July. The cable end was finally fastened in place and mooring leg #3 was attached. The anchor was then placed correctly on the bottom. During the lowering of the heavy anchor for leg #3, the lower track of the DOHB machine jammed and would not rotate. The final placement of the bottomed anchor was accomplished by placing a carpenter stopper on the lowering wire (1 1/4-inch) and dragging the anchor by maneuvering NAUBUC. When positioned, the strain on the wire was relieved by repositioning the ship. The wire was cut forward of the stopper and the stopper released. When the DOHB was examined, it was found that a small piece of nylon line had jammed in the drive track.

With all its AFAR tasks accomplished, NAUBUC got underway at 2115 on 27 July for Ponta Delgada where she prepared for the return trip to New London.

Termination of Operations, 28 July - 2 August

NAUBUC returned to Ponta Delgada early on 28 July and the next 5 days were spent preparing for the return to New London. CURV was off-loaded and taken to Lajes Air Force Base on Terceira for airlift to California. All AFAR material and equipment to be returned to NUSC, New London were loaded and readied for sea.



Buoy, under 12,000 pounds positive buoyancy, is maintained in submerged position, 200 feet below surface, by three mooring legs. Water depth is 2080 feet.

BRAVO BUOY IMPLANTED IN AFAR RANGE

By 30 July the old BRAVO mooring legs had been retrieved and all ships were in Ponta Delgada preparing for the trip home. AFAR operations of the summer of 1971 had been completed satisfactorily. Still continuing were the check-outs of the tower and buoy functions by the Santa Maria Laboratory.

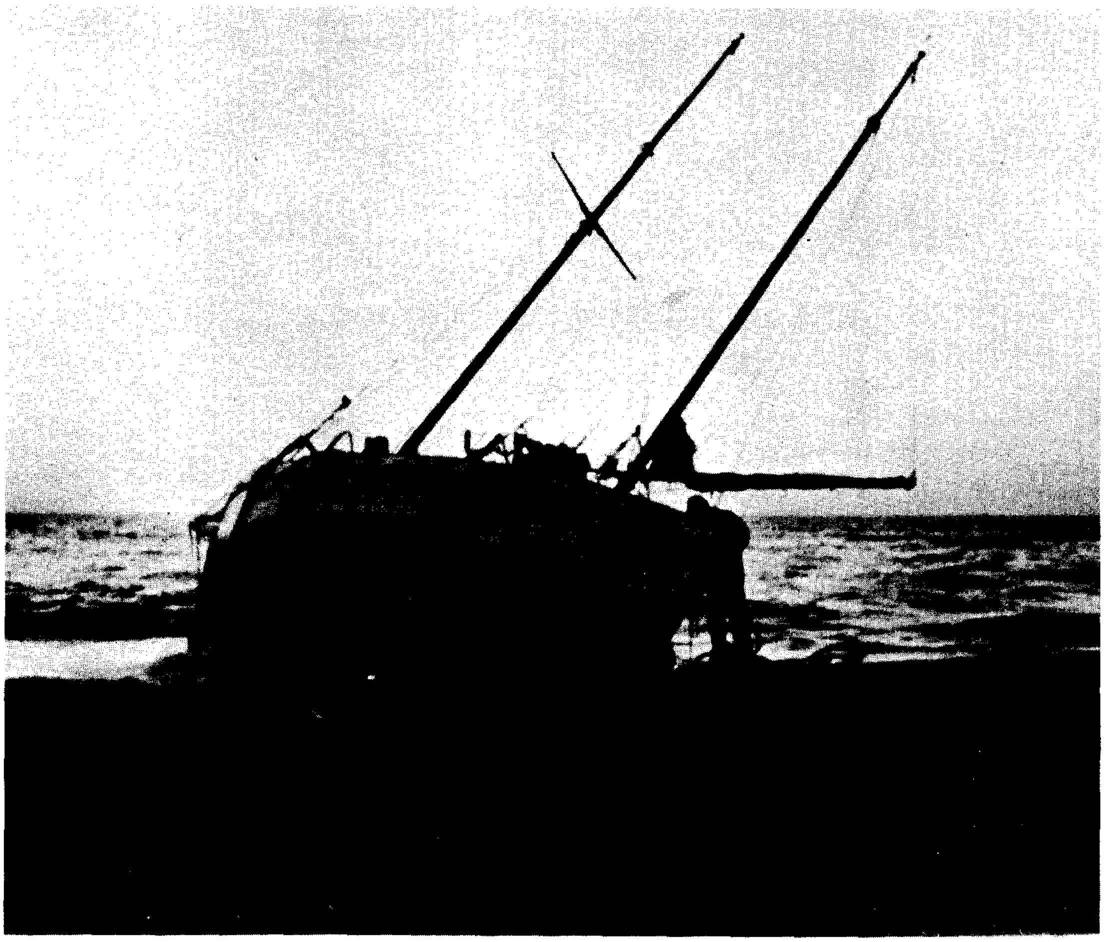
Return to New London, 2-22 August

At 1300 on 2 August, NAUBUC was taken under tow by KIOWA from Mole Salazar at Ponta Delgada; the return trip to the United States was begun. Bad weather developed on 6 August and on 9 August, at approximately 0900, the two cables parted from the KIOWA and NAUBUC went adrift. NAUBUC was forced to proceed under her own power until 0900 on 10 August when the weather moderated enough to permit hooking up the two vessels. KIOWA and NAUBUC finally arrived off Fishers Island in Long Island Sound about 1100 on 22 August. By 1400, NAUBUC was moored at NUSC, New London, Connecticut and off-loading of AFAR-associated material and equipment, the final AFAR task, was begun.

RECOVERY OF THE KETCH, ATOM,

FROM

ASSATEAGUE ISLAND, VIRGINIA



Members of the U.S. Navy salvage team prepare ATOM for towing. The 30-foot ketch ran aground during an unusually high tide following an 108-day crossing from Spain.

ATOM AGROUND ON ASSATEAGUE ISLAND

RECOVERY OF THE KETCH, ATOM, FROM ASSATEAGUE ISLAND, VIRGINIA

INTRODUCTION

On 25 October 1971 a 30-foot ketch, ATOM, with her 69-year old owner and operator, Jean Gau, aboard went aground on Assateague Island, Virginia. Civilian volunteers from nearby Ocean City, Maryland rushed to the old man's assistance but were unable to free his vessel. Hearing of the situation, the U.S. Navy, normally preoccupied with larger and more complex salvage operations, dispatched a team of salvage experts to Assateague. The Navy salvors succeeded in refloating the ATOM on 6 November. The battered ketch was then towed to Ocean City for repair.

The recovered ATOM was worth nothing to anyone except its owner. The recovery effort, however, meant a great deal, not only to its civilian and Navy participants, but also to the thousands who learned about it through the news media. It was an occasion in which the many turned their attention to the one, recognizing something in the plight of the solitary Frenchman that touched upon their own lives.

THE GROUNDING OF ATOM

At approximately 0100 on 25 October 1971, ATOM, a 30-foot double-ended ketch ran aground on desolate Assateague Island. The beached vessel was owned and operated by a 69-year old Frenchman, Jean Gau, who had just become an American citizen the previous year. Gau was completing his tenth solo voyage across the Atlantic, an 108-day crossing from Spain, when his boat went aground. On 24 October, he had located his position as being 14 miles from Assateague. That night, as he lay in his cabin listening to the radio, the wind changed and began to blow straight west toward shore. Gau did not realize the wind had changed until 0100 when he heard the crashing of breakers and went on deck to find the boat already on top of the beach.

Background

Jean Gau had bought his boat in 1945 at Shady Side, Maryland with money he had saved by working as a chef in a New York City hotel. He had named the ketch ATOM "because an atom is a very small thing but powerful. . . ." In addition to the ten solo voyages across the Atlantic, Jean Gau and ATOM had made two trips around the world. During these solo voyages, Gau would busy himself on board by catching fish, studying navigational charts, writing columns for French newspapers, and listening to the radio in his cabin at night. When his uninsured boat went aground on 25 October, Gau stood to lose not only his boat but also his home and companion.

Assateague Island, where ATOM had beached, is a virtually uninhabited sand bar that is part National Seashore and part National Wildlife Refuge. The actual grounding site was 1 1/2 miles south of the Maryland/Virginia border, 14 miles south of the Assateague Park Center, and 16 miles north of Chincoteague, Virginia. By land, Assateague is only accessible by 4-wheel drive vehicles.

Survey of the Site

Gau waited until dawn, then took a heavy sack of clothes and food and started walking along the beach, dragging the sack behind. After walking north for 1 1/2 miles, right at the Maryland/Virginia border, he sighted a cottage, one of the only two private cottages on the 40-mile beach. The owner of the cottage, who was there only because the day was a holiday, took Gau in, notified the Coast Guard, and then drove the old Frenchman to a motel in Ocean City, Maryland.

After hearing that the ATOM was aground, the Coast Guard sent a vehicle by land and a boat by water to investigate. The Coast Guard personnel found the ketch listing at a 22-degree angle and lying 20 yards above the mean low-water line. It was evident that an unusually high tide had been responsible for carrying the boat so high up on the beach. A further examination revealed that several strakes were broken.

OCEAN CITY VOLUNTEER EFFORT

Activities

Hearing of the Frenchman's situation, a group of Ocean City citizens gathered together to help him. This group included members of the Coast Guard Civilian Auxiliary and other volunteers. Under maritime law the first person to get to an unattended stranded boat and move it to a place of safety can claim salvage rights and be rewarded handsomely. Out of fear that some avaricious salvor might take advantage of Jean Gau, these volunteers worked night and day on successive high tides trying to refloat the ketch. They also acted to protect the ATOM from possible vandalism.

The volunteers also went to work repairing strakes and trying to dig the sand away from the boat. They dug and dug around the round-bottom boat hoping that the incoming tide might move her. As days went by ATOM's inside ballast of lead pigs shifted and pounded holes in her port bottom. The volunteers removed 4000 pounds of lead and patched the bottom with sheets of marine plywood covered with roofing tar.

Attempts to Free ATOM

On 4 November the volunteers made an all-out effort to free ATOM from the beach during the early morning (0750) high tide. After assembling in the very early hours, they proceeded to the grounding site. One volunteer went inside ATOM which was now heeling on a 40-degree angle on her starboard side. He began digging out the sand that was everywhere. A second volunteer was in the bow of the boat pumping. Others rigged a 3-inch braided nylon towline around the hull to drag her off.

Another volunteer was bringing a front-end loader to the grounding site to dig out a basin while the tide was out. Unfortunately, his car got stuck in the sand and by the time he arrived with the loader the tide was making up fast. The sand filled in almost as fast as it was dug out.

The plan called for the fishing boat JANET L. to tow ATOM before the tide went out. By the time JANET L. arrived, at 0830, the tide was receding rapidly. At the first attempt to pull ATOM off, a knot came loose in the towline. Other attempts failed to budge her.

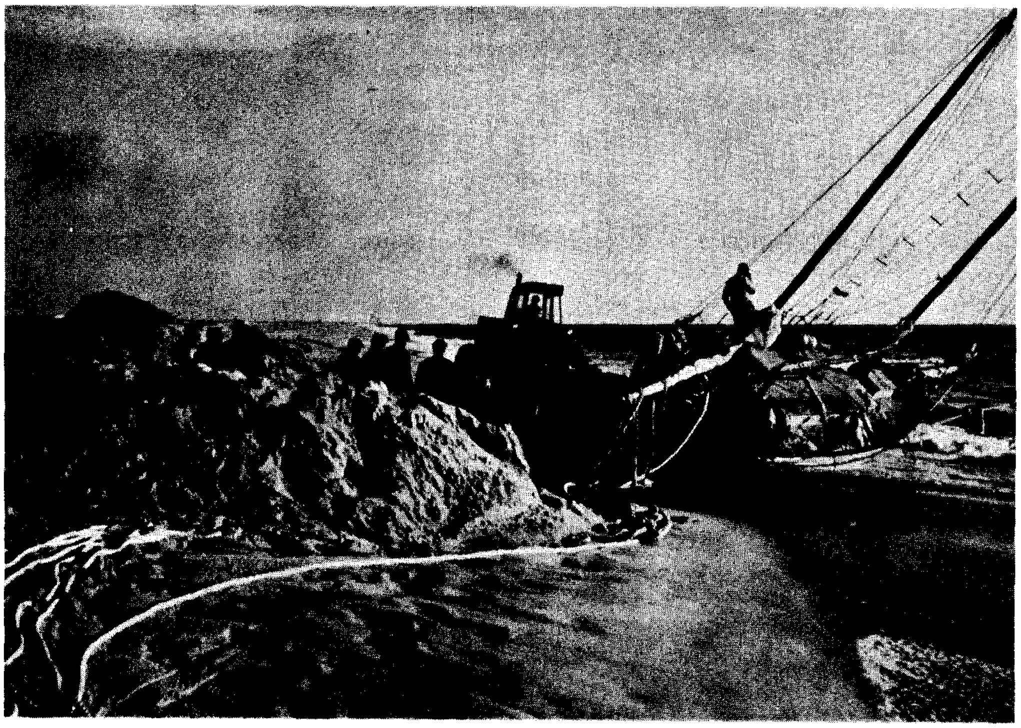
ATOM was broadside to the sea and the loader was called in to push her around to face the bow to the sea. The loader gently pushed against a four-by-four timber and the boat moved around while the JANET L. strained at the towline. By the time the boat was turned toward the water the tide had fallen too far. In desperation the volunteers rigged a line at the stern of ATOM and attached it to the loader. This resulted in tearing away the upper part of the rudder post.

ATOM had now been aground more than 10 days, her condition deteriorating steadily. Her once white topsides were streaked with rust and the seams along her red bottom were beginning to pop open. There was mounting fear that ATOM could not be freed in one piece.

U.S. NAVY SALVAGE TEAM REFLOATS ATOM

Administrative Arrangements

The U.S. Coast Guard was unable to undertake the recovery of the vessel because regulations do not permit it to compete with private enterprise and there were several

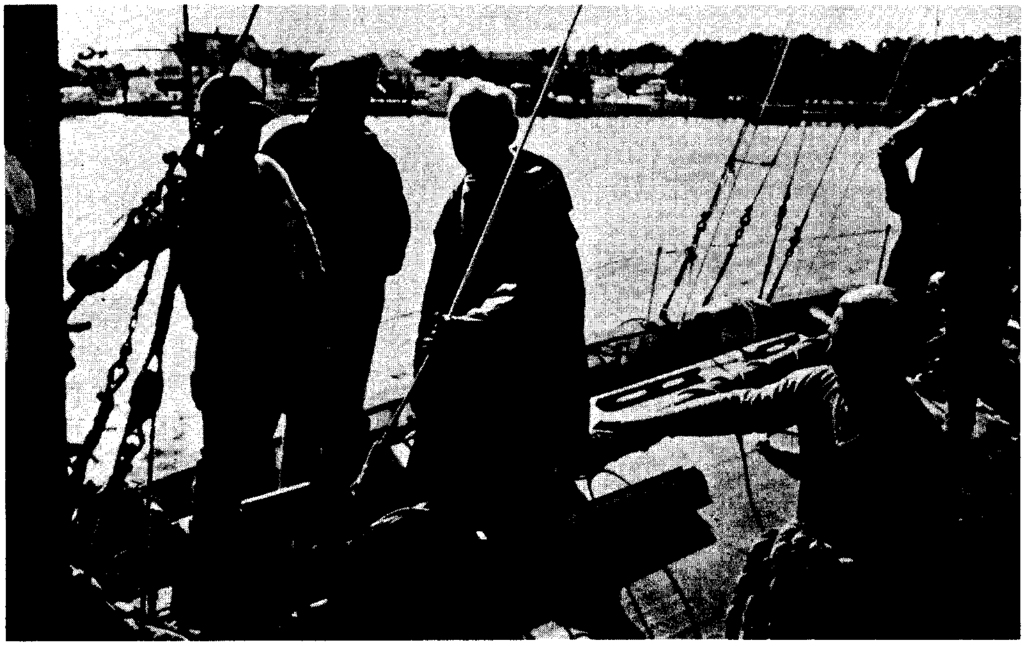


Earth moving equipment dig a trench between ATOM and the sea. During high tide the trench filled with water and ATOM was pulled to sea.

DIGGING SAND AWAY FROM ATOM'S HULL

commercial salvage firms in the area. The U.S. Navy decided to send assistance upon hearing about the Frenchman's plight. According to the Deputy Director of Ocean Engineering, the Navy determined that it would become involved "because of the old gentleman's history with his boat." He was well aware that it was an unusual salvage situation, even for the Navy, ". . . the Navy is hard pressed sometimes to decide how to enter into these things without creating an international incident. Helping a Frenchman with a beached boat is not exactly one of the Navy's official duties," he added, "but we try to help out and show compassion."

COMSERVRON 8, Norfolk, Virginia was contacted about sending Harbor Clearance Unit Two (HCU-2) personnel to assist in the refloating attempt. Approval was gained from CINCLANTFLT and a SERVRON 8 representative and four HCU-2 divers went to Assateague to conduct recovery operations.



A happy Jean Gau aboard his boat shortly after ATOM was refloated and towed to Ocean City. Surrounding Gau are some of the civilian volunteers and Navy salvors.

JEAN GAU ABOARD ATOM IN OCEAN CITY, MARYLAND

Conduct of Operations

On the morning of 5 November, the Navy team assembled on the site to survey the situation. At 0600 on 6 November final preparations were begun. With assistance from the Coast Guard Civilian Auxiliary and the National Park Service, a 30-foot trench, 8 feet wide and 4 feet deep, was dug from the boat to the sea using earth moving equipment. Sand and water were pumped out of the ATOM and potential leaks were caulked with a fast-setting cement. Water jets were used to clear away the sand from around the hull.

A 44-foot Coast Guard vessel provided by the Chincoteague Coast Guard Group, part of the Operations Office of the 5th Coast Guard District, Norfolk, Virginia arrived at the grounding site shortly before the morning high tide. A hawser was attached from the Coast Guard boat to the ATOM. The tide came in, the trench filled, and the vessel tugged at the towline tied around ATOM in a bridle. The plywood patches that the volunteers had applied with nails and roofing tar held. At 0832 the ketch had slipped off the beach and was again afloat as an ecstatic Jean Gau watched the culmination of operations. By noon, ATOM had been towed 16 miles to Ocean City and safely moored.

POSTSCRIPT

ATOM was drydocked in Ocean City with a 15-foot hole in the hull. All winter Gau tried to find a ship's carpenter to repair the boat. In the meantime, he spent almost every day at his boat digging out sand with his hands. He also spent his time speaking to Boy Scouts and other local groups. He lectured at the Naval Academy, explaining to the midshipmen his method of using the sextant. Finally in May 1972, Peter Egli, a portrait painter and son of the man who built ATOM in Shady Side, found two young carpenters in Cambridge, Maryland. They came to Ocean City for 5 days to repair the 34-year old cedar hull.

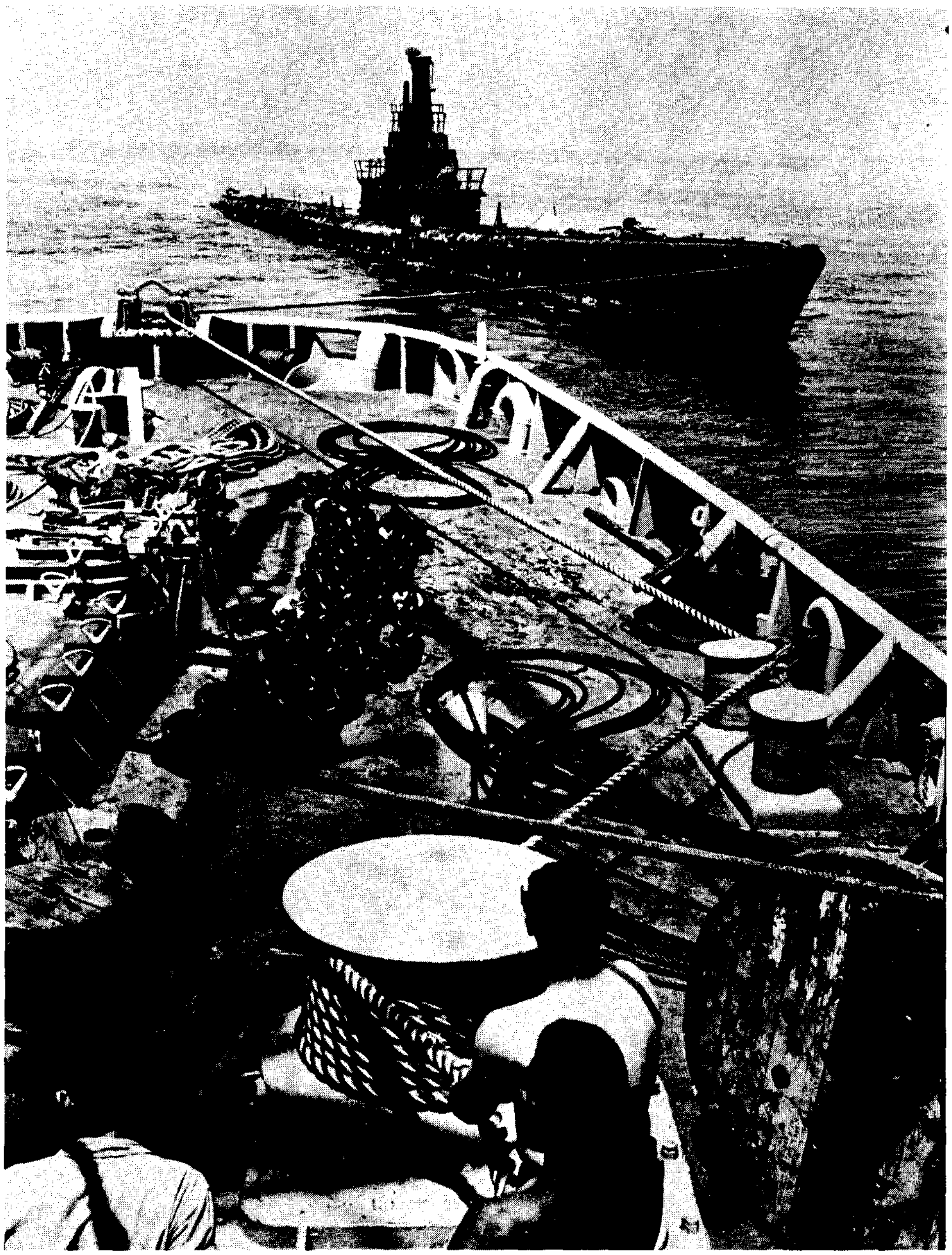
Before the grounding Gau had planned to spend a final year in New York living aboard the ATOM at the Sheepshead Yacht Club in Brooklyn, New York and then make one last Atlantic crossing. There at Valras–Plage in the south of France at a harbor named Basin Jean Gau after him, he would retire aboard ATOM. On 20 July 1972 Gau resumed his long delayed journey. He set sail from Ocean City for New York aboard his repaired ATOM, bidding farewell to all those people who had been so good to him.*

*On 24 June 1973, Gau set sail for Europe and retirement in the Basin Jean Gau. For several months nothing was known of his fate. In January 1974 it was learned that Gau had been shipwrecked on the Coast of Tunisia in December 1973. ATOM had been lost, but Gau had survived and by mid-January was back in France.

RECOVERY OF ex-USS HAKE

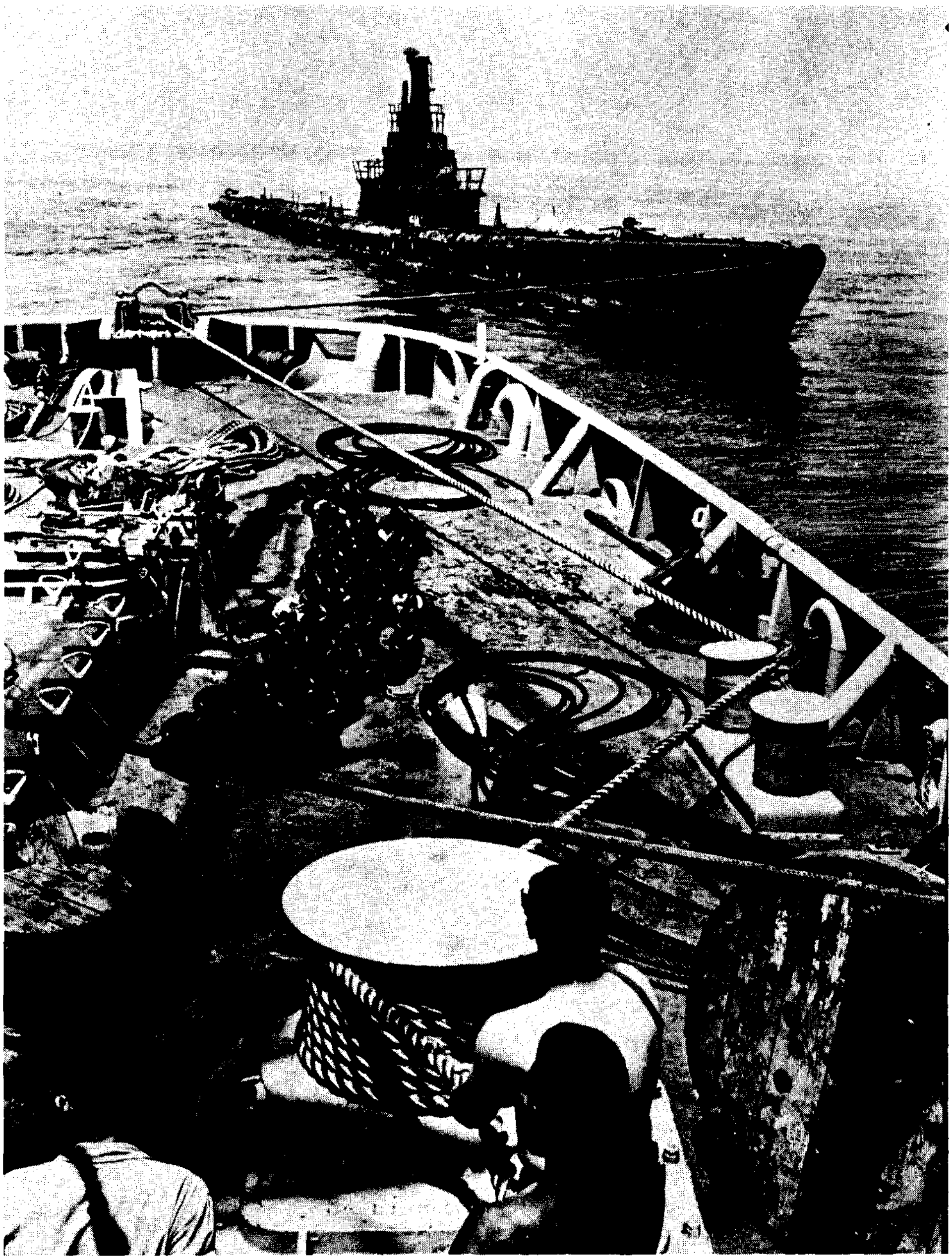
IN

SUBSALVEX-71



USS OPPORTUNE (ARS-41) towed ex-HAKE to the exercise site on 9 August 1971. During SUBSALVEX-71, the forward pontoons were rigged and lowered from OPPORTUNE's fantail.

USS OPPORTUNE TOWS ex-HAKE TO EXERCISE SITE IN CHESAPEAKE BAY



USS OPPORTUNE (ARS-41) towed ex-HAKE to the exercise site on 9 August 1971. During SUBSALVEX-71, the forward pontoons were rigged and lowered from OPPORTUNE's fantail.

USS OPPORTUNE TOWS ex-HAKE TO EXERCISE SITE IN CHESAPEAKE BAY

RECOVERY OF ex-USS HAKE IN SUBSALVEX-71

INTRODUCTION

A major submarine salvage exercise, SUBSALVEX-71, was conducted in the Plantation Flats of the Chesapeake Bay by forces of the Atlantic Fleet from 9 August to 13 September 1971. During this exercise, as during the previous submarine salvage exercise, SUBSALVEX-69, the ex-HAKE was intentionally sunk in 100 feet of water in order to provide needed salvage training and experience for personnel, to evaluate the effectiveness of submarine salvage techniques, and to test the actual submarine salvage equipment.

A number of unanticipated difficulties occurred during SUBSALVEX-71 which gave the exercise realistic dimensions. These difficulties included problems with the pontoons and rigging equipment, flooding of the ex-HAKE's internal compartments, and the passage of Hurricane Doria. On 13 September, SUBSALVEX-71 was completed safely and successfully. The exercise provided invaluable experience to participating personnel, left Service Squadron EIGHT better prepared for an actual submarine salvage operation if required, and emphasized the importance of fulfilling the training requirements of salvage forces.

PLANNING AND PREPARATIONS

Background

The Chief of Naval Operations is required to maintain a salvage force capable of accomplishing submarine salvage. Responsible for meeting this requirement is Commander, Service Force, U.S. Atlantic Fleet (COMSERVLANT) and the personnel and ships of Service Squadron EIGHT which maintain a high state of readiness in the event it is necessary to salvage a submarine.

In 1968 the submarine hulk, ex-USS HAKE, was acquired to assist in training salvage forces for submarine salvage operations. In May 1969 the first submarine salvage exercise (SUBSALVEX) was conducted. The ex-HAKE was sunk in 100 feet of water in the Plantation Flats area of the Chesapeake Bay in order to provide salvage training and experience and to test the effectiveness of pontoon use in this type of operation. Prior to the 1969 SUBSALVEX, pontoons had not been used in an effort to raise a disabled submerged submarine since the USS SQUALUS salvage operation in 1939.

ex-HAKE

The ex-HAKE had been modified prior to SUBSALVEX-69 to make it more suitable for the exercise. Since the ex-HAKE was considered too light to be submerged even with all its main and fuel ballast tanks flooded, weight was added by placing concrete in the forward and after battery wells, reefer and magazine storage areas, and pump and after engine rooms.

The submarine was also modified to facilitate venting and blowing the ballast tanks. Valves were fitted on ballast tanks and tied into low pressure blow lines to allow topside venting control. Blow hoses were led from each of the submarine's nine topside vent valves to a control manifold. Thus, any pair of main and fuel ballast tanks could be selectively vented or blown and positive control maintained. Both the trim and the transition from positive to negative buoyancy could be finely controlled.

Paradoxically, these modifications were partly responsible for some of the difficulties encountered during SUBSALVEX-71. In the 2 years between submarine salvage exercises, the external lines to the ballast systems on the submarine had deteriorated. As a result vent lines leaked and internal flooding occurred during the 1971 operations.

Preliminary Planning

SUBSALVEX-71 was the second submarine salvage exercise. Like SUBSALVEX-69, it was conducted by COMSERVRON EIGHT in order to test submarine salvage equipment and techniques and to provide salvage personnel with submarine salvage experience. The exercise was originally scheduled for April 1971 but was rescheduled by Navy officials in cooperation with Eastern Shore residents and local sport fishermen to eliminate any possible effect that operations might have on the annual run of Black Drum game fish.

Like SUBSALVEX-69, the plan for SUBSALVEX-71 was to sink ex-HAKE in 100 feet of water and raise it in two operations: the first would raise the submarine about 40 feet, allowing it to be towed to shallower water; the second would lift the submarine to the surface. SUBSALVEX-69 had demonstrated that four salvage pontoons (YSP's) would provide sufficient lift to raise the ex-HAKE. Planning for SUBSALVEX-71 was, therefore, based on the use of four YSP's, two for the bow of the submarine and two for the stern. Each pair would consist of a lift pontoon and a control pontoon. Pneumo-fathometer hoses would be used to set the depth in setting the pontoons level.

For SUBSALVEX-71 the salvage pontoons would be towed to the exercise site in an attempt to eliminate problems encountered during SUBSALVEX-69. In the latter exercise, the pontoons had been transported on barges and then launched; however, in almost every instance, the pontoons were damaged during launching. Towing the pontoons would bypass the launching problems.

It was also planned to conduct simulated submarine rescue operations as part of the exercise. As in SUBSALVEX-69, these operations were to be conducted over a 2-day period immediately following the initial bottoming of the submarine and prior to rigging for the salvage operation. USS SUNBIRD (ARS-15) would use the McCann rescue chamber to inspect the sunken hull, simulating that survivors were aboard.

Because difficulties had occurred in SUBSALVEX-69 with two ships working concurrently in the same moor, it was decided that for SUBSALVEX-71 the two ARS's would take turns. First one ship would rig the forward pontoons, then the other would rig the stern pontoons.

This plan was followed for the first lift; for the surface lift, in an effort to complete preparations as rapidly as possible, both ships worked simultaneously in the same moor. Contrary to SUBSALVEX-69 experience, no difficulty was encountered, perhaps because the moor configuration used was different than the one used in SUBSALVEX-69.

Detailed Planning

The following key events for the exercise were identified:

Position and bottom ex-HAKE

Conduct submarine rescue operations

PRESERVER lay 4-point moor

Checkout site

OPPORTUNE and PRESERVER in moor;
begin rigging and positioning of pontoons

First lift of ex-HAKE

Reposition and rebottom ex-HAKE.

At this point it was planned to decide whether or not to conduct the surface lift either by using pontoons or by blowing the ballast tanks, depending on the remaining time. If sufficient time remained, the pontoons would be rerigged and used to surface the submarine; otherwise, the ex-HAKE would be surfaced by recovering the pontoons and then blowing the ballast tanks. Once on the surface, the salvage team would return to port with the ex-HAKE in tow.

Actually, during SUBSALVEX-71 operations, a combination of pontoons and blowing ballast tanks had to be used to lift the submarine. This was a result of flooding in the submarine's internal compartments. In addition, for the surface lift, six inflatable pontoons had to be used along with the four salvage pontoons in order to compensate for the additional weight brought about by the flooding.

Participating Forces

The participating forces were organized as follows:

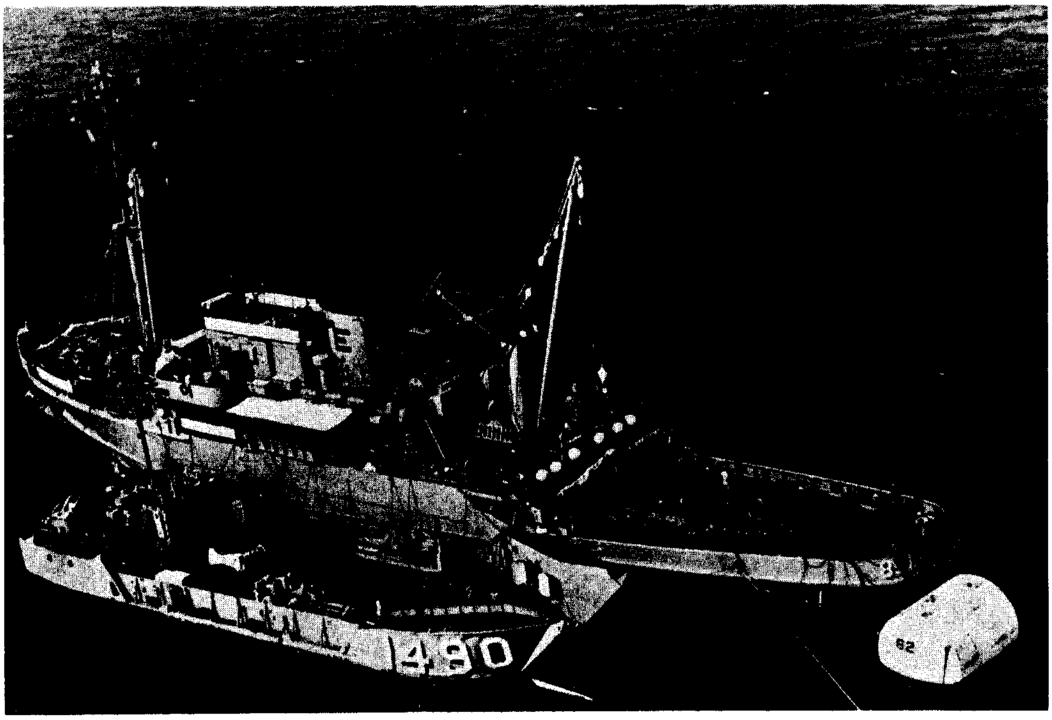
Submarine Rescue Phase – USS SUNBIRD (ASR-15)

Bow Salvage Element – USS OPPORTUNE (ARS-41)

Stern Salvage Element – USS PRESERVER (ARS-8)

Support Salvage Element – Harbor Clearance Unit Two (HCU-2)

Towing/Logistics Support – USS UTINA (ATF-163).



Working side by side, PRESERVER and LCU 1490 rig the stern lift pontoon, YSP-62, for lowering. The well deck of LCU 1490 provided a good area for handling air hoses and the lowered ramp provided an excellent way for divers to enter and leave the water.

USS PRESERVER (ARS-8) AND LCU 1490 PREPARE YSP-62 FOR LOWERING

The key vessels in the exercise were the two ARS's, OPPORTUNE and PRESERVER. Ocean salvage ships of this type would no doubt play important roles in any fleet salvage effort to recover an operational submarine. Accordingly, COMSERVRON EIGHT designed the exercise to provide maximum training for these two ships. Each ARS would have ample opportunity to exercise its varied salvage capabilities. OPPORTUNE was to tow the ex-HAKE to the exercise site and position it on the bottom with PRESERVER assisting as required. They were then to work in tandem throughout the exercise, one concentrating on the bow of ex-HAKE and the other on its stern.

HCU-2 would provide salvage forces to support OPPORTUNE and PRESERVER by operating the LCU 1490, equipped with Worthington compressors, as an air compressor barge and diving platform. Based on a SUBSALVEX-69 recommendation, the barge would be moored in the immediate vicinity of the salvage ships in order to assist in passing messenger and reeving wires and lift slings. The LCU was to prove an outstanding vessel for this role.

Two fleet ocean tugs (ATF's) also participated in supporting roles. UTINA was used primarily to tow the bulky salvage pontoons to the exercise site. A second tug, USS MOSOPELEA (ATF-158), although not in the original task organization, was committed for a short time to assist OPPORTUNE and PRESERVER during the first successful lift attempt.

Following the bottoming of the ex-HAKE at the outset of the exercise, elements of the Submarine Force, Atlantic (SUBLANT) would conduct training in personnel rescue procedures using a McCann rescue chamber launched from an ASR, submarine rescue ship. The USS SUNBIRD (ASR-15) was to conduct this phase.

CONDUCT OF OPERATIONS

Towing ex-HAKE

OPPORTUNE departed for the exercise area on 9 August with the ex-HAKE in tow. The submarine was difficult to tow. Three LCM pusher boats were necessary to keep the ex-HAKE on a steady heading while departing Little Creek Harbor. Once clear of the harbor, ex-HAKE veered off to the starboard and remained there for the duration of the trip.

Meanwhile PRESERVER arrived at the exercise site and surveyed the area where ex-HAKE was to be bottomed. The survey showed that the depth at this position was 150 feet instead of 100 feet as desired. A new site, where the depth was 100 feet, was chosen 630 yards away.

Positioning ex-HAKE

OPPORTUNE arrived at the exercise area and positioned ex-HAKE at 37°14.8'N; 76°04.4'W. Hoses were attached to the vent connections of the submarine's ballast tanks from the LCU 1490 which had followed OPPORTUNE to the exercise site. A line was attached from OPPORTUNE's bow to the stern of the submarine in order to assist in controlling the submarine during sinking. Emergency vent valves within the ex-HAKE were opened; however, leaks in vent lines 3AB and 6CD caused these tanks to flood immediately. The ex-HAKE took on a 10-degree starboard list. The venting of the remaining ballast tanks could not be controlled because of kinks in the air hoses. The hoses were then removed and the vent valves on the main deck were opened allowing ex-HAKE to submerge.

The ex-HAKE was bottomed during ebb tide. It was held firmly in position by OPPORTUNE astern and its own bow anchor. HCU-2 divers inspected the submarine on the bottom and removed all air hoses. All ballast tanks were completely flooded with the exception of FBT 5AB. Buoys were attached to mark the fore and aft hatches, conning tower, and anchor.

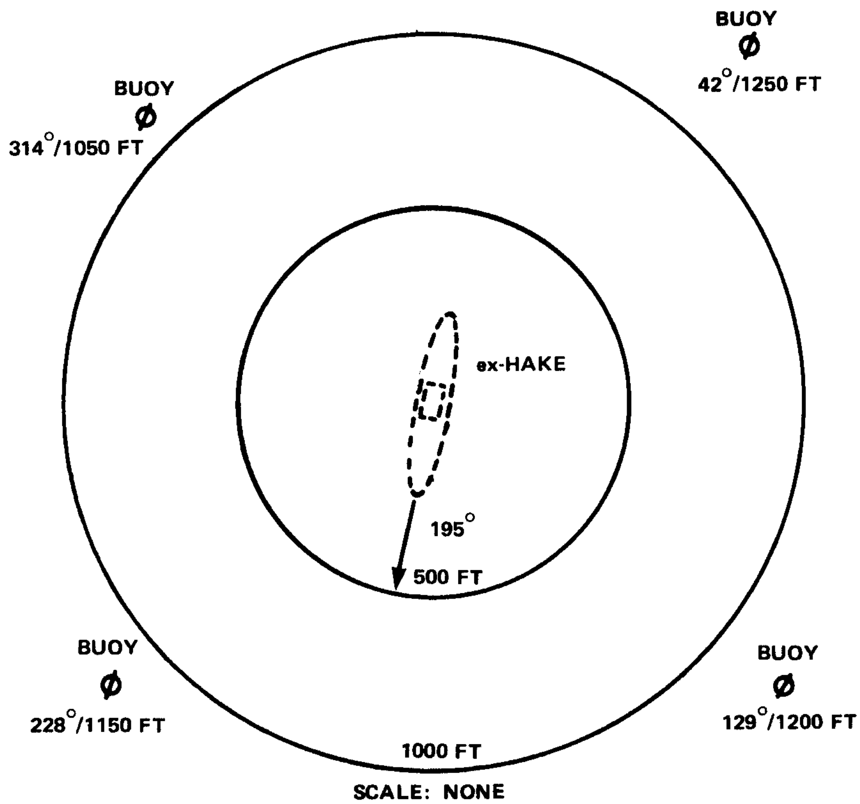
Submarine Rescue Phase

USS SUNBIRD arrived at the exercise site on 10 August to conduct McCann rescue chamber runs. Unable to lay a 4-point moor as planned because of shoal water to the northeast of ex-HAKE's position, SUNBIRD went into a 2-point moor to the east. Bell operations began but the bell was unable to make a seat on the hatch to the after torpedo room. It was found that a small piece of chain and line which were attached to a marking buoy were fouling the seat. Divers corrected the trouble.

Difficulties were next encountered when high currents kept pulling the bell 6 inches forward of the seat. This caused one side of the bell to sit on a downhaul padeye. Finally a proper seat was made and the ex-HAKE was inspected. A slow leak was found in the fuel oil compensating line in the crew's mess. An average of 6 inches of water was found in this compartment. The freeboard indicated that the submarine had a slight starboard list and a down angle forward. The forward torpedo room was pressurized indicating it was flooded; however, the compartment was not entered to determine the amount. All other compartments were dry. Operations with the McCann chamber were completed late that day; early on 11 August SUNBIRD recovered her moor and departed.

Preparations for the First Lift

On 11 August preparations for the first lift got underway. PRESERVER laid a 4-point moor while OPPORTUNE divers checked the submarine's position and began rigging



Because the submarine was only moved a short distance during the first lift, the same moor was also used for the surface lift.

CONFIGURATION OF SUBSALVEX-71 MOOR

descending lines to the forward cleats. Two salvage pontoons, YSP-38 and YSP-62, were towed to the exercise area by UTINA.

The next day tunneling under the ex-HAKE was begun. Reeving lines were passed underneath the hull with little difficulty because sand had been scoured from underneath the submarine by the fast tidal currents. HCU-2 divers began hooking hoses to the forward torpedo room. The plan was to open both salvage fittings and blow compressed air into the high salvage valve forcing water out of the low salvage valve. The high salvage valve was not operating properly so the compartment was pressurized to depth pressure in order to stop any flooding. Meanwhile ex-HAKE's stern was marked with a cork buoy and a third salvage pontoon, YSP-39, was brought to the exercise area by UTINA.

Rigging and Lowering the Forward Pontoons

LCU 1490 brought YSP-39 to OPPORTUNE's stern on 13 August and rigging the forward lift pontoon began. A number of problems were encountered. The tell-tale valve of the pontoon's center compartment was found leaking and had to be capped. The fittings of the white blow valve were found to be incompatible with the coupling on the air hose connection. Several fittings had to be tested before one was found that could be used. Operations were also hampered by abnormal tides and a brisk northeast wind with choppy seas.

When the pontoon was ready for sinking, the hoses were given a positive blow in order to remove the kinks and areas where the hoses had collapsed. This was required throughout the exercise in order to start proper venting because the pressure differential during venting was insufficient to open the collapsed hoses. The pontoon was finally submerged and positioned.

The pontoon was then set on positive, inspected, and found to be level at 2 feet above the submarine's main deck. The hoses were removed and a white vent valve found leaking was capped. In addition, one of the pontoon's center compartment blow valves broke off at the flange as the reeving lines were slacked. It appeared that the failure had originated at a sand pocket formed in the valve during casting, resulting in a weak spot. The valve was replaced with a modified sea valve from OPPORTUNE.

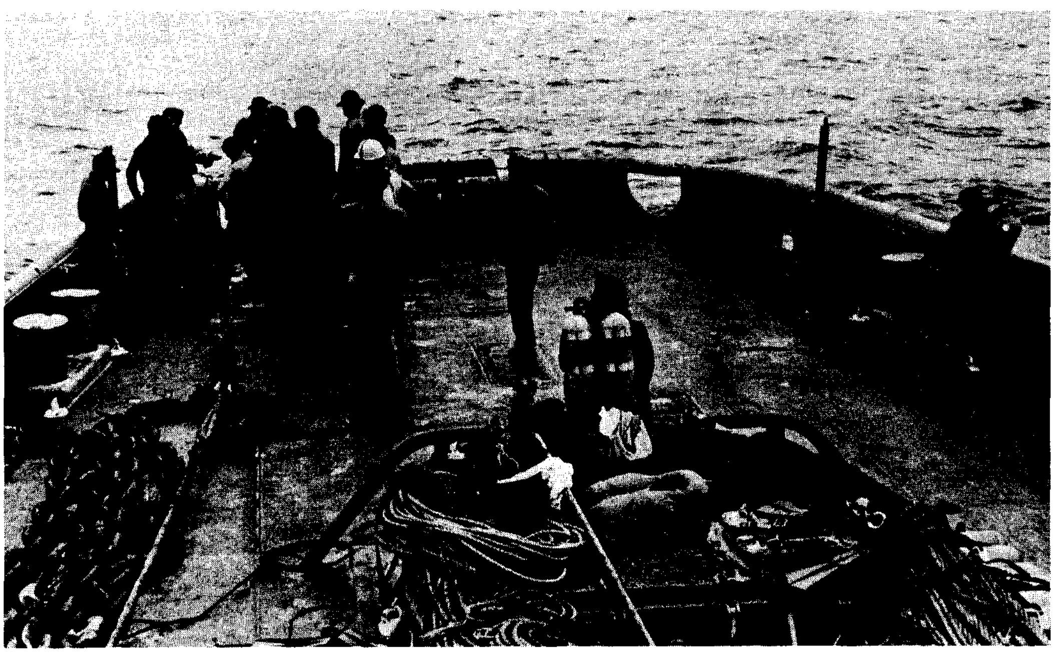
Rigging of the forward control pontoon, YSP-38, was started on 14 August. As in SUBSALVEX-69, flower pots were used in rigging the control pontoon. And again, as in 1969, difficulty occurred when the 1-inch eye on the reeving line would not pass through the flower pot. To correct this, the eye had to be cut off and the wire married to a 1-inch wire which would pass easily through the flower pot.

After the pontoon was rigged, the pontoon was vented and lowered to a depth of 35 feet. As the flower pots were being set, an air hose became wedged in the hawsepipe under the flower pots. To clear the hose, the pontoon had to be lowered to the deck of the submarine. The pontoon was then returned to the 35-foot depth, the flower pots set, and the pontoon set on positive buoyancy. Leaks were found in the white end vent valve of this pontoon also. The valve was capped. All air hoses were removed. OPPORTUNE's divers then rigged preventer wires from the chains of the forward lift and control pontoons to cleats on the submarine's deck. Meanwhile the fourth pontoon, YSP-63, had been towed to the exercise site.

Rigging and Lowering the Stern Pontoons

Early on 16 August mooring lines were transferred from OPPORTUNE to PRESERVER as PRESERVER replaced OPPORTUNE in the moor and began rigging the stern lift pontoon. Reeving wires were run under the stern of the ex-HAKE and the stern lift pontoon, YSP-62, was rigged. The pontoon was then vented; however, it would not sink. Different measures were tried: the pontoon was rocked back and forth using descending lines; several changes in the pontoon's attitude were made. Finally the manhole covers were removed and the vent lines inspected. They were clear; however, it was noted that the vent lines were installed low in the pontoon, running to the bottom of the valve well. The manhole covers were then replaced and the center compartment flooded with 5 tons of water. The pontoon finally submerged.

Because the reeving wires were not taut as the pontoon was lowered, on 17 August, the pontoon was not level. Attempts to level the pontoon were made despite such obstacles as strong currents and the shape of the ex-HAKE in the area of the reeving chain. Finally toggle bars were prepositioned at a specific height and the pontoon set on positive. This was successful in positioning the pontoon 6 inches above the after capstan.



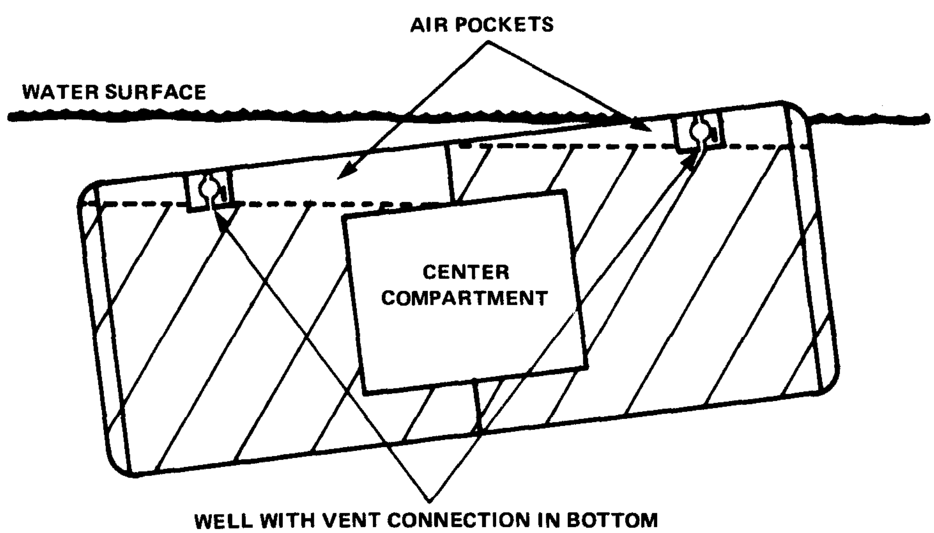
Members of the salvage team on PRESERVER's fantail prepare to reeve lifting chain under the sunken ex-HAKE.

PREPARATIONS ON BOARD PRESERVER

Lines were then hooked up to the high and low salvage fittings of the crew's compartment and 120 tons of water were removed by blowing into the high salvage valve. Because of bubbles escaping from the conning tower and torpedo room hatches, blowing was stopped for fear of progressive flooding. In the evening, while working on the pontoon, the after torpedo room hatch was knocked open. Before the hatch was closed, the space flooded; fortunately the space was nearly filled with cement, one of the pre-SUBSALVEX-69 modifications, and the flooding added very little weight.

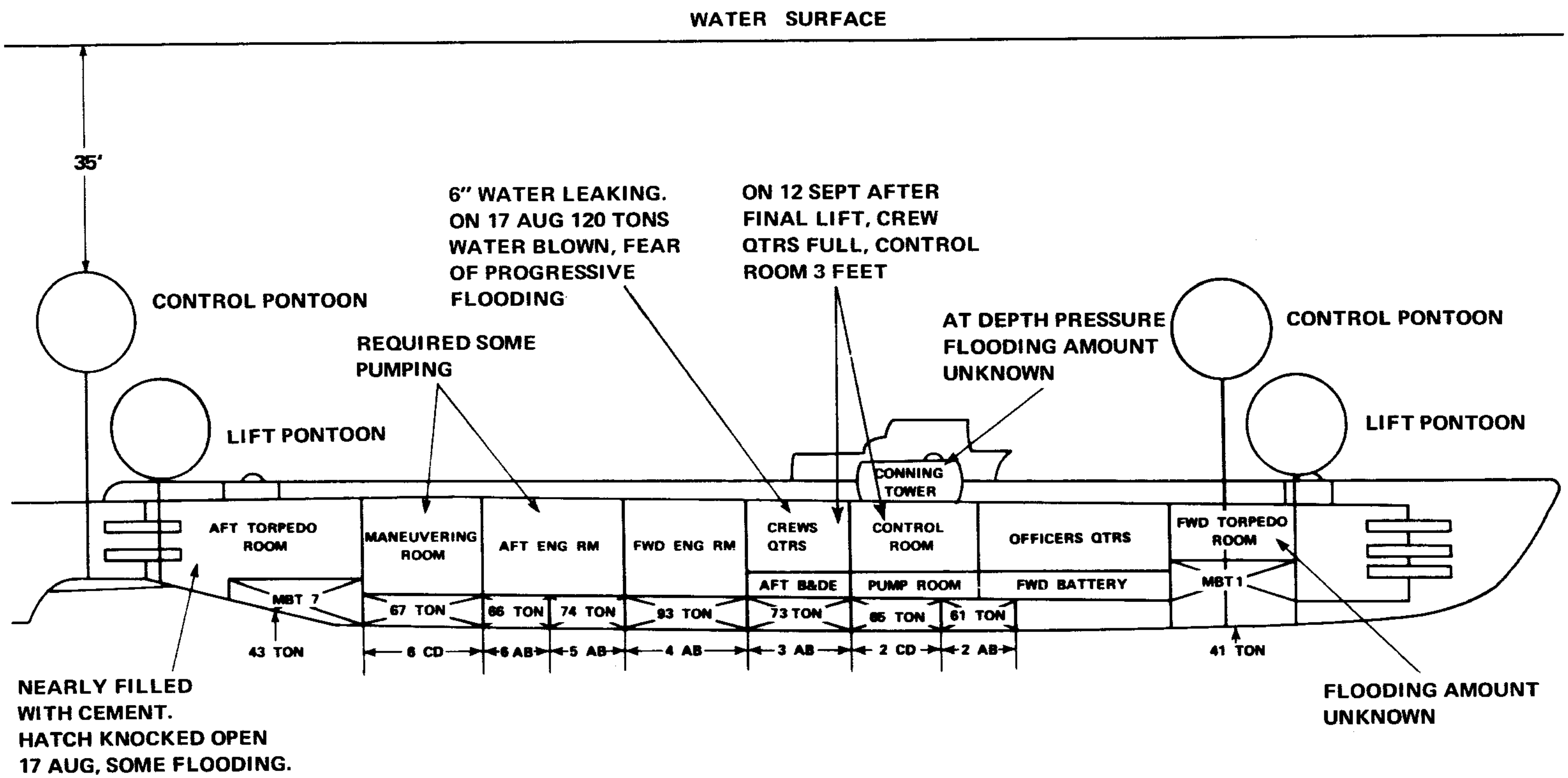
Before rigging operations began on the stern control pontoon, HCU-2 divers checked the submarine's compartments through the high and low salvage fittings. Little or no flooding existed in the compartments except the torpedo rooms and crew's compartment (after battery). The conning tower was at depth pressure but flooding could not be determined. It was decided not to dewater the compartments and that ballast tanks would be blown dry to compensate for the flooded spaces.

While preparations for lowering the stern control pontoon, YSP-63, were being made and reeving lines were being run under the submarine, the stern lift pontoon was found to be tilted on end. The lift pontoon was again placed horizontal and preventers were rigged to



Trouble was encountered in lowering the stern lift pontoon, YSP-62. Because the vent valves were installed low in the pontoon, air pockets formed; there was not enough venting to sink the pontoon. The pontoon finally submerged after the center compartment was flooded with 5 tons of water.

LOCATION OF VENT LINE, YSP-62



Flooding of several compartments complicated the salvors' problems. Decision was made on 18 August to blow ballast tanks dry to compensate for flooding, rather than dewater compartments.

PROFILE OF SUBMERGED ex-HAKE
(PRIOR TO FIRST LIFT ATTEMPT)

keep the pontoon from rendering. However, the pontoon tilted again. Preventers were removed and several unsuccessful attempts were made to level the position of the pontoon. The unstable position of the pontoon was caused by the curvature and narrow size of the submarine's hull. As a result, there was very little contact between the chain and the submarine at that point and the chain was thus able to render easily. Finally, by placing pneumatic hoses and blowing the lift pontoon compartments for 10 minutes, the pontoon was placed on a horizontal plane with approximately 50 tons of positive buoyancy. This appeared to be satisfactory.

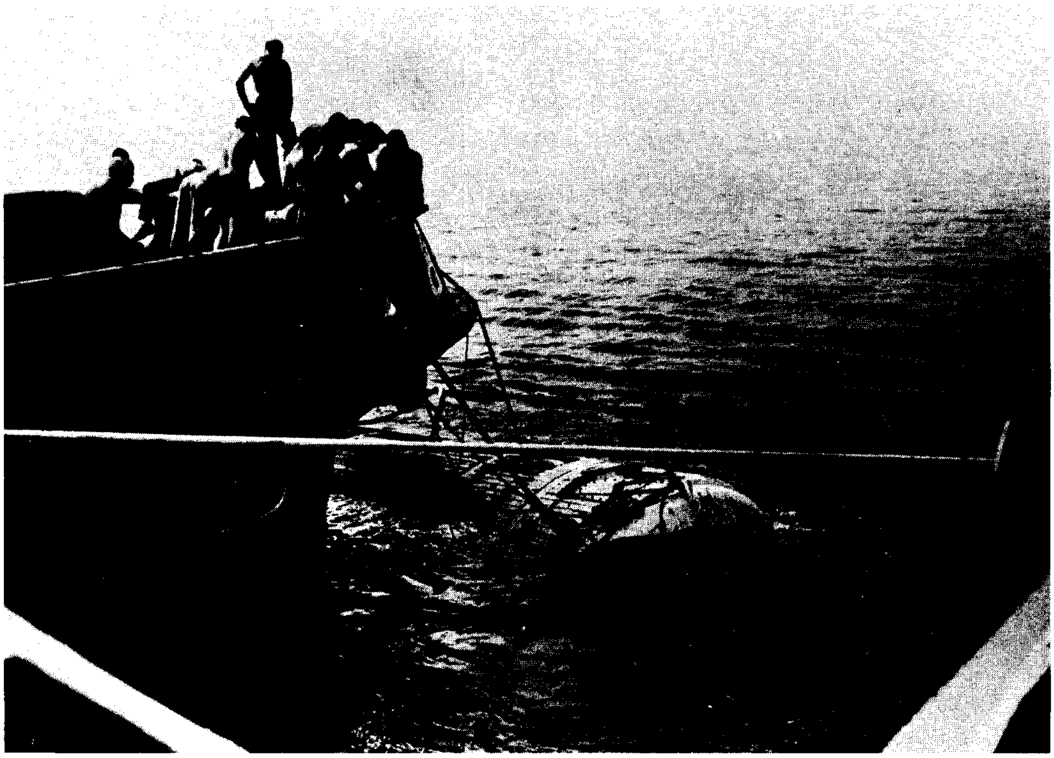
Rigging of the stern control pontoon was completed on 20 August. As had been the case during the lowering of the three preceding pontoons, difficulties were again encountered during lowering. This time, the descending lines of the control pontoon fouled on the lift pontoon as one line slipped around the pontoon. Attempts to free the line were unsuccessful. The control pontoon was then raised to the surface and set on positive.

The fouled wire and chain were freed by lowering chain and wire on 5-inch manila line. Divers worked the manila line around to the rear of the lift pontoon. With descending lines in the proper position, the control pontoon was submerged and put into position with the depth of water to top of pontoon at 32 feet. The pontoon was set on positive and descending lines removed.

Initial Lift Attempt Fails

On 22 August with all pontoons in place, blow hoses connected to the air barge, and with OPPORTUNE stationed to the north of the ex-HAKE and UTINA to the south, lifting operations were begun. Selected ballast tanks were blown. Bubbles were noted coming from the stern lift pontoon; the nipple to the white blow valve had been pulled off. The hose was hooked up again. Then leaks were noted in the elbow to the red blow valve. Therefore, to ensure that the pontoon would be completely dewatered, the red blow valve and white flood valve were closed.

Blowing the forward control and lift pontoons began. After 1 minute an extreme amount of venting activity occurred. The control pontoon came to the surface followed shortly by the lift pontoon, and the bow of the ex-HAKE. The bow then sank, pulling the control pontoon back down with it. The lift pontoon, which had parted its preventers and hose fitting to MBT 1, remained on the surface tangled in 2 1/4-inch wire. Another lift was attempted using only the forward control pontoon and stern pontoons; however, this effort was also unsuccessful.



In lowering a pontoon, hoses were disconnected from the vent valves. The pontoon was then lowered with the blow hoses connected and vent valves open. As long as the lifting slings were taut, the descending lines were able to control the pontoon and keep it level.

THE SALVAGE TEAM LOWERS ONE OF THE PONTOONS

Repositioning the Forward Lift Pontoon

Following the unsuccessful attempt to lift the ex-HAKE, divers inspected the pontoons and removed the air hoses. OPPORTUNE replaced PRESERVER in the moor and began preparing the forward lift pontoon for relowering. All wire and chain were cleared from the lift pontoon, four turns of 3/4-inch wire were passed through the reeving chains, and a second horizontal motion preventer was placed on the control chain. The control pontoon was then set on positive.

On 24 August the forward control pontoon was discovered at an angle. It was reset by tightening the preventers. The lift pontoon reeving wires were run under ex-HAKE and the pontoon was lowered into position.

Checking the Stern Pontoons

With the forward pontoons again in place, PRESERVER replaced OPPORTUNE in the moor and began to check the condition of the stern pontoons. Divers found that the chain for the control pontoon had taken a turn around the port shaft of the submarine. The control pontoon was at a 30-degree angle and the angle of the lift pontoon was 45 degrees. The control pontoon was reset horizontal and preventers were added to the lift pontoon to keep it from rendering.

Hurricane Doria

Because Hurricane Doria was approaching the area, all hoses were disconnected except for MBT's 2AB and 7. These were buoyed off. Buoys were attached to both control pontoons and the conning tower. All units then returned to Little Creek. On 27 August Hurricane Doria passed directly over the salvage site.

USS MOSOPELEA Inspects

On 28 August, USS MOSOPELEA returned to the exercise site and found mooring buoys in place. MOSOPELEA's divers inspected the submarine and pontoons. It appeared that the ex-HAKE had not been affected by the storm except for the air hoses to the MBT's. They had broken loose from their buoys and were draped over the submarine's side, resting on the bottom.

Subsequent Lift Attempt Succeeds

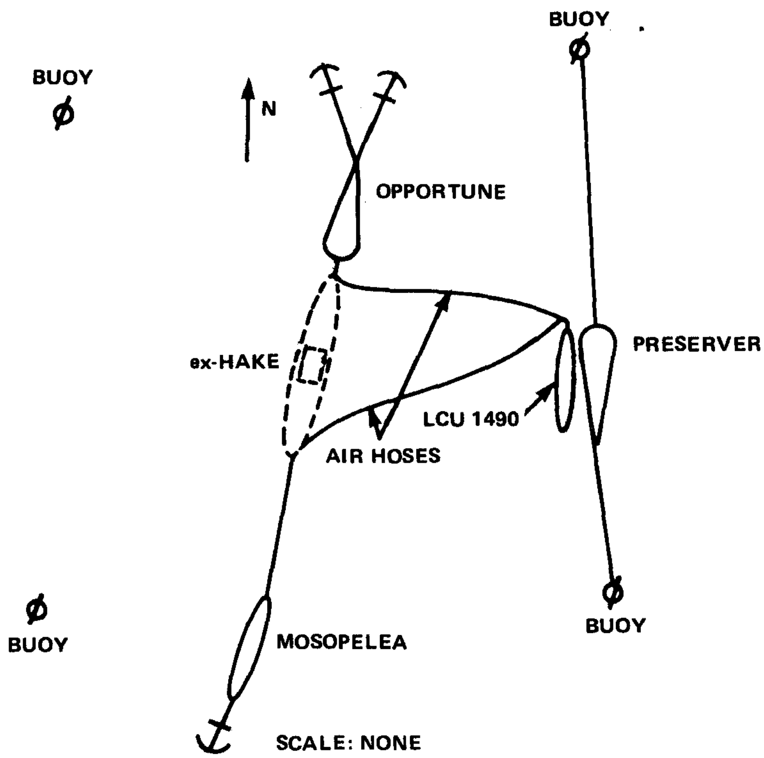
All units returned to the site on 29 August and positioned themselves for the lift attempt. PRESERVER went into a moor with LCU 1490 alongside starboard side, Chinese style. Divers picked up the stern line of ex-HAKE and passed it to OPPORTUNE. This line and a bow line which ran from ex-HAKE's bow to the MOSOPELEA were to be used during lifting to steady the submarine.

During slack water, hoses were attached to the pontoons. One hose to the forward lift pontoon was discovered to be bad during testing. It was replaced. The lift was then scheduled for daylight the next day.

Early on 30 August the pontoons and selected ballast tanks were blown in the following order: stern control pontoon, stern lift pontoon, MBT's 2AB and 7, forward lift pontoon and forward control pontoon. No movement of ex-HAKE was noted. Air hoses were then run to MBT's 4AB, 5AB, and 1. A large leak was discovered in the vent line to MBT 7, so all efforts to deballast that tank were abandoned.

Continuing the effort to lift ex-HAKE, MBT's 4AB and 5AB were deballasted. By carefully blowing MBT 1, the submarine's bow lifted until the control pontoon broke the surface with about 5 feet of freeboard. Despite the line to the MOSOPELEA, the current swung the bow of the ex-HAKE to the west away from the LCU 1490 and PRESERVER. The air hoses to the forward pontoons were pulled off, but quick action by personnel from OPPORTUNE's work boat secured all valves. This maintained sufficient buoyancy in the pontoons to keep the submarine's bow up.

The bow line of the ex-HAKE was shifted to the OPPORTUNE's fantail; the stern line was shifted to the starboard quarter of the PRESERVER. OPPORTUNE swung the heading of the ex-HAKE to 015° from the original heading of 195°. Ballast tanks and pontoons were then vented to allow ex-HAKE to settle to the bottom again. The submarine was inspected and found to have an up angle of 5 degrees with the stern hard aground.



In order to steady the submarine during lift, one line was run from the stern of the ex-HAKE to the OPPORTUNE and another from the submarine's bow to the MOSOPELEA.

POSITION OF VESSELS FOR SUCCESSFUL LIFT, 30 AUGUST 1971

On 31 August ex-HAKE was moved to shallower water. All pontoons and compartments MBT 4AB, 5AB, 6AB, and 6CD were blown alternately. MBT 2AB was blown dry and closed off. The bow of the submarine was raised off the bottom. ex-HAKE was moved up the bottom slope 20 additional yards. The pontoons were then vented which allowed the bow to settle to the bottom. The submarine was inspected. The bow was in 65 feet of water and the stern in 75 feet. The submarine's crew compartment was checked through the salvage fittings; it was found to be only partially flooded.

Preparations For the Final Lift

With the ex-HAKE successfully moved to shallower water, preparations began for the surface lift. Arrangements were made for 16 inflatable pontoons to be readied at the Norfolk ESSM base for transfer to the PRESERVER. It had been determined that at least 60 additional tons of lift would be required to surface the submarine if MBT 7 could be repaired. The plan was to use 12 of these inflatable 8.4-ton pontoons to provide this extra lift.

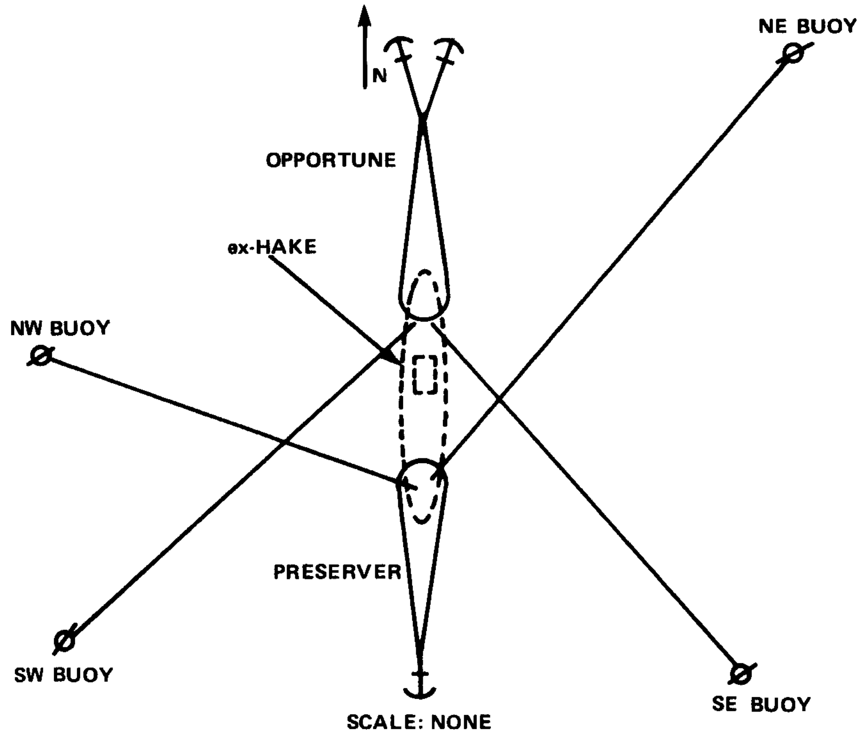
Rerigging the Salvage Pontoons

OPPORTUNE replaced PRESERVER in the moor and began rerigging the forward pontoons. For the surface lift the lift pontoon would be raised and swung to the port side and the control pontoon raised and swung to the starboard side. PRESERVER departed for Norfolk to pick up the inflatable pontoons. Since ex-HAKE had been moved only a short distance, it was planned to use the original moor for the surface lift.

On 1 September PRESERVER picked up the pontoons at the ESSM base along with salvage air fittings and toggle bars for an additional salvage pontoon, YSP-1. YSP-1 would not be used unless all other efforts to surface the submarine were unsuccessful; however, it was prepared in the event it was needed.

On 2 September, PRESERVER returned to the salvage site. It was decided to have both OPPORTUNE and PRESERVER work in the moor at the same time, moored stern to stern with lines from their sterns to opposite mooring buoys and the ships' anchors used to hold the bows. LCU 1490 would be alongside.

PRESERVER began rerigging the stern pontoons with the intent of placing one on the port side of ex-HAKE and one on the starboard side in the same manner that OPPORTUNE was placing the forward pontoons. PRESERVER encountered difficulty, however, in disconnecting the stern control pontoon. The lift pontoon prevented the control pontoon



OPPORTUNE and PRESERVER worked simultaneously in the same moor preparing the pontoons for the surface lift.

POSITION OF OPPORTUNE AND PRESERVER DURING PREPARATIONS FOR SURFACE LIFT

from being lowered. The lift pontoon tilted each time reeving lines on the control pontoon were tightened because of chafing from the lines. The lift pontoon's end was up against the bottom of the control pontoon. Therefore, the control pontoon was set back on positive.

Because the tide was too strong to continue diving operations, all units were allowed to return to port on 3 September for the holiday weekend. All lines to the submarine were cleared. A buoy was attached to the conning tower and the Coast Guard placed a submarine exercise buoy 50 yards to the west of the conning tower buoy. All units returned to port.

On 7 September PRESERVER returned to the exercise site, moored, and began diving operations. However, currents were still strong and preparations for resurfacing the stern control pontoon could not be completed. In addition, removing the toggle bars was difficult because of the distortion of the metal caused by the chain's stresses during lifting.

OPPORTUNE, with YSP-1 in tow, arrived at the exercise site. YSP-1 was buoyed off to the northwest crown buoy of the moor. OPPORTUNE joined PRESERVER in the moor and preparations for the surface list continued. LCU 1490 arrived and moored alongside PRESERVER.

On 8 September the toggle bars were removed from the stern control pontoon by passing a 7/8-inch wire strap between the chain and toggle bar and running it to the ship's capstan. PRESERVER raised the stern control pontoon and swung it around one reeving wire to the port side. The stern lift pontoon was surfaced and swung around to the starboard side. The other reeving wires were then dipped through the pontoons' hawsepipes to prepare the pontoons for lowering into position on a parallel axis with the submarine.

HCU-2 divers patched the leak in MBT 7 and the ballast tank tightness tested satisfactorily with only a very small leak. OPPORTUNE completed adjustment of the forward pontoons and, after recovering ex-HAKE's anchor, departed for Little Creek.

During the next 2 days, PRESERVER lowered the stern pontoons and set them on positive. Divers ran hoses to MBT's 1, 2AB, 4AB, and 5AB. The depth of the toggle bars were adjusted several times and the pontoons set at the right depth. Difficulties were again encountered because of the curvature of the ex-HAKE and the narrowness of the hull.

Rigging the Inflatable Pontoons

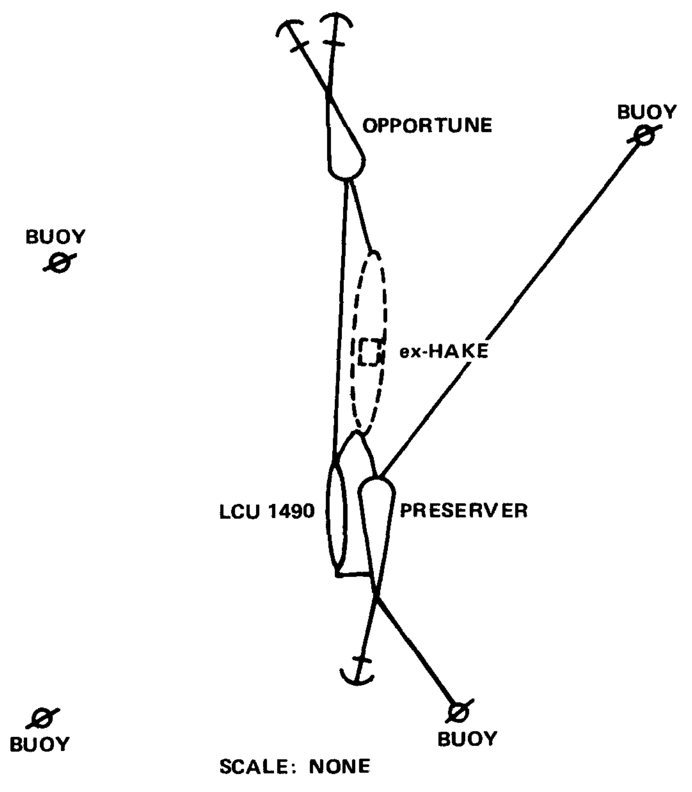
The inflatable pontoons were then rigged. It was planned to have the pontoons connected in groups of three onto the chain just above each hawsepipe on the salvage pontoon. The pontoons would then be lowered into the water with the use of the ship's boom. The pontoons were easy to rig since all rigging could be completed on deck except for attaching the lower pontoon to the lifting sling. On 11 September rigging of the 12 inflatable pontoons was completed and blowing began.

When the lower inflatable pontoon on the forward port side of the ex-HAKE was blown, three pontoons came to the surface rupturing two of them. The pontoons then sank to the bottom. When the pontoons were brought aboard the PRESERVER and inspected, it was discovered that the lower pontoon was missing the taper pin and shackle pin from the shackle connecting the chains inside the pontoon. There was no indication that the taper pin had ever been installed and no excessive scoring existed on the shackle. The shackle pin had either slipped out as a result of the missing taper pin or it also had never been installed. Since these three portside pontoons were inoperable, it was decided to remove three inflatable pontoons from the starboard side and lift the submarine using the remaining six inflatable pontoons and the four salvage pontoons.

Surface Lift

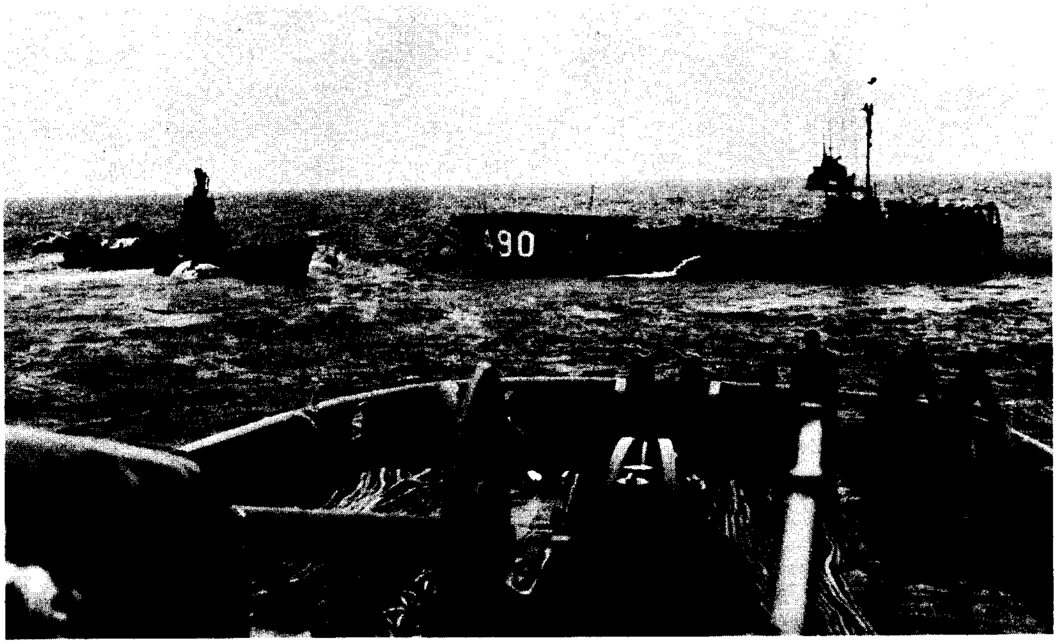
On 12 September lines were rigged for the surface lift. A stern line was rigged from the submarine's stern to the PRESERVER's fantail. Another line was run from the PRESERVER to the stern of the LCU 1490. The bow line of the ex-HAKE was retrieved and run to the stern of the OPPORTUNE. A towing line was also run from the OPPORTUNE to the LCU 1490 and an additional line from LCU 1490 to the buoy attached to ex-HAKE's after torpedo hatch.

Blowing of the pontoons and ballast tanks took place in the following sequence: MBT's 4AB, 5AB, stern pontoons, forward pontoons, MBT 1, MBT's 6AB, 6CD, 7 and MBT 2CD. As a result, the stern rose to approximately 8 feet below the surface.



Lines were rigged from the PRESERVER and OPPORTUNE to the submarine and also to the LCU 1490 in an attempt to control the ex-HAKE during surface lift and to provide an adequate supply of air.

POSITION OF VESSELS FOR SURFACE LIFT, 12 SEPTEMBER 1971



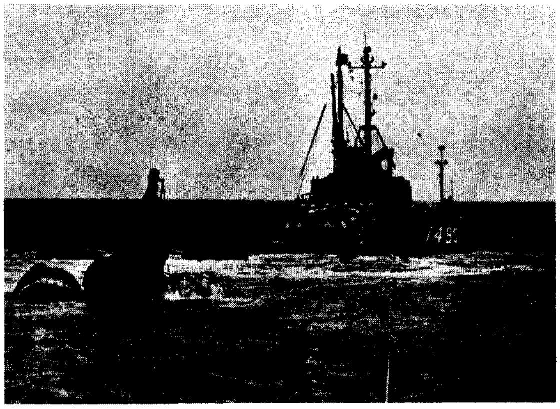
During the surface lift on 12 September, LCU 1490 was swung away from the ex-HAKE by tidal currents causing the air hoses to the pontoons and ballast tanks to part.

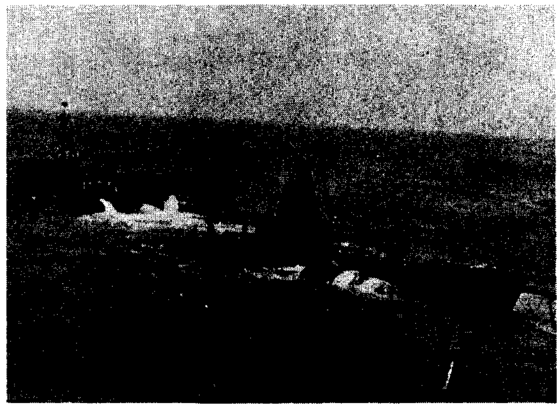
AIR HOSES FROM LCU 1490 TO ex-HAKE PART

OPPORTUNE began towing ex-HAKE into shallow water with LCU 1490 alongside by heaving on her anchors and going ahead on her engines. The boarding party went aboard the submarine but because of the inside pressure, the forward torpedo hatch and conning tower hatch could not be opened. The pressure had to be bled off before the hatches could be opened safely. When the ex-HAKE was finally entered, it was found that the control room had approximately 3 feet of water and the crew compartments were full.

Before pumps could be rigged and pumping started, the LCU 1490 was caught by the current and swung around. Nearly all the air hoses were parted. The submarine hatches were closed and equipment removed from the ex-HAKE. The submarine was vented and settled in 35 feet of water at 37°15.35'N; 76°04.15'W.

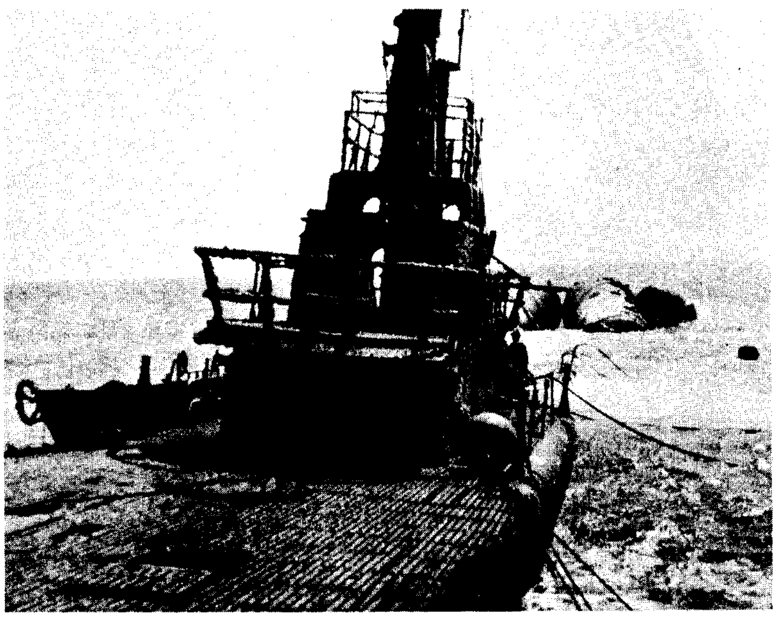
During the night, the pressure manifold on the LCU 1490 which had been ripped from its legs was repaired. The next day hoses were recovered and hooked again to the submarine and pontoons. The submarine was again surfaced. This time pumping of the control area was completed. The crew's compartment was dewatered by blowing compressed air through high and low salvage fittings.





To lift the submarine to the surface, six inflatable pontoons were used in addition to the four YSP's.

Boarding party prepares to open the submarine's hatches.



After 5 weeks on the bottom of the Chesapeake Bay, ex-HAKE was finally surfaced. Note the open hatches. Pumps were lowered through these hatches to dewater the internal compartments.

ex-HAKE ON THE SURFACE

When the crew's compartment hatch was above the surface of the water, blowing was secured and pumping began. The compartments aft of the crew's compartment were pumped out in succession until the hatch to the engine room was above the surface. Pumping of the after engine room and maneuvering room were completed through this hatch.

Return to Port

With the submarine finally on the surface and under control, the salvage force made preparations to return to port. PRESERVER recovered the moor and then removed the inflatable pontoons. OPPORTUNE rigged the hulk for towing. All units proceeded into port at Little Creek. OPPORTUNE towed ex-HAKE with LCU 1490 and PRESERVER in company. The tow was completed without incident culminating a 5-week salvage effort which provided extensive and indispensable training for SERVRON EIGHT and HCU-2.

CONCLUSIONS

SUBSALVEX-69 had demonstrated that the use of submarine salvage pontoons (YSP's) is a valid salvage technique and should be considered and applied in future salvage operations as the circumstances dictate. SUBSALVEX-69 also concluded that salvage of a sunken submarine is feasible if the submarine is within reach of divers. SUBSALVEX-71 concluded that salvage forces need more training than is now being provided. This became evident during the exercise because, as the personnel gained experience, their proficiency improved rapidly. Additional training is thus necessary to improve the readiness of the salvage forces and to maintain salvage personnel familiarity with submarine salvage procedures, equipment and possible problems. In view of this, the Commander Service Squadron EIGHT, recommended that submarine exercises be conducted at not less than 2-year intervals, if feasible, so that the Service Force will always have a small nucleus of submarine salvage trained personnel.

An important part of any training exercise is the experience gained and lessons learned, especially concerning the methods and equipment used. SUBSALVEX-71 was no exception. Specific conclusions were reached by Service Squadron EIGHT concerning the submarine salvage methods and equipment used during the submarine salvage exercise. These conclusions are listed below.

Methods

1. Deck valves only should be used to submerge the submarine. In both SUBSALVEX-69 and SUBSALVEX-71, air hoses were used in an attempt to control the sinking

of the ex-HAKE and in both cases problems developed. The hoses had to be removed and the submarine sunk by opening the deck valves.

2. In laying a 4-point moor, the accuracy of the anchor positions is very important in positioning the ship in the moor. Thus, the ship's boat should be positioned in the center of the moor with a radar reflector and stadimeter. The workboat crew with the stadimeter can provide accurate ranges to the ship during maneuvers to position the ship at the drop point. In addition, all buoys marking the submarine should be plumbed. This assists the ship in positioning over the submarine.

3. One vessel in the moor can rapidly replace another in a moor by having a workboat take off one line. This allows the vessel coming into the moor to come alongside the ship already in the moor. The lines are then readily transferred one at a time from one ship to another. Weather permitting, this is less time consuming than having the ship in the moor remove all lines from the mooring buoys, transfer them to the ship coming into the moor, and the incoming ship having to rerun them to the buoys.

4. During both SUBSALVEX-69 and SUBSALVEX-71 flower pots were used in rigging and positioning the control pontoons and, in both exercises, difficulties occurred. A method of rigging the lifting equipment is available which eliminates the use of flower pots. By this method, lifting wire is divided into 25-, 50-, 75-, and 100-foot lengths. With two extra 25-foot sections of chain for each lifting sling, toggle bars can be used in every instance. The salvor would calculate where the pontoons should be set and how many feet of chain and wire would be required. The chain would be reeved around the submarine. Then the wire sections would be made up to the reeving chain with the 25-foot section of chain connected to their ends at the required depth for the top of the pontoons. The 25-foot of chain would give a plus or minus 12.5 feet to make corrections to the tilt of the pontoon. For example: if the pontoon's toggle bars were desired to be set 110 feet above the ends of the lifting chain, a 75-foot and 25-foot section of wire would be connected to each end of the lifting chain. Then the 25-foot section of chain would be added allowing the toggle bars to be set between 100 and 125 feet above the ends of the lifting chain.

5. Initially, in lowering the pontoons, attempts were made to reduce negative buoyancy with the vent hoses connected; however, this was time consuming. The pontoons were then lowered with only the blow hoses connected and the vent valves open. As long as the lifting slings were taut, there were no problems, and the pontoons were easily controlled by the descending lines. However, when the slings were not taut, as happened in lowering the stern lift pontoon, difficulties in handling and positioning the pontoons occur. Also, in order to provide a bigger safety margin, descending lines should be made stronger. This could be done by replacing the present 5-inch line with 6-inch braided line.

6. Because difficulties had occurred during SUBSALVEX-69 when the blow hoses were buoyed off after connecting them to the positioned pontoons, during SUBSALVEX-71 the hoses were removed after the pontoons were set and reconnected just prior to the lift attempt. This seemed to work satisfactorily and it took very little time to reconnect the hoses.

7. Recommendations were made for future submarine salvage exercises. First, for operations of this size, all ship's personnel should participate in the various tasks rather than just divers and deck hands. This would give everyone a sense of responsibility, prevent the small diving and deck force from becoming overtired, and increase the effectiveness of the ship as more people become interested and involved. Second, divers from the ATF's should be integrated into the ARS diving team for a minimum of 1 week in order that they receive training that, because of the ATF operating schedule, they have little opportunity to receive. In addition, all ARS and ATS vessels should have a copy of the U.S. Navy Submarine Salvage Manual (NAVSHIPS 0900-006-2010), a useful reference of submarine salvage techniques and procedures.

Equipment

1. The deteriorating condition of ex-HAKE accounted for some of the difficulties experienced during SUBSALVEX-71. As a result, the submarine should be completely overhauled or another submarine obtained before conducting any future submarine salvage exercises. Furthermore, if another submarine is obtained, it should not be modified as ex-HAKE was prior to SUBSALVEX-69. Even though such modifications facilitate venting and blowing of the ballast tanks, it also leaves the submarine more vulnerable to damage and deterioration. It is more realistic, and thus better for training purposes, to use the original installed salvage fittings to ballast or deballast the tanks. In addition, a preexercise check of the submarine should include: the emergency vent valves are opened when vent lines are checked; and high and low salvage valves are positively checked for proper operation.

2. The plastic hose used during SUBSALVEX-71 was subject to kinking and fatigued easily at the places where kinks developed. One reason why the kinks were so prevalent at first, was because the hose had been removed from its coil on deck. As the hose was used, it was pulled off the pile and each coil tightened into a kink. Pulling the hose off a reel would prevent this. When the hose was recovered it was run into a figure 8 coil which helped to eliminate the kinks when the hose was used the next time. Otherwise, the hose was easy to handle and remained buoyant when full of air, allowing one to keep track of where the hoses were.

3. SUBSALVEX-71 illustrated a number of things concerning the salvage pontoons. The first pertained to the wells in which the pontoon valves had been placed in an effort to eliminate the difficulty experienced during SUBSALVEX-69 when the exposed valves were frequently knocked off. During SUBSALVEX-71, in those pontoons where the vent lines were run to the bottom of the well, air pockets developed which prevented the pontoons from sinking. This was remedied by welding nipples in holes cut into the manhole covers. In order to prevent a recurrence of this problem, pontoons with vent lines installed similarily should be modified to eliminate the air pockets. For example, pontoons with vent lines that run to the side of the well do not have this venting problem. The second concerned the pulling forces on the pontoon's vent and blow lines which often caused leaks or rupture of the nipples connected to the valves. If a padeye had been located near the well, air hoses could have been tied off after installation and most of the strain on the connection point would have been removed. And thirdly, all relief valves should be external. YSP-62 and YSP-63 had internal relief valves. In the event of a malfunction, pontoons with internal relief valves cannot be adjusted externally, and the pontoons must be entered through the manhole cover to correct any problems.

4. Equipment available to salvage forces in the event of an emergency should be operational. Training exercises provide an opportunity to test such equipment. Problems such as experienced with the vent valve configuration on the salvage pontoon are not discovered until the equipment is actually put in use. Also, during SUBSALVEX-71, the air compressors had installation deficiencies. Two additional compressors had to be obtained. If air compressors are to be ready in the event of an emergency, they must be checked out frequently and kept operational. In addition, technical manuals should be forwarded with the compressors to the users (none were provided during SUBSALVEX-71).

5. Difficulties were encountered with one of the 8.4-ton inflatable pontoons used for the surface lift. The bending shackle failed when the pontoon was inflated. It appeared that the taper pin had never been installed. The shackle pin either slipped out as a result or it also had never been installed. All pontoons of this type should have a load test or internal inspection to determine if a similar deficiency exists.

6. The dimensions of the toggle bars should be checked before use. Even though the bars may fit over the chain, there should be enough clearance to reduce the effect of any distortion to the toggle bars from lifting stresses. After problems were experienced in removing the toggle bars, the dimension between the pieces that fit over the chain were found to be less than the 2 3/4 inches specified in the Submarine Salvage Pontoon Manual (NAVSHIPS 250-631-2).

7. A number of items should be added to the Emergency Ship Salvage Material (ESSM) base inventories. These include a socket wrench to fit submarine deck fittings and a

water level gauge. For SUBSALVEX-71 the wrench provided the salvage forces for the deck fittings was awkward; instead, the divers used a small socket wrench which proved much easier to handle. Internal flooding of the ex-HAKE's compartments raised questions as to where the most advantageous places would be to place the lifting equipment. With the use of a water level gauge, the extent and location of the flooding can be determined and thereby increase the efficiency of the salvage operation. In addition, every salvage base having chain for use with salvage pontoons should ensure that the chain stoppers in stock are compatible. During SUBSALVEX-71, one salvage base provided salvage equipment which included stud-link chain stoppers with die-lock chain. Stud-link chain stoppers should be replaced as soon as possible with die-lock chain stoppers since die-lock stoppers can be used with either type of chain and stud-link chain stoppers cannot.

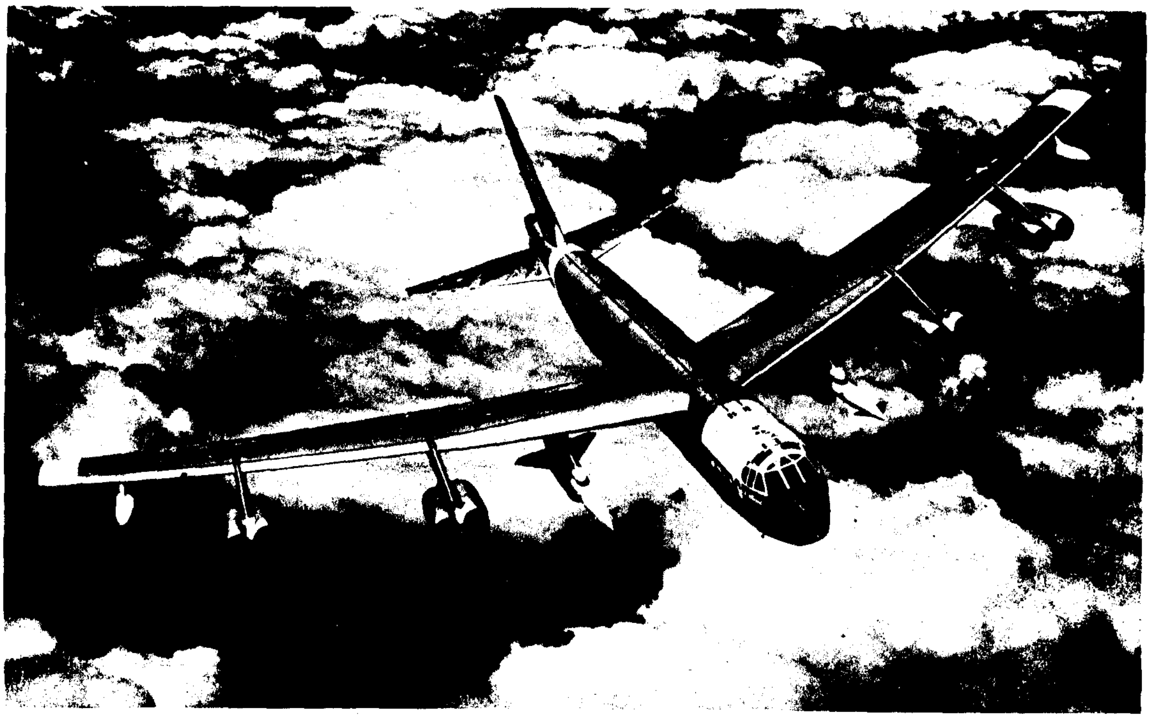
8. There are a number of possible means to assist the diver and concurrently reduce the diving time required for submarine salvage operations. Although the tool inventory of the fleet diver is adequate for submarine salvage, if pneumatic tools for rigging were provided, the time required for rigging could be shortened. Time would also be saved if the U.S. Navy approved the use of the shallow water diving suit with communications from the surface to the diver. This would reduce the time spent by divers in surfacing to explain problems or situations. Also, at present, the divers have difficulty in identifying the different valves despite a system of different shape valve handles. A system of studs similar to the submarine's salvage fitting would assist the diver.

SEARCH AND RECOVERY

OF

U.S. AIR FORCE B-52 AIRCRAFT

IN LAKE MICHIGAN



A B-52 bomber, similar to this one, crashed into Lake Michigan on 7 January 1971. Search and recovery operations were begun shortly after the crash but had to be deferred to spring because of severe winter weather.

THE B-52, LONG RANGE BOMBER OF THE U.S. AIR FORCE'S STRATEGIC AIR COMMAND

SEARCH AND RECOVERY OF U.S. AIR FORCE B-52 AIRCRAFT IN LAKE MICHIGAN

INTRODUCTION

A U.S. Air Force B-52 with nine crew members aboard crashed in northern Lake Michigan on 7 January 1971. A search was begun immediately but nothing of significance was located. The Air Force, Supervisor of Salvage, and Ocean Systems, Incorporated (OSI) worked together to conduct underwater search and recovery operations. Using sonar and underwater television at the outset and then following up with divers wearing heated diving suits, operations continued until 26 January despite poor visibility, extreme cold, winds, rough seas, and snow. A blizzard on 25 January finally forced postponement of recovery attempts until spring.

Operations resumed in May to recover key pieces of wreckage which would enable the Air Force Accident Investigation Board to determine the cause of the crash. OSI's commercial diving system, the ADS-IV, was used in conjunction with sonar and underwater television. During a month's intensive operations, more than 30 dives were made with this equipment. Numerous pieces were sighted and identified; many, at Air Force direction, were recovered.

B-52 SALVAGE OPERATIONS PHASE I
7-26 JANUARY 1971

Circumstances of the Crash

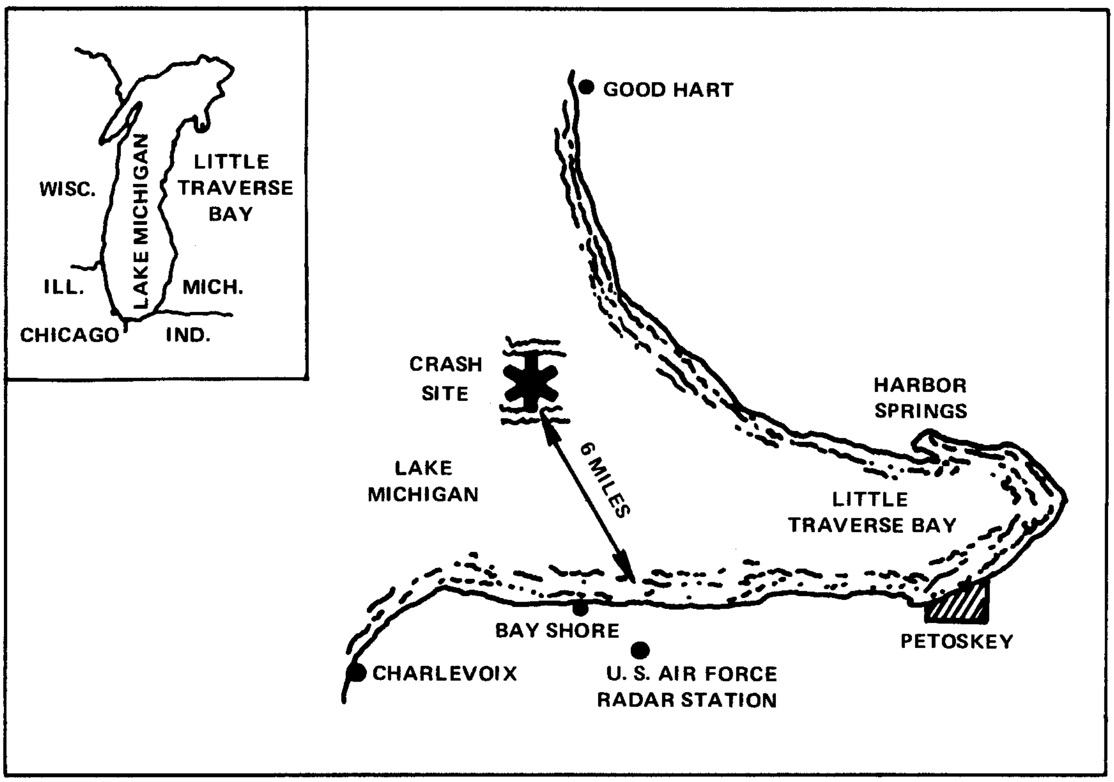
The B-52, operating out of Westover Air Force Base, Massachusetts, was under continuous ground radar tracking at the time of the crash, approximately 1833. Its last recorded position was 312.8°T., 6.5 miles from the Radar Bomb Scoring site at Bay Shore, Michigan which is operated by the Strategic Air Command. Weather at the time of the crash was overcast with a light blowing snow falling.

Immediate Search Activities

An intensive search was launched immediately using U.S. Coast Guard helicopters and two Coast Guard surface vessels. No personnel were found at the scene and only a small amount of debris was recovered. The search continued throughout the night but was hampered by darkness and a lack of visibility caused by the blowing snow. In addition, a shoreline search was initiated on 8 January but nothing of significance was located. A small oil slick, however, did form on the surface of Lake Michigan and was sighted during the day.

Survey Team

The Supervisor of Salvage (SUPSALV), U.S. Navy was requested to dispatch a diving/salvage survey team to assist the U.S. Air Force Accident Investigation Board in establishing survey and search procedures. Representatives from SUPSALV and Ocean Systems, Incorporated (OSI) arrived on 9 January. They met with members of the Accident Board at the



The B-52 crashed while on a simulated bombing mission off Bay Shore. Prior to the 7 January crash, the Strategic Air Command had operated the Bay Shore simulated bombing program for more than 7 years without incident.

LOCATION OF B-52 SEARCH AND RECOVERY OPERATIONS IN NORTHERN LAKE MICHIGAN

Radar Bomb Scoring site to discuss the feasibility of conducting an underwater search with a possible follow-on recovery. During the afternoon the survey team surveyed the crash area aboard the local buoy tender, USCGC SUNDEW which was stationed at Charlevoix, Michigan.

Planning Search Procedures

After returning to port, the survey team again met with Air Force and Accident Board representatives to review search and recovery probabilities, weather constraints, and cost estimates. After these details were studied and SAC headquarters consulted, it was decided to proceed with search and recovery operations with the radar fix at the time of the crash being the most reliable data upon which to base a search.

Towed dual side-scanning sonar, underwater television, and an auto tape precision navigation system were considered the best method for broad coverage search operations in water of this depth (up to 240 feet). Operations would be staged from Charlevoix which was about 45 minutes steaming from the datum point. Two NAV-AIDS shore stations were established, one at Harbor Springs, and the other on the nearby atomic power plant property.

CONDUCT OF PHASE I OPERATIONS

Initial Search Operations

SUNDEW got underway on 11 January. An initial formation and contact search located the aircraft wreckage at 1438 in an area approximately 650 feet wide by 2600 feet long along both sides of the original track of the aircraft. A buoy was placed for datum marking.

Because the SUNDEW was scheduled elsewhere for an "ice breaking" mission, the USCGC WOODBINE from Grand Haven, Michigan was assigned to be the working platform for the effort. The equipment was off-loaded from SUNDEW and installed on WOODBINE. On 12 January WOODBINE sailed to the datum point to continue the search.

During the next four days, 13-16 January, many attempts were made to get good underwater television coverage. Efforts were also made to lay the standard Coast Guard navigational buoys and moorings for a 4-point moor for which the deck handling arrangement and equipment of WOODBINE were designed. The windy, cold weather, however, interfered with both operations.

By 16 January, WOODBINE was able to establish a 3-point moor. The camera and side-scanning sonar were over the side; however, visibility was very poor, 1 or 2 feet, and there was a static suspension of silt at least 3 feet above the bottom.

Divers Join the Search and Recovery Operations

It had been intended to use underwater television to try to identify the various pieces of aircraft prior to recovery. Because of the extremely poor visibility, this proved to be impossible. It was therefore decided to bring in divers and hot water diving equipment. The divers would dive at selected points in the wreckage area where large pieces had been recorded by sonar in an attempt to pick up pieces of wreckage for the Accident Board to identify. The divers would also try to determine the debris pattern. Although this method would be very time consuming, with a bottom visibility of zero to 2 feet it appeared to be the only feasible way to conduct recovery operations.

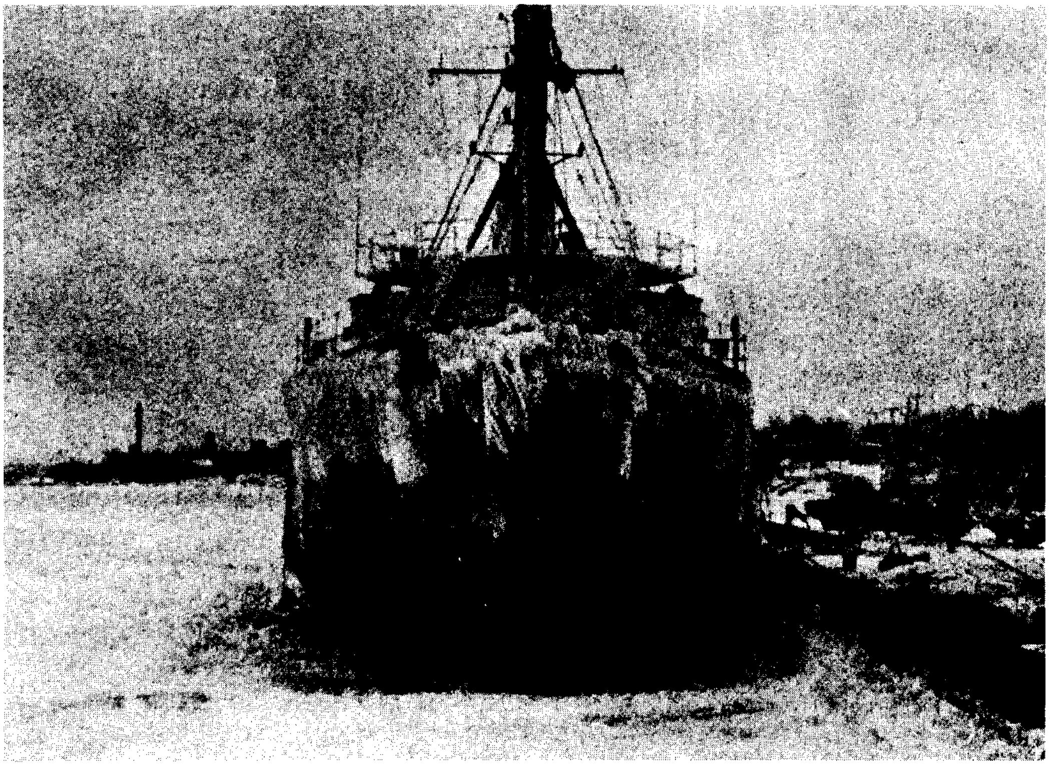
Accordingly arrangements were made to bring the necessary recovery equipment to Charlevoix. The equipment arrived on 19 January. In addition arrangements were made to use, if necessary, a barge from Michigan College, Great Lakes Maritime Academy to collect wreckage.

On 19 January all diving equipment was loaded and made ready for use onboard WOODBINE. WOODBINE got underway for diving operations early the next day. Upon arriving in the wreckage area it was found that floating ice had moved one of the previously planted mooring buoys 1000 yards closer to shore. The moor was reestablished and another attempt was then made to get pictures with the underwater TV; zero visibility made it impossible.

It was decided to leave the television in the water and use the cables as a descending line for the divers. The first diver entered the water, located, and tied into a large piece of wreckage on the bottom. The diver could not identify the wreckage because of poor visibility. While the diver was on the bottom he became fouled in the TV cables and descending line, making it necessary for a second diver to go into the water to clear him. In addition, the wreckage was lost when the ship's motion caused the line to chafe.

Weather Worsens

Although the weather had never been good, it was now worse, getting very cold with high winds and rough seas. There was a wind chill factor of well below zero and ice floes floated by on the lake almost constantly. The floating ice further hampered operations by continually moving the moorings, thereby forcing the anchors to be repositioned a number of times.



WOODBINE, the working platform for Phase I operations, was covered with ice 90 percent of the time. Ice covered everything, including the diving gas cylinder racks, steam generating equipment, and mooring lines, thus making working conditions very difficult and extremely hazardous.

U.S. COAST GUARD CUTTER WOODBINE ALONGSIDE PIER AT CHARLEVOIX

Personnel on deck had to be relieved every 30 minutes to keep them warm. Equipment required constant attention and hot air blowers were kept in continuing use to prevent air compressors, gauges, and other equipment from freezing. Mooring lines were difficult to handle as they became stiff from the ice and cold. The boat and crew which were used to run the mooring lines were sheathed in ice after each run.

WOODBINE attempted to reach the worksite early on 21 January but very rough seas and winds of 25-35 knots forced her to return to port. Later in the day, WOODBINE reached the wreckage area and repositioned a mooring buoy before snow flurries and 10-12-foot swells brought a halt to the day's operations.

Two dives were made on 22 January; only small pieces of wreckage were found. Difficulties occurred again when one diver's hot water line kinked during descent. The sudden loss of heat caused the diver to go into cold shock but he was brought up safely with no post-dive ill effects.

At this time the Air Force sought the opinion of the SUPSALV Representative on continuing search and recovery operations. The SUPSALV Representative recommended that the operations be secured for three reasons:

1. The lack of bottom visibility meant the divers could not use underwater cameras as a means of getting topside approval on what wreckage to recover.

2. The pitching and rolling of the ship lifted the divers off the bottom.

3. Since the wreckage area was 2400 yards long and 1600 yards wide, it was unlikely that the divers would be able to retrieve the vital pieces by bringing up everything they felt.

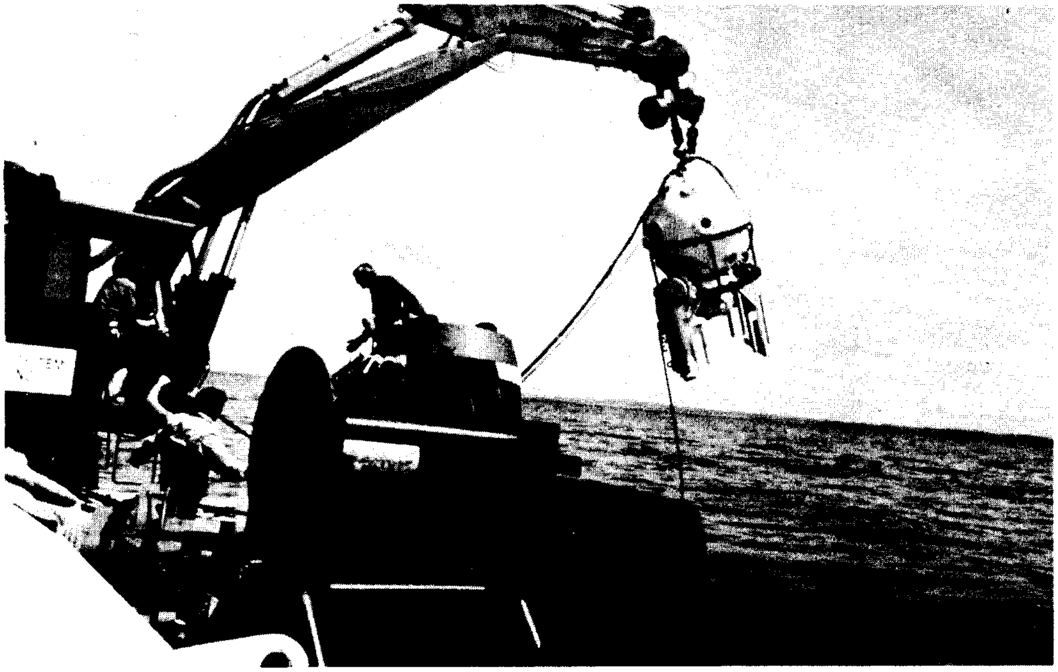
The Air Force, however, decided to continue search and recovery operations because a great many B-52's would be flying before any possible renewal of operations in the spring and if a structural weakness had caused this accident, subsequent flights might be effected.

WOODBINE was unable to leave port on 23 January because of 20-40-knot winds and 12-14-foot seas; the day was spent working on equipment. Calm weather, wind, and seas on 24 and 25 January enabled diving operations to resume. As ice floated through the wreckage site, various small sections of the aircraft were recovered. An engine oil cooler and a 9-foot section of the mid-body fuselage containing a fuel tank were found; however, none of these were considered significant to the on-scene aircraft safety specialists.

Mid-Winter Recovery Operations Are Terminated

A blizzard hit Charlevoix during the evening of 25 January with winds of 50-60 knots and driving snow. This storm was predicted to last 2 or 3 days or more. Air Force officials, after a thorough review of recovery efforts thus far, the extremely marginal working conditions, and increasing ice cover and frequency of winter storms, decided to suspend any further mid-winter recovery attempt even though not enough wreckage had been recovered to allow the Accident Board to reach any conclusions as to the cause of the accident.

Demobilization of men and equipment began on 27 January. The entire process was very lengthy because of the fierce storm conditions. Roads were blocked, air travel was cancelled, and WOODBINE with all the recovery equipment aboard was diverted to the port of Grand Haven, Michigan, 200 miles to the south after a fruitless SAR mission. Personnel unloaded the recovery equipment at Grand Haven on 29 January.



The ADS-IV diving bell was used to lower two divers to the bottom. At the bottom, one diver would leave the bell and attach salvage lines to the wreckage.

ADS-IV BELL ENTERS LAKE MICHIGAN

B-52 SALVAGE OPERATIONS PHASE II
12 MAY – 11 JUNE 1971

Planning

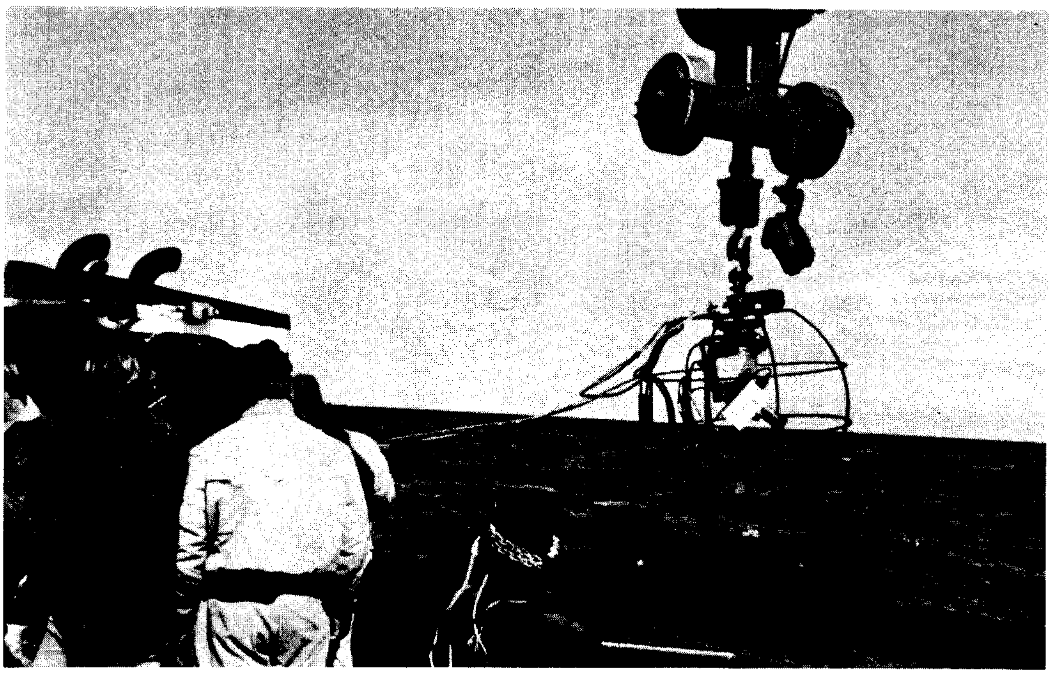
During the weeks following the end of Phase I operations on 26 January 1971, the Supervisor of Salvage, the Air Force Accident Board, and OSI worked together to plan a follow-on salvage effort to recover the wreckage. Much thought and preparation went into the planning of Phase II operations in order to determine what techniques and equipment would be most effective for search and recovery operations at a depth of 240 feet.

It had been determined during Phase I operations that the wreckage site had a soft mud bottom ranging in depth from 1 to 3 feet and an initial bottom visibility from 6 inches to 3 feet. Such conditions made it necessary to select techniques and equipment which would ensure minimal bottom disturbance and most probable success each time.

Considering these factors, plus communications, cold water, and decompression requirements, OSI's Advanced Diving System (ADS-IV) was selected. The ADS-IV is composed of two major units, a diving bell with a 2-diver capacity, and a deck decompression chamber. With this system, a diver in a dry diving suit is able to lockout of the bell to do underwater work; in this case, to connect salvage lines to the aircraft wreckage. Since the diver is not pressurized until he is able to see the object, his cold water working exposure time is optimized; he is unencumbered with descending lines, hot water hoses, and salvage lines; and decompression can be safely carried out in a dry, warm environment.

The Search and Recovery Cycle

The plan called for the M/V SEA SYSTEMS, OSI's salvage vessel, to be placed in a 4-point moor. A sled with dual side-scanning sonar and a closed circuit underwater television system would be put over the side and lowered to near bottom by the ADS-IV crane. The



Because of poor underwater television visibility and the necessity to move from one site to another, the side-scanning sonar was "married" to the TV vehicle. This sonar/TV sled was lowered to the bottom by the ADS-IV crane.

SONAR/TELEVISION SLED IS LOWERED OVER THE SIDE

wreckage would be located with side-scan sonar; then SEA SYSTEMS would be maneuvered over the area and the wreckage identified via closed circuit television. The Air Force Identification Team would then decide if the wreckage should be recovered. If the wreckage was to be recovered, the sled would be retrieved and the ADS-IV diving bell would be attached to the crane in its place. Two divers would then enter the bell and be lowered to the bottom.

When the divers sighted the wreckage, one would lockout and attach lift wires to it. The diver would reenter the bell and the bell would be brought aboard SEA SYSTEMS. After the bell had been mated to the deck decompression chamber, and while the divers were being decompressed, the ADS-IV crane would raise the wreckage to the surface and load it on a barge. SEA SYSTEMS would then move her position, lower the sonar/TV sled, and the search and recovery operation cycle would begin again. Later the wreckage would be off-loaded from the barge onto the pier at Charlevoix, the staging area.

CONDUCT OF PHASE II OPERATIONS

Preparations

On 13 April 1971, the U.S. Air Force decided to proceed with Phase II of the B-52 salvage operations; SUPSALV tasked OSI to implement the approved plan. During the next 9 days, the M/V SEA SYSTEMS, ADS-IV, and related equipment were made ready for transit from West Palm Beach, Florida, to Charlevoix, Michigan via the St. Lawrence Seaway.

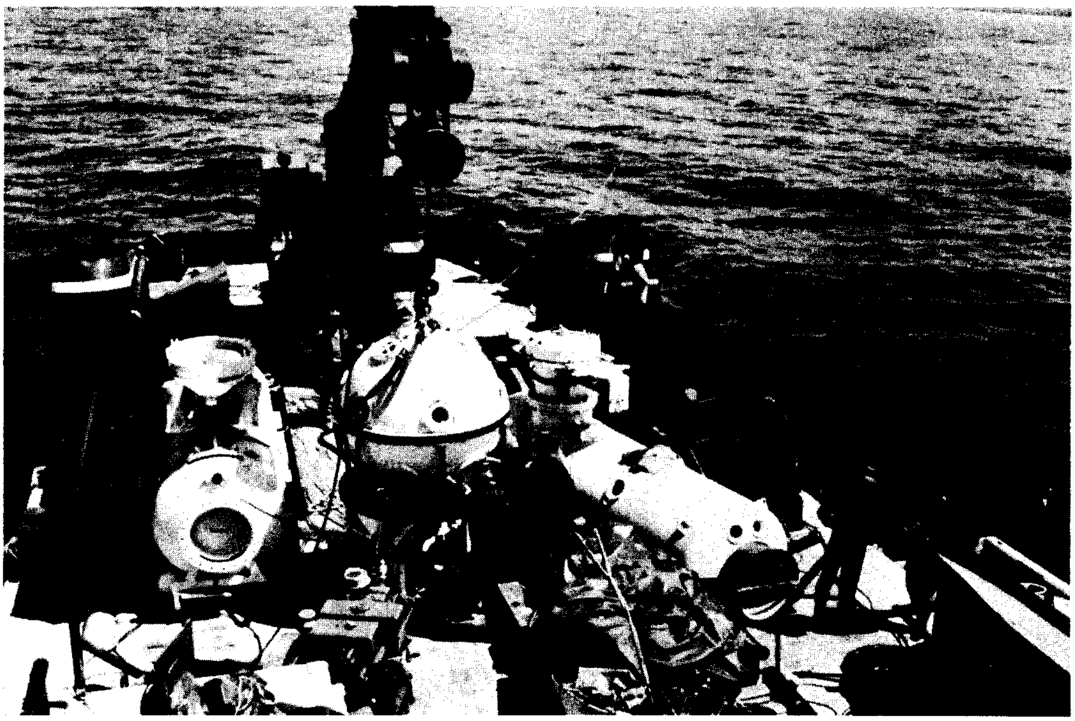
SEA SYSTEMS arrived in Charlevoix at 0115 on 13 May. The next 2 days were spent rigging the ship, splicing cable for the mooring legs, and making other preparations. Two NAV-AID stations were set up, one in Harbor Springs at the same site it had been during Phase I operations, and the other on the property of the Lexolite Plant. In this case, the previous site, a nearby atomic power plant, could not be used because of a strike and severe local labor unrest there. Representatives from the Air Force, SUPSALV, and OSI arrived and held discussions on the planned salvage operations.

Preparing the Work Site, 16-20 May

While awaiting a winch and TV cable to arrive in Charlevoix, SEA SYSTEMS began to prepare the work site. Enroute to the wreckage area on 16 May, SEA SYSTEMS checked out and calibrated the NAV-AID stations and communications net. Once at the wreckage site, 12 passes of the sonar auto tape system were made to reverify the debris pattern. The debris area was divided into two halves, a northern half and a southern half. Four sets of moorings were laid outside each half.

On 17 May a 3-hour observation dive was conducted with the ADS-IV bell. Bottom debris was checked and logged and visibility in the northern half of the debris pattern was noted. Bottom visibility was found to be about 5 feet and many small pieces of wreckage were sighted.

Choppy seas, wind, and fog hampered activities during the next 2 days. Another ADS-IV observation dive was made on 19 May, but had to be terminated after 2 1/2 hours because of adverse weather conditions.



The ADS-IV equipment, including diving bell and deck decompression chamber, were installed on SEA SYSTEMS in Charlevoix in mid-May. Note the ADS-IV crane. In addition to lowering and raising the diving bell, the crane was used to lower the sonar/TV sled and to recover aircraft wreckage.

ADS-IV EQUIPMENT ON DECK OF SEA SYSTEMS

During this time the sections of the flexifloat barge to be used to receive recovered wreckage arrived at Charlevoix. SEA SYSTEMS remained in port on 20 May while equipment and supplies were assembled. With the arrival of the TV cable, the television camera was finally operational.

Operations in Northern Area, 21-30 May

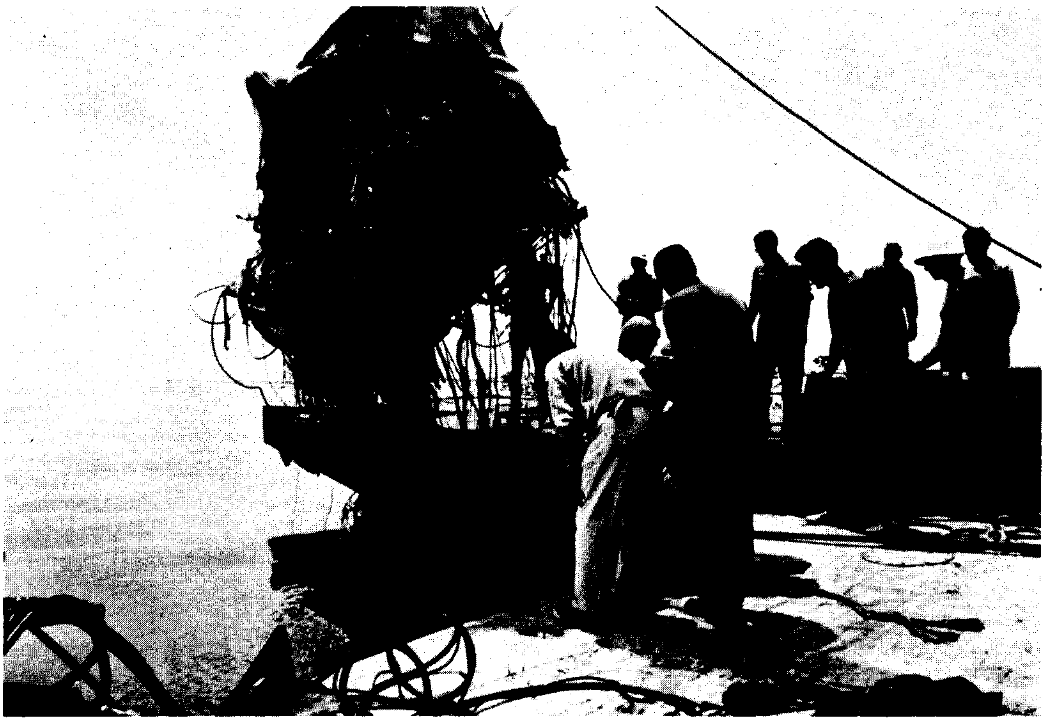
Search and recovery operations got underway on 21 May. All equipment was available and operational. SEA SYSTEMS departed Charlevoix at 0730. By 1010, the ship was in a 4-point moor and the sonar/TV sled over the side and searching. Various pieces of wreckage were located and examined with the sonar and television. One piece was selected for recovery and the sonar/TV sled was retrieved to be replaced on the ADS-IV crane by the ADS-IV bell.

The ADS-IV bell went over the side at 1425 with two divers inside to attempt recovery. At 1725 a large section of the horizontal tail section was recovered. Operations were then secured and SEA SYSTEMS returned to port to off-load wreckage.

Search and recovery operations resumed the next day. Activities focused on moving around in the moor so that objects once located by the sonar might be completely identified by television before sending divers down in the ADS-IV bell to attempt recovery. Several visual identifications were made which members of the Air Force Accident Board decided not to retrieve. One lockout dive was made, from 1510-1735. A part of the upper fuselage forward of the tail was retrieved and loaded on the barge. Before securing operations for the day, sonar and television search was resumed in an effort to moor SEA SYSTEMS over a recoverable object for the night. In this way, recovery operations could begin early the next day.

Operations on 23 May were delayed until an inoperative light on the sonar/TV sled was repaired. A bundle of wire was located but not recovered. One lockout dive did occur and a large piece of vertical fin was retrieved. Although it had been intended for SEA SYSTEMS to remain moored over night, a heavy storm, beginning about 2100, forced SEA SYSTEMS to return to port.

SEA SYSTEMS spent the 24th in port off-loading wreckage and overhauling salvage equipment because the weather was too rough for safe diving operations. SEA SYSTEMS departed for the wreckage site at 0610 on 25 May in order to make maximum use of available daylight. Despite severe weather, the task force recovered a section of the main landing gear. The weather deteriorated during the day, making it unsafe to continue diving operations. SEA SYSTEMS returned to port to await better operating conditions.

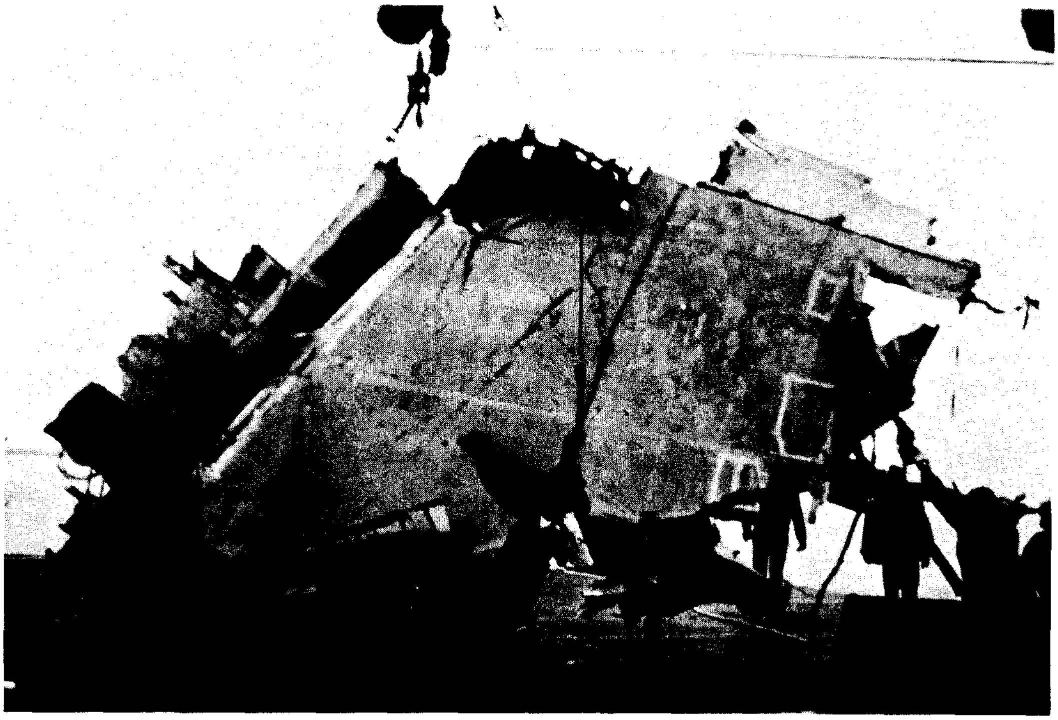


Only pieces of wreckage deemed significant in determining the cause of the crash were recovered. Air Force representatives used underwater TV to help identify pieces for recovery.

SALVAGE TEAM RECOVERS WING SECTION WITH WIRE BUNDLE

The weather on 27 May was excellent, a clear, warm, calm day. SEA SYSTEMS departed at 0615, and resumed sonar and television searching by 0755. Although one of the NAV-AID stations was malfunctioning for short periods causing minor delays, four lockout dives were accomplished. Wreckage recovered included the left wing upper inspar skin, cockpit window frame #5, pieces of the engine compressor blades, and the lower section of the bulkhead with drag chute mechanism. Operations for the day were secured at 2110 with SEA SYSTEMS remaining in the moor overnight.

Operations in the northern half of the debris area were very productive during the next 3 days. Seven lockout dives during this time recovered the external fuel tank, pieces of the fuel control mechanism, the skin off the drop tank, a section of the port wing tip, the outboard half of the right horizontal stabilizer, a large section of wing with motor mounting pad attached, and a large wire bundle and tubing with the right wing section. Several small



During Phase II operations, 12 May – 11 June 1971, various parts of the B-52 were recovered. From this wreckage Air Force investigators hoped to determine what caused the crash.

ADS-IV CRANE RAISES THE ELEVATOR SECTION OF THE B-52 FROM LAKE MICHIGAN

pieces of wreckage were also located which members of the Accident Board did not want retrieved. At 1912 on 30 May preparations were made to break moor in order to return the loaded salvage barge to Charlevoix for off-loading.

Operations in Southern Area, 31 May – 9 June

After off-loading the wreckage from the barge to the Coast Guard pier, SEA SYSTEMS departed for the debris area. A number of sonar runs were made in the northern half to make sure all significant plane wreckage was found. SEA SYSTEMS then moved into the southern half, completed the moor, and began search and recovery operations. One lockout dive was made late in the day and a lower wing inspar section was recovered. Operations were then secured with SEA SYSTEMS remaining in her moorings for the night.

Much was accomplished during the next few days. Small pieces of wreckage were sighted which the Accident Board did not want retrieved along with larger significant pieces designated for recovery. Three lockout dives on 1 June recovered the left wing lower section, the lower wing inspar and life raft release, and the nacelle strut and portion of the spar. Two lockout dives on 2 June recovered the number one strut and part of the left wing section, and a large section of the upper right wing skin.

Most of the morning of 3 June was spent moving in the moor to investigate various sonar contacts with the television. One lockout dive was made early in the afternoon; however, the diver was unable to locate the object because heavy winds suddenly moved through the area causing the boat to shift in its moored position. Small pieces of wreckage, including a piece of the landing gear, fuselage bulkhead, and tail gunner structure were recovered instead. Wind conditions prohibited any more diving. At 1615 SEA SYSTEMS released the moor and started for Charlevoix with the barge in tow. At 1830 off-loading the wreckage from the barge was begun.

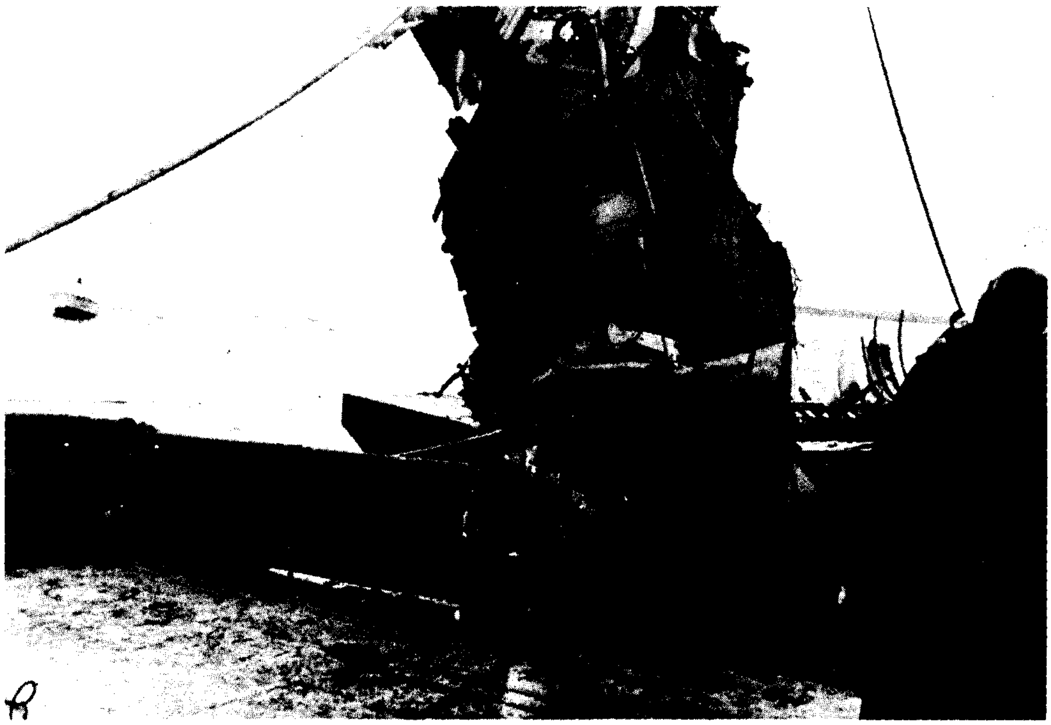
SEA SYSTEMS was back on station early the next day, 4 June. Two lockout dives recovered the #7 hydraulic pack and the stiffener from the wing center section along with a large wire bundle and hydraulic fittings. In addition two grapnel drags were made to pickup another bundle of wire which was of interest to the Accident Board. Another dive could not be made because of a lack of diver's breathing gas (HeO_2). At 2015, SEA SYSTEMS returned to Charlevoix to get a new supply of HeO_2.

No salvage operations were conducted on 5 June because of high winds and heavy rains. A shipment of diving gas, enough for two dives, arrived at the Coast Guard station at 1100. The day was spent off-loading aircraft wreckage from the barge to the pier, repairing the salvage winch and overhauling all diving equipment.

SEA SYSTEMS departed on 6 June at 0705 for another day of search and recovery operations. Although the day's operations were hampered by intermittent high winds, which prevented the ship from maintaining station over the sighted objects, and a malfunctioning NAV-AID station, two lockout dives were completed. Wreckage recovered included the #3 engine nacelle and a large section of the cockpit area. By 2136 the last piece of wreckage was on board, operations were secured, and SEA SYSTEMS was returning to port for more diving gas. The next day was spent in port awaiting a shipment of diving gas. Plans were made to attempt to complete all diving operations by 9 June. All sonar tapes were carefully examined to pinpoint possible diving positions so as to reduce movement in the moor.

At 0715, 8 June, SEA SYSTEMS left Charlevoix. Operations for the day did not go smoothly because of the high winds and choppy seas. Positioning in the moor was extremely slow. One lockout dive was made early in the afternoon. Part of the cockpit crew section was recovered. When it was brought to the surface, the odor of body decay could be detected. It was decided to stay and search this area in an attempt to possibly recover the bodies of the crew members; however, attempts at positioning in the moor were futile because of the wind. At 1640 the search was terminated in order to reset the moor anchors and then remoor in a new position for the night.

Search and recovery operations were resumed the next morning, 9 June. Two lockout dives retrieved a wing flap with jack actuator and a piece of the wing center section. SEA SYSTEMS then left the moor in order to drop marker buoys for the stern trawler of the Bureau of Fisheries which had been chartered by the Accident Board to sweep clean the northern area.



A flexifloat barge was used to receive recovered B-52 wreckage. The small boat (100 hp) in the background was used to tow the salvage barge into position to receive the wreckage.

SALVAGE BARGE RECEIVES B-52 TAIL SECTION RECOVERED FROM LAKE MICHIGAN

Termination of Operations, 10-13 June

As planned by Air Force and SUPSALV representatives, 9 June marked the last day of diving operations by OSI under provisions of its Navy contract. SEA SYSTEMS extended its diving operations through 10 June, under separate arrangements with the Air Force, recovering two final pieces of wreckage, a right wing skin and a fuel cell. The OSI salvage vessel also helped mark the debris area for trawling operations which were to commence under Air Force auspices at this time in an effort to recover remaining small pieces of wreckage.

The task force initiated demobilization on 11 June, recovering the moors from the operating sites and off-loading wreckage at Charlevoix. On 13 June, SEA SYSTEMS got underway for the return trip to its home port in West Palm Beach, Florida, stopping off enroute at St. Ignace, Michigan to deliver air frame parts to the Air Force.

CONCLUSIONS

Persistent efforts by the search and recovery force culminated in a successful salvage operation despite difficult working conditions. Substantial portions of the downed B-52 were located and recovered for analysis by Air Force investigators.

Daily Operations

The daily search and recovery operations were time consuming. At least 4 hours were required to complete the search and recovery cycle, from the start of a search with the sonar/TV sled to the final recovery of wreckage aboard the barge. As a practical matter, only one dive and recovery was made on many days; when more than one was accomplished, the working day stretched to 14-16 hours. Each lift of debris from the bottom had to be made very deliberately in order to minimize any possibility of further damage or loss. Locating each piece of wreckage and identifying it for recovery were difficult, tedious tasks.

Equipment Considerations

All search, diving, and recovery operations depended heavily on one piece of equipment, the ADS-IV crane and nonspin cable. This crane not only handled the sonar/TV sled and diving bell but also raised wreckage from the bottom to the barge. The flexifloat barge was not really suitable for salvage work. Even a small salvage barge, with its own lift capabilities, would have been far superior. Such a barge would have left SEA SYSTEMS and the ADS-IV crane free to do other work. Maneuvering the flexifloat barge to receive the wreckage from the SEA SYSTEMS' crane was also a slow process.

Underwater Conditions and Weather

Also influencing the conduct of Phase II operations were the poor underwater visibility and soft mud bottom at the wreckage site. Visibility for the diver on the bottom was approximately 3 feet at best, although most of the time it was considerably less. This required that the vessel be positioned directly over the wreckage before a dive in order that the diver could see the debris initially and thus be able to attach salvage lines to it.

When disturbed the soft mud bottom created a "zero visibility" condition. This meant that the diver had to swim to the wreckage while remaining clear of the bottom. He had to be physically on the debris to attach the salvage line before losing visibility.

Weather conditions in northern Lake Michigan during May are extremely variable; high winds, choppy seas, fog, rain, and thunderstorms may be encountered. During Phase II operations, work had to be suspended several times because of lightning storms in the vicinity. Although lightning presents very little danger to a ship at sea, it could easily have stricken the crane while the manned diving bell was suspended in the water or touching the bottom.

USE OF

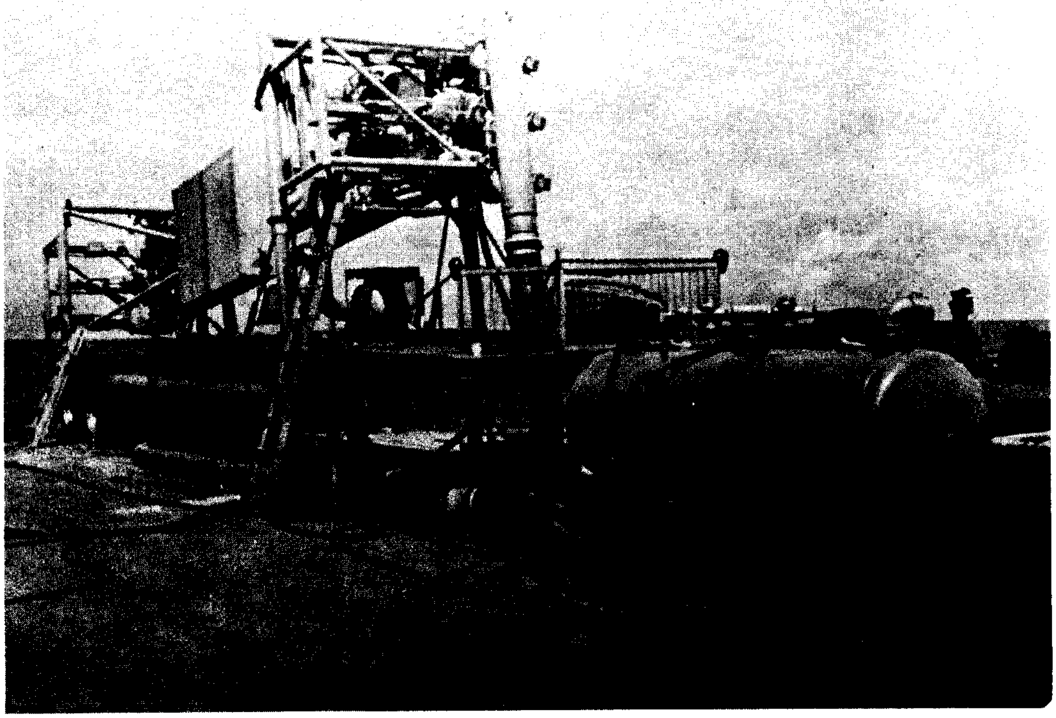
PRESSURIZED SPHERE INJECTOR (PSI)

IN

LIFTING THE BARGE, BOOTH,

FROM THE GULF OF MEXICO

Acknowledgement is made to the Cyclo Manufacturing Company of Denver, Colorado, developers of the PSI system, for materials used in preparing this article.



PSI system rigged for BOOTH salvops. System pressurizes polyethylene spheres in three-barreled structure mounted on platform, then feeds spheres through tubing down into compartments of sunken barge. Spheres displace water inside barge, providing buoyancy for lift to surface. Pressure is supplied from diesel-powered air compressor via storage chamber (at right).

PRESSURIZED SPHERE INJECTOR (PSI) BUOYANCY SYSTEM EMPLOYED FOR LIFT OF BARGE, BOOTH

USE OF PRESSURIZED SPHERE INJECTOR (PSI) IN LIFTING THE BARGE, BOOTH, FROM THE GULF OF MEXICO

INTRODUCTION

On 23 August 1971, the BOOTH, a 2400-ton pipelaying barge was raised from 50 feet of water in the Gulf of Mexico. A new salvage technique, Pressurized Sphere Injector (PSI), was used. Developed by the Cyclo Manufacturing Company, Denver, Colorado, the PSI system uses pressurized spheres, 11 inches in diameter, to raise sunken objects. Pressurized to the pressure-depth of the submerged object, these spheres are injected through a conduit into the sunken object until there are enough of them to create sufficient buoyancy to raise the object to the surface. As the object rises and water pressure lessens, the spheres gradually depressurize through the two-way valves with which each is equipped. Thus, any threat of explosion from the internal pressure is precluded.

The raising of the BOOTH was entirely a commercial salvage operation, with no Navy involvement. However, the Supervisor of Salvage presents this article here in this review because the successful use of the pressurized spheres demonstrated an innovative approach to the solution of salvage problems, an approach of great interest to all salvors.

THE PIPELAYING BARGE, BOOTH

BOOTH, 242 feet long, 14 feet deep, and 50 feet wide with a 10-foot cantilevered ramp, had sunk during a storm in 1969. BOOTH was located in about 50 feet of water about 38 miles south of Sabine Pass, Texas. The barge had been considered a navigational hazard ever since its sinking. Early in the summer of 1971, the owners of the barge, Brown and Root Construction Company, Houston, Texas, contracted with Cyclo Manufacturing Company to conduct salvage operations using the PSI system. Lifting operations were begun in August 1971.

PRESSURIZED SPHERE INJECTOR

General Description

Pressurized Sphere Injector (PSI) is a buoyancy system involving the use of thin-walled, hollow polyethylene spheres. Each sphere is equipped with a two-way diaphragm valve with a small preset pressure differential which allows the transfer of air for pressurizing and depressurizing, but which prevents the transfer of water as long as the internal and external pressures remain approximately equal.

The spheres are pressurized with air or other gas in a pressure chamber to an internal pressure equal to or slightly greater than the ambient water pressure at depth of delivery. Therefore, there is no tendency for the spheres to crush at any depth. The spheres are delivered to the submerged object through an air-filled conduit which is maintained at ambient bottom pressure. The spheres rise immediately to the uppermost part of the compartment or container into which they are discharged and permanently displace the water, thereby creating a buoyant force. When sufficient buoyancy has been delivered and the submerged object begins to rise, the ambient sea pressure decreases and the spheres expel air or gas through the valves. This precludes the possibility of explosion because of internal pressure.

Although any size sphere can be used, Cyclo's PSI system uses 11-inch diameter spheres because it has found that the larger spheres are more practical for containment and are less expensive per pound of buoyancy. This is based on the principle that the displacement of a sphere is proportional to the cube of the diameter and therefore, the number of spheres required to obtain a ton of buoyancy is inversely proportional to the cube of the diameter.

The PSI buoyancy system can be applied to any object at any depth. The spheres are recovered after use by vacuum or other mechanical means. For extreme depths beyond diver capabilities and where required lengths of delivery conduit would be impractical, PSI can be used in conjunction with a deep-diving submersible.

The spheres are extremely durable, being designed for repeated use through many salvage operations. This capability of repeated use is an important factor in calculating the cost effectiveness of the system.

Theory of Operations

At sea the PSI equipment, including the pressurizing chamber and spheres, is loaded aboard a barge. Divers operating from the barge prepare the sunken object for admission of the spheres. Openings for the conduit pipe are readied, either through the use of holes already existing in the object or by cutting new openings in the water-filled compartments. Concurrently, on the barge the spheres are being pressurized for their trip into the sunken object. In the BOOTH operations standpipes were inserted in the hull. The spheres passed through the conduit and standpipes to the barge's compartments.

Once the divers have attached the conduit to the openings, the pressurized spheres are sent down the conduit and enter the body of the object, where they rise to the top of the compartment. As the compartment or compartments begin to fill with spheres, water within the compartment(s) is displaced. When enough spheres have been introduced to offset the pressure of the water, the object begins its ascent to the surface. As the object rises and water pressure lessens, the small diaphragm valves in the spheres enable the spheres to gradually depressurize in ratio to the decreasing outside pressure. Without the valves, the spheres would explode.

Once the object has surfaced several possibilities exist: the object may be towed to a docking area elsewhere with the spheres still in place; in the case of high seas or bad weather at sea, the object can remain, spheres intact, at the site of its surfacing; and if the holes in the object can be repaired at the surfacing site, the spheres can be removed and the object repaired and towed to the docking area. The spheres, once their job is done, are retrieved from the object by means of a vacuum conduit. They then are stored for future use.

Previous Use of the PSI

Prior to the raising of BOOTH in August 1971, the Pressurized Sphere Injector technique had been used to raise an 850-ton railroad barge in April 1970. The railroad barge, 257 feet long, 39 1/2 feet wide, and 10 1/2 feet deep was raised from 40 feet of water from dockside in the Providence River, Providence, Rhode Island. Although performed partly during a snow storm, PSI worked perfectly, and the barge was raised successfully in about 2 weeks.

MAJOR COMPONENTS OF PSI BUOYANCY SYSTEM

Pressurized Sphere Injector is made up of a number of major components, including the 11-inch polyethylene spheres, each equipped with a diaphragm valve, a pressure chamber, a conduit, and two counters.

Spheres

The spheres have an outside diameter of 11 inches, a 5/32-inch wall, and are rotationally molded of high density polyethylene. They are black in color because black molds better and is less vulnerable to sunlight deterioration. Each sphere weighs 2 pounds and is capable of a 50-70 percent displacement in any space. Each sphere has a net lifting force of 25 pounds, 80 spheres producing 1 ton of buoyancy.

A vacuum conveying system is used in handling the spheres. It is used both to load the spheres into the pressurizing chamber and to remove the spheres from the sunken object after it has surfaced. An additional piece of equipment, the "ball loader," is needed in the recovery operation. The "ball loader" is simply a vacuum box which separates the spheres from the suction air and feeds them back to their original bulk container. The same equipment also serves to transfer or handle the spheres from any point or container to another, eliminating manual handling of the spheres.

The spheres may be stored in various kinds of storage areas such as circular cribs made with sections of snowfence or in a barge where they would be readily available. For the BOOTH operation, the spheres were contained in a wire basket approximately 20 feet long, 8 feet wide, and 8 1/2 feet high, the exact dimensions being such that the spheres packed and nested properly. Each basket contained 26.4 tons of net buoyancy and had a gross weight of 6000 pounds.

Diaphragm Valve

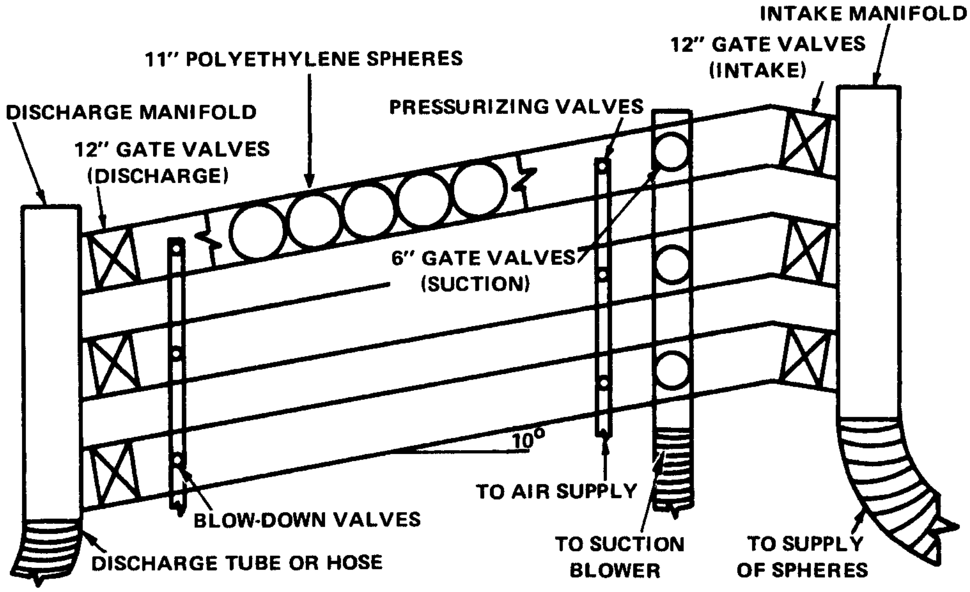
Each sphere is manufactured with a special two-way pressure equalizing valve. This valve, about 5/8 inch in size, consists essentially of a precision slit in a rubber diaphragm. The rubber diaphragm is mounted in a brass retainer which is molded into the wall of the polyethylene spheres. This makes the diaphragm readily replaceable if damaged.

The diaphragm allows a comparatively free flow of air in either direction when a slight differential pressure is applied; but when the pressures are essentially equal on both sides, the passage of water is prevented by the capillary effect of the silt.

The diaphragm can be manufactured to operate at various pressure differentials by adjusting the durometer of the neoprene rubber as well as the thickness of the diaphragm and the length of the slit. It is desirable to have at least a minimum of 5 pounds differential pressure to prevent pressure variations from tide or wave action working small quantities of water into the spheres. The valves are designed so that a single freely rising sphere (at its terminal velocity) will be able to relieve its internal pressure fast enough to prevent explosion.

Pressure Chamber

The pressure chamber consists of three 30-foot lengths of standard 12-inch pipe. With a 12-inch gate valve at each end, the pipes are mounted one above the other with a 10-degree slope to the discharge end. The pipes are manifolded to a common intake manifold and to a common discharge manifold. Both manifolds are equipped with mechanical diverters synchronized to the main valves which prevent misalignment or jamming of the spheres.



The pressure chamber consists of three 30-foot sections of standard 12-inch pipe. The pipes are mounted one above the other with a 10-degree slope to the discharge end. Pressure is provided by a diesel-powered air compressor. PSI is capable of pressurizing spheres up to a 500-foot water depth.

DIAGRAM OF THE PSI PRESSURIZING CHAMBER

The three-tube arrangement is used in order to increase delivery capacity. When one tube is being loaded, another tube is being pressurized, and the third is discharging the pressurized spheres. By proper cycling with the three-tube system, 50-70 tons of buoyancy can be delivered per hour.

The pressure chamber must be pressurized to the ambient water pressure (or bottom pressure) at the depth to which the spheres are to be delivered plus approximately 20 psi. The "overpressurizing" is needed to overcome the built-in differential of the valve and to reduce the pressurizing time by maintaining an even pressurizing rate as the internal pressure of the sphere approaches the "bottom pressure."

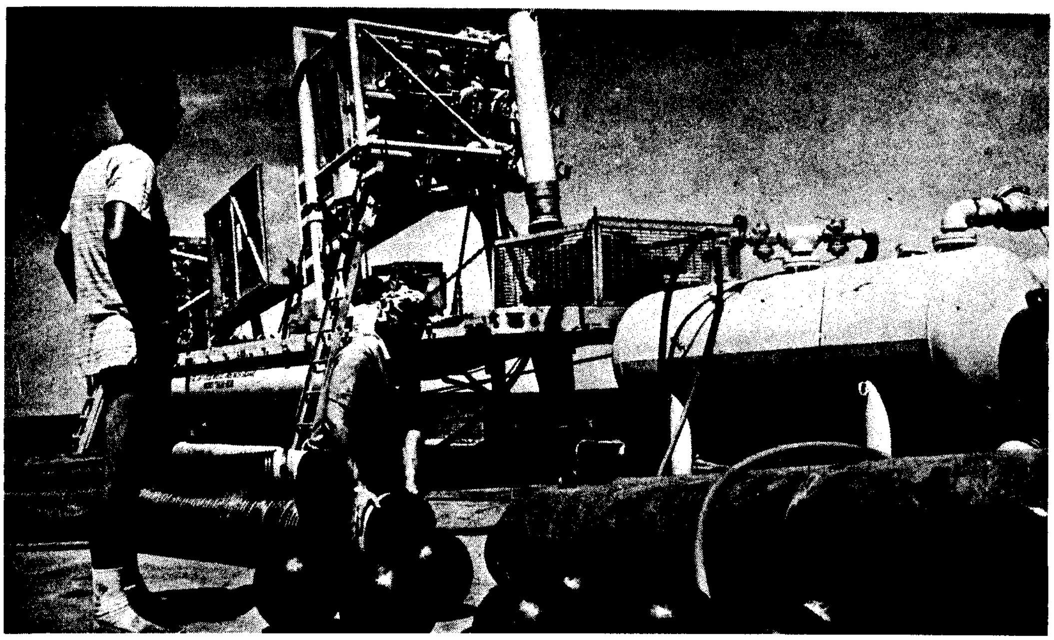
The entire unit is framed and mounted so it can be shipped on a standard flatbed trailer. It weighs approximately 13,000 pounds. It is designed for use with the 11-inch diameter spheres, thus the spheres can pass freely through the 12-inch pipe, valves, manifolds, fittings delivery tube, etc. Pressure is provided by a diesel-powered air compressor. The PSI system is capable of pressurizing spheres up to a 500-foot water depth.

When set up for use, the pressure chamber is mounted on a boat or barge with the discharge end extending several feet over the side. The delivery conduit is attached to the bottom of the discharge manifold. From there, the conduit extends to openings in the sunken object. The spheres pass from the pressure chamber through the conduit and openings and into the compartments of the sunken object.

Conduit

A delivery tube or conduit made of neoprene tubing, 12 inches in diameter, connects to the pressure chamber through a gate valve. The lower end of the conduit is placed in the compartment or openings in the sunken object where the pressurized spheres are to be discharged.

The length of the conduit is determined by the distance between the pressure chamber discharge manifold and the opening(s) in the sunken object. To form the necessary length,



Cyclo personnel prepare to join the flexible delivery conduit to the rigid delivery system. Note the 11-inch black spheres. These spheres are pressurized in the pressure chamber, then sent through the conduit into the compartments of the sunken barge.

WORKMEN PREPARE THE PSI SYSTEM

11-foot sections are joined with standard flange couplings. In the BOOTH operation a rigid conduit leading from the neoprene tubing on deck to the sunken hull was used because there is frequently considerable underwater turbulence in the Gulf of Mexico.

The delivery conduit is pressurized to equal the bottom pressure. This forces all water from the delivery tube down to the point of discharge, thus leaving the delivery conduit filled only with pressurized air. After the spheres have been pressurized to the proper pressure, the gate valve connecting the delivery conduit to the pressure chamber is opened; the spheres are fed down the air-filled conduit. If the conduit can be maintained at an angle of approximately 45 degrees or more, the weight of the spheres will cause them to discharge themselves from the lower end of the conduit. In instances where the angle cannot be maintained, a mechanical conveyor located near the lower end of the conduit can be used to discharge the spheres.

Counters

There are two counters, one at the discharge manifold and one at the lower end of the conduit. These counting devices record the number of spheres delivered.

ADVANTAGES OF THE PSI BUOYANCY SYSTEM

There are several advantages to the PSI system, according to its developers:

1. No depth limitation (the only qualification is that at extreme depths it may be desirable to use helium instead of air for pressurizing the spheres because at 25,000 feet the density of air would approach that of water).

2. The extremely tough plastic spheres are reusable almost indefinitely.

3. The exact amount of buoyancy applied to any compartment can be determined at any time by a counting device which gives the exact number of spheres delivered.

4. The buoyancy spheres are noncompressible and have the same displacement and therefore, the same lift at any depth.

5. The cost of buoyancy remains constant regardless of depth.

6. Once the buoyancy has been applied to a sunken object, it may be left almost indefinitely with no loss of buoyancy, even in high seas or inclement weather.

7. When PSI spheres are placed in a compartment, the spheres' lifting forces are applied to side walls, frames, bracing, machinery, etc. This spreads the lifting forces over much more area as compared to using air for buoyancy which applies lifting force only to the top of the compartment.

8. Rates of application as high as 70 tons per hour with a single unit have been attained.

9. Because of the relatively large size of the spheres, 11 inches in diameter, the buoyancy is easily contained in ruptured compartments or even large mesh nets.

CONDUCT OF OPERATIONS

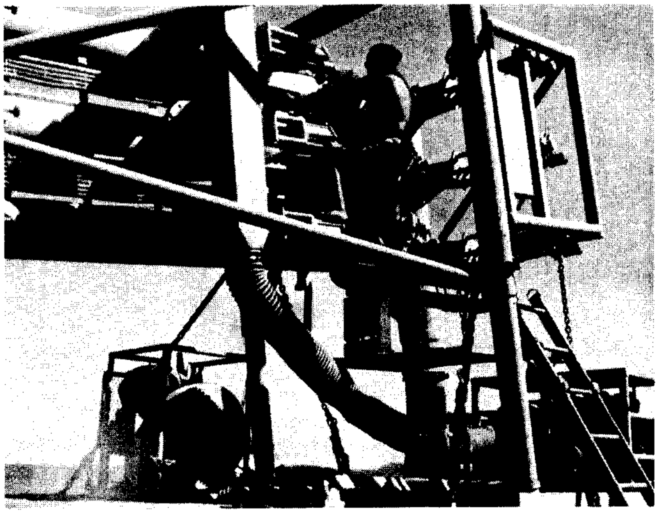
Preparations

On 2 August 1971, personnel from Cyclo Manufacturing Company and PSI equipment and operators were at the salvage site. All PSI equipment, including the huge pressurized chamber, delivery hose, and thousands of 11-inch plastic spheres (2400 tons of buoyancy) were on board the 140-foot salvage barge which was positioned almost directly above the sunken BOOTH. Standing by were a tug boat and work boat to house the crew. There was also a crew boat which provided daily transportation to and from Sabine Pass.

During the preliminary preparatory work, divers surveying the sunken barge discovered that apparently another vessel had collided with the sunken barge despite a lighted buoy marking the site. The damage to the barge indicated that it had been a heavily laden freighter or tanker with a draft of more than 30 feet that had collided with the BOOTH. Although the collision was not reported, it was believed to have occurred during the preceding 5 months; an underwater survey of the hull in March 1971 had revealed no such damage.

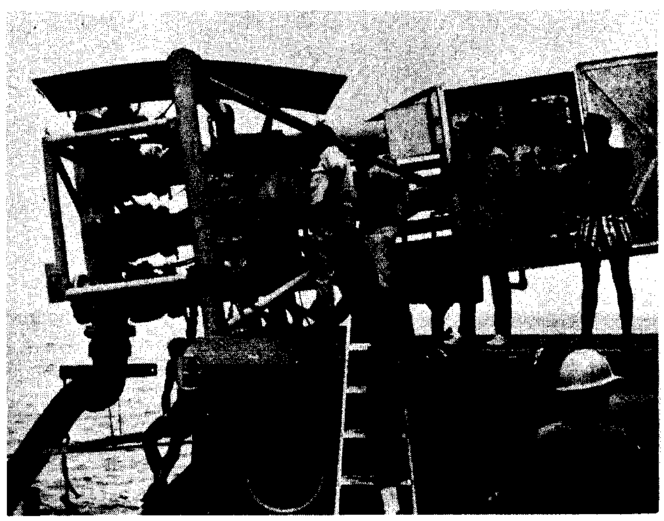
The apparent collision left a portion of the barge deck strewn with rubble. Divers reported that an area from about the center of the barge to some 70 feet back was littered with piping, conduit, motors, assorted other dislodged equipment, and sections of the barge wheelhouse torn loose by the impact. Parts of the deck were depressed 3 to 4 feet by the collision.

The extent of the damage necessitated clearing the rubble from the barge's deck prior to cutting holes for the standpipes through which the PSI spheres were to be delivered. On 12 August special salvage teams began to inject the spheres into standpipe openings in the sunken barge. In all, divers cut eighty 12-inch in diameter holes in the hull's compartments and attached standpipes to receive the delivery tube.



A technician checks the controls of the pressure chamber in which the spheres are pressurized.

Salvage personnel observe the operation of the pressure chamber as it pressurizes the spheres and feeds them down the delivery conduit (left) and into openings in the sunken object.



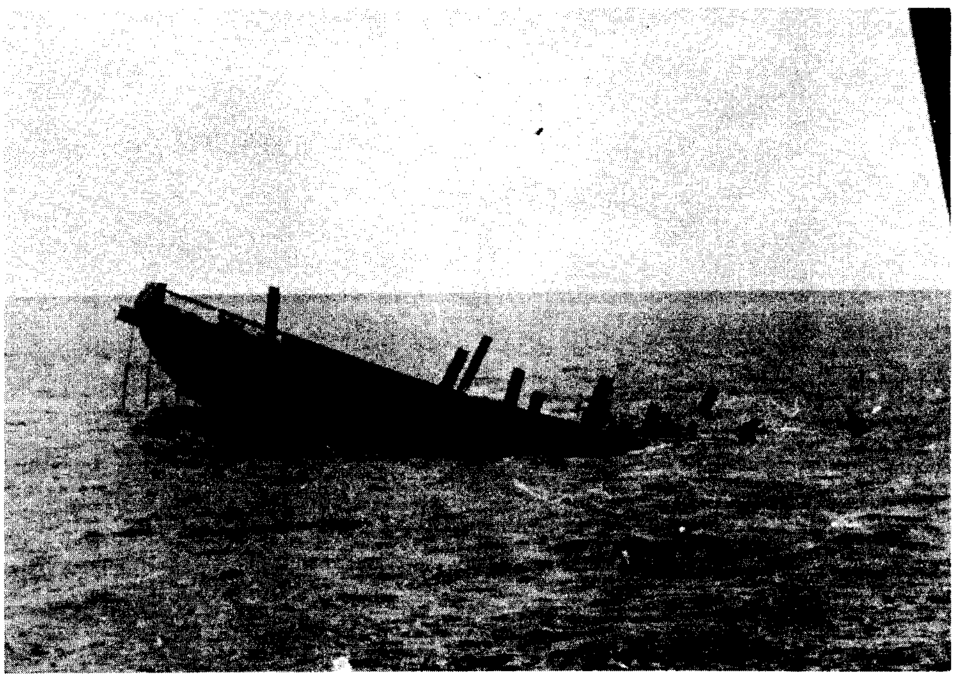
PERSONNEL OPERATE THE PSI SYSTEM IN THE GULF OF MEXICO

In addition the hull was secured in place by cables attached to screw anchors, anchors which literally screw into the ocean floor. The barge was anchored so that it could be raised on command. This was done primarily to facilitate filming the actual surfacing as part of a complete motion picture record of the entire salvage operation.

BOOTH is Raised

On 23 August the barge was raised. Enough 11-inch diameter spheres pressurized to the depth of the sunken vessel had been propelled through standpipes into the vessel's holds and compartments to create the necessary buoyancy. As the barge rose, the system's two-way valves built into every sphere automatically released pressure.

Although the project was never in jeopardy, a number of unscheduled events did occur. The lift had been scheduled for 1200 on 23 August; however because of the possibility of bad weather, it was decided to conduct the lift a day early, on 22 August. As additional



The pipelaying barge, BOOTH, comes to the surface. Note the standpipes on the deck of the barge. Through these standpipes passed thousands of 11-inch spheres to provide the buoyancy to raise the barge.

BOOTH SURFACES AFTER 2 YEARS ON BOTTOM

buoyancy was achieved and the barge began to rise against cables which were attached to screw anchors at both the bow and stern to hold the hull in place, the cable over the bow snapped. The forward section of the barge rose above the surface, while the stern remained submerged.

Cyclo technicians went to work to increase the buoyancy in the stern but the effort had to be halted because of approaching darkness. Work began again shortly after daylight the next day and at 1250 the stern rose, only to settle beneath the surface. This submerging of the stern was attributed to "false buoyancy" which was created by air escaping from the spheres and being trapped temporarily in the hull. Then as air escaped from the hull, the buoyancy was lost and the stern submerged.

Another 100 spheres were sent into a stern compartment and by 1320 the barge was floating. The delivery of the additional buoyancy spheres had provided sufficient additional lift to return the stern to the surface and hold it there. Although the deck of the BOOTH was still awash, the superstructure amidships was well out of the water and the barge's position in the water had begun to stabilize.

After the barge was surfaced, members of the salvage crew boarded the BOOTH and began preparing it for towing. When preparations were complete, the SEA KING, an ocean going tugboat, towed the BOOTH to Sabine Pass. At the dock in Sabine Pass, the reusable spheres were removed from the BOOTH by using the delivery hose as a big vacuum cleaner.

CONCLUSIONS

The successful raising of the 2400-ton barge in 50 feet of water using the PSI system demonstrated that the PSI system can be useful in raising heavy sunken objects. It also showed that the PSI concept of providing buoyancy could be an asset in solving some salvage problems, Naval as well as commercial.

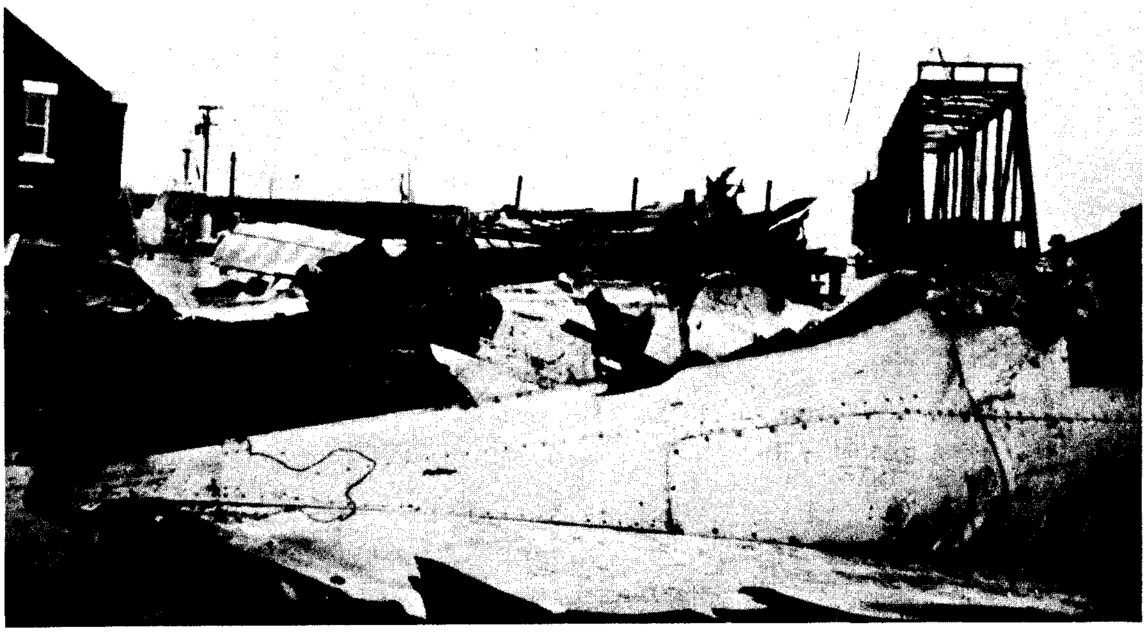
The Cyclo Manufacturing Company indicated that as a result of experience gained during the BOOTH operation, Cyclo planned to construct a self-contained unit which would enable the firm to do future jobs similar to the BOOTH operation in 1 week; BOOTH took 23 days.

SEARCH AND RECOVERY

OF

U.S. AIR FORCE B-57 AIRCRAFT

IN GREAT SALT LAKE, UTAH



Despite minimum bottom visibility and remote crash site, salvors recovered approximately 40 percent of fragmented wreckage of Air Force B-57 aircraft.

B-57 AIRCRAFT WRECKAGE RECOVERED FROM GREAT SALT LAKE

SEARCH AND RECOVERY OF U.S. AIR FORCE B-57 AIRCRAFT IN GREAT SALT LAKE, UTAH

INTRODUCTION

On 13 April 1971, a U.S. Air Force B-57 aircraft crashed into Great Salt Lake, Utah. Precise information on the crash site was not available. The general area of the crash was in a remote location, requiring about 2 1/2 hours of transit time by boat from the nearest available shore facility. The wreckage was dispersed in a large area, with pieces lying in about 22 feet of water with extremely limited underwater visibility. Search and recovery operations initiated immediately after the crash by Air Force authorities from Hill Air Force Base, Utah proved unproductive, leading to an Air Force request to the Supervisor of Salvage (SUPSALV) for assistance in expanding the scope of the effort.

A SUPSALV representative deployed to the site with a sonar-equipped search team provided by SUPSALV's search and recovery contractor, Ocean Systems, Incorporated (OSI). Navy divers from west coast shore facilities at Vallejo and Hunters Point, California and from Harbor Clearance Unit Two (HCU-2) at Norfolk, Virginia participated in the operation. The OSI team employed its side-scan sonar to locate the wreckage. The Navy divers then proceeded to recover about 40 percent of the downed aircraft, including several vital pieces sought for purposes of accident investigation.

CIRCUMSTANCES OF THE CRASH

The B-57 from Hill Air Force Base, Ogden, Utah, was in the last portion of a functional check flight when it crashed into Great Salt Lake at approximately 1315. Until then the 30-minute flight had apparently been routine. The aircraft disappeared without any distress calls or prior communications to indicate an emergency situation. There were no witnesses who saw the aircraft in flight prior to impact. However, several distant observers saw a brief column of smoke on the lake. The suddenness of the crash suggested that the aircraft had undergone some catastrophic failure, lending great importance to the tasks of locating the wreckage and recovering it for analysis as to the cause of the accident.

The aircraft was not under radar track or control at the time of the crash and was assumed missing when the fuel exhaustion time limit was reached. An immediate air search revealed an oil slick and debris on the surface of Great Salt Lake approximately 30 miles west of Hill Air Force Base. The debris was recovered and the slick location marked by a buoy from an Air Force helicopter. Unfortunately this buoy was dragged and cut free shortly after implantment by a boat assisting in the search.

NATURAL FEATURES OF GREAT SALT LAKE

Environs

Great Salt Lake has unusual natural features including the high salt and mineral content of the water, limited bottom visibility, and variable weather conditions. The saline content of the water in the center of the lake where recovery operations took place is about 16 percent of its specific gravity, about 1.12. The majority of the salt is sodium chloride. As a ratio to sea water, this is less than 1.1. Because accurate density data was not available, a ratio of 1.2 was assumed for safety. This made the 22-foot depth equivalent to 27 feet of sea water.

The altitude, 4200 feet, was also considered in planning diving operations. A relative atmospheric pressure of 0.85 was calculated by estimating a decrease of atmospheric pressure equivalent to 1 inch of mercury for every 1000 feet of elevation (30 inches being normal pressure at sea level). When this factor was applied to the no decompression limit of 33 feet from the decompression tables, an adjusted no decompression limit of 28 feet was calculated. At an actual depth of 22 feet, the divers were within 1 foot of the no decompression limit depth due to the special environment in which they were diving. As it turned out, average dives were about 30 minutes long, the longest running just under an hour, well within the no decompression limits, even if the water had been slightly deeper.

An extremely gradual shore table exists on the west coast of Great Salt Lake. This shore table prohibits docking and staging, thus the closest possible staging area for salvage operations was 2 1/2 hours from the wreckage site.

The lake bottom is a mineral crust of mud and soft clay. It is solid enough to permit easy movement but can also be easily penetrated, even by a diver's arm. Although deeper holes are said to exist, the deepest depth measured in Great Salt Lake is 32 feet. The depth at the crash site was approximately 22 feet. Although no measurable currents have been detected, the divers reported a current on the bottom of 1-2 knots from the southwest.

Underwater Visibility

Underwater visibility varies radically throughout the year. This is believed to be caused principally by the amount of algae in the water. Beginning in the latter part of May and through the summer, brine shrimp hatch and begin to consume the algae, thus clearing the water. During salvage operations underwater visibility was limited to a few feet; agitation of silt limited visibility to 6 inches in the initial 2 feet across the bottom. The underwater conditions of Great Salt Lake affected the sonar search in that the returning sound resolutions were rather unusual and it took awhile to get accustomed to them.

Weather

Because Great Salt Lake is at the mercy of the surrounding mountain ranges and their associated winds, the weather can be extremely erratic. A zero-state sea can be whipped to 6- to 8-foot waves by 30-knot winds in a very short time. Such possibilities made diving operations very difficult to plan.

As it turned out, the weather during search and recovery operations was generally sunny and warm, although wind, overcast, and cold rain were not uncommon, particularly in the early morning and late afternoon. Air temperatures ranged from 65°F to 85°F and water temperatures from 52°F to 60°F. It was found during salvage operations that the weather tended to be better on the lake than it did at the operating base which was near the mountains surrounding the lake.

VESSELS USED

Two vessels were used to support the search and recovery operations. One was a 40-foot geological survey boat owned by the State of Utah. The other was a 25-foot Chris Craft cabin cruiser.

The steel-hulled survey boat was used as a diving platform. Powered by diesel waterjets, it was equipped with a single sheave mounted on the center of the crossbar over which ran a 3/8-inch wire whip connected to a small winch driven by a power-take-off from the port engine. The structure had never been load tested. Furthermore, the winch had no reverse gear and no method of gradually releasing the brake under load. Despite these limitations, the salvors planned to use this equipment to lift the pieces of wreckage. Ironically, the wreckage was so fragmented that there was no requirement to lift heavy objects.

The Chris Craft cruiser was on the scene primarily for safety reasons because it was much faster than the survey boat. It was also used to transport some personnel or equipment to and from the wreckage site. Most importantly, the cabin cruiser had the only communications with the shore base.

In addition to these two boats, a wooden float was moored at the site and used as a receptacle for wreckage as it was recovered each day. The wreckage was back-loaded into the boats for transportation to the base at the close of each day's operations.

INITIAL SEARCH ACTIVITIES, 13–26 APRIL 1971

Initial diving attempts were made by Air Force personnel but the high density of the water caused them difficulties. Navy divers were requested from the Naval Inactive Ship Maintenance Facility (NISMF), Vallejo, California. The Navy divers used deep sea diving equipment apparently because excess buoyancy problems were experienced with Scuba equipment. They undertook a bottom search along the reconstructed flight path of the downed aircraft. The wreckage was located, then lost. On 26 April, Hill Air Force Base requested the Supervisor of Salvage to provide search assistance in locating the wreckage.

SEARCH OPERATIONS, 27 APRIL – 4 MAY 1973

Preparations

The Supervisor of Salvage (SUPSALV) committed Ocean Systems, Incorporated (OSI), the search and recovery contractor, to the task of locating the wreckage using side-scan sonar equipment. Representatives from SUPSALV and OSI deployed immediately to Utah, arriving at Hill Air Force Base on 27 April. They met with the President of the Accident Investigation Board who briefed them on the circumstances of the crash and the search and recovery operation to date. Preliminary Air Force analysis indicated that the aircraft had crashed at a dive angle of about 80-90 degrees causing tremendous breakup and scattering of debris.

SUPSALV and OSI representatives determined that a methodical search using side-scan sonar and the CUBIC navigation system was required. Arrangements were made to have the necessary equipment delivered.

The next day was spent selecting shore sites for the navigation system, obtaining charts, weather, and related data on the lake, and inspecting the boat to be used as a search platform. In addition, a continuing review of facts surrounding the aircraft loss was conducted in order to define the search area.

On 29 April SUPSALV and OSI representatives deployed to the assumed crash site to conduct an initial sonar search. During this first day's search, the water depth was found to be about 20 feet in the prime area with numerous rock faults and outcroppings. These conditions and the cold, dense brine of the lake, made the sonar sensitivity somewhat marginal. Search lane widths were therefore narrowed to 100-meter spacing so as to ensure good area coverage. It was also decided that test runs should be made each day because of the marginal acoustic conditions of Great Salt Lake. These runs would be made close in and parallel to fixed targets so as to confirm a sonar signature and maximum acquisition range.

Maximum detection reliability range was estimated to be not greater than 70-75 meters, hence the 100-meter lane width.

Conduct of Search Operations

A full day of search activities on 30 April did not locate the wreckage. The area searched included an area to the south and west of the estimated oil slick point as well as an area of interest about 4 miles to the northeast. The helicopter that had dropped a buoy on the site of the oil slick observed 2 hours after the accident was reported was called upon to drop another buoy using the same coordinates, flight plan, altitude, etc. This was done; the point proved to be 1 1/2 miles north of the estimated oil slick position.

The next 3 days were spent carefully searching the area close to the buoy and the general area to the west and south of the buoy. Operations were interrupted on 2 May when the search boat began to have engine cooling problems because of the intensive corrosive action of the lake brine. Repairs were made and operations resumed. At 1635 on 3 May, the aircraft wreckage was identified by sonar. Recovery of a wing tip and wire bundle using a grappling hook verified the wreckage location. The area was marked by a buoy.

Operations on 4 May centered on defining the wreckage perimeters and placing buoys on each corner of a rectangle surrounding the debris. The central wreckage pattern was about 50 feet in diameter. A second area of lesser concentration was about 50 feet away.

RECOVERY OPERATIONS, 5–27 MAY

Recovery operations resumed on 5 May with the return of Navy divers. Five divers participated, three from NISMF, part of the previous diving team, and two from San Francisco Naval Shipyard (SFNSY), Hunters Point, California. Personnel were underway each morning at about 0600 and returned by 1800; 5 hours were spent in transit, 7 hours at the work site.

Diving Methods

Diving was performed exclusively with lightweight diving equipment using full wet suits, standard lightweight shoes (weighted) and about 80 pounds of weight. Normally there was only one diver in the water at a time; however, a second lightweight outfit was always ready for use. A set of Scuba was also available for backup. Although the first dives were in the general area of the wreckage, it was several days before the central pattern of concentrated wreckage was firmly located.

At first only a single air compressor was used for diver's air. This was a civilian compressor that had been used earlier in the operation by NISMF divers. It was a diesel-powered 125 CFM, 125 psi compressor with a small volume tank. The divers had replaced the compressor lubricating oil with castor oil and had had the air checked for purity in an Air Force laboratory. On 7 May the compressor ceased to function properly and diving operations had to be suspended for the day.

A second civilian compressor was acquired, this one a gasoline-powered 85 CFM, 125 psi Ingersoll Rand which used turbine-type mineral oil as a lubricant. The automatic blowdown valve had to be plugged as it bled off the volume tank as soon as the compressor stopped. On 8 May, after this compressor had been operating for a short time, it became apparent that the compressor air was heavily laden with oil. Operations were again suspended for the day.

By this time a standard Navy 125 CFM diesel-powered Ingersoll Rand diver's air compressor which had been requested from SFNSY had arrived and was placed in service on 9 May. At the divers' request, the Air Force conducted an air purity test on the compressor air. The results were satisfactory. This compressor was used for the remainder of the operation.

Recovering Wreckage

Two methods were used primarily in recovering the wreckage. For small pieces a large wire basket was lowered to the bottom. The diver filled the basket during his dive. The basket was then hauled to the surface with the winch at the completion of each dive. Larger pieces were raised with 21 thread nylon that the diver attached to the wreckage. The life line/air hose was used to send the nylon line to the diver when he requested it.

HCU-2 RECOVERY OPERATIONS, 27 MAY – 9 JUNE 1971

Despite the delays caused by the malfunctioning air compressors, diving/recovery operations proceeded well but nevertheless very slowly. Despite concentrated effort, the divers had recovered only 10 percent of the aircraft by 26 May. This was partly because the wreckage was extremely fragmented and partly because much time was spent travelling to and from the work site. On 26 May COMSERVLANT was asked to provide divers from Harbor Clearance Unit Two (HCU-2), Norfolk, Virginia in the hopes that a two-diving team operation would reduce diver fatigue and improve the rate of salvage. In addition, the Air Force advised that a second B-57 had been lost elsewhere under similar mysterious circumstances. It was now imperative that a maximum recovery effort be undertaken in an attempt to determine the cause of the crash of the B-57 into Great Salt Lake.

Seven HCU-2 divers arrived at Salt Lake City at 2030 on 26 May. The next day they met with the Accident Investigation Board to determine objectives and to discuss the operation to date. Approximately 10 percent of the aircraft had been recovered.

U.S. Air Force Support

HCU-2 personnel found good U.S. Air Force support available. To facilitate collecting and transporting wreckage to Hill Air Force Base, a 10-foot square barge had been constructed along with some light harvesting baskets. A portable 125 CFM salvage air compressor and a 22 CFM hp air compressor were used as primary and secondary air sources. Shallow water diving equipment and miscellaneous support gear were also available.

A base of operations had been established by Air Force personnel at Antelope Island. Water and fuel for craft and personnel were trucked to this site. Transit from there to the work site took about 2 hours.

Conduct of Operations

Diving operations with both teams began on 29 May; however, winds to 30 knots and seas of 6-8 feet limited bottom time to 2 hours. Search and recovery operations were further affected when four of the five West Coast divers were ordered to return to California. The fifth diver was incorporated into the HCU-2 team.

Diving operations were cancelled on 30 May because of bad weather and again on the 31st because of damage to one of the boats. Operations resumed on 1 June. Six hours of bottom time were logged and a number of miscellaneous small parts were recovered.

A shift in mooring sites on 2 June resulted in the discovery of a large area of debris in the easternmost section of the wreckage area. Nine hours of bottom time were logged and a considerable amount of wing and engine wreckage was recovered. The position of the boat was triangulated and buoyed off.

Bad weather on 3 June forced diving operations to be cancelled again. However, good weather prevailed the next day and 8 1/2 hours of bottom time were logged. During the day's operations a large section of the tail, about 3 feet by 5 feet, was recovered as well as miscellaneous engine and wing components. By 4 June, approximately 25 percent of the aircraft had been recovered.

During the next 5 days, 5–9 June, diving/recovery operations went smoothly. Many small pieces of wreckage were recovered including a portion of the tail elevator control unit. Operations ceased on 9 June after a thorough search of the entire impact area was made without recovering any additional significant pieces. When operations were terminated approximately 40 percent of the aircraft had been recovered including the stabilizer actuator control unit which was considered a critical item in determining the cause of the crash. Evidence from this wreckage indicated that the aircraft must have crashed in a near vertical dive.

CONCLUSIONS

A number of factors influenced the conduct of search and recovery operations. One major factor was the long transit time, 5 hours, to and from the wreckage site. Another factor was the elevation of Great Salt Lake and the density of the water, aspects which had to be considered in planning diving operations.

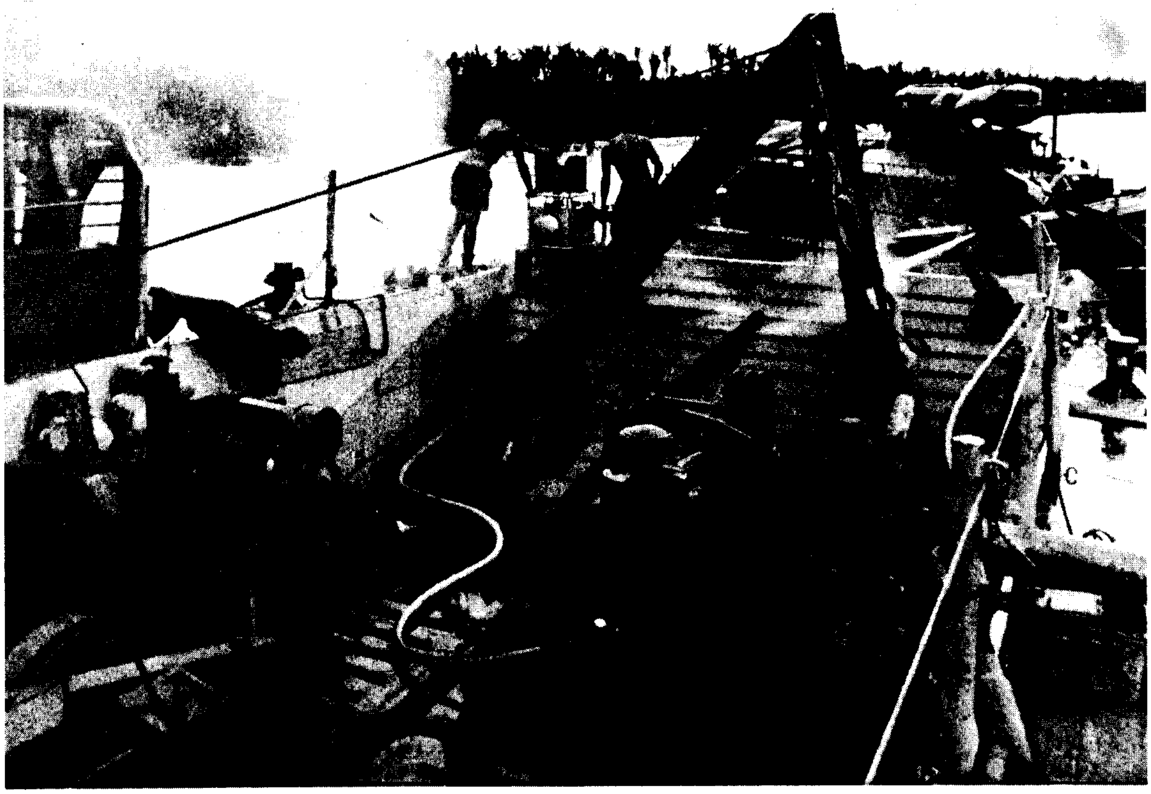
The reliable side-scan sonar equipment again proved its worth in this operation, locating major portions of the wreckage within a few days despite adverse conditions for sonar search. Persistent efforts by Navy divers, deployed from three different activities on both coasts, finally succeeded in recovering vital pieces of the wreckage for subsequent investigation and analysis. Support facilities and equipment had to be marshalled primarily from local assets and were therefore less than ideal. This is often the case in operations in remote and unusual locations. The search and recovery team demonstrated considerable resourcefulness in making the best possible use of available facilities and equipment.

SALVAGE OPERATIONS

OF

HARBOR CLEARANCE UNIT ONE

IN VIETNAM



For more than 5 years, HCU-1 personnel conducted most of the in-country salvage work, clearing rivers and harbors of wreckage caused by groundings, collisions, breakdowns, and enemy action.

HCU-1 PERSONNEL CONDUCT SALVOPS IN VIETNAM

SALVAGE OPERATIONS OF HARBOR CLEARANCE UNIT ONE IN VIETNAM

INTRODUCTION

Commissioned by the U.S. Navy on 1 February 1966 to provide much needed salvage services along the coast and waterways of Vietnam, Harbor Clearance Unit One (HCU-1) bore the brunt of salvage work in country for more than 5 years. During 1970 and 1971 elements of HCU-1 were withdrawn as the Vietnamese Navy assumed more and more responsibility for salvage operations. By 30 June 1971, HCU-1's role in Vietnam, for all practical purposes, had come to an end. Before leaving Vietnam, however, HCU-1 turned over selected craft and equipment to the Vietnamese Navy and provided the Vietnamese sailors with training in all phases of salvage operations.

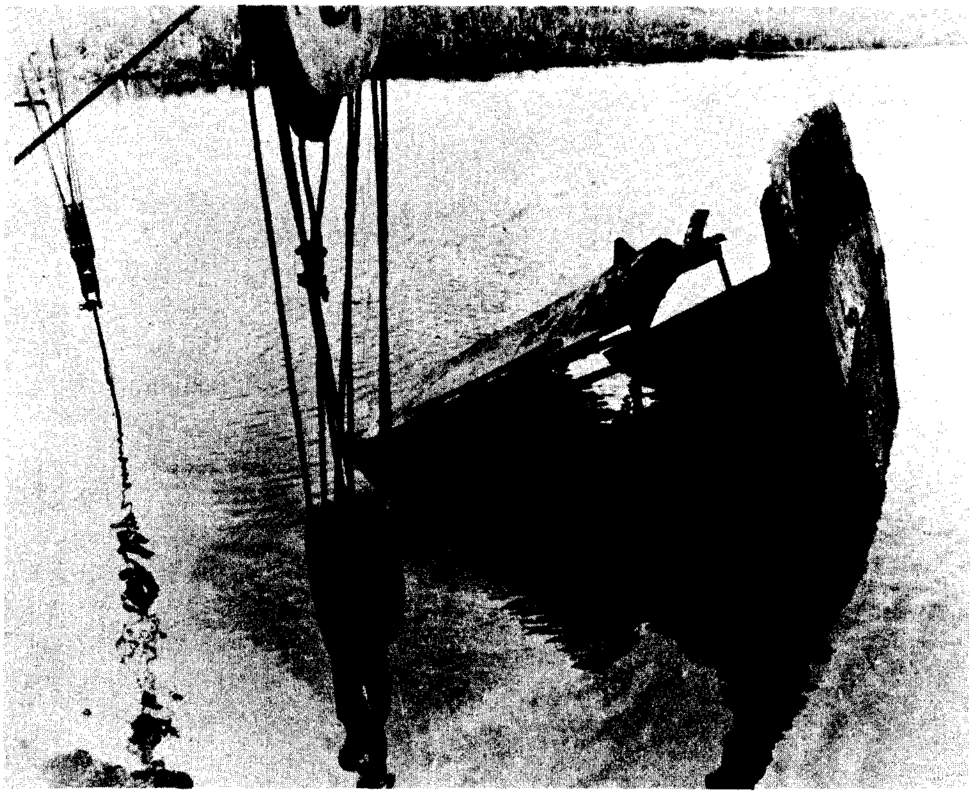
HCU-1's last months in Vietnam were busy ones. In addition to turning over craft and providing training, HCU-1 personnel conducted salvage operations in the Mekong Delta and other areas. These tasks met with the same success that characterized all of HCU-1's operations thanks to the courage, coordination, and skill of the men and efficiency of the equipment. During HCU-1's years in country, its skilled divers and salvage specialists, using a number of versatile lift craft, contributed greatly to the salvage effort in Vietnam.

HARBOR CLEARANCE UNIT ONE

HCU-1 is a unit of Service Force, U.S. Pacific Fleet (SERVPAC). Throughout most of the period of Vietnam operations, HCU-1 was home based at U.S. Naval Station, Subic Bay, Republic of the Philippines. In 1971, during the phase down of military forces, HCU-1's homeport was changed to Pearl Harbor, Hawaii. HCU-1 was under the direct administrative and operational control of Commander Service Group Three until 1 June 1971 when command of the unit was shifted to Commander Service Squadron Five.

The mission of HCU-1 is to provide SERVPAC with a harbor/river clearance and salvage capability. This capability was especially essential in Vietnam where damage inflicted by the enemy could not be allowed to restrict the use of coastal and inland waterways vital to military transportation.

In order for HCU-1 to be effective, it had to be mobile enough to ensure quick access to shallow, restricted waters, yet with sufficient lift capability to lift a sunken craft and move it to a safe haven. To meet the requirements of high mobility and sufficient lift, HCU-1 was outfitted with a family of versatile lift craft. Most were small, highly



Bow of a sunken craft protrudes from the water after HCU-1 salvage team parbuckled the wreck to an upright position.

WRECKAGE LIMITED THE USE OF INLAND WATERWAYS

maneuverable, A-frame-equipped, landing craft. A few were heavier lift craft for use in special contingencies. These craft, coupled with the skilled divers and salvage specialists assigned to the unit, enabled HCU-1 to contribute greatly to the salvage effort in Vietnam.

During its years in Vietnam, HCU-1 operated deep in the Mekong Delta and up and down the coastline. HCU-1 was normally task-organized into Harbor Clearance Teams (HCT's) according to necessary personnel skills and equipment for specific salvage assignments. These teams were usually small, relatively independent and highly mobile. For a small task, an HCT might consist of as few as three to five men operating from a single salvage craft. Typically, several operations would be underway concurrently with HCT's deployed in widely separated areas.

SALVAGE CRAFT

During its peak commitment HCU-1 had as many as 16 salvage craft available for salvage operations. Many of these were continually deployed in Vietnam. Others were maintained at Subic Bay and deployed to Vietnam only as needed. As the United States withdrew its salvage assets from Vietnam, selected salvage craft and equipment were turned over to the Vietnamese Navy in order to enhance its salvage capability.

In the beginning of 1971, the following craft were operating in Vietnam.

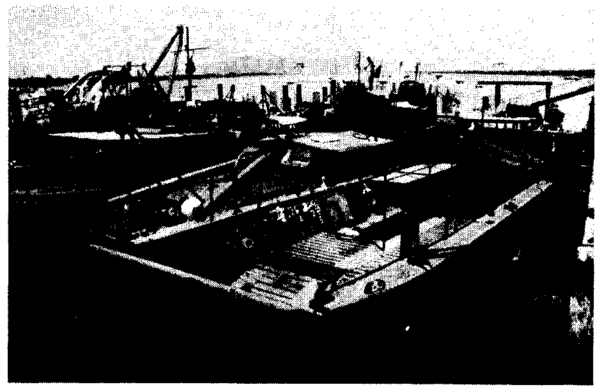
YRST-1	**Salvage Craft Tender**
YHLC-1 and YHLC-2	**Heavy Salvage Lift Craft**
YLLC-3	**Light Salvage Lift Craft**
CSB-3	**Combat Salvage Boat**
YDB-1 and YDB-2	**Yard Diving Boats**

In addition, HCU-1 used LCM's that had been converted into diving and salvage workboats. Early in 1971 these LCM's were outfitted with an A-frame assembly, designated LCM(S)'s and deployed to the southern Mekong Delta to conduct salvage operations in areas that were inaccessible to existing salvage craft.

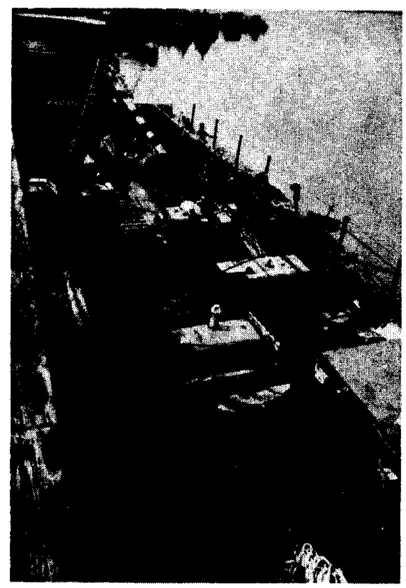
These salvage craft, like elements of the unit, were phased out during 1971. The two craft, YLLC and CSB, which were used most extensively by HCU-1 during the height of its Vietnam salvage operations, were turned over to the Vietnamese Navy on 29 April 1971. In early June, YHLC-1 and YHLC-2 were turned over to the custody of the Ship's Repair Facility, Subic Bay, Philippines for maintenance and preservation. YRST-1 arrived in Pearl Harbor, Hawaii at the end of July. The LCM(S)'s and YDB's, manned almost entirely by COMNAVFORV, continued to operate along the Vietnam waterways conducting minor salvage operations as required.

SOUTHERN MEKONG DELTA OPERATIONS

The beginning of offensive riverine operations against the enemy by the Vietnamese Army in the southern and western areas of the Mekong Delta presented HCU-1 with a new problem: the area in which craft were sunk during these operations was inaccessible to



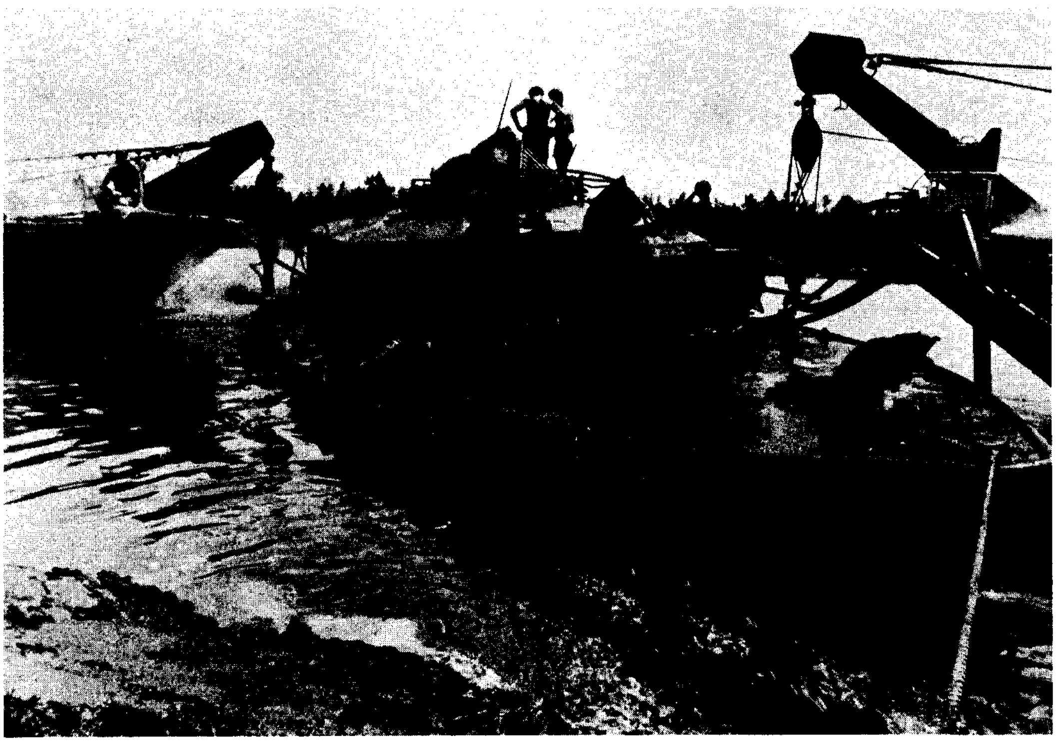
An A-frame assembly (above) is installed on an LCM-8 (above right). Designated LCM(S), the new craft is ready for salvage operations (bottom right). Note the compressor, generator, beach gear, winch, welding machine, bar armor and armament.



AN LCM-8 IS CONVERTED TO AN LCM(S)

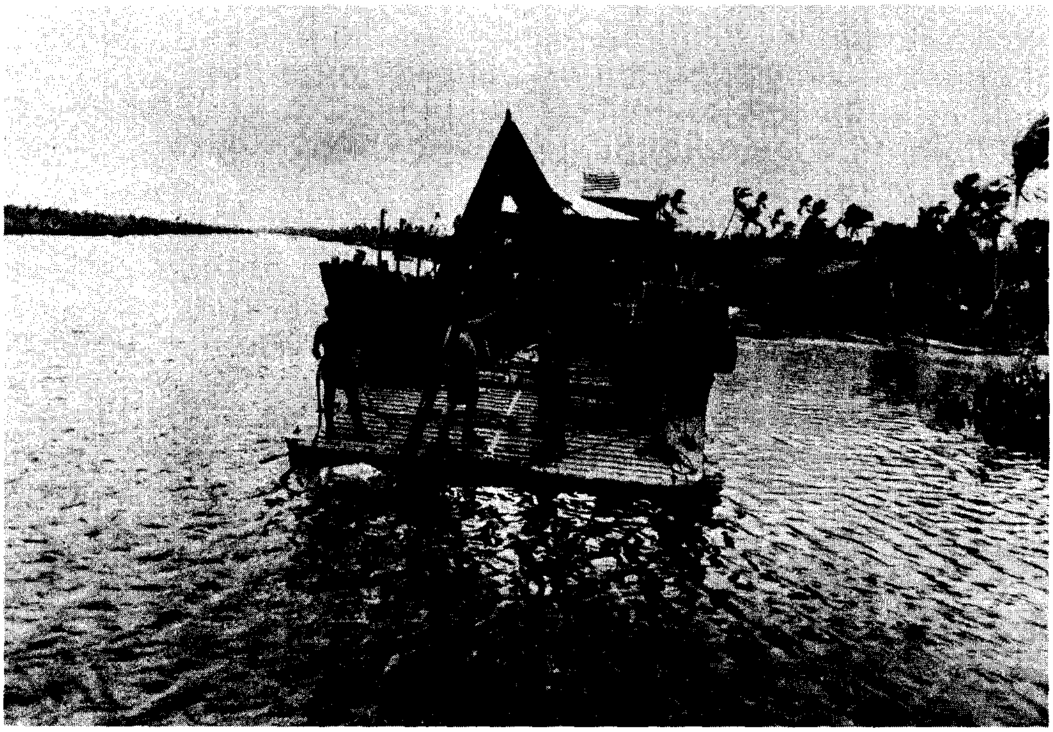
existing salvage lift craft. These narrow stretches of water leading into the dense U Minh Forest were frequently used by Vietnamese Navy convoys to provide logistic support for troops in the U Minh operation. Therefore, it was important that these waterways be cleared of wrecks and objects which posed navigational threats to combat craft and civilian fishing boats.

In early January 1971 it was decided to use modified LCM's for salvage operations in the southern Mekong Delta. These boats, converted into diving and salvage workboats, had been used repeatedly by HCU-1 as diving platforms in small operations and as propulsive forces to aid in towing a refloated craft to a repair base. A-frame assemblies with a lift capacity of 35 tons were constructed and installed on the LCM-8. By 15 February 1971, preparations were completed and the first modified LCM-8, now designated LCM(S)-1, sailed for U Minh Forest in company of CSB-3. LCM(S)-2 was ready a month later and replaced CSB-3 at the salvage site.



Two LCM(S)'s hold wreck on the surface as the salvage team patch, dewater, and prepare it for tow.

A-FRAMES AT WORK IN SALVAGE OPERATION



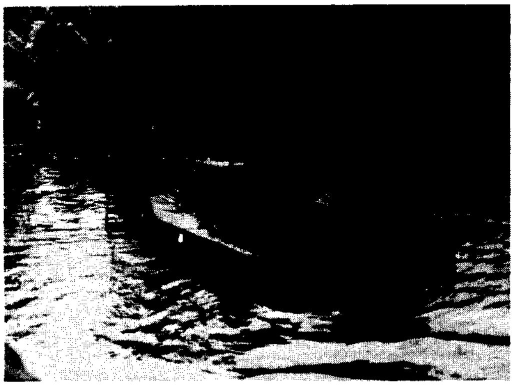
Lowering the ramp on the LCM(S) provided the divers and salvage personnel with a work area close to the water.

LCM(S) DEPLOYED ON VIETNAM WATERWAY

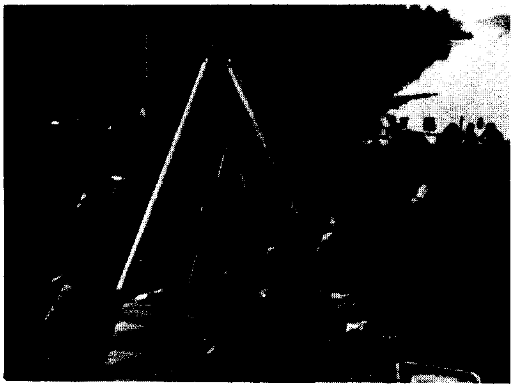
During the next 3 months a number of objects and craft were salvaged along the Can Gao Canal. In most cases the craft were lifted, patched, dewatered and demudded, and towed to a safe haven. Some that were so badly damaged that they could not be towed were lifted and dragged onto the canal bank and secured. Those that could not be salvaged or beached were destroyed with explosives. By the end of April salvage operations were concluded in the northern end of the Can Gao Canal.

VIETNAMESE SALVAGE TRAINING

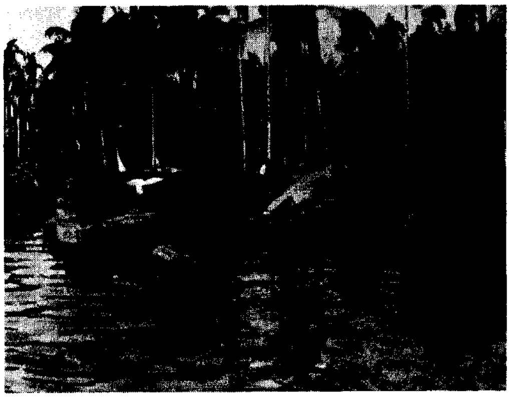
During 1970, as the Vietnamese capabilities increased through training in salvage techniques, operation of salvage craft and machinery, and diving operations, the Vietnamese Navy assumed more and more responsibility for salvage operations. In anticipation of complete turnover of salvage operations to the Vietnamese Navy by mid-1971, arrangements were made with COMNAVFORV and salvage advisors for HCU-1 to provide the Vietnamese Navy's salvage forces with training in all phases of salvage.



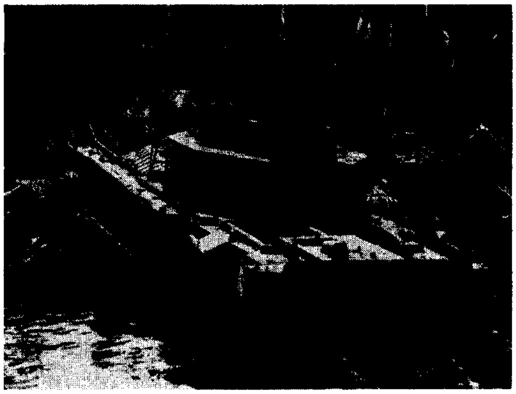
Wreck was in 10 feet of water; extensive damage made towing impractical.



Using a large tree as a deadman, A-frame on LCM(S)-1 and LCM(S)-2 pull wreck toward canal bank.



To remove wreck from the canal, salvage team blew a slip in the bank.

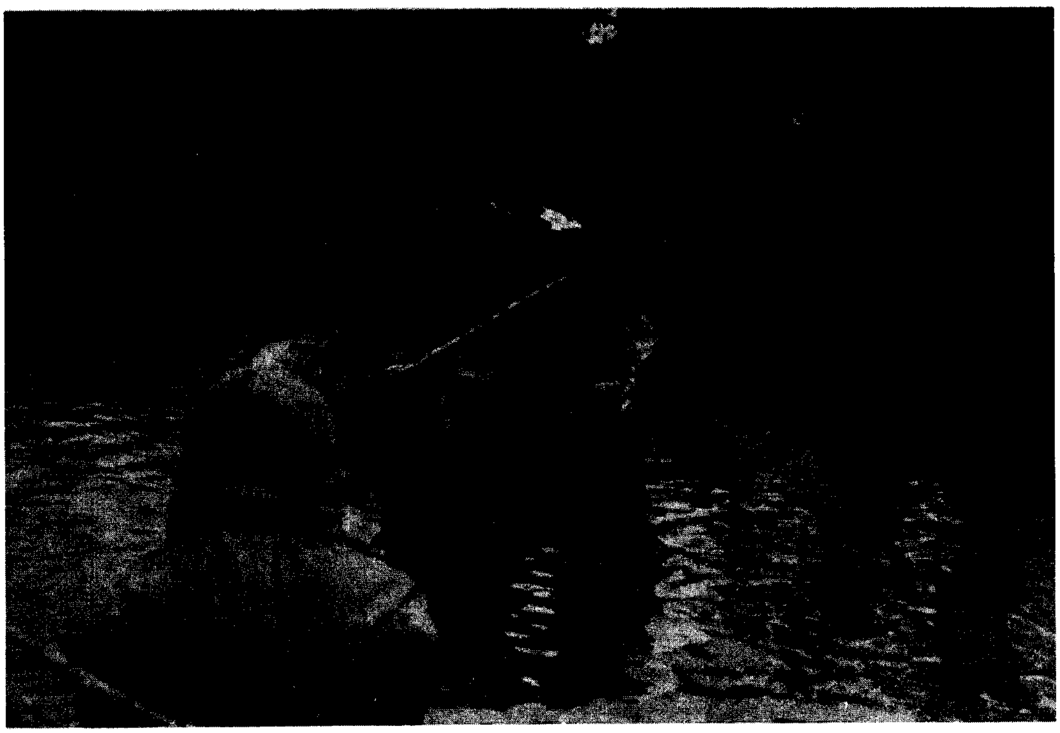


Operation completed. Wreck out of canal and secured in slip.

SALVORS USE LCM(S) TO CLEAR CAN GAO CANAL IN MEKONG DELTA

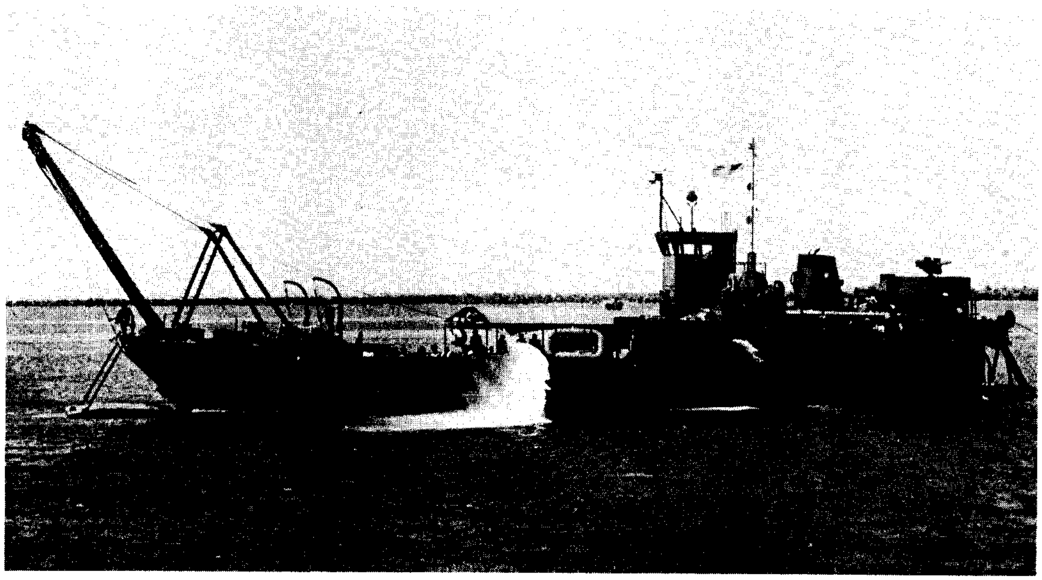
In early February 1971, training began. Each member was trained in diving and patching, operation of all types of portable salvage equipment, and theory of salvage. Each sailor was required to show his proficiency in these areas. Records were kept on all trainees to ensure each one received full benefit of the training.

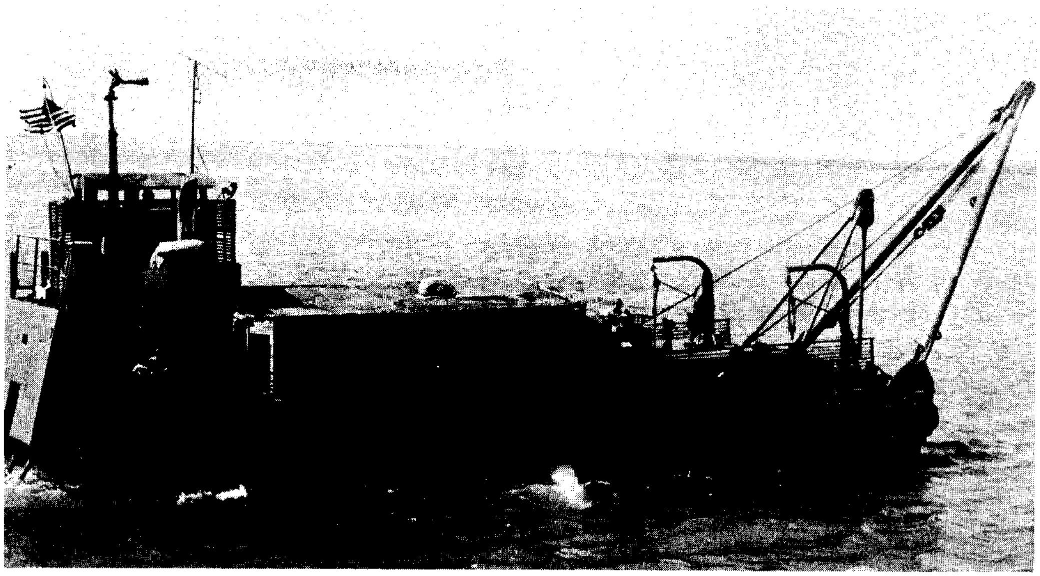
As a practical salvage project, the wreck of an LCM-8 was obtained for training. After the classroom phase, the wreck was sunk for the Vietnamese salvors to raise. The wreck was sunk in several different manners in order to present different problems for the salvors. The project provided an opportunity for the Vietnamese students to practice what they had learned in the classroom and to demonstrate their operational proficiency.



To clear this craft which had been destroyed by a large mine, HCU-1 salvors blew the wreck into three smaller pieces and removed them from the canal.

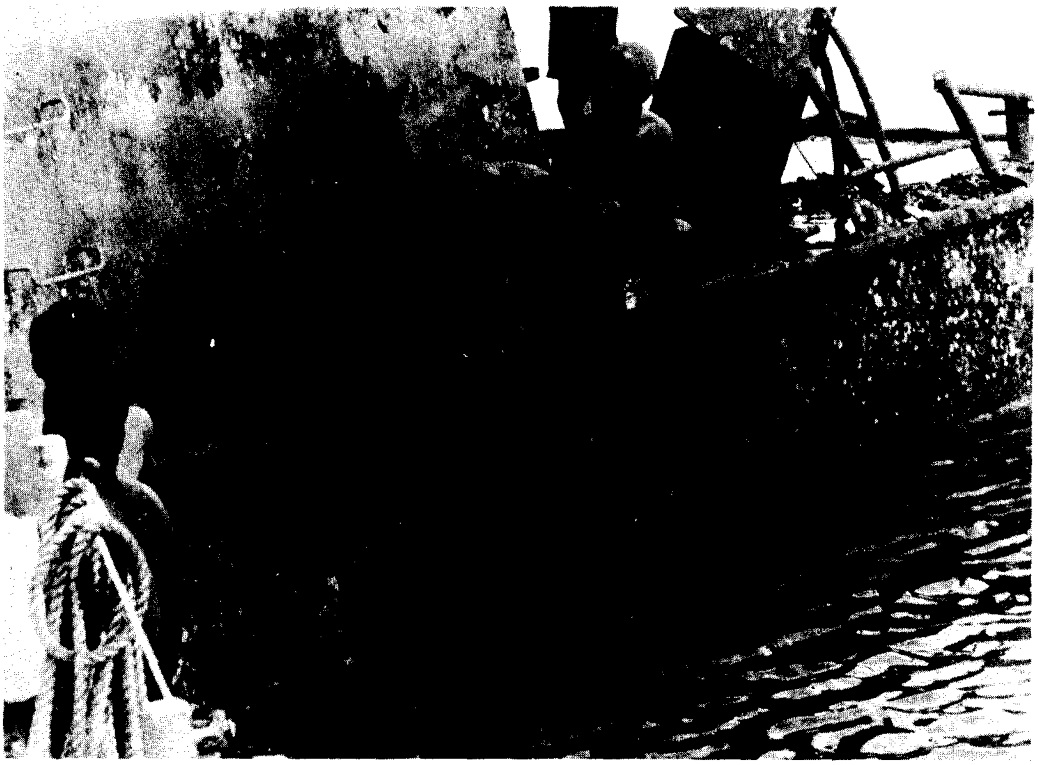
TYPICAL WRECKAGE BLOCKING INLAND WATERWAYS IN VIETNAM





Because of their versatility and suitability for small scale salvage work, the Light Salvage Lift Craft, YLLC-3, above, and the Combat Salvage Boat, CSB-3, below, were among those craft turned over to the Vietnamese Navy as the United States withdrew its salvage assets from Vietnam.

YLLC-3 AND CSB-3, VERSATILE SALVAGE CRAFT



As part of their salvage training, qualified Vietnamese salvors accompanied and assisted HCU-1 salvors in salvage operations.

HCU-1 AND VIETNAMESE NAVY SALVORS SECURE A PATCH

TURNOVER OF SALVAGE CRAFT

During 1970 most of HCU-1's craft and equipment had been turned over to the Vietnamese. On 29 April 1971 the last two salvage craft, YLLC-3 and CSB-3, scheduled for turnover joined their sister ships as units of the Vietnamese Navy.

The YLLC and CSB were two of the most versatile salvage craft used in Vietnam. The YLLC is a converted Landing Craft Utility (LCU), A-frame-equipped with a lift force of 25 tons, and capable of 100-ton ballast bow lift. The YLLC is outfitted with shops for cutting and welding and has berthing and messing facilities, thus providing a capability for sustained salvage operations. In addition, its shallow draft and amphibious landing capability enable the YLLC to be accessible to many restricted water areas. Normally HCU-1 manned the YLLC with a salvage team tailored for the job on hand.

The CSB, a converted Landing Craft Mechanized (LCM), was the most active salvage craft in Vietnam. Fitted with an A-frame and other special lift equipment, the CSB has a 10-ton lift capacity. The CSB is also highly maneuverable, thus very well suited for riverine salvage work. HCU-1 typically deployed CSB with a salvage crew of four to six men.

In order to prepare the prospective Vietnamese crew for their new craft, the United States crew of the YLLC-3 and CSB-3 began to train their Vietnamese counterparts. This involved familiarizing the crew with the craft and, in most cases, completely training the prospective crew members in all phases of their jobs. In addition, practical training in operation of the craft, such as seamanship, laying beach gear, making a lift, and operation of portable salvage equipment was covered in detail. Whenever the salvage craft was sent on a salvage job, Vietnamese sailors who qualified went along in place of U.S. crew members. Prospective crew members were thus provided with practical on-job training. One week prior to turnover, both craft were materially inspected and sea trials with the new crew were conducted.

Related to the turnover was the problem of equipping these unique craft with operating supplies and spare parts. This problem had occurred in the past with the turnover of craft. Therefore, prior to the turnover of YLLC-3 and CSB-3, HCU-1 compiled a loadout list derived from several years of usage data. All the necessary equipment and supplies were ordered and delivered to the craft in order that there would be a reasonable supply of parts available with the craft.

PATCHING OF THE SS ROBIN HOOD

In addition to the Mekong Delta operations, training the Vietnamese, and turnover of salvage craft, HCU-1 was also assigned other salvage tasks as the need arose. These salvage operations involved various craft, an old French patrol boat, a sonar dome and propeller blades, and two pontoon fuel barges. One of the most extensive of these 1971 salvage operations was that of the SS ROBIN HOOD.

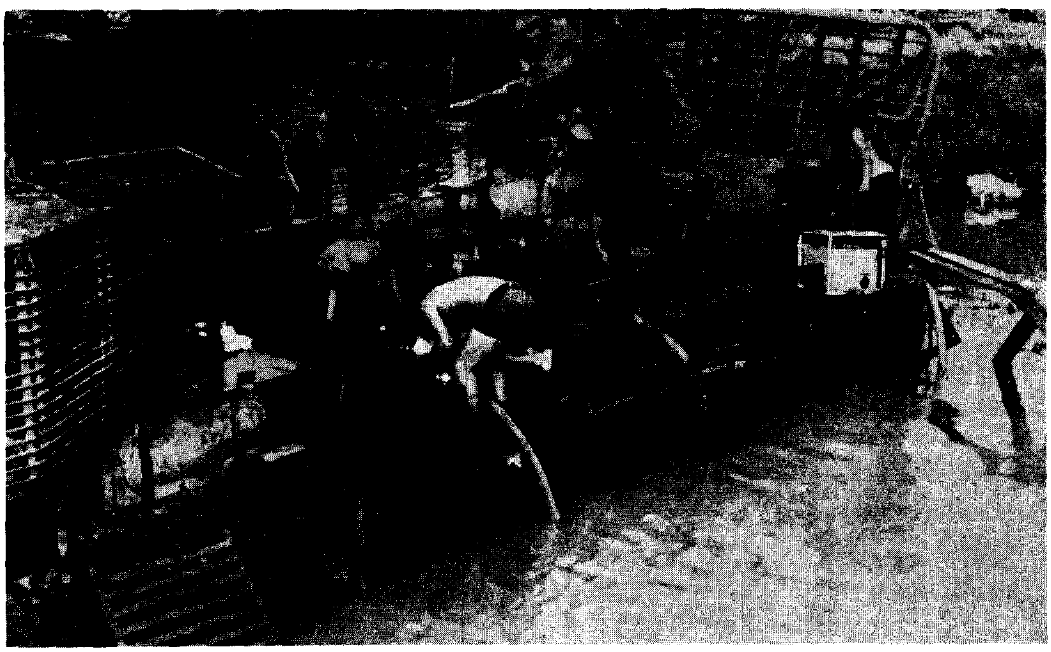
The SS ROBIN HOOD was mined on 27 March while alongside the De Long Pier, Qui Nhon. The explosion blasted a 27-foot long by 14-foot high hole in the starboard side with half of the hole below the waterline. Despite the damage and subsequent flooding, the ship did not sink.

HCU-1 was tasked to survey the damage, patch the hole, and dewater the ship. In surveying the damage, HCU-1 found that, in addition to the hole in the starboard side, the explosion ruptured the forward bulkhead and cracked the side shell and tank top of number three starboard double bottom.

By 4 April detailed plans for a 24- x 35-foot steel patch were developed, the cost of salvage operations estimated, and permission to go ahead with the patching received from the owners. The river salvage craft USS COHOES (ANL-78) arrived on 6 April with the material for the patch. A template was made and HCU-1 personnel, assisted by shipfitters from the COHOES, began fabricating the patch.

The patch was completed and placed over the hole on 19 April. Three days later the ship was dewatered. Welding of the patch to the ship was completed on 29 April. ROBIN HOOD got underway for Hong Kong but leaks in the patch forced the ship to return. The leaks were patched and on 4 May ROBIN HOOD again sailed for Hong Kong.

By 30 June 1971, HCU-1 had departed Vietnam after providing salvage services along the in-country waterways for more than 5 years. HCU-1's efforts and influence will not be quickly forgotten. The Vietnamese Navy, prepared by HCU-1 to continue harbor/river clearance and salvage operations, is equipped with ex-HCU-1 craft and equipment and trained in HCU-1 procedures and techniques.



Although each task had to be handled as an individual salvage operation, many followed a similar pattern. In most instances if the craft were salvageable, the wrecks had to be lifted, patched, dewatered, and demudded prior to tow.

HCU-1 SALVORS PREPARE TO DEWATER DAMAGED CRAFT

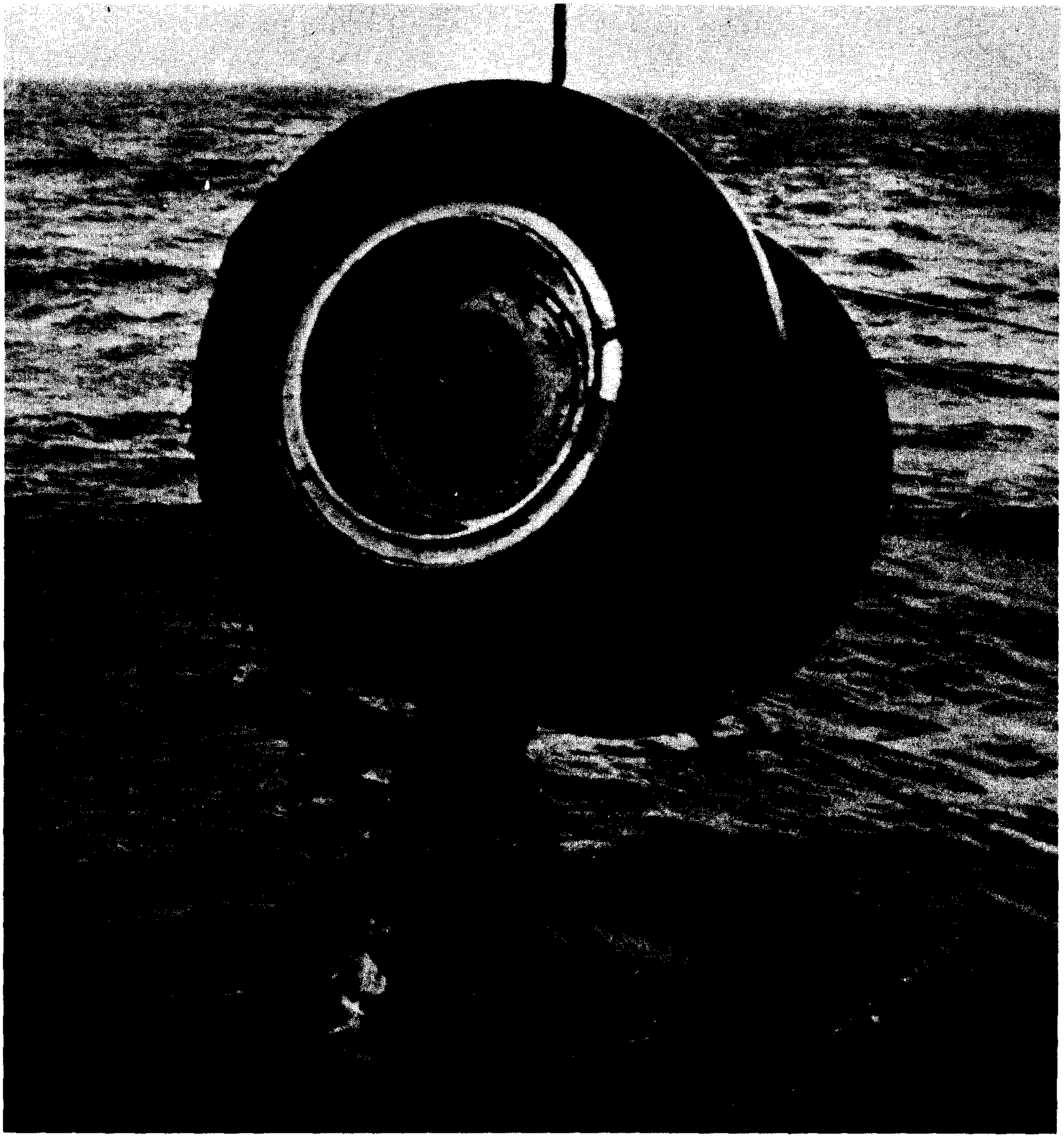
SUMMARY

OF

DOWNED AIRCRAFT

SEARCH AND RECOVERY OPERATIONS

IN 1971



Search and recovery of downed aircraft is a major, continuing salvage task. Recovered wreckage provides essential evidence for investigating and determining causes of the crash.

AIRCRAFT WRECKAGE PROVIDES VITAL CLUES TO CAUSE OF CRASH

SUMMARY OF DOWNED AIRCRAFT
SEARCH AND RECOVERY OPERATIONS IN 1971

INTRODUCTION

Each year the Supervisor of Salvage (SUPSALV), U.S. Navy, receives numerous requests for assistance in locating and recovering downed aircraft. The scope of assistance varies with the nature of each request. In some cases advice and recommendations are given; for others, full-scale, on-site, operational support may be provided.

This article summarizes the search and recovery services provided by SUPSALV in 1971 in connection with four different downed aircraft. The search and recovery efforts for two additional aircraft, a U.S. Air Force B-52 which crashed in Lake Michigan in January 1971 and a U.S. Air Force B-57 which crashed in Great Salt Lake, Utah, in April 1971, have been the subject of individual articles presented previously in this 1971 review. In each case the importance of accurate crash site information is evident. Salvage operations can not begin until the wreckage is located. If the location of the wreckage is not well defined, timely and costly search techniques must be methodically applied before the recovery operation can get underway. The four cases presented in this article reflect the scope and diversity of services required to conduct operations of this type.

Each of the following operations is summarized in this article.

OPERATION	DATE OF CRASH
Search for U.S. Navy F-4 Phantom in Gulf of Mexico	25 May 1971
Search and Recovery of U.S. Marine Corps AV-8G Harrier in Chesapeake Bay, Maryland	18 June 1971
Search and Recovery of U.S. Navy F-4J Phantom off Nag's Head, North Carolina	17 September 1971
Recovery of U.S. Air Force F-4 Phantom II in Hillsborough Bay, Tampa, Florida	30 September 1971

SEARCH FOR U.S. NAVY F-4 PHANTOM IN GULF OF MEXICO

Date:	25 May 1971
Location:	Gulf of Mexico, off Florida
Condition:	Lost in 70 feet of water
Task:	Search

Background

A U.S. Navy F-4 Phantom aircraft from the U.S. Naval Air Station, Boca Chica, Florida crashed into the Gulf of Mexico approximately 33 miles northwest of Key West, Florida on 25 May 1971. The Phantom jet fighter was on a training flight when it began a descent from 10,000 feet, leveled momentarily at 1000 feet, then rolled over on its starboard side, and crashed into the water at a 70-degree angle. Both the pilot and navigator were killed in the crash.

At the time of the crash, the F-4 aircraft was on a southeasterly course. A second F-4, accompanying the downed aircraft but flying in the opposite direction, reported a TACAN reading of 323 degrees, 33 miles from Boca Chica Naval Air Station. This converted to a latitude of 25°01'40"N and a longitude of 82°02'12"W. The water depth in the area of impact was approximately 70 feet with a fairly smooth bottom composed of white sand with few obstructions.

An immediate search effort was launched using U.S. Navy aircraft as well as a U.S. Coast Guard cutter from the Coast Guard base at Key West. The cutter dropped a drifting buoy in the vicinity of the crash in order to determine current and drift characteristics in hopes of finding the pilot and navigator. Later both a diver and wire drag search were conducted with negative results.

Planning the Search Effort

On 1 June 1971, SUPSALV tasked the search and recovery contractor Ocean Systems, Incorporated (OSI) to assist in search operations. On 2 June representatives from SUPSALV and OSI arrived in Key West and met with Coast Guard and Naval Air Station personnel to review and discuss the available information.

During this meeting, it was decided that an area 24 square miles could be searched in a 10-day period. This area 6 miles long and 4 miles wide would be oriented northwest/ southeast to parallel the course of the aircraft. The actual search pattern would be run in an approximate east-west direction. Search lanes were established 800 feet apart to allow a 200-foot overlap with the sonar covering 500 feet on each side.

During the next 2 days a search team was established. A 42-foot charter fishing vessel, LOOKOUT II was leased to serve as a search platform. Search equipment, including a side-scan sonar and a long range precision navigational system, was also obtained.

On 5 June, datum was reestablished by having the same F-4 aircraft and pilot which had accompanied the lost plane return to the TACAN position and vector a hovering helicopter into position. The helicopter then dropped a temporary buoy which was immediately replaced with a larger Dan buoy. LOOKOUT II was then anchored at the site.

Conduct of Search Operations

On 6 June search operations were begun at 0730. During the period 6–14 June, the 24-square mile area was covered with side-scan sonar. Four possible contacts were detected which were later investigated by Navy divers from the Key West Naval Station. The sonar was checked periodically against known objects on the bottom, such as shrimp boat anchors and chain, to ensure that it was functioning properly.

On 14 June the search team was notified that search operations would be extended for an additional 10-day period. It was also decided to transfer the sonar and navigational equipment from LOOKOUT II to a U.S. Navy Underwater Ordnance Research Vessel, UOR 526, for the extended search period.

An additional 10-mile search area was also established. This increased the original 24-square mile area on all sides but primarily in an east-west direction near datum. Based on all the available information, this area was still considered to be the most promising in which to locate the aircraft.

By 1715 on 15 June all equipment had been transferred from LOOKOUT II to the Navy UOR 526. At 0740 on 16 June the vessel was underway for the search area. UOR 526 arrived at the scene at 1100 and proceeded to reinvestigate the four possible contacts using 250-foot side-scan sonar.

Although none of the contacts had a high probability of being the aircraft, it was decided to request Navy divers to investigate. At 1135 on 17 June divers arrived on the scene and began diving at the sites of the possible contacts. Water depth was approximately 70 feet with bottom visibility ranging from 6–10 feet. The diver teams swam circle search patterns with radii of approximately 100 feet. Divers found 1-2-foot ridges as well as sponges 18 inches in height, but no aircraft wreckage.

The search continued from 18–22 June without making any significant sonar contacts. On 23 June, the Navy directed the search team to investigate in the vicinity of 24.57°N 18.18°W, a distance of about 15 miles southwest of the original datum. A shrimping vessel had reported losing its nets on a bottom object in approximately 80-90 feet of water in that area. A 3-square mile search of the area with 500-foot side-scan sonar failed to produce any significant sonar contacts.

On 24 June the search was terminated. The search team returned to Key West. During the entire unsuccessful search operation, a total of 37 square miles were covered.

Conclusions

Although the search operation was unsuccessful in locating the F-4 aircraft, there were no major problems that affected the amount of area searched, the accuracy of the sonar readout, or the exact positioning of the vessel. The primary difficulty during the search operation was the capability of the vessels to remain at sea for more than a few days at a time. Neither the LOOKOUT II nor UOR 526 were able to accommodate personnel for extended periods of time. Thus valuable time was used transiting to and from Key West and the primary search area.

Because of the distance from Key West to the search area, a simple line of sight navigation system could not be used. Instead a long range system was employed. The latter system offers an acceptable degree of accuracy but also has some disadvantages. Since it is not a line of sight system, it is based instead on a lane count from a known calibration point. It is necessary to return to the calibration point whenever the lane count is lost. For the F-4 search operations the calibration point was Smith Shoal off Key West, approximately 20 miles from the primary search area. On two occasions lane count was lost and the search team had to return to the calibration point. However, neither loss of lane count seriously affected the amount of area searched.

Another difficulty encountered during the F-4 search operation was the amount of shrimper activity. Heavy shrimper activity during the nights made it impossible to maintain any moored buoys either for navigational assistance, locating sonar contacts, or marking datum unless the search vessel was moored alongside. On occasion, as many as 30 shrimp vessels would make runs across the search area to within 150 feet of the moored vessel.

SEARCH AND RECOVERY OF U.S. MARINE CORPS AV-8G HARRIER IN CHESAPEAKE BAY, MARYLAND

Date:	18 June 1971
Location:	3.5 miles south of Naval Air Test Center, Patuxent River, Maryland
Condition:	Wreckage in 35-40 feet of water
Task:	Search and Recovery

Background

A U.S. Marine Corps AV-8G aircraft crashed into Chesapeake Bay, Maryland about 3.5 miles south of the Naval Air Test Center (NATC), Patuxent River, Maryland on 18 June 1971. This aircraft, the British-built Harrier, a short take-off and landing jet fighter was conducting dummy bombing runs on an evaluation visual surveillance when the accident occurred. The pilot did not eject before impact and was lost with the aircraft.

The aircraft was being tracked by theodolites and a tracking camera recorded the flight from before rocket launching until impact. An immediate search effort was launched using both Navy aircraft and crash boats. Buoys were set in the general area of the theodolite fix and a diver search was begun; however, nothing was recovered.

Planning Search Operations

The Naval Air Test Center requested SUPSALV's assistance for the search effort. SUPSALV committed a sonar-equipped search team, provided by the search and recovery contractor, Ocean Systems, Incorporated (OSI). A conference was held at NATC on 19 June. Attending were representatives from SUPSALV, OSI, NATC, and the Navy Safety Center (NAVSAFCEN). Films of the crash were viewed and all available data analyzed. A point of impact was plotted and the search plan was formulated, employing the search team's side-scan sonar and precision navigation system. The equipment was mobilized as soon as possible with the search operation scheduled to begin on 21 June.

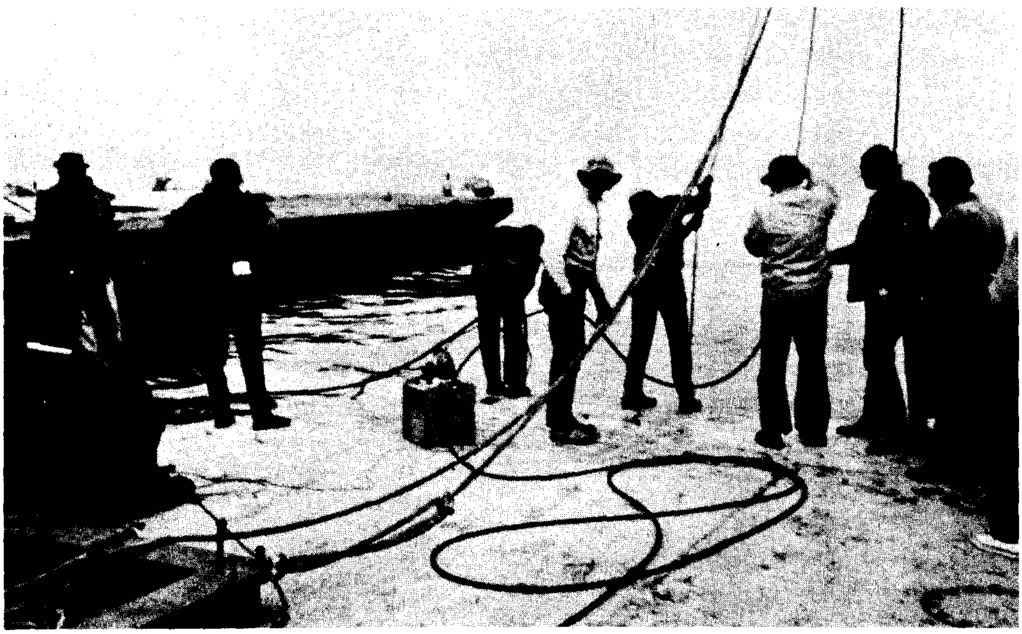
Conduct of Search and Recovery Operations

On 21 June at 1300, after all the equipment had been installed and checked out, search operations began. The area where the buoys had been placed by the fix from the theodolite stations was searched first. No contacts were detected with the side-scanning sonar around the buoys.

On 22 June engine problems developed in the 35-foot AVR-4 crash boat being used to conduct search operations. All equipment was transferred to a larger, 65-foot, crash boat and search operations resumed.

At approximately 1015 on 22 June, sonar contact was made. The sonar recorder indicated possible aircraft wreckage on the bottom. After a few more passes had been made to determine the perimeter of the wreckage area, two divers investigated the sonar contacts, verifying that the wreckage was from an AV-8G.

At this time, Naval Ordnance Laboratory Test Facility (NOLTF) divers, standing by across the bay in Solomons Island, Maryland, were deployed to the scene for the recovery operations. While waiting for the NOLTF divers, AVR-4 personnel placed perimeter buoys around the area and local divers located a large fuselage (and wing) section intact. Additional dives in the area indicated a scattering of debris near the main wreckage. At 1700, YSD-72 arrived from NOLTF, anchored over the wreckage, and began preparations for lifting the large fuselage and wing section.



Aircraft wreckage is recovered in a number of ways: small, light pieces are collected in baskets; larger pieces are raised via attached surface lines; and extremely heavy sections require special lifting equipment.

SALVORS PREPARE TO RAISE AIRCRAFT WRECKAGE

On 23 June, an additional search was initiated to locate the engine. The engine was located by sonar; Navy divers verified its position and a buoy was attached. The engine's position and other areas of small debris were then plotted for Navy personnel aboard the YSD.

Following the recovery of the fuselage and wing section and engine, the Navy Safety Center evaluated the progress of operations. Since the pilot's body and other pertinent pieces of the aircraft had not yet been recovered, it was decided that further search and recovery efforts would be conducted. Arrangements were made to augment the diving team from NOLTF with divers from Harbor Clearance Unit Two (HCU-2).

Participation of HCU-2 Divers

On 27 June divers from HCU-2 arrived at NATC. Information concerning progress to date, contacts, and support details were exchanged. An LCM-8 was provided as a diving platform.

Recovery operations began again on 28 June at the southern end of the impact area with very little wreckage recovered. Side-scan sonar reworked the crash area and a new anchorage was determined for the following day. On 29 June the body of the pilot was recovered. Also recovered were miscellaneous pieces of wreckage including a key instrument, the in-flight recorder. Support continued to be excellent and large collection baskets were delivered to aid in the recovery.

On 30 June the area was rescanned with the sonar and divers recovered more miscellaneous wreckage. During the next few days scattered pieces of wreckage were recovered, although bad weather and high winds and seas prevented diving operations on 2 July and limited bottom time on 3 July to 3 hours.

The final day of operations, 4 July, was spent trying to find two cockpit cameras and the port wing with no success. One main landing gear was located but not recovered. Recovery operations terminated with approximately 75 percent of the aircraft recovered.

Conclusions

The successful search effort and subsequent recovery of the pilot's body and 75 percent of the aircraft illustrate the effectiveness of cooperation and the professional performance of the personnel involved. Although the vicinity of the wreckage was known, the fragments and sections of the downed aircraft were widely scattered. The fact that search and recovery could be completed within a relatively short period of time reflects the competence and soundness of the techniques and procedures used.

SEARCH AND RECOVERY OF U.S. NAVY F-4J PHANTOM OFF NAG'S HEAD, NORTH CAROLINA

Date:	17 September 1971
Location:	Off Nag's Head, North Carolina
Condition:	Wreckage in 80 feet of water
Task:	Search and Recovery

Background

On 17 September 1971, a U.S. Navy F-4J Phantom aircraft crashed into the sea off Nag's Head, North Carolina. The plane had been on a routine training flight from the U.S. Naval Air Station at Oceana, Virginia. The two men in the aircraft ejected safely and were recovered a short while later by a rescue helicopter.

The U.S. Coast Guard Station at Oregon Inlet, North Carolina immediately dispatched a 30-foot utility boat to the crash site. Coast Guard personnel recovered floating surface debris and took visual fixes using the boat's magnetic compass. This boat remained on the scene until a 44-foot utility boat arrived. The 44-foot boat took radar fixes and set a reference buoy at position 35°39'N 75°31.5'W.

On 20 September, the USS HOIST (ARS-40) began a diver's search of the area around the buoy, fixing the position as 36°01.5'N 75°34.4'W. Although visibility on the bottom was about 10 feet, divers could find no sign of the wreckage in the vicinity of the buoy.

Initial Plans and Preparations

On 21 September the Supervisor of Salvage was asked to conduct a search for the wreckage. A presearch conference briefing was held in Norfolk, Virginia on 22 September. Attending were representatives from SUPSALV, COMSERVRON 8, the Naval Air Safety Center, VF-101, and the Commanding Officer of the USS HOIST. At the conclusion of this meeting, SUPSALV tasked Ocean Systems, Incorporated (OSI) to assist in the search.

The USS PRESERVER (ARS-8) was assigned to act as a platform for a towed side-scan sonar search and subsequent recovery of pieces of the F4-J aircraft. The ship got underway on 27 September with four search technicians and their gear aboard. Two navigation stations had been established ashore by OSI, one atop Engagement Hill and the other at the Oregon Inlet Coast Guard Station. Communications with the beach were established via a portable VHF transceiver.

The initial plan as a result of the presearch meeting was that OSI would coordinate a search pattern to cover the area of the crash and conduct diving operations as necessary to recover pieces found during the search. All elements would return to Little Creek, Virginia by 1 October in the event the search was unsuccessful.

USS PRESERVER Conducts Search Operations

PRESERVER arrived at the salvage site and briefly searched for a 5-gallon can buoy reportedly placed by the Coast Guard to mark the oil slick noted at the time of the crash. When the buoy could not be found, a sonar search of the area was begun with the sonar scanning a 600-foot wide bottom area. During the first sweep the Coast Guard buoy was observed approximately 600 yards south of its reported position.

An area of approximately 1 1/3 miles was covered during the first day's search operations. No firm contacts developed, although a review of the tape showed two small areas of low probability. These two areas were reinvestigated during the first sweep the next day but the sonar contacts did not prove to be the aircraft wreckage.

Good sonar contacts were obtained on 28 September at 36°00'0"N and 75°33'0"W in 85 feet of water. A number of sonar runs were made to define the debris pattern and overall size. The target was in a compact elliptical area roughly 50 feet in diameter and showed all the characteristics of a typical aircraft wreck trace. Because of rough, 10-15-foot sea conditions, diving operations to confirm the contacts as aircraft parts could not be conducted.

PRESERVER marked the position with an orange Dan buoy and established a fix by visual bearings. Four drags using a 25-pound grapnel towed astern were made in the vicinity of the wreck. No wreckage was recovered, partly because the grapnel was believed to be bouncing along the bottom as a result of the ship's pitch and roll, and partly because the main wreck area was not dragged to avoid damaging possible evidence. PRESERVER remained nearby during the night.

Hurricane Ginger

Weather conditions continued to deteriorate. Winds had increased to over 25 knots and seas were in excess of 15 feet as Hurricane Ginger entered the area. PRESERVER set another Dan buoy which was dropped slightly northeast of the first. This buoy was attached to a 25-pound grapnel and weighted with an additional 200 pounds of chain. PRESERVER then returned to Little Creek, Virginia to await passage of the hurricane. On 30 September the search team was demobilized.

Search Operations Resumed

PRESERVER returned to the salvage site on 5 October and immediately began a search for the buoys planted before Hurricane Ginger. The buoys could not be found and visual fixes were not possible because mist and rain limited visibility.

Foggy weather still prevailed the next day. An area search proved that the buoys had carried away during the hurricane. A systematic dragging operation was then conducted until 1300 when visibility improved and visual fixes were obtained.

PRESERVER went into a 2-point moor based on the best fix obtainable. A bottom search with divers on a 150-foot circling line was begun; bottom visibility was 5 feet. Simultaneously the area was dragged by a grapnel towed behind a work boat in a systematic pattern.

The bottom search for the aircraft wreckage was unsuccessful. As a result, OSI was again tasked to search the area with side-scan sonar. On 8 October, two shore stations were set up again and the search team boarded the PRESERVER and set up shipboard equipment. The sonar search succeeded in relocating the wreckage early in the afternoon of 8 October. A buoy was placed squarely in the wreckage; the ship was then placed in a 2-point moor over the debris site and recovery operations began. Recovery operations continued during the next few days despite strong easterly winds which set the ship further away from the wreckage and forced it to remoor several times.

Recovery Operations

Items recovered included the aircraft's tailhook, a section of landing gear, catapult hook, generator, aileron and flap actuators, aileron section, and several miscellaneous smaller pieces of debris. The bottom was covered with many small unidentifiable parts indicating extensive aircraft breakup. The largest piece sighted was an unidentifiable section approximately 4 x 5 feet which appeared to be imbedded in the hard sand bottom. Bottom visibility during recovery operations was less than 3 feet.

During the early morning of 10 October, a sudden westerly squall with 30-40-knot winds forced PRESERVER out of her 2-point moor. The stern mooring leg (towing wire) had collapsed the towing roller assembly and began sweeping across the fantail of the ship. The wire and fantail were finally secured and the stern leg was recovered allowing the ship to ride to its starboard bow anchor. With weather conditions making diving unsafe, PRESERVER marked the crash site with buoys and returned to Little Creek. Equipment was dismantled and demobilization began.

USS OPPORTUNE Replaces USS PRESERVER

On 12 October it was decided that the USS OPPORTUNE (ARS-41) would continue the recovery efforts of the F-4J aircraft previously assigned to the PRESERVER. OPPORTUNE got underway and arrived at the salvage site on the 13th. OPPORTUNE went into a 2-point moor at the wreckage site with the marker buoy left by PRESERVER close aboard on the port quarter. Diving operations began with a systematic bottom search; however, only very small light scraps were found.

During the afternoon OPPORTUNE was remoored with four salvage balloons buoyed off for use in a systematic grid-type bottom search. Average depth for the day's search efforts was 80 feet with a hard sand bottom and visibility of 1-foot. Diving operations the next day focused along a 500-foot bottom line north from PRESERVER's buoy. Divers also searched with a 60-foot circling line from weights dropped at the stern of the ship. However, the wreckage area was not located.

On 14 October divers began searching along the 500-foot line, pivoting from the OPPORTUNE's stern and passing through positions believed to be marking the area of wreckage. The search line was pivoted in 45-degree increments by the work boat, thus utilizing a dragging search as well. The search efforts were still unsuccessful. OPPORTUNE was remoored with the PRESERVER buoy 20 yards off the port beam. Circling lines were again used; search efforts were again unsuccessful.

Final Recovery Operations

At 1800 on 14 October, divers discovered the wreckage 50 feet southeast of the PRESERVER's buoy. A cement clump and buoy were immediately placed at that site. Divers recovered small but recognizable pieces of the aircraft. A heavy metal basket was lowered as near as possible to the wreckage for retrieving pieces recovered by the divers. Recovery of aircraft pieces continued throughout the night.

By early 15 October all wreckage had been recovered in that area. A Dan buoy was rigged to a cement clump to mark the wreckage site. Parts recovered included half of the burner section, the main landing gear sidebrace actuator, and miscellaneous parts of the starboard inboard engine and wing section.

OPPORTUNE returned to Little Creek to obtain hand held sonar sets from Harbor Clearance Unit Two (HCU-2) to aid in locating other areas of wreckage at the recovery site. The divers were also instructed in the use of the sonar sets.

OPPORTUNE returned to the salvage site on 16 October and divers began a 360-degree search from the OPPORTUNE's stern using sonar gear. The Dan buoy and cement clump were off the starboard quarter. Divers located a very large area of wreckage in the vicinity of the diver's descending weight placed near the port beam. The sonar search was discontinued and recovery operations were begun.

OPPORTUNE was remoored to place the stern of the ship over the wreckage to facilitate retrieving the pieces with the heavy metal basket. Divers recovered a large portion of the tail section, the horizontal stabilizer, stabilator actuator, dual servo hydraulic of the stabilator actuator, and trailing edge of the flap actuator.

Divers searching the area of wreckage on 17 October with the heavy metal basket and 40-foot circling line experienced difficulty because of the heavy bottom currents. Heavy winds and sea conditions necessitated remooring the ship over the wreckage area. Only minor pieces of wreckage were found. Deteriorating weather conditions forced termination of the recovery efforts. OPPORTUNE returned to Little Creek.

Conclusions

The major problem affecting the entire operation was the weather. At first the weather was marginal for searching and unsafe for mooring or recovery. The adverse weather further hampered and delayed operations by carrying off the buoys marking the wreckage site and forcing additional search operations to be initiated. The weather often deteriorated during the conduct of operations to such an extent that further recovery attempts were useless.

The search techniques and sonar equipment used were completely satisfactory; the wreckage was found with a minimum of time and effort whenever this equipment was used. The prompt action taken by the first on-scene Coast Guard cutter in marking the crash site was largely responsible for OSI being able to locate the wreckage. The fixes made by the Coast Guard cutter enabled OSI to place the sonar equipment in the approximate vicinity. The successful F-4J search and recovery effort under adverse sea conditions demonstrated the admirable "can do" spirit and professional skill of the personnel involved.

RECOVERY OF U.S. AIR FORCE F-4 PHANTOM II IN HILLSBOROUGH BAY, TAMPA, FLORIDA

Date: 30 September 1971
Location: Hillsborough Bay, Tampa, Florida
Condition: Wreckage in about 10 feet of water
Task: Recovery

Background

A U.S. Air Force Phantom II crashed in Hillsborough Bay, Tampa, Florida on 30 September 1971. The aircraft went down in about 12 feet of water approximately 1 mile offshore.

On 1 October, MacDill Air Force Base asked for Navy assistance in recovering the aircraft. A team of seven divers from the Navy Experimental Diving Unit (NEDU) was deployed from Washington, D.C. to Tampa to recover the wreckage. Arriving in Tampa on 2 October, the team was briefed on the wreckage and available support facilities.

The MacDill AFB SCUBA Club had made previous dives at the site and the U.S. Coast Guard cutter, COSMOS, had placed a buoy. During the recovery operations the NEDU diving team used the SCUBA Club's facilities for charging bottles and also their 72-cubic-inch steel Scuba cylinders (72's) which proved to be particularly valuable.

Conduct of Operations

COSMOS was employed as the diving platform and salvage vessel because she was a shallow draft vessel and already had a crane barge bridled to her bow. Four spuds were used for mooring. These were lowered and raised by winches. COSMOS proved to be well suited for the job.

The diving team arrived at the wreckage site on 3 October. A survey of the wreck determined that the plane, although not widely scattered, had been completely torn apart and buried in the silt, mud, clay, and shell bottom, which was layered in that order. It was later determined that parts of the plane were imbedded up to 15 feet in the mud.

The divers began to recover the wreckage by picking up the most obvious pieces. In 5 days, approximately 50 percent of the plane was recovered. The largest pieces seemed to be concentrated in one area. The divers tried working by hand to remove the relatively soft layers of silt and mud from the area where cables and pipes were protruding. However, the stirred up silt and mud caused trouble with their MR-12 regulators.

It became evident that deep sea gear and tunnel equipment would be needed to complete the underwater work. Adaptors were fabricated to connect the MK V deep sea rigs and the ship's ability to provide tunneling capabilities was checked. A 1 1/2-inch hose at about 60-70 psi was immediately available; however, this proved to be inadequate. A P-250 was borrowed from the U.S. Coast Guard cutter JUPITER with a 2 1/2-inch hose at about 100-110 psi. This was very effective. With the exception of 10 and 11 October, which were spent alongside the pier because of high winds and heavy rain, tunneling by deep sea diving and rigging, and search by Scuba diving continued through 22 October.

On 23 October COSMOS was relieved by the U.S. Coast Guard cutter VISE. VISE also had a barge and crane rigged forward. The deep sea gear was transferred to an Air Force truck to be stowed for the night and then put aboard the VISE the following morning.

Arrangements had been made for contractor-supplied dredging equipment. This gear was on board and ready for operation on 24 October; however, the pump for dredging operations was a 6-inch pump that proved to be too small. It was replaced the same evening with an 8-inch pump. Dredging began and continued until the evening of 28 October when all efforts were secured. Diving and dredging operations had recovered 90 percent of the aircraft.

Conclusions

Recovery of most of the aircraft buried in 10 feet of water and 15 feet of silt and mud bottom reflect the competence of the personnel involved and the effectiveness of the techniques and procedures used. The primary purpose of the dredging was to locate one generator and a constant drive shaft. They were not found, although it was believed that they should have been in proximity of the other pieces. Other than small hand-sized fragments, these two pieces were all that was missing from the plane. Representatives from the U.S. Air Force appeared to be very pleased with the recovery results.