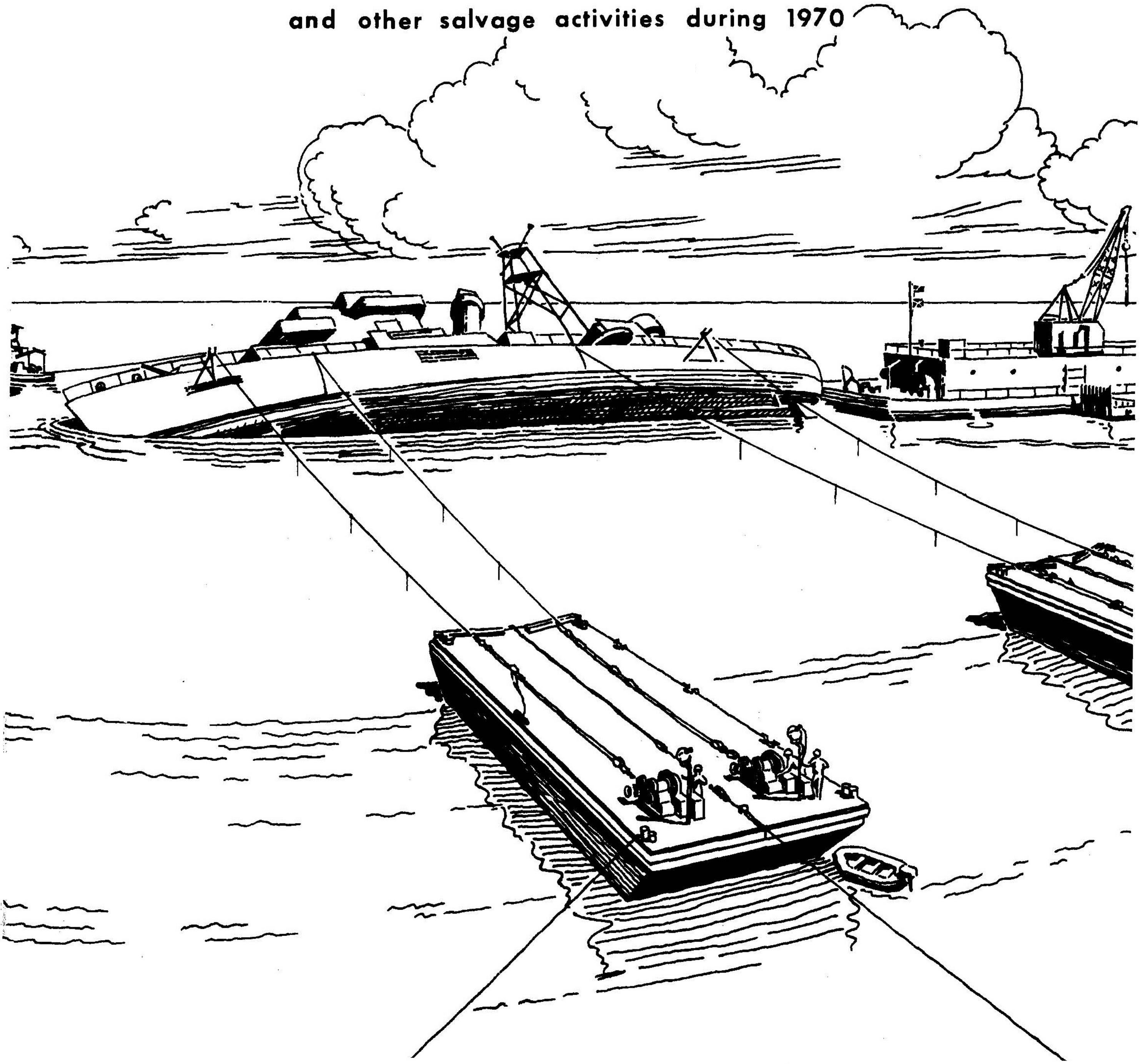
NAVSHIPS 0994-012-6020

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
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FOREWORD

The year 1970 was, in one sense, a routine one for U.S. Navy salvors. Salvage operations continued at the same hectic pace that the Navy has come to accept as routine in recent years. Apart from the operational tempo, however, little else about our salvage efforts could be described in that manner. Indeed, the outstanding characteristic of 1970 Navy salvage operations was their astonishing diversity. They were conducted in the forbidding cold of the far North, in the stifling heat of Southeast Asia, in such unlikely places as Lake Mead, Nevada, and they were conducted for a wide variety of purposes.

The year began with the threat of two major oil spills, one from a sunken tanker off Nova Scotia, and the other from an off-shore oil platform in the Gulf of Mexico. These two incidents helped to focus attention on the need for comprehensive programs to combat the problem of oil pollution control. The Navy has established pools of special equipment such as oil containment booms and has taken other practical steps to improve readiness in this area. It is also sponsoring vigorous research and development aimed at technical breakthrough on the problem.

The year ended with research and development activities of a completely different type, yet of equal significance for salvage work. The Navy tested its newly acquired Mark I Deep Dive System, signaling its capability and intention to project useful underwater work far below the traditional diving depth limitation of 380 feet. The deep submergence rescue vehicle for mating with downed submarines was also tested as 1970 drew to a close. These events, coupled with productive work on the Large Object Salvage System (LOSS), pointed to a new kind of salvage force in the future.

Deep ocean recovery and implantment were as prominent in 1970 operations as they had been in 1969. CURV III, the cable controlled underwater recovery vehicle, used its sonar, television, and manipulator systems to locate and recover an exotic solar eclipse instrumentation package at a depth of 5800 feet off the coast of Virginia. Salvage forces of the Pacific Fleet implanted the SQUAW, a submarine hull, in an underwater moor, 300 feet below the surface, at a depth of 3500 feet off San Diego, California.

Other salvage operations in 1970 were more conventional and familiar. Aircraft went down, as they often do, in remote areas, posing vexing problems for search and recovery forces. Harbor Clearance Unit One fought to stay abreast of the salvage caseload in Vietnam which, predictably, did not diminish as U.S. forces began their withdrawal from Southeast Asia. Its counterpart in the Atlantic Fleet, Harbor Clearance Unit Two, proved its mettle in two important salvage operations, the raising of ex-REUBEN JAMES at Dahlgren, Virginia and YTM-538 at Mayport, Florida.

In summary, salvage operations in 1970 illustrate the full range of the interests and responsibilities of the Office of the Supervisor of Salvage. At one time or another, the Navy's deployed operational salvage forces were heavily engaged not only in conventional salvage activities but also in environmental pollution abatement, deep ocean search and recovery, implantment of objects in the deep ocean, and search and recovery of downed aircraft. The scope and diversity of these operations have been faithfully portrayed in this 1970 review. It is a review which makes worthwhile reading for any salvage professional.

E. B. MITCHELL
Captain, USN
Supervisor of Salvage, U.S. Navy

ABSTRACT

This 1970 operational report of the Supervisor of Salvage, U.S. Navy, is one of a series of annual reviews of significant salvage operations. The report is intended for general reading. It covers operations of contractor salvors as well as those of U.S. Navy salvage forces. Two operations concerning oil pollution control are highlighted: the debunkering of the sunken tanker, ARROW in Chedabucto Bay, Nova Scotia and the Chevron off-shore oil platform fire in the Gulf of Mexico. The report includes accounts of the raising of the destroyer escort hull, REUBEN JAMES and the harbor tug, YTM-538. Deep ocean recovery and implantment operations receive detailed treatment in two articles, one on the recovery of a NASA solar eclipse instrumentation package and the other on the underwater mooring of SQUAW, an experimental submarine hull. Operations to locate and recover seven different downed aircraft are summarized, including the recovery of an amphibious Cessna U-206 aircraft from 400 feet of water in Lake Mead, Nevada.

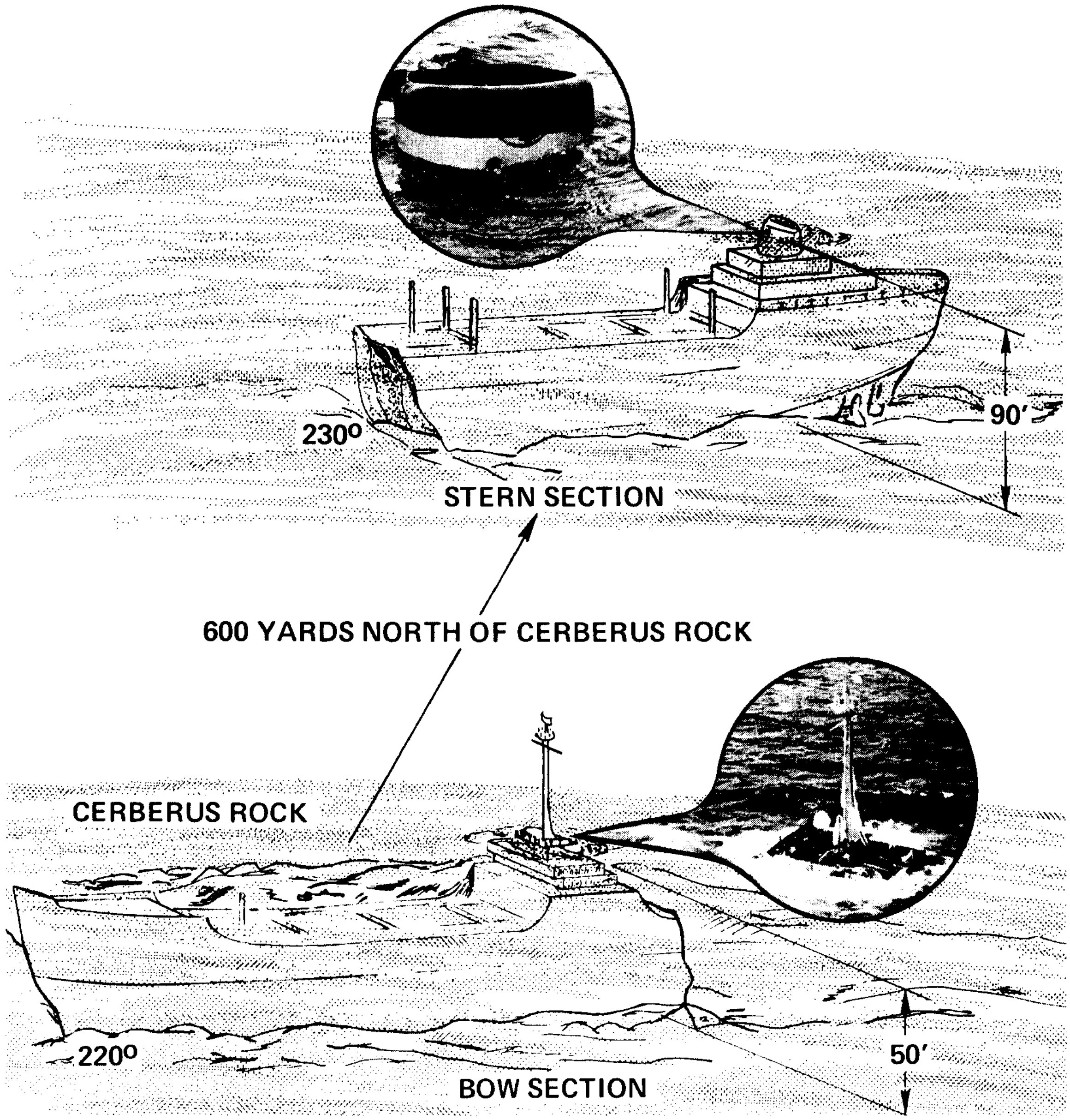
CONTENTS

THE RECOVERY

OF

BUNKER "C" FUEL OIL

FROM THE SUNKEN TANKER, SS ARROW



Divers reported the bow section badly smashed and stern section relatively intact. Over 6,000 tons of high viscosity fuel oil remained in the ARROW's cargo tanks. Canadian Government initiated salvage operations to debunker the wreck.

THE ARROW, BROKEN IN TWO SECTIONS, ON THE BOTTOM OF CHEDABUCTO BAY, NOVA SCOTIA

THE RECOVERY OF BUNKER "C" FUEL OIL FROM THE SUNKEN TANKER, SS ARROW*

INTRODUCTION

The oil tanker, SS ARROW, grounded and sank in Chedabucto Bay, Nova Scotia, in February 1970, spilling about 10,000 tons of fuel oil. Over 6,000 tons of oil remained in the ARROW's cargo tanks, threatening further pollution. The sunken tanker, broken in two sections and bottomed at a depth of 90 feet, posed a unique salvage problem. The oil was highly viscous Bunker "C" fuel. Debunkering a tanker at near-freezing temperature had never been attempted. The feasibility of pumping the oil was unknown.

The salvage force developed a steam supported pumping system to recover the oil and applied a hot tap technique, adapted from oil refinery procedures, to penetrate the ARROW's cargo tanks and install fittings on the deck for pumping. Steam traces were inserted in the salvage hoses to heat the high viscosity fuel oil. These measures succeeded in debunkering the tanker.

LOSS OF THE ARROW

Initial Recovery Efforts

The ARROW smashed into a rock formation on 4 February. It remained impaled for several days and appeared initially to be in no immediate danger of sinking. The Imperial Oil Company which had chartered the ARROW, dispatched one of its coastal tankers, the IMPERIAL ACADIA, to take off the ARROW's cargo. It was assumed that this could be done by using the ARROW's steam system to heat the remaining Bunker "C" in its cargo tanks to the minimum of 135°F required for pumping. However, the ARROW's fires had been permitted to die down and neither the salvage force nor the ship's crew members were successful in their attempts to restore the steam. The steam lines had evidently been wrenched and broken in the convulsions of the ship.

Vulnerable amidships where the #5 cargo compartment was empty, the ARROW's back was soon broken by the pounding of the seas. Within a few days the deck plates and side plating began buckling and the tanker split into two sections on 8 February.

The initial salvage efforts focused on the recovery of the severed stern section. These attempts, hampered by heavy weather, finally failed on 12 February. Tugs could not control

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*For the complete report, see ARROW, NAVSHIPS 0994-008-1010.

the stern section and it sank in an upright position in 90 feet of water about 600 yards north of the rock formation. The bow section had also gone under by this time, remaining near the rock in shallower water. Both the ARROW's funnel on its stern section and the upper part of its bridge structure on its forward section remained awash.

Damage Estimates

A detailed diver's survey of the wreck was not made until a few weeks after the ARROW had split and sunk. The survey revealed that the bow section was badly smashed while the stern section remained essentially intact. Both sections were hard aground. Oil had escaped from cargo tanks in both sections.

The bow section, wedged by rocks, was lying on a general 220° heading, listing about 20° to starboard with a slight trim aft. Its starboard side was crushed from the bridge structure to the forecastle break, the crushed area extending from the bottom to within 6 to 8 feet of the deck in the vicinity of the #2 starboard wing tank. The crushed area tapered downward from this point to within a few feet of the bottom at both ends of the bow section. All cargo tanks appeared open to the sea with the possible exception of two port wing tanks. The deck itself was in shambles, having split open along both sides of the catwalk. The hull was completely broken and open aft of the bridge structure.

The stern section, lying on a 230° heading at a depth of 90 feet, had suffered relatively little damage. Divers reported that it was resting on a firm gravel bottom with little or no list or trim. The hulk was lying upright in a southwest/northeast direction. Seven cargo tanks appeared intact. Although oil was seeping from several vents and pipelines, the wreck seemed relatively secure. It was not being subjected to the buffeting of surface waves which was threatening to break up the bow section. The stern section was also in a reasonably accessible position for diving and salvage operations. The deck was about 55 feet below the surface and the nearest navigational obstruction was Cerberus Rock, 600 yards to the south.

THE SALVAGE PROBLEM

The breakup of the ARROW and the sinking of its stern section on 12 February presented a difficult salvage problem. The characteristics of the Bunker "C" fuel oil, the large quantities to be recovered from many different cargo tanks, and the severe weather conditions in Chedabucto Bay offered formidable challenges to any salvage force.

Condition of Cargo Tanks

The amount of spilled oil and that remaining in the wreck could not be determined with precision. Although it was established that the ARROW was carrying about 110,000 barrels of oil when it hit Cerberus Rock, it was not clear just how this load had been distributed among the various cargo tanks. In addition, there was no known method for measuring the amount of oil left in each tank. The salvage master developed an estimate of the quantities of oil involved. This estimate (67,150 barrels spilled and 42,850 barrels remaining in the wreck) was based on his detailed knowledge of the ship's construction, on divers' reports of the damage to each tank, and on divers' observations of oil discharge when the ullage covers were opened.

It was established that the amidships, #5 cargo compartment, was empty before the ship went aground. The salvage master assumed that the cargo was generally spread evenly throughout the remaining compartments. He proceeded with salvage planning on the basis that the ARROW had been carrying about 1000 tons in each of 8 center tanks and about 500 tons in each of 16 wing tanks.

Other Considerations

In addition to the cargo tanks, it was also necessary to consider the ship's fuel oil that was carried aft in the ship's bunker. The bunker was flanked by two settling tanks that also had to be checked for oil. It was probable, however, that the ARROW had already consumed most of its fuel before it went aground. The ship was about to enter port and it was apparently a routine practice to carry only enough fuel for the voyage plus three days' reserve supply on runs of this type from Aruba.

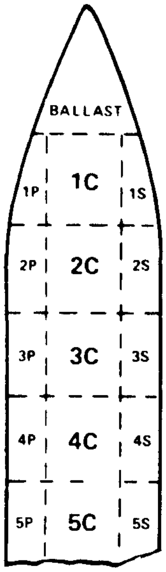
The condition of the ship's bottom under the cargo tanks still containing oil was an important factor. The hull evidently had been pierced under these tanks when the ship sank. They were open to the sea at the bottom. Sea water had entered the tanks, forcing the oil upward against the tank tops. This process served both to trap the oil in the tank and to help make it accessible for pumping operations.

Characteristics of Bunker "C" Fuel Oil

Bunker "C" is a heavy residual fuel oil of exceptionally high viscosity. It is one of the cheapest fuel oils produced, and is normally used in large scale heating installations equipped with preheaters. The central problem at the outset of planning the salvage operations was the lack of reliable knowledge concerning the flow characteristics of this fuel at the near-freezing temperatures encountered in Chedabucto Bay. It was known that the viscosity of the Bunker "C" at 122°F was 280 seconds SSF (Saybolt Furol Seconds); the pour point was 30°F; and the specific gravity at 60°F was 0.964.

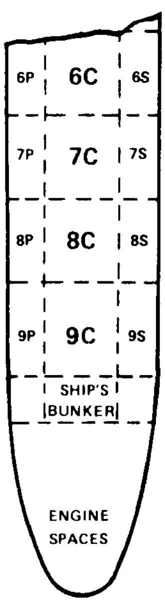
The viscosity of fuels of this type increases radically as temperature decreases. The increase is so radical that normal viscosity-temperature tables do not attempt to show viscosity measurements at temperatures lower than 70°F. The viscosity of the fuel oil in the wreck, given a temperature of 35°F, no doubt exceeded 1000 seconds (SSF). Therefore, there was good reason to believe that the oil simply could not be pumped under such conditions.

SITUATION IN BOW SECTION



1P, 1C, 1S 2P, 2C, 2S 3P, 3C, 3S	These three cargo compartments ruptured. Wing tanks on port side may still have some oil in a wedge effect only. Residual only in center and starboard tanks.
4P, 4C, 4S	Little or no oil left. Tanks ruptured on grounding. Remaining oil probably escaped when ship broke.
5P, 5C, 5S	Empty on trip; now completely open to sea, dividing bow and stern sections.

SITUATION IN STERN SECTION



6P, 6C, 6S	Port and center tanks flooded when ship broke; now open to sea. Starboard tank may still have oil.
7P, 7C, 7S 8P, 8C, 8S	All tanks in these two cargo compartments appear tight and full of oil.
9P, 9C, 9S	Tank covers open and no oil remaining in wing tanks. Center tank appears tight and full of oil.
Bunker & Settling tanks	Appear intact; amounts of fuel oil in these tanks unknown.

The ARROW had nine major cargo compartments. Each compartment was subdivided longitudinally to form three cargo tanks, those in the center of the ship being approximately twice the capacity of their respective port and starboard wing tanks.

THE CONDITION OF EACH CARGO TANK AS IT APPEARED TO THE SALVAGE MASTER ON 27 FEBRUARY

ASSEMBLING THE TASK FORCE

The Imperial Oil Company assumed initial responsibility for the first salvage attempts and the early efforts to combat the oil spill. It was soon evident, however, that the scope of the disaster warranted immediate intervention by the Canadian Government. The Department of Transport was assigned the task of coordinating cleanup and salvage operations. The civilian and military resources deployed to Chedabucto Bay were organized in one centrally-directed task force.

Dr. Patrick D. McTaggart-Cowan, Executive Director of the Science Council of Canada, was designated task force director. Captain Sven A. Madsen of Esso International of New York was engaged as the salvage master. This assured that the salvage operation would be headed by a person with extensive background and knowledge of oil tankers and of the characteristics of Bunker "C" fuel oil. Arrangements were also made for the participation of the Murphy Pacific Marine Salvage Company. The Supervisor of Salvage, U.S. Navy, directed the commitment of the MV CURB, a fully equipped Navy salvage ship leased to Murphy Pacific and located in New York. Captain Robert Belsher assumed responsibility for Murphy Pacific's participation, reporting directly to Captain Madsen for the conduct of salvage operations. LT D. G. Floyd, USN, and Mr. B. W. Sanders of the Office of the Supervisor of Salvage, represented SUPSALV at the salvage site.

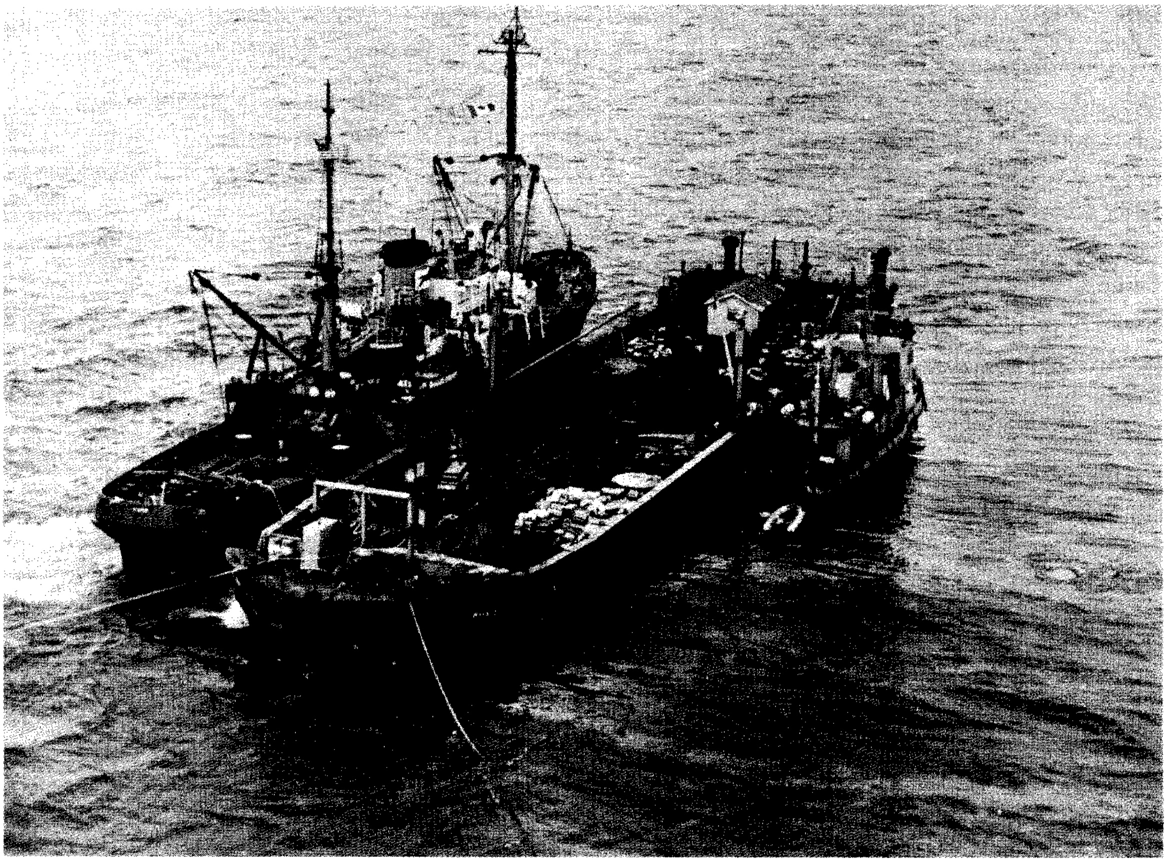
VESSELS IN THE SALVAGE FORCE

The salvage force used three principal vessels for the recovery effort. Each played a key role.

MV CURB	–	a U.S. Navy salvage ship (ARS type) operated by the Murphy Pacific Marine Salvage Company.
YMT-12	–	a diving tender of the Royal Canadian Navy.
IRVING WHALE	–	an oil transfer barge belonging to the Imperial Oil Company.

The Motor Vessel (MV), CURB

The CURB is 213 feet long and weighs 1,202 gross tons. It normally carries a crew of 30 to 35 men, including the salvage force, although it can accommodate 49 persons. The CURB's equipment includes a complete salvage workshop, a machine shop, diving locker, automatic towing engine, pumps, compressors, and eight 4-ton Eells anchors. Capable of functioning as a towing vessel as well as a salvage tender, the CURB has the necessary spaces and communications equipment to provide headquarters facilities afloat for on-site command of salvage operations.



The oil transfer barge, IRVING WHALE, with the U.S. Navy salvage ship, CURB, and the Royal Canadian Navy diving tender, YMT-12, alongside.

SALVAGE NEST OVER THE SUNKEN ARROW

The Diving Tender, YMT-12

The YMT-12 is a 90-foot long Royal Canadian Navy (RCN) diving tender. It arrived in the operational area on 28 February and its divers began the critical task of penetrating the ARROW's cargo tanks on 2 March. The YMT-12's sea-keeping capabilities are relatively limited, thus restricting the capability for all-weather diving in the Cerberus Rock area. The YMT-12 used the barge, IRVING WHALE, or the CURB, as a lee at the salvage site, normally taking up a three-point moor for diving operations. The YMT-12 withdrew to sheltered areas each evening following diving operations and returned to the salvage site at first light each day that weather permitted.

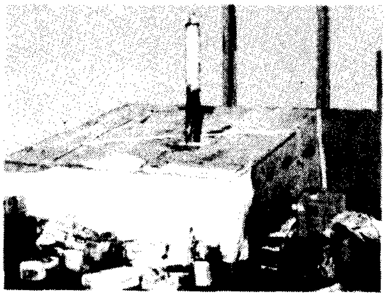
The YMT-12 supported 12 divers during the operation and also provided medical support for the salvage force afloat. The RCN divers from the YMT-12 participated in all phases of the salvage operation. They mastered the hot tap method of penetrating the ARROW's cargo tanks, concentrating their main efforts on the difficult underwater work of attaching spool pieces and gate valves, tapping the tanks, and attaching and maintaining the cargo hoses. Other diving work included conducting surveys, assisting with mooring the barge, and applying explosives to remove underwater obstructions.

The Oil Transfer Barge, IRVING WHALE

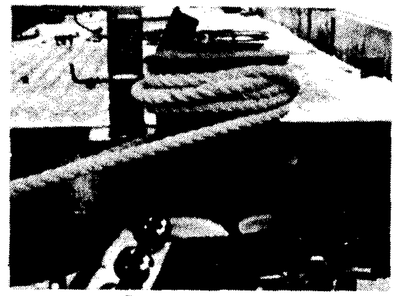
The IRVING WHALE served both as a salvage pumping platform and as a receptacle for the retrieved oil. It could carry about 30,000 barrels of Bunker "C" at 170°F. This was important since the estimated amount of oil remaining in the ARROW's tanks was between 30,000 and 50,000 barrels. It meant that operations would not have to be interrupted excessively to transfer the recovered oil to other vessels.

The size and design of the IRVING WHALE made it well suited for use as a salvage pumping platform. It was 265 feet long and had a beam of 65 feet. The wide beam and flat bottom made it extremely stable. The extensive deck area provided adequate work space to install and operate the salvage pumps and their supporting equipment, such as boilers, generators and hoses. The barge was also equipped with hydraulic booms amidships that could be used to maneuver the heavy hose rigs needed for pumping and for general purpose work in support of the operation. It also had a newly installed 225 KW diesel electric generating set as well as tank facilities for the supply of fuel oil and feed water, important resources in developing a pumping system.

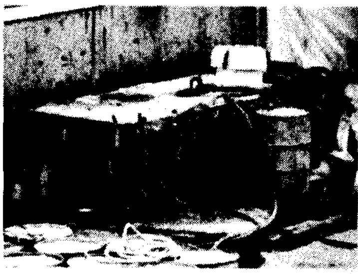
The IRVING WHALE, however, was not self-propelled. Nor had it been designed for mooring and unmooring in the open sea. These limitations, coupled with its great size, made mooring operations difficult. A mooring winch had to be installed and the necessary



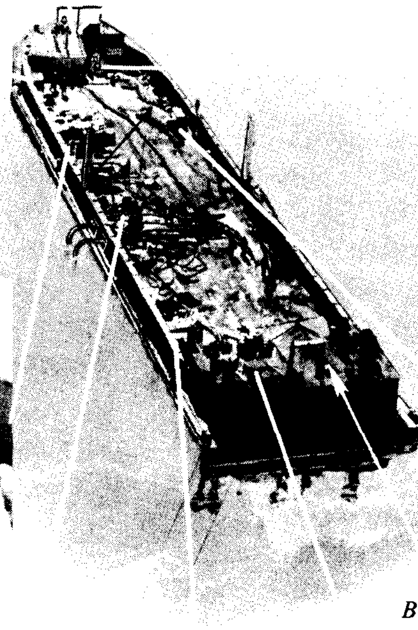
Portable Boiler in Shack

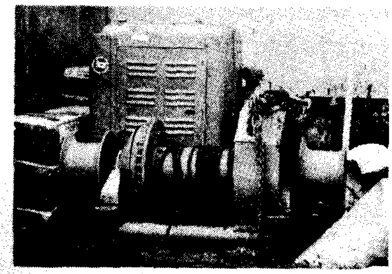


Powered Capstan

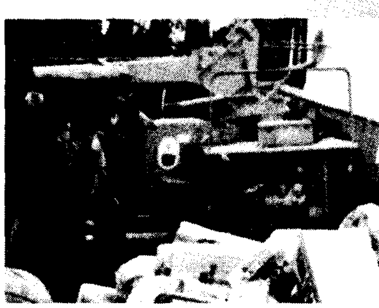


Primary Feed Water Tank

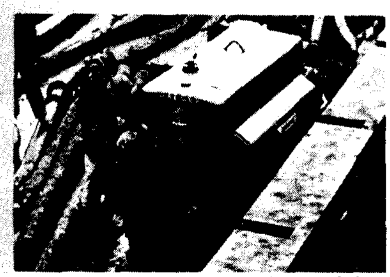




Mooring Winch

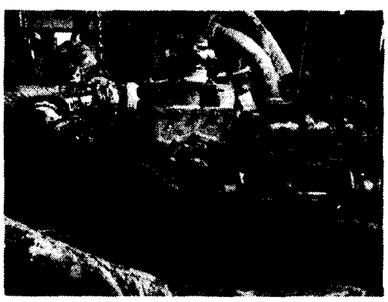


Mulching Machine and Peat Moss for Oil Spill Contingencies

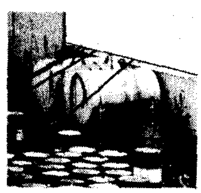


Air Compressor for Airlift

Bunkhouse



Pumping Stations Amidships



Fuel Tanks For RCN Steam Generator

RCN Steam Generator and 30 KW Generator in Shack. Fuel Tank for 30 KW Generator and Secondary Feed Water Tank in Front of Shack.

Two steam power plants were installed to support the pumping system and to heat the Bunker "C". Extensive outfitting was required to transform the barge into an effective tender for extended salvage operations.

THE OIL TRANSFER BARGE, IRVING WHALE, OUTFITTED FOR SALVAGE OPERATIONS

mooring lines, legs, and anchors provided. In addition, the barge had not been designed as a salvage lighter. For example, its high capacity pumps were centrifugal pumps intended to move fuels at high temperature and low viscosity. They were not suitable for pumping the high viscosity Bunker "C" from the wreck.

A major outfitting effort was necessary to provide the IRVING WHALE with the equipment and facilities needed for the salvage attempt. During the course of the salvage operations, the barge was outfitted with two steam power plants installed on the main deck, one forward and one aft, to support the pumping effort. Pumping stations were set up amidships. An air compressor was brought aboard to provide an airlift capability. A mooring winch was placed in the forward deck area. Feed water tanks were positioned near each steam power plant and the necessary fuel service tanks were also installed.

The salvage force was provided principally by the CURB and by the Royal Canadian Navy. The CURB provided a rotating salvage force of five men to operate the pumping system on a 24-hour basis. The CURB's salvage force operated all aspects of the system except the two steam generators, which were normally tended by three RCN operators and two civilian boiler tenders. Both RCN and civilian technicians were brought aboard the barge periodically for repair jobs beyond the capabilities of the on-board force.

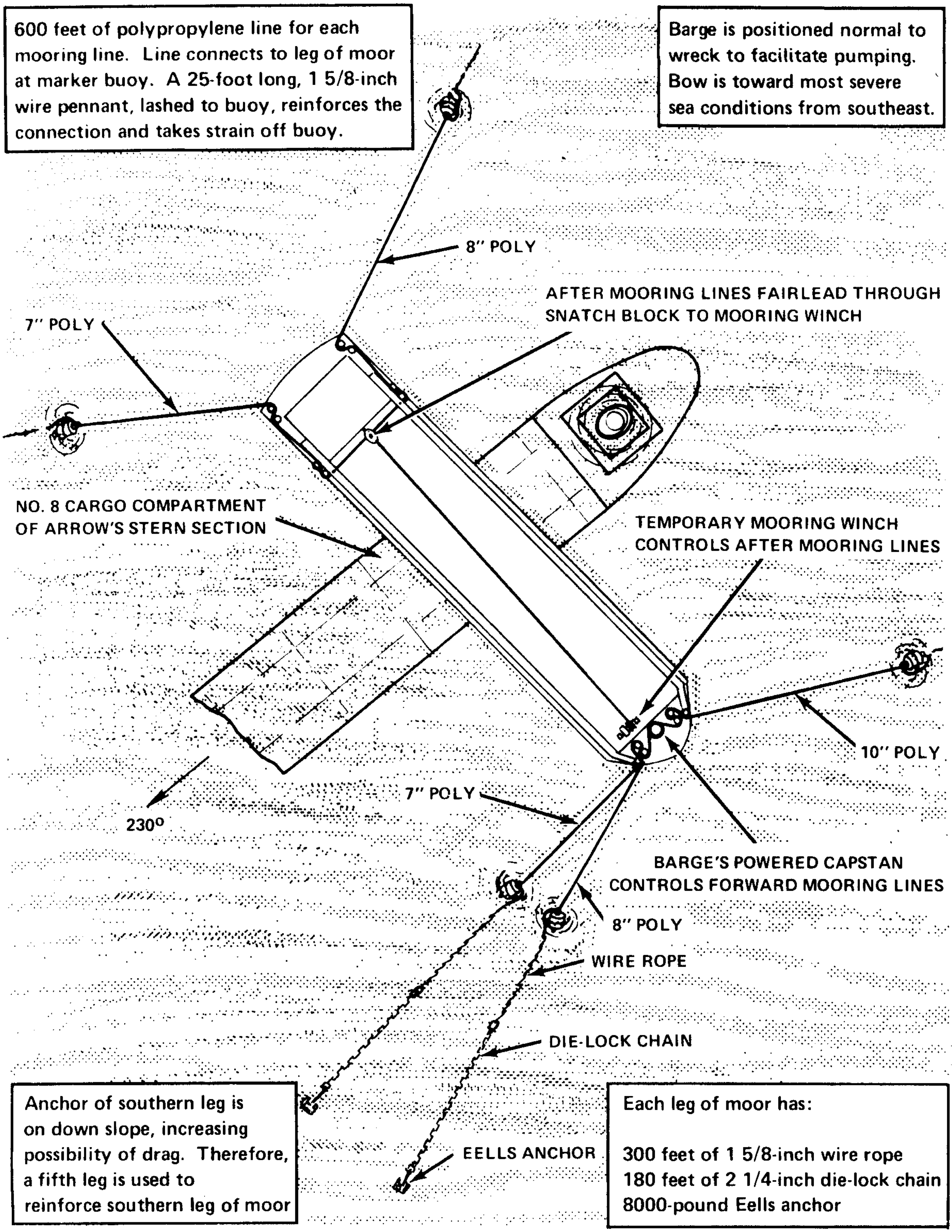
MOORING THE IRVING WHALE

The CURB arrived in the operational area on 2 March and assumed responsibility for preparing and laying the moor. The CURB's beach gear, a normal element on its load list, was more than adequate for this task. However, the only mooring lines initially available were four 7-inch circumference polypropylene ropes. There was concern that these lines might not be adequate. The principal worry with respect to equipment was the lack of a tug. It was feared that the CURB might not be capable of putting the heavy and awkward barge into the moor without the assistance of a tug.

Planning Considerations

The salvage master, having established that the bulk of the remaining oil was in the stern section, decided to attack it first, leaving the bow section for later consideration. Salvage planners determined that the IRVING WHALE should be positioned in a four-point moor directly over the center of the stern section and perpendicular to it.

Placing the barge in this position would equalize the distances between the various pumping stations aboard the barge and the cargo tanks of the ARROW thus providing maximum flexibility for shifting the suction hoses. The perpendicular orientation also avoided the ARROW's deck house and funnel. The funnel was awash and there were 13 to 18 feet of water above the deck house, depending on the height of the tide. Centering the barge would leave only 55 feet between it and the funnel.



The barge was positioned directly over the center of the stern section and perpendicular to it in order to equalize the distances between the barge's pumping stations and the ARROW's cargo tanks.

THE IRVING WHALE IN A FOUR-POINT MOOR

A four-point moor was used because the barge had to be in a highly stable position to minimize tensions on the suction hoses, and extended salvage operations of four to five weeks and possibly longer duration were anticipated. The salvage site was in open water where a four-point moor would be the minimum required to hold the heavy barge in place. The winter weather and high winds normally experienced from several directions made a strong moor essential.

Mooring the Barge, 12 March

The CURB sailed for Cerberus Rock on the morning of 12 March with the IRVING WHALE towed alongside, a trip of about 3 hours. It took the better part of the afternoon to put the barge into the moor. Exceptional seamanship was required to maneuver the barge and to make sure the anchors would hold. Maneuver room was limited by the fact that the sunken ARROW was only 0.3 mile from Cerberus Rock. Wooden chips, one of the oldest but still highly effective mooring aids, were used to gauge relative speed and distance. The CURB controlled the barge's movements from the turning point on the port side and the two LCM's provided power fore and aft on the starboard side.

The mooring winch that was installed forward on the main deck of the IRVING WHALE was used to control the mooring lines to the after legs of the moor. These mooring lines were run through bollards on the stern and sides of the barge in order to fairlead them from the stern through a snatch block forward to the mooring winch. The barge's powered capstan on the bow was used to control the mooring lines to the forward legs of the moor.

In this first deployment to the salvage site, the IRVING WHALE was placed in the moor with its bow to the northwest. A meteorological service facility, established by the task force, had anticipated that prevailing winds would be from this direction. Additionally, it was thought that heavy seas from the southeast occured so seldom that there would be ample time to warn the CURB. The CURB planned to take the barge out of the moor and retire to a safe haven if wind conditions exceeded 30 knots.

Mooring Lines Give Way in Storm

Debunkering had barely gotten underway when a major storm developed on 15 March forcing a halt in pumping operations at 1500. The moor appeared to be holding well. Since the weather forecast predicted winds of only about 35 knots, the CURB decided to remain at the salvage site. During the night a southwesterly gale engulfed the area battering the IRVING WHALE with winds up to 70 knots and waves of 10 to 15 feet. These tremendous forces blew the barge out of the moor.

The two southernmost mooring lines gave way first. The barge swung around causing the two remaining lines to cross, creating the danger of chafing and weakening both lines. The hazard was eliminated by cutting one of the two lines. The IRVING WHALE then rode out the storm held by the one remaining mooring line and its own anchor underfoot. It was too dangerous for the CURB to come alongside the barge during the storm. However, it stood by, ready to assist in case the barge broke loose. The following morning the weather cleared sufficiently by 1000 to permit the CURB to move close enough to the barge to throw over lines and take it under tow.

Subsequent Moorings

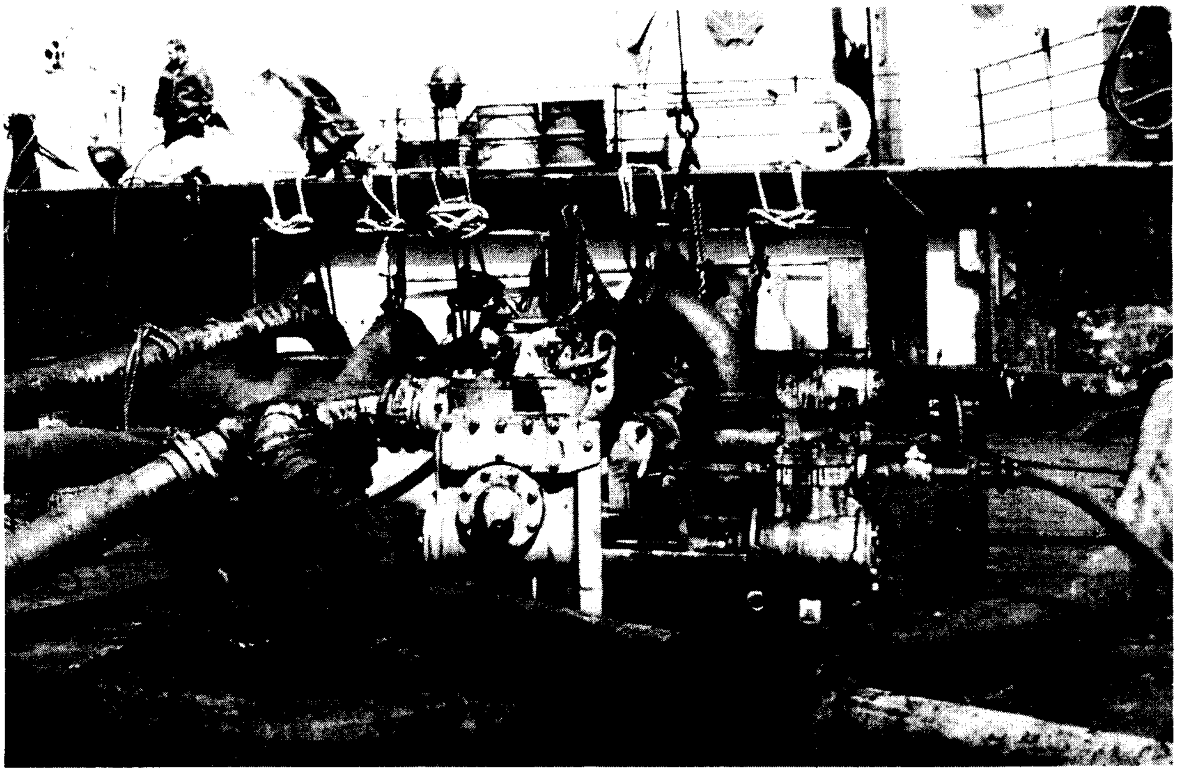
The barge was moored and unmoored at the salvage site on two subsequent deployments. Some heavier line had been obtained and a combination of 7-, 8-, and 10-inch polypropylene lines were used on these occasions. A fifth leg was also laid on the southern side to give the moor additional holding power. Finally, the orientation of the barge was reversed. It was positioned in a southeast/northwest orientation with the bow seaward toward the southeast. No unusual problems were encountered in mooring or unmooring the barge on the last two deployments.

CONDUCT OF DEBUNKERING OPERATIONS

Initial Preparations, 1-11 March

Preparations for the salvage effort to debunker the ARROW were well underway by the end of February. RCN divers had completed tests and experiments in Halifax with equipment for penetrating the ARROW's tanks and attaching valves and fittings for hose connections. Equipment for pumping, such as pumps, hoses, boilers, and generators, had been located. YMT-12's divers also began tapping the ARROW's tanks. Working in 28°F water temperatures, erratic seas, and highly adverse weather, they succeeded in penetrating two tanks and fitting them with hose attachments by 11 March.

Concurrently, work went forward at Mulgrave to outfit the barge for extended salvage operations. The nucleus of a pumping capability was assembled first. This consisted of one steam boiler and sufficient cargo hoses and steam traces to man two pumping stations. Other equipment, including a second boiler, and the necessary cargo hoses for four additional pumping stations, was expected shortly. The salvage master decided to initiate debunkering operations with just the partial pumping capability, anticipating that the remaining equipment could be delivered to the salvage site to complete the remainder of the outfitting.



The salvage force used 6-inch steam-driven, reciprocating pumps. They were well suited for the task of pumping the Bunker "C", being reliable, general purpose rigs. Both 6-inch and 8-inch heavy duty discharge hoses were used as suction hoses.

PUMPING STATION ABOARD IRVING WHALE

First Pumping Effort, 13-16 March

The CURB placed the barge in its moor at the salvage site near Cerberus Rock on 12 March. It took the better part of the next day for the YMT-12's divers to connect the first cargo hose. This was an 8-inch hose rig with a closed-loop steam trace. This rig was connected to tank 8C, the first target of oil recovery operations. The steam pump was turned on at 1730. Although bad weather forced disconnection of the cargo hose at 2030, the flow of Bunker "C" into the tanks of the IRVING WHALE in these first few hours of pumping was tremendously significant to the salvage force. A rate of about 40 barrels per hour at a discharge temperature of 117°F was achieved. It was enough to demonstrate that the debunkering technique was workable.

Pumping did not resume until the following evening when the weather abated sufficiently to permit the divers to retrieve the cargo hose. The CURB proceeded to fabricate another steam trace in preparation for hooking up a cargo hose to tank 8P and putting a second pumping station in operation. The CURB also topped off the barge with feed water and, on the following day, with fuel for the temporary boiler and for the barge's generators. The salvage force injected steam into tank 8C through a second spool piece in an effort to heat the sluggish oil and increase the pumping rate.

The storm on 15 March terminated this first pumping effort. The salvage master decided to put in to port to complete outfitting the IRVING WHALE with a second steam generator and additional pumping station.

The salvage force returned to Mulgrave on 17 March having recovered 2,610 barrels of Bunker "C" in 32 hours of actual pumping and with the expectation that debunkering could proceed faster on the next deployment.

Refitting and Completion of Preparations, 18-21 March

During this period, the Royal Canadian Navy installed a second power plant aboard the barge. The Port Hawkesbury Shipyard also delivered four 6-inch cargo hose rigs with open steam traces. Installation of the RCN steam generator and the arrival of these hose rigs enabled the salvage force to develop a multiple-station pumping capability. Repair work was also performed on the first or portable boiler that had been used during the first pumping deployment.

The CURB took advantage of this brief period in port to prepare heavier mooring lines for the barge and to arrange for laying a fifth leg for the moor. Its salvage gang was also heavily engaged in the work of completing the barge's outfitting. YMT-12 divers destroyed the ARROW's funnel with explosives on 19-20 March to ensure that it would not obstruct the IRVING WHALE. The divers also continued their work of penetrating the ARROW's tanks and installing fittings for the hoses.

Second Pumping Effort, 22 March - 2 April

The salvage force returned to Cerberus Rock late on 22 March, resumed pumping the next afternoon, and immediately encountered an ice storm. Hoses had to be slipped overboard and communications between the CURB and IRVING WHALE were lost temporarily. However, a second effort was begun the following day and by 25 March four pumping stations were in operation.

Pumping continued, primarily from three tanks, 8C, 9C, and 8P, in spite of boiler breakdown and generator problems. The pumping rate by now had reached 250,000 gallons per day using three suction hoses. The salvage force looked forward to increasing this daily rate to as much as 420,000 gallons using all facilities. Since the capacity of the barge was limited to about a million gallons (30,000 barrels), arrangements were initiated to have a lighter come alongside to receive the recovered oil.

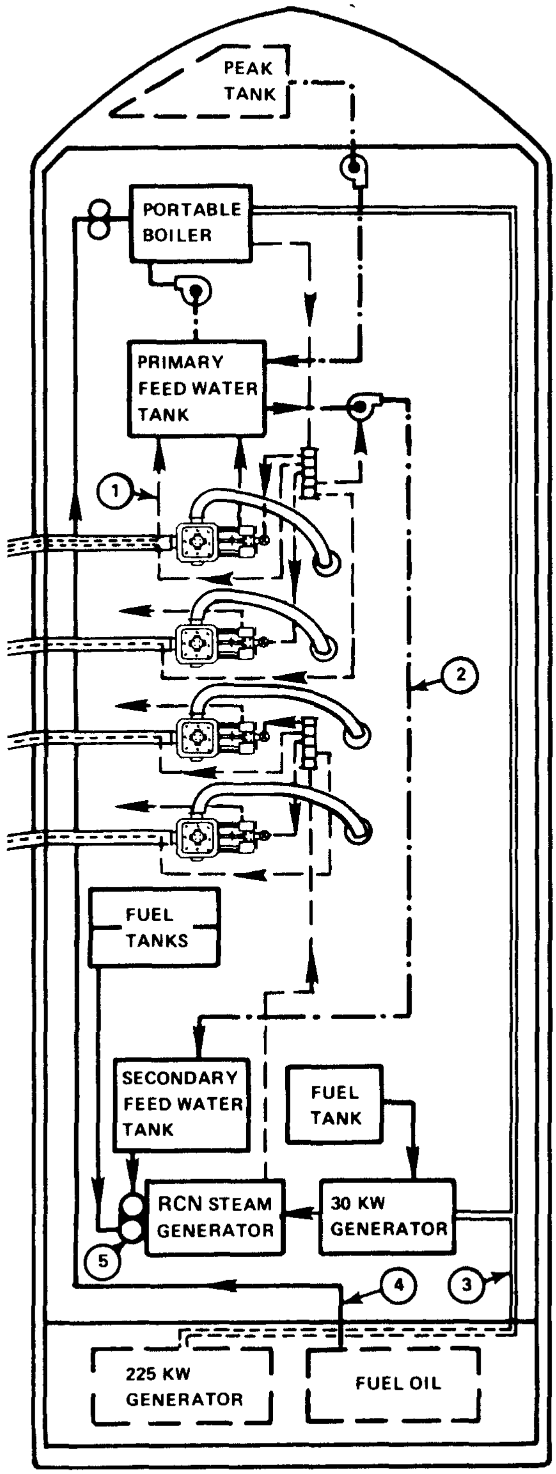
The salvage master reported tank 8C clear of oil on 27 March. This was the first tank to be discharged. To ensure that no oil remained in the tank, either through cavitation or for other reasons, it was decided to pump this tank several times during the ensuing 24-hour period. This was done until no oil was visible in the discharge from the pump. This procedure was followed on every tank pumped during the debunkering operation.

The feed water problem became severe by 28 March as sustained pumping continued from multiple pumping stations and the total amount of Bunker "C" recovered rose past the 12,000-barrel mark. Delivery of 150,000 gallons of feed water by the ARCTIC SHORE, an oil rig tug, alleviated this problem. The two steam power plants supporting the pumping system aboard the barge had by now reached a consumption rate of 5,000 gallons of feed water per day.

The salvage master, working from his original estimate of the amount of oil in each cargo tank, was proceeding on the assumption that the cargo tanks were about half full. Having recovered 6,500 barrels from tank 8C, he calculated that a maximum of 30,000 barrels remained in the other tanks.

Major problems were encountered with the two steam power plants as well as their supporting generators during the next few days, reducing the overall discharge rate. However, the salvage force managed to keep two pumps in operation. The amount of cargo recovered rose past the 16,000-barrel mark as March drew to a close. Plans were being made to transfer the oil from the lighter to the coastal tanker IMPERIAL CORNWALL. The salvage force was working an average of 16 hours per day per man in this period.

In spite of the maintenance problems with the boilers and generators, the salvage force had succeeded in putting four pumping stations on line by 1 April and brought the discharge total well past the 20,000-barrel mark. The next day, with heavy weather expected, both boilers again in need of repair, and the barge's cargo tanks nearly full of recovered Bunker "C", the salvage master decided to break off pumping operations. The IRVING WHALE slipped all cargo hoses and was removed from the mooring. The salvage force then headed for port with an estimated 23,304 barrels of Bunker "C" aboard the IRVING WHALE and the end of the debunkering effort clearly in sight. Offloading to the IMPERIAL CORNWALL was completed on 3 April.



SYMBOLS

- SALVAGE PUMPS
- FUEL PUMP
- FEED WATER PUMPS
- STEAM MANIFOLDS
- CARGO HOSE WITH CLOSED LOOP STEAM TRACE
- CARGO HOSES WITH OPEN STEAM TRACES

NOTES

1. THE FORWARD SALVAGE PUMP AND CLOSED LOOP STEAM TRACE EXHAUST TO TANK TO HEAT FEED WATER. THE OTHER PUMPS EXHAUST TO ATMOSPHERE
2. FEED WATER PUMPED AFT BY 2-INCH STEAM DRIVEN PUMP
3. THE BARGE'S 225 KW GENERATOR OR THE TEMPORARY 30 KW GENERATOR COULD SUPPORT EITHER OR BOTH STEAM POWER PLANTS
4. COPPER TUBING FUEL LINE FOR FORWARD BOILER
5. SERVO MODULATOR ON RCN STEAM GENERATOR CONTROLLING BOTH FUEL AND FEED WATER

Recurring equipment breakdowns often prevented the system from operating at its full capacity. But the salvage force kept at least two pumps functioning by interchanging components of the system.

SCHEMATIC OF PUMPING SYSTEM ABOARD THE BARGE

Debunkering Completed, 5-11 April

After offloading the Bunker "C", the salvage force remained in Mulgrave a few days, repairing the boilers, refueling the barge, and topping it off with feed water. Heavy weather kept the force in port until 5 April. The salvage master estimated that five more pumping days might be needed to complete the salvage effort.

The CURB, with the barge in tow, left Mulgrave for the salvage site on 5 April. It moored in protected waters that evening as it was too windy to undertake salvage operations. Mooring was completed, hoses reconnected, and pumping underway by late the following day, 6 April. The pumping effort concentrated first on finishing tank 9C and the port and starboard wing tanks in the #7 cargo compartment.

The following day, divers from YMT-12 reported that the bow section of the ARROW was completely free of Bunker "C". They had physically swum through the ship's forward wing tanks on the port side. The hull had continued to disintegrate and all the forward tanks were now open to the sea.

The salvage force had recovered an additional 6,000 barrels by the evening of 8 April when the RCN steam generator failed. Pumping had been completed from tank 9C and was in progress on all three tanks in #7 cargo compartment. Tank 6S had been tapped and rigged for pumping and divers were preparing to check the settling tanks in the after portion of the wreck for possible oil. The problem with the RCN steam generator appeared to be in the feed water modulator valve system.

Pumping proceeded, nevertheless, in the next few days, with principal reliance being placed on the portable boiler to finish the job. Divers confirmed that the ship's settling tanks were clear. By 10 April, all tanks had pumped clean water except tanks 6S, 7S, and 8S. Although the latter tank had been thought to be empty, subsequent checking revealed a recurrent buildup of oil. It appeared that oil from tank 7S was seeping into tank 8S and that the latter would continue to buildup until the former was empty. This proved to be the case; they had, in effect, become one common tank.

With pumping obviously nearing completion and over 10,000 barrels of Bunker "C" safely recovered during this third and final deployment, wind-up preparations began. Divers retrieved 10 of the 13 gate valves that had been installed on the ARROW's deck and blanked off the spool pieces. Three hose rigs were also recovered.

On 11 April, 66 days after the ARROW had smashed into Cerberus Rock, the salvage force retrieved the last few barrels of oil. Tanks 6S, 7S, and 8S were all pumping water by 1330 with no evidence of any remaining oil. These three tanks were blanked off during the afternoon and the remaining three cargo hoses were brought back aboard the barge. The

CURB proceeded to break the moor and returned to Mulgrave with the IRVING WHALE in tow, arriving in port late in the evening. The salvage force had recovered 13,620 barrels of Bunker "C" during the third deployment, making a grand total of 36,924 barrels salvaged from the wreck of the ARROW.

HEATING AND LIFTING THE BUNKER "C"

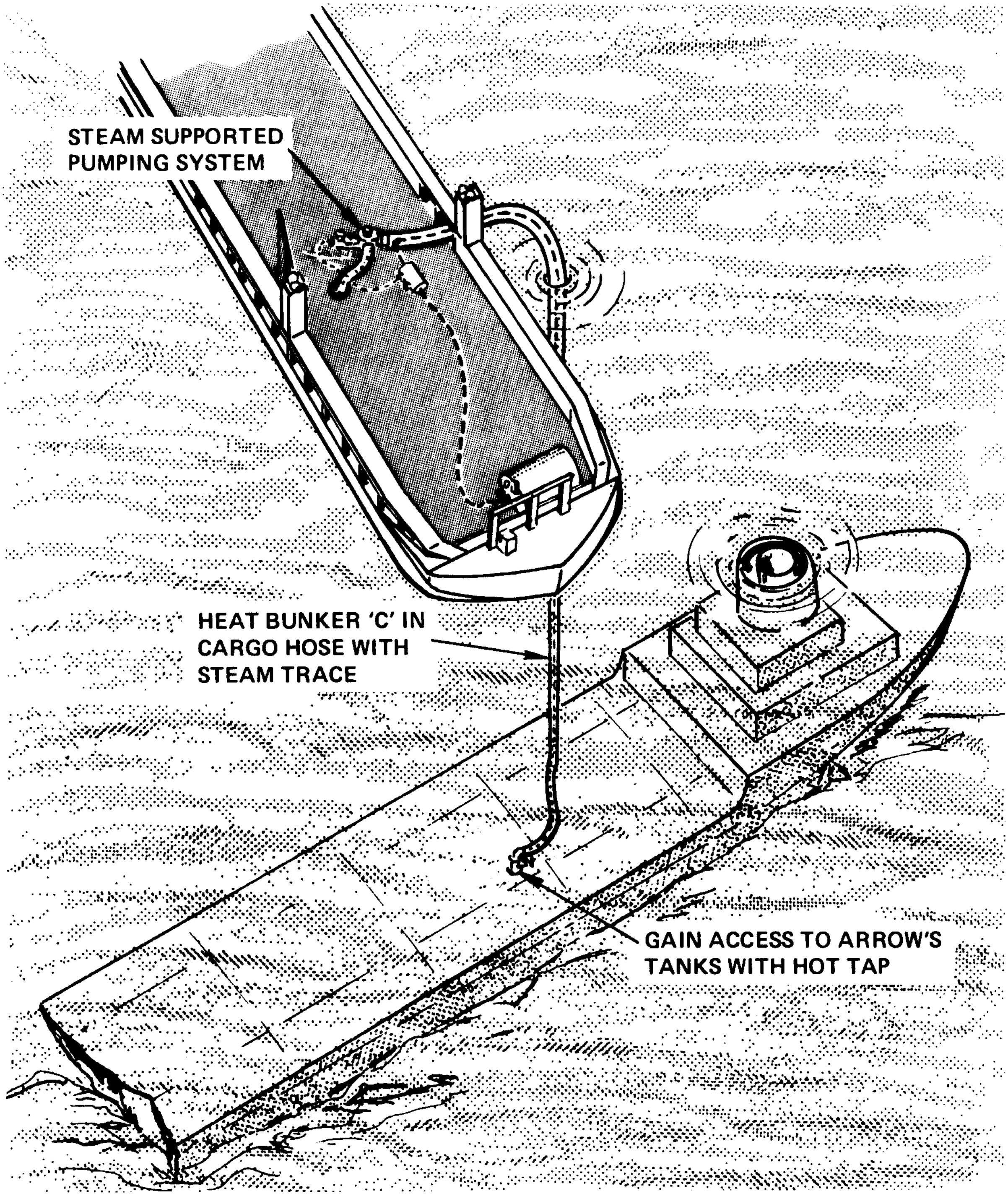
Selection of the Primary Method

The salvage master selected one primary method for heating and lifting the Bunker "C" from a wide variety of methods under consideration. The primary method was designed to gain access to the ARROW's tanks by drilling holes in the ARROW's deck with a hot tap drilling rig and attaching a gate valve connection for the cargo hose. The Bunker "C" heated in the cargo hose by a steam trace, would be lifted to the tender by means of a steam supported pumping system aboard the barge (steam generated for the pumping system was also used to heat the steam traces).

The method combined both principle and expediency. The object was to use tested techniques and the most readily available equipment wherever feasible in order to get the salvage operation underway as soon as possible. Much of the equipment needed for the steam traces and the pumping system was available in the operational area. The CURB provided the rest. Equipment needed to gain access to the ARROW's tanks was also available or could be fabricated. The salvage force was experienced in the use of the pumping equipment, although not with the hot tap drilling rigs. The steam pumping system gave the salvage master a good chance of maintaining control over the progress of debunkering operations in the face of varying sea and weather conditions. The primary method also made specific provision for combating the high viscosity of the cargo oil through the use of steam traces to heat the sluggish oil in the suction hose.

Backup Techniques

Several backup techniques were also developed. These included injecting steam into the ARROW's cargo tank, injecting steam into the spool piece, inserting an airlift near the bottom of the suction hose, and inserting an outfit near the top of the suction hose. These backup techniques provided flexibility in executing the overall salvage plan and made alternatives available to reinforce or replace the techniques for heating and lifting the oil in the primary way. All of them were used to some extent during the course of the operation, although none played a major role in influencing its outcome.



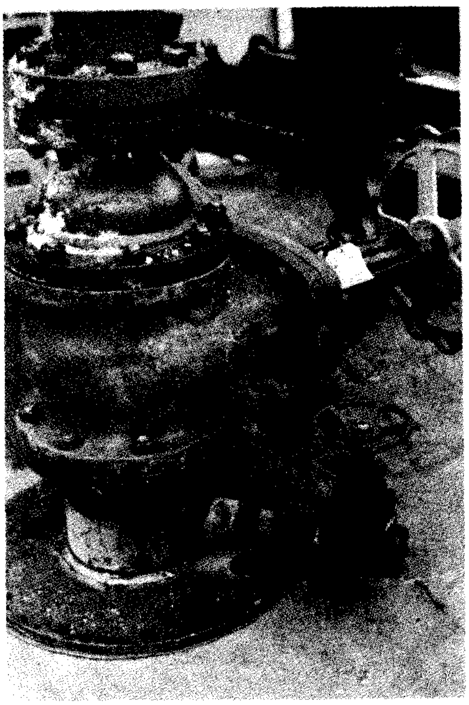
The primary method was designed to gain access to the ARROW's tanks, to heat the Bunker "C" in the cargo hose, and to pump the heated Bunker "C" to the barge.

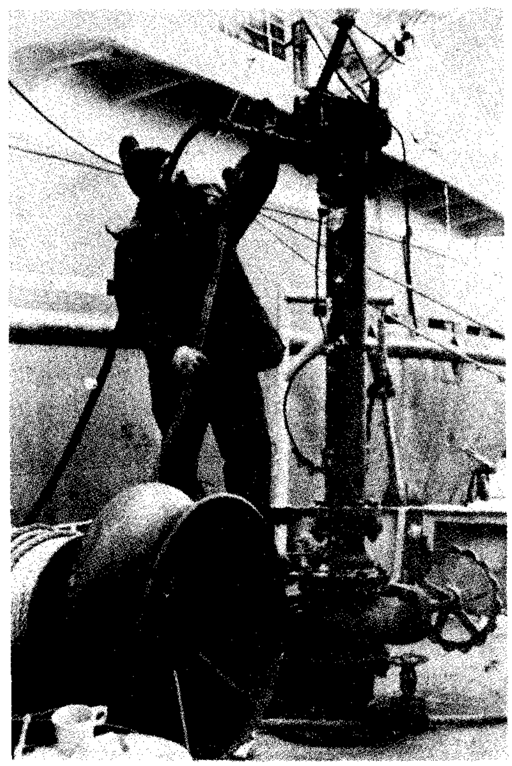
PRIMARY METHOD FOR HEATING AND LIFTING THE BUNKER "C"

Gaining Access to the ARROW's Cargo Tanks

Before the oil could be recovered from the sunken ARROW, a method had to be found for penetrating its cargo tanks, and suitable fittings for attaching the suction hoses had to be provided. Captain Madsen suggested the "hot tap" method used in the oil industry to drill holes in high temperature oil refinery pumping systems while maintaining the flow of oil during drilling. This method involves the use of an enclosed rotary cutter or "hot tap" machine. A hot tap machine and experienced operator were located and successful experiments were conducted in Halifax to test their use underwater.

The technique, as applied to the salvage operation, required that the cutting operation be conducted through a gate valve attached to the deck above the cargo tank. The gate valve arrangement provided positive control over the opening in the deck to prevent upward discharge of oil caused by the pressure differential between the Bunker "C" and the sea





Hot tap machine is flange mounted on gate valve which, in turn, is secured to spool piece bolted to ship's deck. Rotary cutter is lowered through gate valve and spool piece and then withdrawn after cutting through deck. Complete rig is shown in right photo. Details of gate valve and spool piece are shown in left photo.

DRILLING RIG (HOT TAP MACHINE) ASSEMBLED ABOARD YMT-12

water beneath it. The base of the gate valve sat on a spool piece which was first bolted to the tanker's deck. A suction hose was then connected to the gate valve via a 90° elbow fitting after the drilling rig was withdrawn.

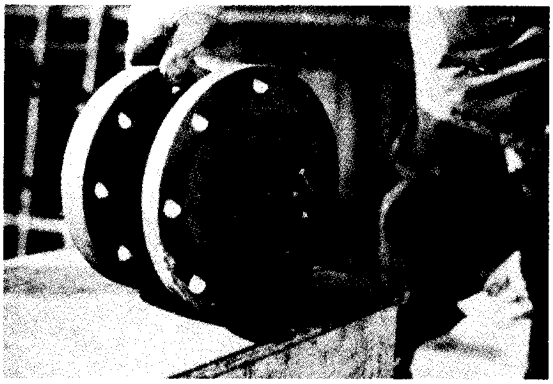
Operational Aspects

Two different techniques were used to lower the drilling rig and attach it to the ARROW's cargo tanks. The first was to preassemble the components of the rig on the surface. The second was to lower each component individually and mount the spool piece, gate valve and cutting machine in sequence. Both techniques were effective. It took 2 divers, working together, about 7 hours to complete the hot tap beginning with installation of the spool piece, through the cutting operation to the final hook up of all connections for the cargo hose.

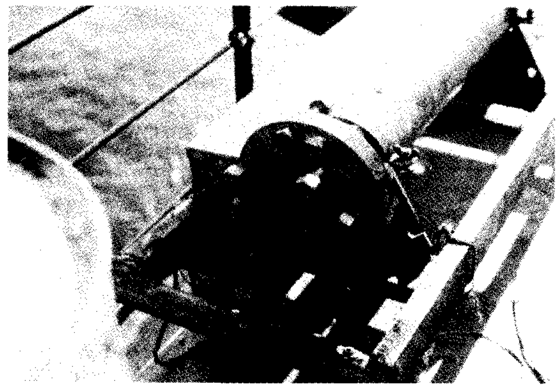
The task of penetrating the ARROW's decks and installing the related fittings and hoses posed formidable problems for the RCN divers from YMT-12. Diving conditions were dangerous and difficult. Divers had to contend with near-freezing temperatures, frequent storms and adverse sea conditions, and the continuing difficulty caused by oil seepage about the wreck. The oil affected their face masks, regulators, and suits; oil saturation caused the wet suits to lose their insulating ability. Therefore, routine work schedules were not possible. Frequent modifications were required and the problem of available bottom time was a central factor affecting pumping progress throughout the operation.

The selection of proper locations for the hot taps was complicated by the lack of a detailed plan of the location of internal structural members of the ARROW's hull. The ship's prints did not reveal the locations of all the members as the deck had been renewed since the original construction. As a result, longitudinal beams under the ARROW's deck were struck on the first four hot taps attempted. These obstacles added significantly to the diver's required bottom time, although they were ultimately successful in breaking the weld between the deck and the beams in three instances. The most reliable method of avoiding the longitudinals was eventually found to be simply by tapping the ship's deck with a hammer.

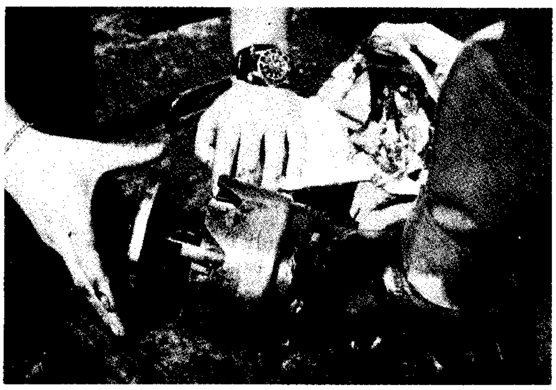
Divers worked and experimented with the hot tap machines continuously in an effort to improve their reliability for underwater work. The machines were well conceived and designed, however, they were topside pieces of equipment. Considering this fact, they performed surprisingly well in the underwater environment. Several modifications had to be made on the hydraulic rig before it could be made to operate satisfactorily in the cold water. These modifications were made in consultation with the manufacturer's representative. Divers also experimented with the cutting head, removing some of the teeth in an attempt to get better performance. The most successful modification to the cutting head appeared to be one in which every other tooth was removed.



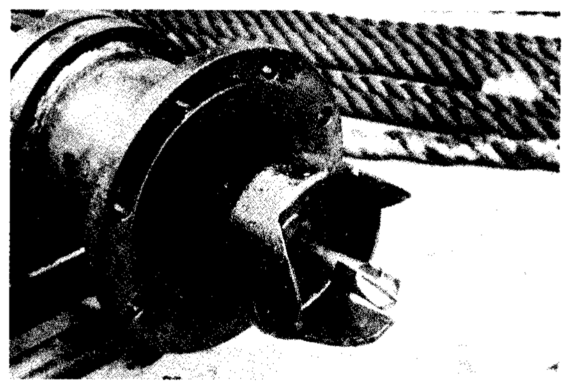
Cutting head and drilling bit recessed in flanged housing.



Flanged housing is bolted to base of drilling rig. Drill bit is connected to shaft at base of rig.



Cutting head is bolted to drill bit. Note the piece of steel cut from ARROW's deck.



This assembly was also used. Note slightly different design features and removal of cutting teeth.

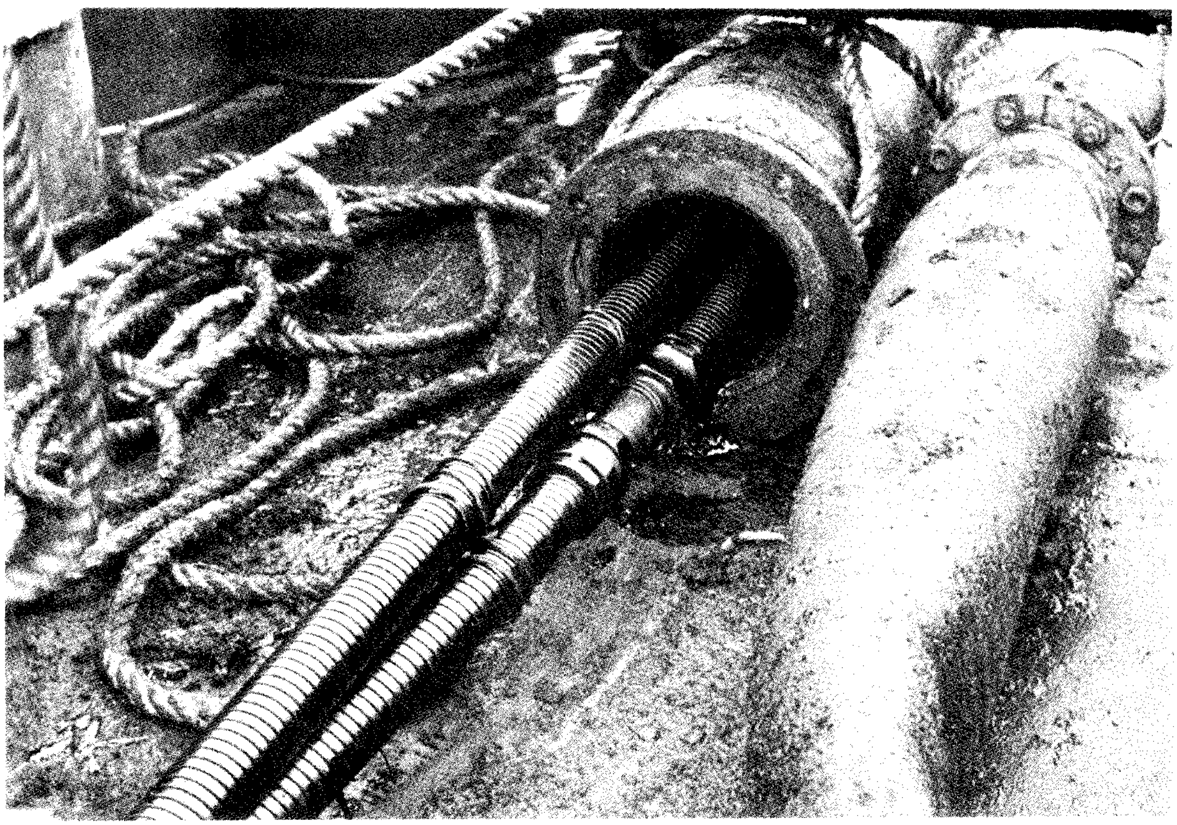
DETAILS OF CUTTING HEAD ASSEMBLIES USED WITH HOT TAP MACHINES

STEAM TRACE CONFIGURATION

Purpose of Steam Tracing

Steam tracing, because of its importance and the extent to which it was used, emerged as a major feature of the primary method of heating and lifting of the Bunker "C". The salvage master relied on the steam traces throughout the operation as the principal means of heating the cargo oil.

All cargo hoses used during the operation were steam traced. Steam tracing consisted of inserting a 1 1/2-inch diameter flexible metal hose inside the 6-inch and 8-inch diameter cargo (suction) hoses. The surface of the metal steam hose was convoluted to add to its heat transfer capabilities. Saturated steam at 100 psi and 300°F was circulated through the metal hose to heat the Bunker "C" as it flowed upward through the cargo hose to the tanks of the IRVING WHALE. Heating was considered necessary not only to facilitate oil flow inside the



The surface of the metal steam hose was convoluted to add to its heat transfer capabilities. Trace shown is the closed-loop configuration.

FABRICATED STEAM TRACES

cargo hose but also as a precautionary measure. Should it be necessary to discontinue pumping for any reason, it was feared that oil in the hose could block further flow if it were allowed to become too cold. The steam trace provided insurance against such an eventuality.

The metal hose of the steam trace did not extend beyond the bottom end of the suction hose. Although extension below the suction hose itself would have provided heat in the critical area of the gate valve connections to the ARROW's cargo tanks, it posed a major potential disadvantage should a cargo hose rupture. A rupture would have caused an immediate oil spill. With the metal coil inserted through the open gate valve, there would have been no way to shut the valve to stop the escape of the oil. The steam trace was, therefore, terminated near the bottom end of the cargo hose.

Three Configurations Used

Three different steam trace configurations were tried. The first, a closed-loop trace, was used successfully in the initial debunkering effort. The temperature of the Bunker "C" was measured at 117°F as it reached the IRVING WHALE, confirming that a substantial heat transfer had been produced within the cargo hose.

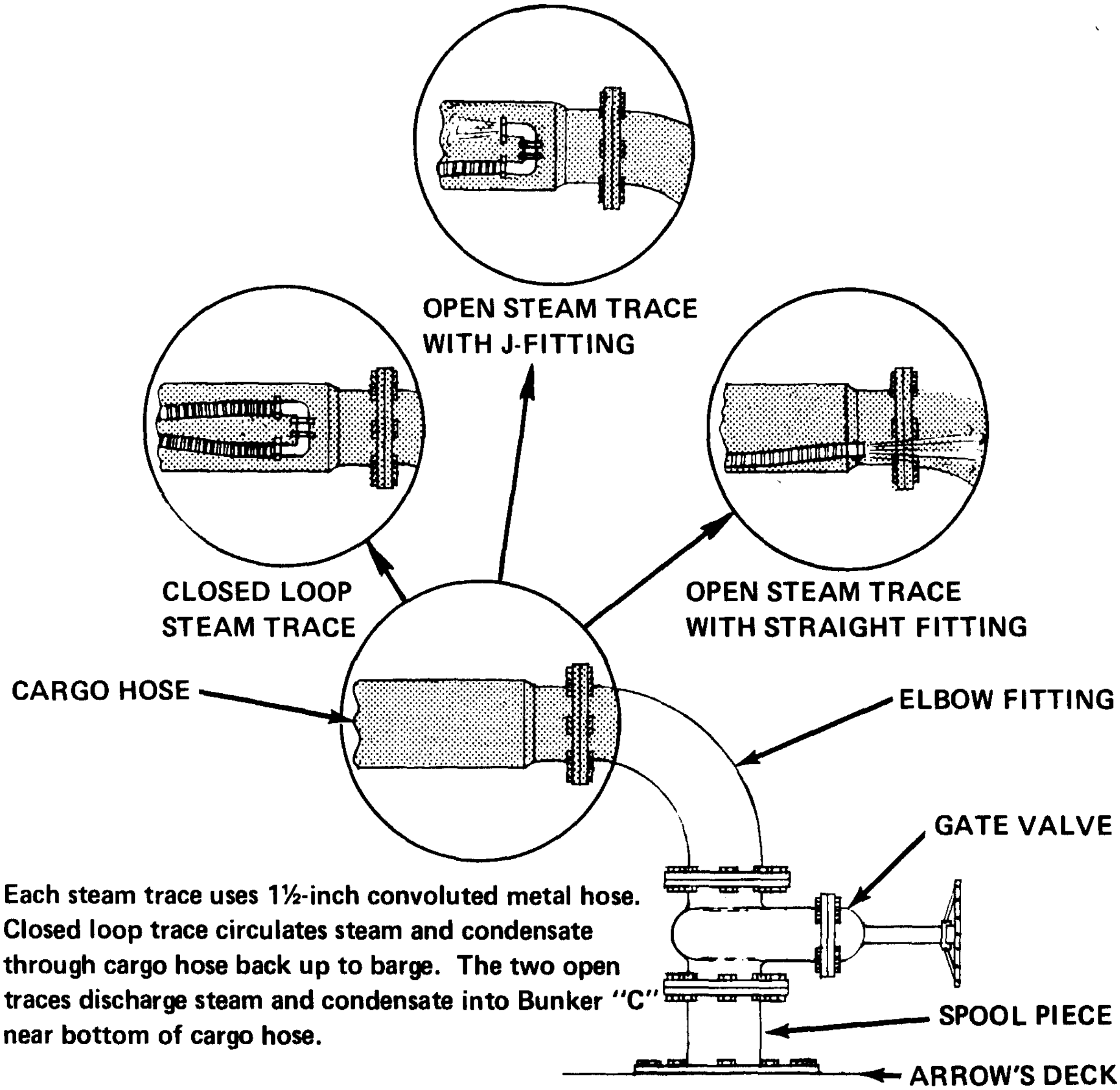
The other two were open traces, designed to exploit the affinity of western heavy fuel oils for water. It is comparatively easy to achieve emulsion with fuel oils such as Bunker "C". If emulsion could be achieved then the viscosity of the oil could be reduced quickly. This was the key to the open steam traces, although it was also conceived that the discharge of steam and condensate into the oil would produce some heating and agitating effects.

All three configurations definitely produced heat transfer within the cargo hoses. The temperatures of the oil recovered through the various hoses were consistently well above 100°F. However, the operational conditions precluded reliable quantitative comparisons of their relative effectiveness. There was, in particular, no opportunity to relate pumping rates to the temperatures of the oil recovered with each configuration.

CONCLUSIONS

The factor of time is critical in salvage operations, particularly at the outset when immediate action is required to prevent further deterioration of the situation. The longer the time consumed in the conduct of operations, the greater is the likelihood that weather and other factors will disrupt and delay the effort.

There is a clear need for oil tankers, Naval as well as commercial, to be fitted with deck access connections and, possibly, hull connections to each of their cargo and fuel tanks. Connections, such as those made to the ARROW's tanks by the YMT-12 divers, would be simple and inexpensive to make under shipyard conditions and easy to maintain thereafter.



The salvage force steam traced all cargo hoses. Each configuration produced heat transfer within the hose. Temperatures of the recovered oil were consistently above 100°F.

THE THREE STEAM TRACE CONFIGURATIONS

Stockpiling of equipment and material in locations readily accessible to a task force and provisions for deploying it in appropriate contingency plans would appear to be prerequisite to immediate, effective response to future disasters. With few exceptions such equipment is air transportable and contingency planning should provide for this transportation means.

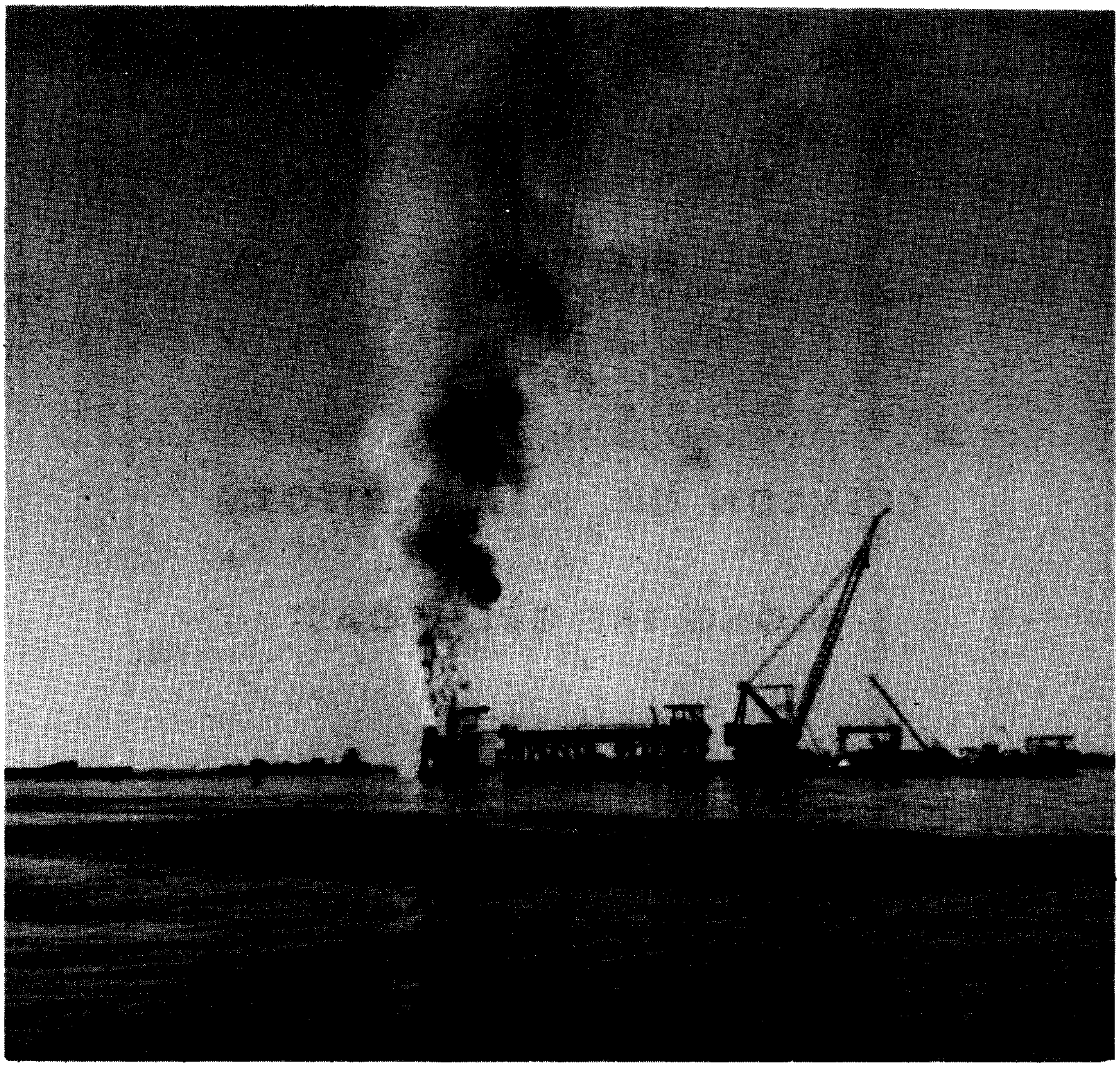
Future involvement of the U.S. Navy in pollution control operations resulting from damaged or sunken tankers appears highly probable. The report on the TORREY CANYON noted that in the period 1964-1967, 91 tankers were stranded and 238 involved in collisions in various parts of the world, an average of two potentially serious accidents a week. A Navy tanker could be stricken, requiring the Navy to assume full responsibility at sea and on shore. Various circumstances could oblige the Navy to participate, partially or fully, in sea and shore efforts in response to a commercial tanker accident.

BLOWOUT

OF

CHEVRON OIL WELL PLATFORM

ALONG THE GULF COAST



Chevron forces constructed a huge work platform to gain access to the blowout. Barges in the background formed a boom/barge barrier to contain the oil spill from the wild wells.

CHEVRON PLATFORM AFLAME OFF THE GULF COAST

BLOWOUT OF CHEVRON OIL WELL PLATFORM ALONG THE GULF COAST

INTRODUCTION

A multi-well, off-shore oil platform of the Chevron Oil Company blew up in flames in Breton Sound off the coast of Louisiana on 10 February 1970. The blowout was a matter of grave concern because major oil spills from the wild wells were expected once the fire was extinguished. The pollution threat was severe not only because of the large volume of oil that might escape but also because of the proximity of the platform to shrimp producing water, oyster beds and wildlife preserves in the Mississippi Delta. The platform was only 10 miles from shore, near the "Main Pass" outlet of the Mississippi River, east of Venice, Louisiana.

The Chevron Oil Company conducted extensive operations over the next two months to extinguish the fire, contain the wild wells, and combat the resulting oil spill. The Supervisor of Salvage, although not operationally involved, provided advice and sent representatives to the site to observe the oil pollution control techniques that were used. The employment of containment booms and oil skimmer boats was of particular interest to Navy observers.

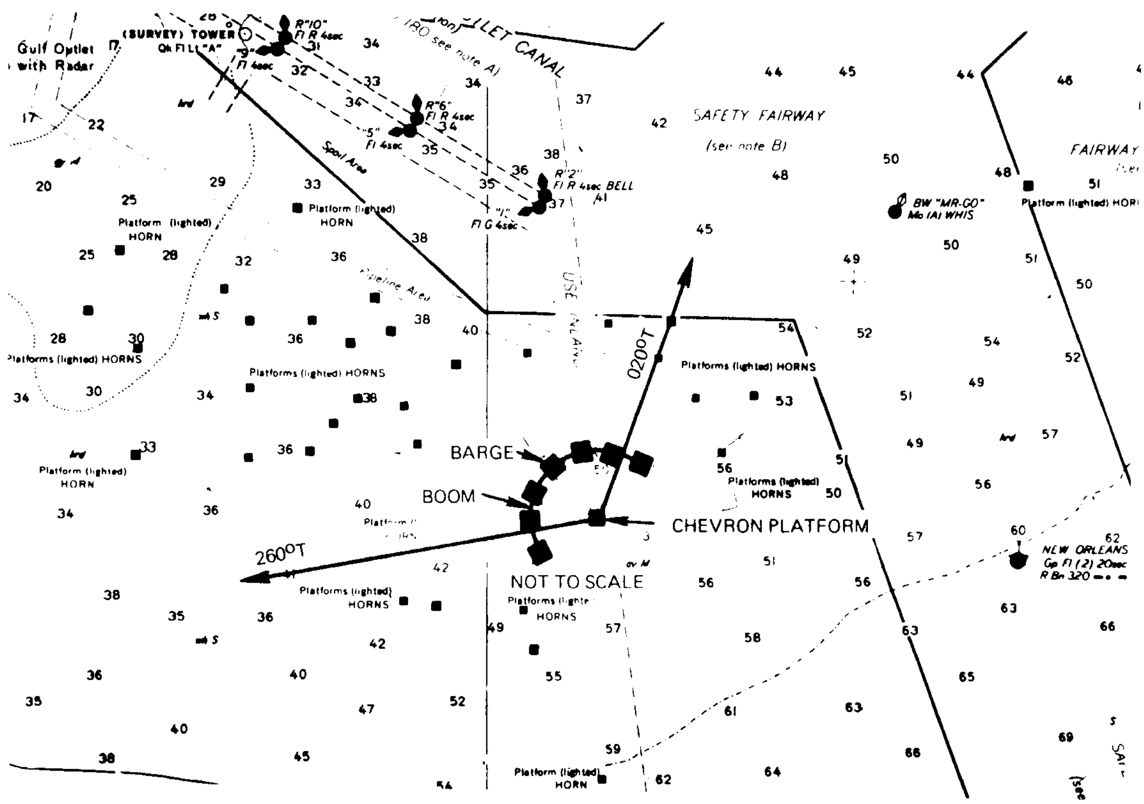
PLANNING FOR OIL POLLUTION CONTROL

Concept

The area most vulnerable to pollution from an oil spill lay west and north of the platform toward the coasts of Louisiana and Mississippi, respectively. In consultation with the Supervisor of Salvage, Chevron planners decided to construct a stationary barrier, made up of booms and barges, to contain the spilled oil and prevent it from penetrating to these vulnerable areas. Skimmer boats were also to be deployed to supplement the barrier operation by corralling and picking up the most threatening pockets of oil. In view of the teeming wildlife in the area, federal and local officials authorized only a very limited, essentially experimental use of chemicals. Consequently, chemicals did not play a significant role in the oil pollution control operation.

The Boom/Barge Barrier

The boom/barge barrier was the key instrument in Chevron's plan. The barrier was arrayed in a crescent-shaped line, some 3,300 feet long, covering a 120-degree sector about



The crescent-shaped barrier, 3,300 feet long, was deployed to block the oil erupting from the wild wells from penetrating to the vulnerable area northwest of the platform.

DEPLOYMENT OF THE BOOM/BARGE BARRIER

100 feet from the burning oil well platform. Seven 300-foot barges were used to form the barrier, each held in place by a 4-point moor. The barges were positioned about 200 feet apart with the gaps being spanned by oil containment booms.

Two types of booms were selected initially for employment in the barrier. These were commercial booms that were the most readily available in the local area. Since they had not been designed primarily for open sea work, Chevron decided to proceed with construction of a stronger boom, using plans provided by the Supervisor of Salvage for this purpose.

FIRE FIGHTING OPERATIONS

Techniques Applied

Chevron tasked the Adair Fire Fighting Company to put out the fire. To gain access to the site, a long work platform, 450 x 50 feet, was constructed adjacent to the burning oil well platform. The giant floating crane, "George S. Brown", provided by the Brown and Root Construction Company, was used in building the work platform.

Fire fighters detonated TNT in the heart of the fire and engulfed the site with massive sprays of water from the work platform and a trenching dredge. Their second attempt on 10 March succeeded in putting out the fire.

COORDINATED ATTACK TO GAIN CONTROL OF THE RAGING FIRE

The basic technique for extinguishing the fire was to blow it out by detonating a large explosive charge. Adair planned to do this by attaching a 300-pound charge of TNT to the end of a long boom. A tractor would then push the boom along the work platform toward the burning well, positioning the charge in the heart of the fire ball. Detonation of the charge was to be followed immediately by a massive dousing of water from water spray nozzles emplaced on the platform.

Two Attempts Required

Preparations, not only for extinguishing the fire but also for positioning the oil pollution control devices. took about a month. Adair made the first attempt to put out the fire on 9 March. The detonations blew it out momentarily but it reignited within six minutes despite the inundation of water from the arrays of spray nozzles. Reignition occurred, apparently as a result of residual platform heat from the month-long fire.

Adair made a second and successful attempt the next day, 10 March. The same technique was applied. However, a larger TNT charge, one of 400 pounds, was used and a trenching dredge, equipped with spray nozzles reinforced the water dousing. With the fire finally out, work was then able to proceed on controlling the wild wells.

CAPPING AND RELIEF WELL OPERATIONS

Scope of the Problem

A survey after the fire had been extinguished revealed that eight wells were "blowing wild" to varying degrees. Although estimates differed, it appeared that the total flow of oil from the well complex was averaging 1000 barrels a day. Seven wells were blowing only minor amounts of oil. These could be capped. The eighth well, known as C-6, was the major pollutant well, accounting for at least 75 percent of the escaping oil. The extreme pressures and high float rates from C-6 rendered capping infeasible; relief well operations would be necessary to kill this well.

Capping

The capping procedure involved first removing the "Christmas Tree" structure from the top of the well with shaped charges and then installing a valve to stop the flow of oil. All but two of the seven wells to be capped were brought under control in this manner by 19 March. The remaining two wells were blowing gas primarily and had already begun to sand up. They died, without capping, a few days later, leaving only C-6, the major pollutant well, still blowing.

Relief Well Operations

The strategy in the relief well operation was to kill the flow of oil by sealing the wild well at its base. This required directional drilling of a relief well near the wild well. Water and drilling mud could then be pumped through the relief well into the subsurface oil deposit, clogging up the wild well at its source.

Sinking of the relief well had proceeded concurrently with the fire fighting preparations and pumping got underway in mid-March, a few days after the fire had been put out. It was hoped, originally, that the wild well could be brought under control within several days. However, tight sand deposits were encountered and there had been evidently some slight miscalculations in drilling direction. Two weeks of pumping were required before C-6 was finally killed on 2 April. Almost two months had elapsed since the fire had started.

CONDUCT OF OIL POLLUTION CONTROL OPERATIONS

Functioning of the Boom/Barge Barrier

The boom/barge barrier had been positioned by 5 March anticipating the heavy flow of oil that would ensue when the fire was extinguished. Moderate seas, running 6–8 feet, were encountered that night and four of the booms failed. Only two booms could be replaced by the time that fire fighting operation got underway. In addition, a barge shifted position on 10 March, causing two more booms to fail.

As a consequence, the boom/barge barrier had several gaps in it when the fire was finally put out on 10 March. Some of the spilled oil penetrated the barrier through these gaps. Fortunately, northerly winds drove this oil well to the south, away from the shore, sparing the coastline of heavy pollution. The gaps were closed temporarily by installing two Merritt–Navy TSF booms. However, three of the Cain and Johns–Mansville booms failed creating new gaps.

Work continued during the period 10–16 March to repair the barrier. All booms and barges were fully in position for the first time when a storm hit on 17 March with seas of 10–12 feet. The impact of the storm broke loose several of the barges, completely disrupting the barrier. It was never fully repositioned after the storm.

With the barrier thus incomplete or disrupted during much of the 3-week period of active oil flow, the coastline was highly vulnerable to pollution. Southerly winds pushed the oil toward shore on several occasions. In addition, the wind was strong enough intermittently to blow some of the gushing oil beyond the barrier before it fell back to the surface. In each instance, however, offshore currents from the Mississippi's many outlets and timely changes in wind direction prevented the oil slicks from reaching the Gulf Coast beaches.

Assessment of the Barrier's Performance

The boom/barge barrier, sound in concept, failed in execution. It broke up and lost its effectiveness when the seas rose. The two principal booms that were used initially to form the barrier posed different types of problems. The Johns–Mansville boom, an asbestos sail and skirt arrangement, although easy to deploy, had low strength and stability, failing in seas of 4–6 feet. The Cain boom, on the other hand, was relatively strong but difficult to deploy. The fabric covering it, a permeable membrane materiel, tended to tear under prolonged working in the sea. The Cain boom did have the advantage of being easily transported since it is stored in rolls.

The Merritt–Navy TSF boom, the strongest of the three, was used later in the operation to close gaps in the barrier. It was the only boom truly suited for open ocean work, although it too was sea state limited, failure occurring in the 10–12-foot seas that accompanied the storm on 17 March. This boom is described in detail in a subsequent section.

Quite apart from boom limitations, however, the principal weakness of the barrier lay in the design of moors for the barges. Even though the barges were in a 4-point moor in only 40 feet of water, they broke loose in the 10–12-foot seas, destroying the barrier. The moor design was evidently ad hoc, by "seaman's eye." The design had not been subjected to systematic and careful ocean engineering.

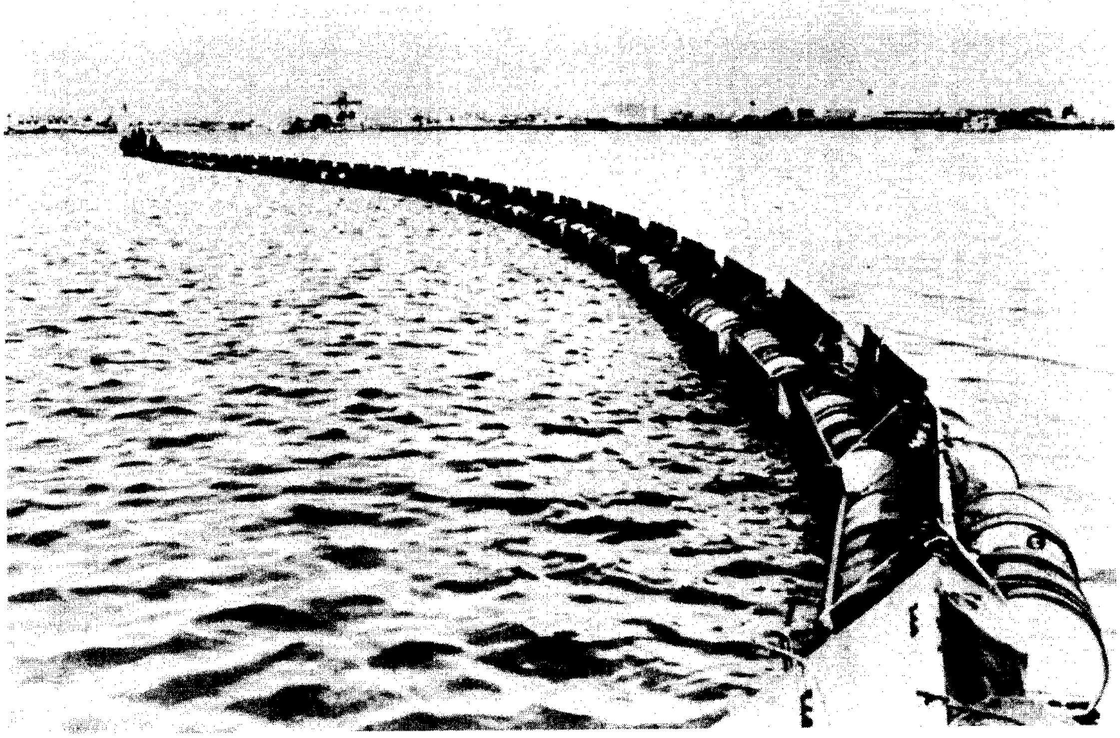
The important lesson here is that an oil containment boom, whether it includes barges or not, must be designed as a complete system. The mooring arrangement is an essential component of the system and, indeed, must be stronger than the booms, themselves, to hold the system in place. Similarly, the interface seal between the booms and barges is an important design consideration. The boom's mooring system must be tailored to the existing or anticipated wind and sea conditions and depth of water.

THE MERRITT–NAVY TSF OIL CONTAINMENT BOOM

Background

The Merritt–Navy TSF* oil containment boom is designed for use as an all weather deflection or containment system in the open seas where swell, wind and chop preclude the

*TSF–Comes from the names of the three Marine salvage officers primarily involved in the boom's development: Capt R.T. Thurman, formerly Senior Salvage Master, Murphy Pacific Marine Salvage Co.; Capt. W.F. Searle Jr., USN, formerly Supervisor of Salvage, U.S. Navy; and LCDR J.J. Fee, USN, formerly Salvage Officer, 11th Naval District.



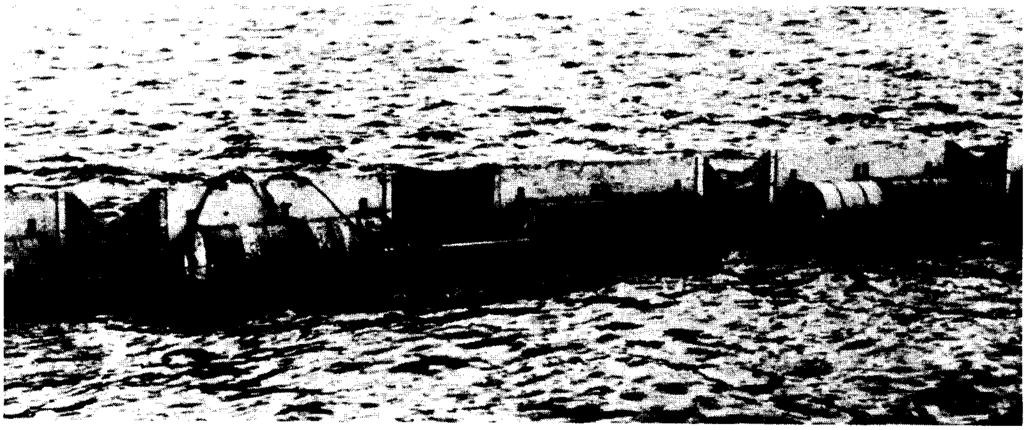
Designed primarily for heavy duty use in the open sea, the line is a series of 10-foot segments. A plywood sheet, oil drums, and a skirt and joint of plasticized canvas form each segment.

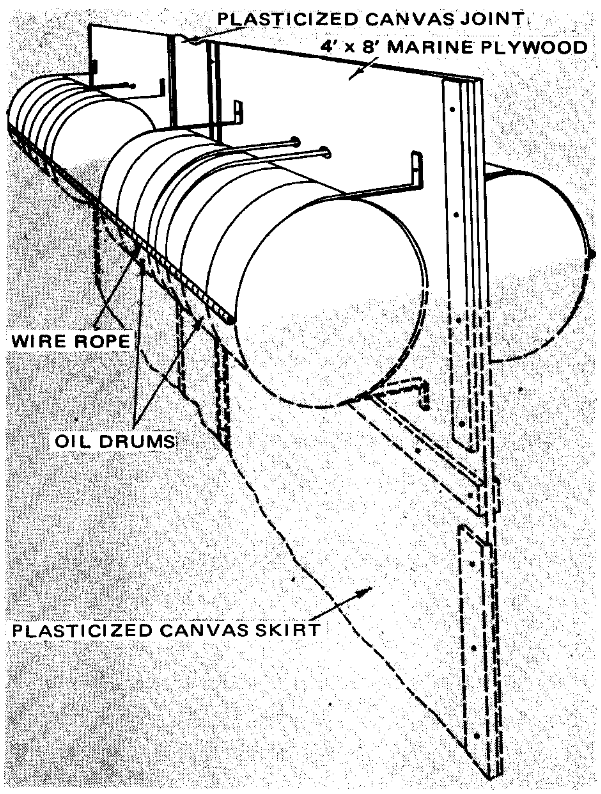
MERRITT-NAVY TSF OIL BOOM CONTAINMENT LINE

use of lightweight booms. Originally conceived and built by the Merritt Division of the Murphy Pacific Marine Salvage Company, it was first used in 1968 when the broken oil tanker, OCEAN EAGLE, created an oil pollution threat off San Juan, Puerto Rico. The Navy moored a similar boom, designed by the Office of the Supervisor of Salvage, off Long Beach, California in early 1969 during the Santa Barbara oil spill. The Supervisor of Salvage has participated extensively in the development and trials of the boom system because of its potential application in random tanker salvage incidents.

Construction Aspects

Although not particularly cheap nor easy to rig and moor, the TSF boom can be constructed with readily available materials. It's principal advantage lies in its ruggedness–in





Segments are tied together by wire rope secured along the outboard edges of the oil drums. Canvas joints provide flexibility between segments. Segments can also be connected with chains if necessary.

SEGMENTS OF MERRITT-NAVY TSF BOOM

the simplicity and realism of its ocean engineering design. It is simply a series of 10-foot segments tied together with wire ropes to form a boom line. The boom line's mooring system can be varied to meet different operational conditions. For heavy duty applications, 5-ton concrete drydock clumps are well suited for use in anchoring the moor.

Each segment is made up of a standard sheet of marine plywood, extended by a 2-foot flexible joint of canvas. Four ordinary oil drums are strapped to the plywood sheet, enabling it to float vertically as a barrier. A plasticized canvas skirt along the underside of the plywood provides a deep barrier, helping to contain the oil slick in heavy rolling swells. The bottom edge of the skirt has a sewn-in hem into which ballast materiels are placed to give the barrier stability and maintain a 3-foot freeboard.

In forming the boom line, segments are clamped to 1/2-inch wire ropes, stretched taut lengthwise along the outboard edge of the drums on each side of the barrier. These ropes provide the longitudinal strength to the boom and maintain spacing between the segments. It is essential that the wire rope, and not the plasticized canvas joint, takes the strain when the boom develops catenary and works due to wind or current. Chain can be used to reinforce the connections as needed. Clamps and eyes are provided along the line for mooring cables which are typically spaced every 12–18 segments.

Application of the TSF Boom in the Chevron Oil Spill

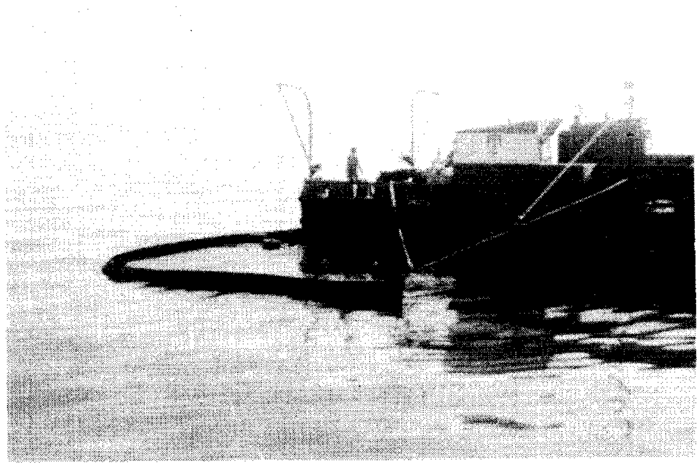
The TSF boom was not available in the local area at the outset of the operation. However, Chevron borrowed Navy engineering drawings and proceeded to construct nearly 5,000 feet of the boom segments at its nearby operational base in Venice, Louisiana. As needed, tailored lengths were towed the 20 miles to the blowout site and used to close gaps in the boom/barge stationary barrier, replacing the lighter booms originally used.

Shorter lengths of the TSF boom, 150–200 feet long, were also used for corralling drifting oil slicks. The length of TSF boom was towed between two boats; oil was corralled in the boom's pocket and then a skimmer equipped boat sucked up the oil. The rugged construction of the TSF, combined with its greater draft and free-board, allows faster towing and makes it more readily adaptable for corralling than most other booms. This technique proved to be a particularly successful pollution control measure during the operation.

EMPLOYMENT OF SKIMMERS

Types of Craft

Chevron outfitted six work boats with skimmer devices and settling tanks. The company also rigged a larger craft, a work barge, for skimming operations, installing settling tanks and a skimmer of its own design. This skimmer barge was similar in concept to the "Norfolk Skimmer" developed at the Norfolk Naval Shipyard. The skimmers were intended to complement the boom/barge stationary barrier, with priority of operations being given initially to picking up any oil that had escaped the barrier and was threatening the coastline.



The skimmer is suspended over the side and maintained just below the surface with the four flotation barrels. Oil is pumped up into tanks on the boat through a hose connected near the top of the cone-shaped receptacle at the center of the device. Pumping through a separate connection at the bottom of the receptacle helps to separate the oil from the heavier water.

SKIMMER BOAT OPERATIONS

Effectiveness of Skimming Operations

The skimmer boats were only effective in less than 3-foot seas. Choppy seas and ground swells caused them to bob and take in water. Their slow speed and low pumping and storage capacity also limited their capability. The Chevron design skimmer barge was more stable in a sea way and, of course, had a greater capacity than the boats. It worked reasonably well in seas of 3 feet but became ineffective in seas of 5 feet or more.

Despite these limitations the skimmers did some valuable work in picking up oil during periods of calm seas. They were employed initially on 9 March when small amounts of oil escaped during the brief 6-minute period that the fire was extinguished. They were employed, thereafter, as the weather and sea state permitted, most successfully in conjunction with lengths of the TSF boom. Fundamentally, however, the oil slicks developed during periods of high sea states and were dispersed and driven away from shore by favorable winds, dissipating eventually in the open sea.

CONCLUSIONS

This operation demonstrated again that our technology is inadequate for controlling a large oil spill in the open seas. Chevron officials had over three weeks in which to prepare for the spill. They planned well and executed the plans vigorously, sparing no effort or expense. However, the task force did not succeed in containing and controlling the spill. That no significant pollution of the beaches occurred was the result of friendly winds blowing the oil out to sea rather than of the effectiveness of the techniques applied.

Research and development are proceeding on many fronts to improve our oil pollution control technology. In the interim, however, it is important for the operating forces to realize that much can be done with available equipment and techniques, providing that sound principles of seamanship are applied. For example, the Merritt–Navy TSF boom, although not perfect, can be very useful providing that it is properly emplaced. Conversely, no boom line can possibly be effective if its mooring arrangements are not carefully designed.

Perfect solutions to the problem are unlikely, given the ubiquity of spilled oil and the speed with which it can be spread. A single barrel can cover up to 10 acres of water under the right conditions. It appears, then, that control will come about through applying a combination of techniques, each one perhaps less than perfect. Techniques that are only 60–70 percent effective are still extremely valuable if the alternative is no control at all. There is little doubt that many of the necessary improvements in our current technology will emerge as much from the practical experience of the operating forces as from the theoretical calculations of our laboratories. The operating forces have, therefore, an important role to play in the effort to contain and control oil pollution. On the one hand, they must react quickly and efficiently when committed to a specific operation, prepared to make the best possible use of resources on hand. On the other hand, they must document the results of their practical experience in a manner that will help the theoreticians understand the interaction of specific techniques with the massive forces of the open seas.

SALVAGE

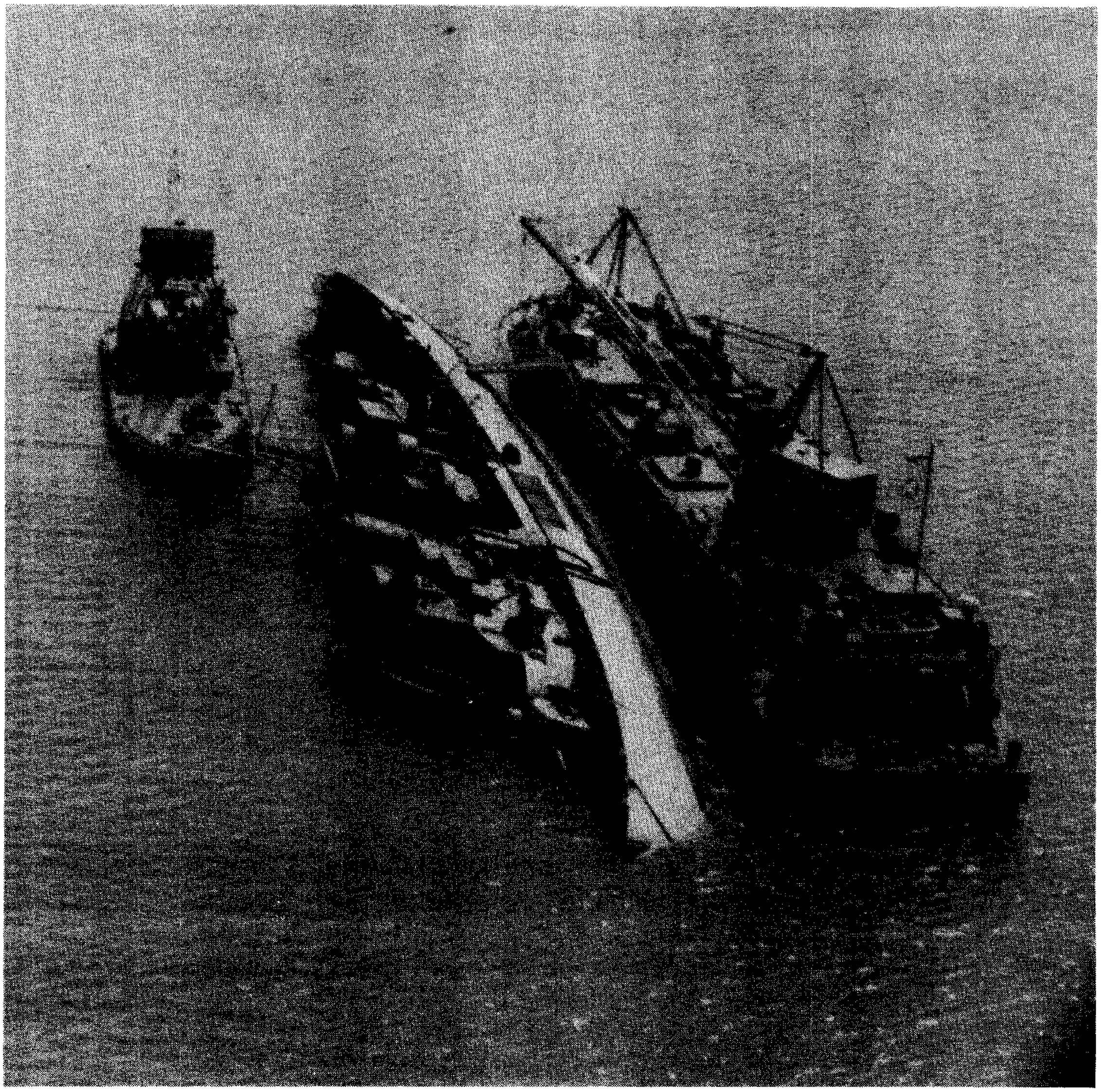
OF

THE ex-USS REUBEN JAMES (DE-153)

AT DAHLGREN, VIRGINIA

During the early 1800's, a Boatswain's Mate named Reuben James, achieved distinction by saving the life of Commodore Stephen Decatur during battle. Subsequently, two ships were named in his honor. The first, a destroyer, DD-245, was sunk by a German U-boat in World War II.

On 1 April 1943, a second REUBEN JAMES was commissioned as a destroyer escort, DE-153. It served during World War II as a convoy escort and as a member of a submarine killer group. It was decommissioned in October 1947 and placed in the Atlantic Inactive Fleet. On 30 June 1968, it was stricken from the U. S. Naval Vessel Register, thereby becoming the ex-USS REUBEN JAMES (DE-153).



HCU-2 salvors moored YRST-2 (on right) and YSD-53 (on left) alongside REUBEN JAMES to prepare it for the big pull. Both craft were also used later in the operation to help control the hulk during the lift.

HCU-2 SALVAGE CRAFT PREPARING CAPSIZED REUBEN JAMES FOR LIFT

SALVAGE OF THE ex-USS REUBEN JAMES (DE-153) AT DAHLGREN, VIRGINIA

INTRODUCTION

The destroyer escort hulk, REUBEN JAMES, capsized off Dahlgren, Virginia on 14 March 1970. The hulk was anchored in a 4-point moor, 2,000 feet from the shore, in 10 feet of water when the accident occurred. It had been in that position for about a year. The Naval Weapons Laboratory (NWL) at Dahlgren had been using it for explosive ordnance testing.

Harbor Clearance Unit Two (HCU-2) was assigned the task of righting and refloating the hulk. The operation provided this unit with an excellent opportunity to apply its salvage capabilities. The REUBEN JAMES constituted a formidable challenge for HCU-2's salvors. It was laying starboard side down on an extremely muddy bottom, over half-submerged at a list angle of 87 degrees.

HCU-2 proceeded to plan and conduct the entire salvage operation in less than 30 days. It combined and applied a wide variety of salvage resources and techniques in a methodical, highly professional manner.

PLANNING

Preliminary Salvage Inspection

Representatives of Commander Service Squadron EIGHT (CONSERVRON EIGHT) inspected the capsized hulk on 15 March and determined that it was feasible to raise and refloat the ship. The Commanding Officer, HCU-2, was designated as Salvage Master and assumed responsibility for the planning and execution of the operation. The COMSERVRON EIGHT Salvage Officer provided back-up calculations and stability test criteria.

Phases of the Operation

HCU-2 planned to deliver the refloated hulk at the Dahlgren pier on 30 April and to complete the operation in six phases:

PHASE 1 – Preparations
PHASE 2 – Taking the Initial Strain
PHASE 3 – Breaking Free
PHASE 4 – Patching and Plugging
PHASE 5 – Stability Testing
PHASE 6 – Refloating and Termination

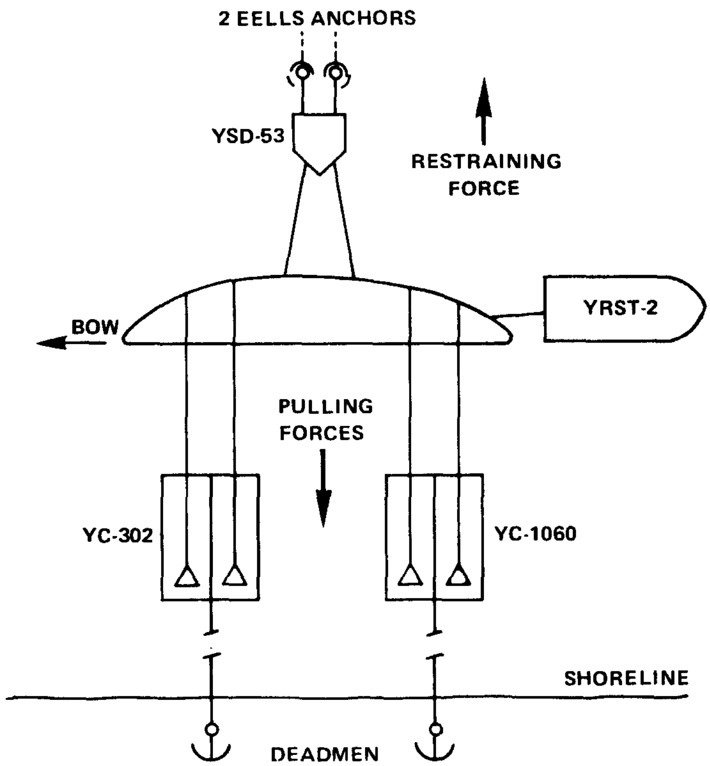
Requirements for Salvage Craft

The plan developed for lifting the REUBEN JAMES called for the coordinated use of four service craft

2	**Open Lighters (YC's)**	**YC-302 and YC-1060**
1	**Seaplane Wrecking Derrick (YSD)**	**YSD-53**
1	**Salvage Craft Tender (YRST)**	**YRST-2**

The two YC barges provide highly stable platforms for salvage tasks of this type. These large lighters have firm, unobstructed decks which are ideal for the rigging and operation of pulling equipment. HCU-2 borrowed them from the Naval Supply Center (NSC), Norfolk.

The other two craft are HCU-2 assets. The YRST is extensively outfitted with shops, diving and salvage equipment, and crane facilities. It also has living and working spaces for a headquarters staff. The YSD, although small, is a versatile, self-propelled salvage craft. The YC's and the YRST are not self-propelled. Fleet ocean tugs towed them from Norfolk to the salvage site at Dahlgren for the operation.



The two YC's, backed by deadmen ashore, apply the pulling forces. YSD-53 to seaward applies restraining force and YRST-2, astern, maintains the hulk in line.

POSITIONING OF CRAFT AND RIGGING FOR LIFT OF REUBEN JAMES

Concept for Lifting the REUBEN JAMES

The two YC's were to apply the lifting force. Each would be rigged in a pulling harness, positioned between the hulk and the shore, and backed by deadmen buried 120 feet inland. The YSD, in a restraining harness and backed by two sets of beach gear, would apply restraining force from a position seaward of the hulk. The YRST would be positioned astern of the REUBEN JAMES to hold the hulk in line as pulling and restraining forces were applied by the other craft.

PHASE 1 – PREPARATIONS
22 March – 7 April

Preparations for the lift effort got underway on 22 March with the arrival of YSD-53 at the salvage site. The YRST-2 joined the effort a few days later and moored alongside the REUBEN JAMES upon its arrival. The two YC barges were delivered to the site on 1 April. HCU-2 brought over 100 tons of salvage equipment with it, including six sets of beach gear. Two weeks of hard work were required to make all the necessary preparations.

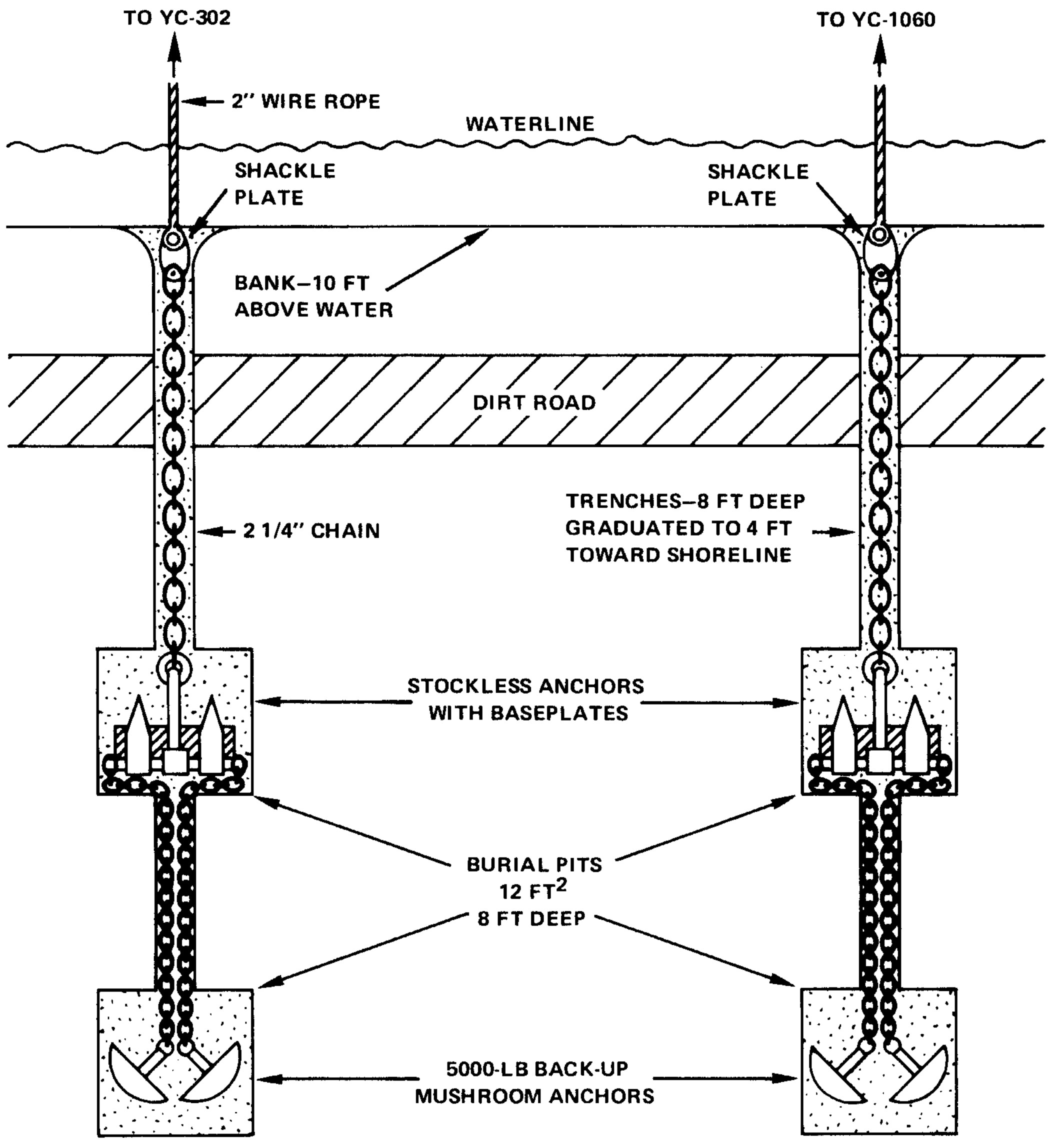
Preparations Aboard the Hulk

The hulk's topside weight was substantially reduced by removing equipment and structures that were accessible to the salvage force. This work was complicated by the capsized position of the hulk. Nonetheless, several major structures were successfully removed, including the forward gun director with its range finder, several 40-mm gun mounts, and both anchor chains. The foremast was also removed down to the 03 level.

All compartments were made watertight in preparation for dewatering. Salvage pumps were rigged on swinging brackets to maintain suction at all degrees of list, 3-inch and 6-inch diesel pumps being used for this purpose. The salvage force also rigged three 250-pound pumps, with eductors, for additional pumping as required. In addition, four 6-inch holes were cut in the port side of the hulk. These holes would serve to dump water during the lift and to reduce free surface effect. All spaces were test-pumped prior to the first lift attempt.

Laying the Deadmen

Implantment of the deadmen ashore was accomplished with earth-moving equipment. The arrangement of the deadmen was similar for each YC. They were put into burial sites 8 feet deep and 12 feet square at a distance of 120 feet from the shore. Narrow trenches connected each burial site to the shoreline. The trenches were graduated in depth from 8 feet at the burial sites to 4 feet at the shoreline.



Deadmen for each YC were a stockless anchor and two back-up mushroom anchors. Burial sites were located 120 feet inland, 140 feet apart.

ARRANGEMENT OF DEADMEN FOR BACKING UP THE LIFT PLATFORMS

The deadmen for each YC were comprised of a stockless anchor buried in one hole backed by two mushroom anchors in a second hole a short distance inland. A 40-pound baseplate was welded to the stockless anchor to keep it from sinking further into the earth as it resisted the lifting forces.

The salvors used 2 1/4-inch chains buried in the trench to connect the implanted anchors to a shackle plate at the shoreline. A 2-inch wire linked each YC, in its pulling harness position, with a shackle plate ashore.

Rigging of Bridles

HCU-2 personnel rigged chafing gear and 2 1/4-inch chain bridles for righting and controlling the REUBEN JAMES. One pair of pulling bridles was rigged in the forward deck area of the hulk for connection to YC-302. A second and similar pair was rigged aft for connection to YC-1060.

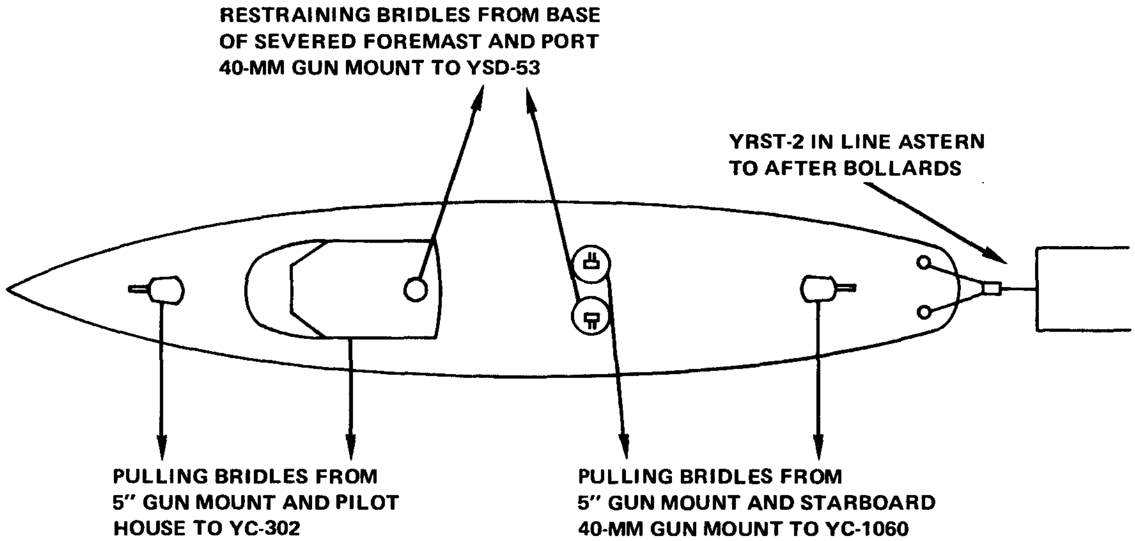
The two forward pulling bridles were rigged around the base of the forward 5-inch gun mount and the pilothouse, respectively. The bridles aft were connected to the after 5-inch gun mount and to the starboard twin 40-mm gun mount. Stand-offs were constructed with steel beams to provide better pulling leverage for the bridles around the 5-inch gun mounts. The other two bridles were rigged for parbuckling, chains being passed underneath the hull for this purpose.

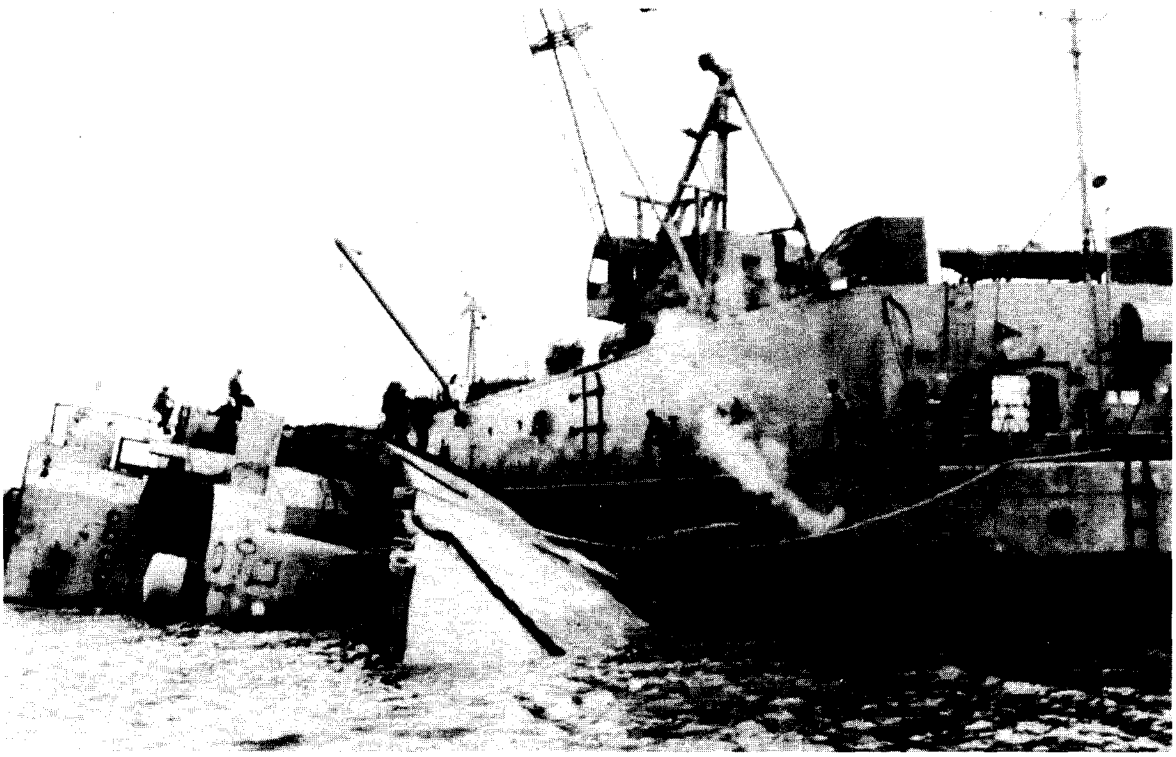
A third pair of bridles were employed as restraining bridles for control by YSD-53. Salvors used the stub of the severed foremast and the port twin 40-mm gun mount as bases for securing these two bridles.

PHASE 2 – TAKING THE INITIAL STRAIN
7 – 8 April

With preparations complete, the four service craft were placed on their respective stations for taking the initial strain prior to breaking the hulk free of the bottom forces. The two YC's were moved into their pulling harnesses. YSD-53, its restraining harness rigged, took up position to seaward and the YRST-2 moved in line, stern to stern of the REUBEN JAMES.

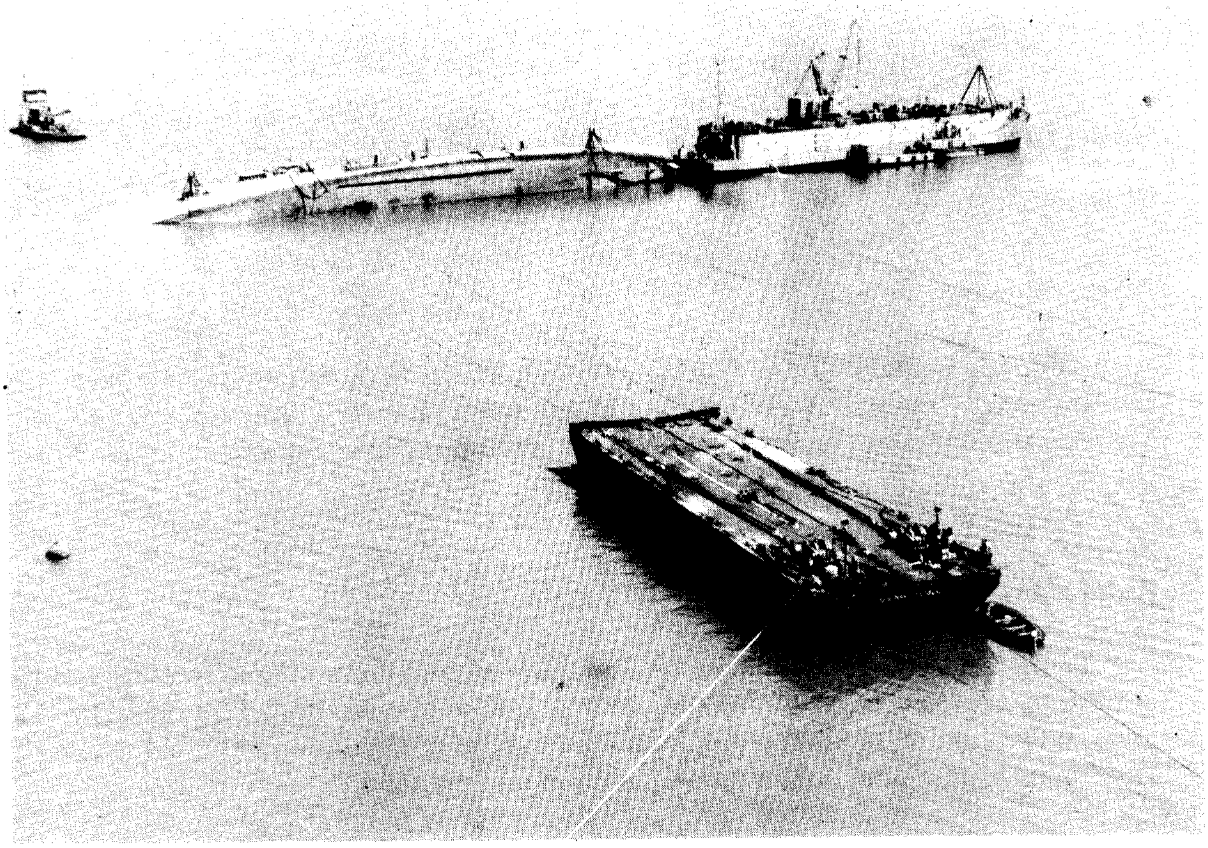
Pumping operations got underway on 7 April. The next morning, as pumping continued, the task force began setting taut on all pulling and restraining harnesses. The two YC's developed a 10-ton pull on each leg with the YSD easing its strain as the YC's gradually increased their pull.





HCU-2 salvors rigged four pulling bridles and two restraining bridles. In the photograph, they are rigging a pulling bridle around the pilothouse.

RIGGING OF CHAIN BRIDLES ABOARD THE HULK



YC-302 is in foreground, rigged in its pulling harness. The other YC, not shown, was rigged the same way. The two triangular structures on the capsized hull are the stand-offs for the pulling bridles around the 5-inch gun mounts.

SALVAGE FORCE IN POSITION FOR THE LIFTING EFFORT

This effort continued into the early afternoon. The initial pull, exerted after all lines had been set taut, verified that all gear was holding as planned. Conditions were favorable for proceeding to break the hulk free. The water level in the superstructure area had been lowered 6 feet by this time. Water in the hull was down 3 feet.

PHASE 3 – BREAKING FREE
8 – 9 April

The effort to break the REUBEN JAMES free began at 1400 on 8 April as pumping continued and the two YC's increased the pulling force to 35 tons per leg, reducing the list to 55 degrees.

A Chain Breaks

At 1700, a chain to the deadmen backing YC-1060 carried away. Two men were thrown into the water, and one man was injured when hit by a 2-inch carpenter's stopper. The men were wearing lifejackets and hard helmets, thus limiting the injuries to one broken rib.

Righting Effort Continues

YC-302, meanwhile, continued to hold a 35-ton pull until 1930 when repairs to the chain were completed and YC-1060 resumed a pull of 35 tons. Both YC's then increased their pull slightly to 36 tons per leg, reducing the list to 45 degrees by 2030. With the lift at this critical stage, righting efforts had to continue into the night.

The list lessened to 40 degrees by 0015. The pull was then increased to 40 tons per leg over the next few hours, easing the list to 35 degrees by 0418.

The Main Deck Awash

The 40-ton pull per leg was held throughout the next day until 1645 when the plate shackle pins in YC-302 were observed to be slightly bent. The salvors then relaxed the strain and held the pull with a carpenter's stopper while the pins were replaced. YC-302 then restored its 40-ton pull. The list had been reduced to 25 degrees by early evening.

At this point, YSD-53 moved from its restraining harness to rig additional 6-inch pumps aboard the hulk. YSD-53 returned to its harness and all strains were held with the hulk at a 24-degree list. Pumps continued to dewater compartments, as the starboard main deck gradually appeared at the surface.

With the REUBEN JAMES finally under control, the Salvage Master reduced the work force and the crews proceeded to get some much needed rest.

PHASE 4 – PATCHING AND PLUGGING
9 – 13 April

With the hulk almost righted, work could begin on the task of making the starboard hull watertight. The salvage force began patching and plugging the starboard hull on 9 April as the pumps continued to dewater the ship. The list was reduced from 24 degrees to only 7 degrees during the next few days as the hulk became increasingly watertight and further adjustments were made in the pulling and restraining forces.

With the REUBEN JAMES in this nearly upright position, all holes in the starboard hull could be reached and permanent repairs could be made. Welding of permanent patches continued through 13 April. Completion of these repairs enabled the task force to proceed to the next phase of the salvage effort, that of stabilizing the ship.

PHASE 5 – STABILITY TESTING
14 – 16 April

Stabilizing the Ship

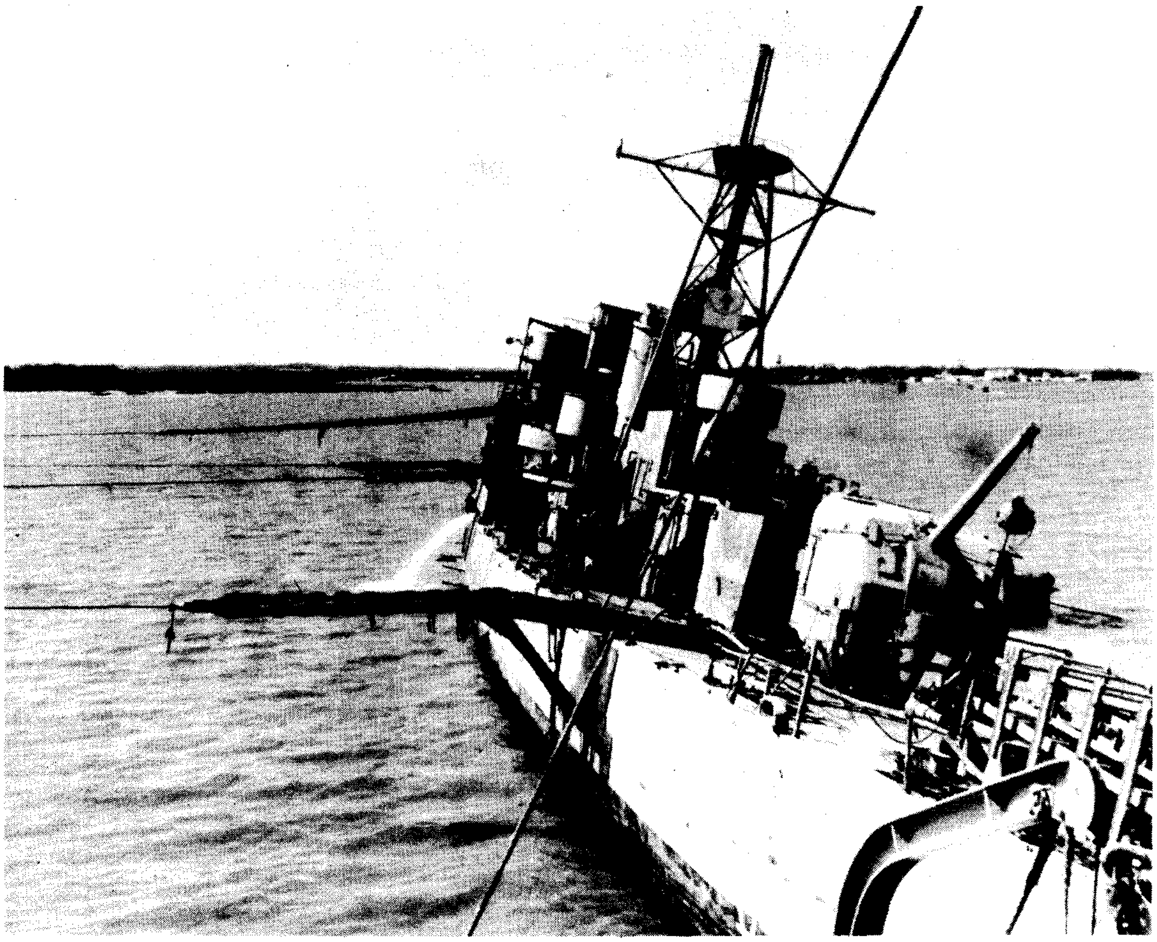
Counter-flooding of the port fuel ballast tanks was undertaken early on 14 April in order to improve the ship's stability. It appeared for a brief time that the hulk was stable for it was listing only 2 degrees at 1100. However, it rolled back gradually to an 8-degree list as the day wore on, holding in that position at 1700.

An estimated 20 tons of mud had accumulated on the starboard weather decks. In addition, the pumps that had been used to dewater the starboard side of the hull were still in place. These weights were producing the moments that caused the roll-back.

The salvage force, therefore, set about the task of reducing the starboard load by removing the mud and the excess pumps. Salvors from YSD-53 dismantled and removed the pumps, the YSD being relieved in its restraining harness by YC-1060 during this period. In addition, this maneuver was a preparatory step for the stability tests. Reductions of the starboard weight continued through the following day, 15 April.

Stability Tests

The REUBEN JAMES was ready for its first stability test at 2000 on 15 April. The list at this time was 3 degrees to starboard. At 2245, one hour before high tide, all ballasting



Chain bridles stretch taut as the pulling force is applied from port side. Stand-offs, fore and aft, improve pulling leverage for bridles around 5-inch gun mounts. Diesel pump is suspended from gun barrel.

THE LIFT EFFORT NEARING COMPLETION

was completed, and a 2 1/2-ton pull by YC-302 slid the hull about 13 feet to port. This effort secured the first stability test.

Ballasting for the second test was completed at 0900 the next day. At 0909, one hour before high tide, a 5-ton pull to port was made by YC-302, and the escort hulk moved 3 feet more to port. A 5-ton pull was then exerted to starboard by YC-1060, and the hulk moved 6 feet to starboard. At 0955, YC-302 salvors developed a 10-ton force to port and the hulk moved 10 feet to port without change of list.

As the fall of tide to low water was only 0.4 feet, the stability tests were judged to be satisfactory for refloating. The salvors were then ready to refloat the REUBEN JAMES.

PHASE 6 – REFLOATING AND TERMINATION
16 – 20 April

Deballasting and Refloating

With the completion of stability tests on 16 April, deballasting commenced immediately to refloat the escort hulk. Deballasting continued all that night until 0800 the next morning. Final adjustments in trim were then made and the REUBEN JAMES refloated a few hours later.

It was immediately taken in tow to the Dahlgren pier. The first line was over to the pier at 1012, and HCU-2 returned control of the ex-USS REUBEN JAMES to the Commanding Officer at NWL.

Clean-up

The salvage team continued with the unrigging and recovery of all salvage equipment. Operations terminated 20 April with all equipment recovered and salvage forces returned to home bases.

CONCLUSIONS

It was originally estimated that six weeks would be required to complete the righting and refloating of the REUBEN JAMES. The task was accomplished in less than a month. A formidable amount of salvage work was done, and done well. The record of the operation provides ample evidence of energetic and effective leadership by the Salvage Master and the resourceful application of many useful techniques by his salvage force.

The salvage force applied standard and well-tested techniques to accomplish its task. Their successful application again demonstrates their utility. The following list illustrates the range and variety of techniques that were involved:

1. Beach gear was rigged on YC's for pulling and on YSD for restraining.

2. Anchors were planted ashore as deadmen to back-up the YC's in their pulling harnesses.

3. Mooring chains were rigged under the hull for parbuckling effect and control by the YC's.

4. Stand-offs were constructed from 5-inch gun mounts to increase leverage.

5. Diesel salvage pumps were rigged on swinging brackets to provide continuous suction at all degrees of list during the big pull.

6. Holes were cut above the waterline on the port side to allow water drainage from high compartments which were difficult to dewater with pumps.

7. Watertight integrity was set within the hulk.

8. Excess topside weight was removed to reduce the righting moment.

9. Compartments on the port side were selectively counter-flooded to improve stability.

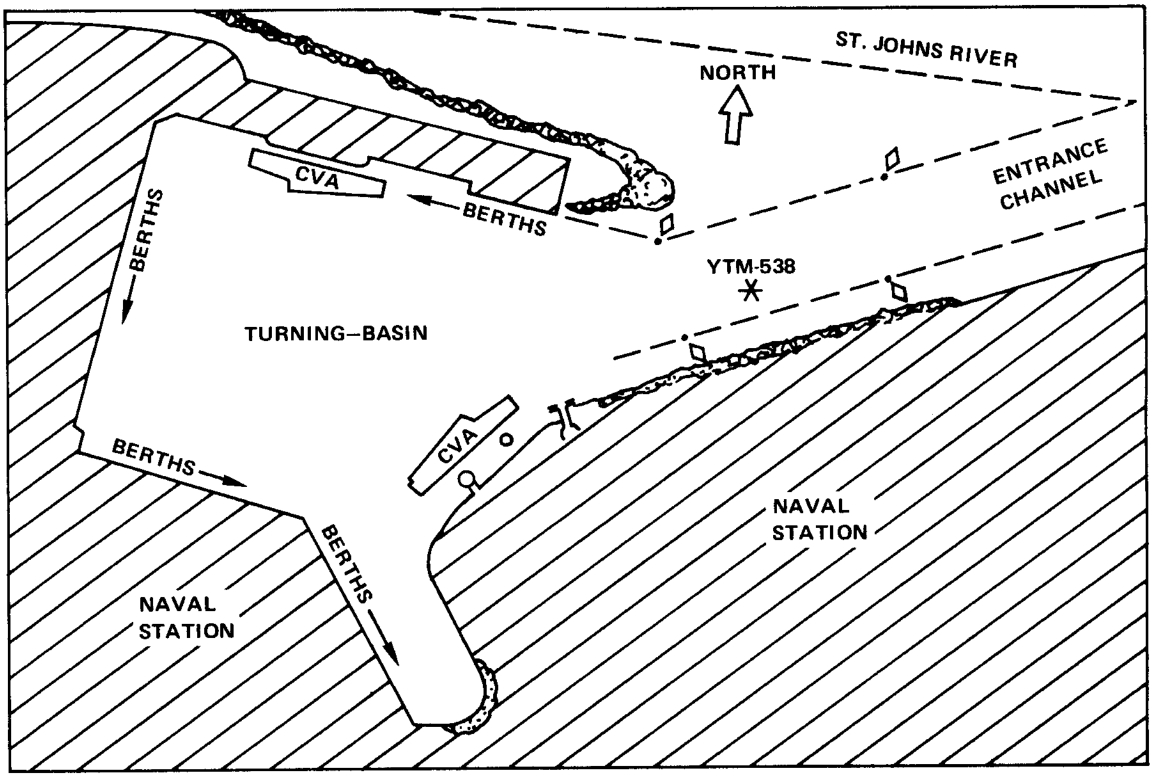
10. J-bolt patches were used to expedite hull watertightness.

SALVAGE

OF

THE SUNKEN HARBOR TUG, YTM-538

AT MAYPORT, FLORIDA



YTM-538 sunk in entrance channel while assisting USS PAWCATUK. Hazardous to navigation, it was essential to raise and refloat the tug at the earliest opportunity.

LOCATION OF SUNKEN HARBOR TUG NEAR ENTRANCE TO NAVAL STATION BASIN AT MAYPORT, FLORIDA

SALVAGE OF THE SUNKEN HARBOR TUG, YTM-538
AT MAYPORT, FLORIDA

INTRODUCTION

The USS PAWCATUK (AO-108) struck and sunk YTM-538, a medium harbor tug, at Mayport, Florida on 17 July 1970. The tug was assisting the fleet oiler into port when the collision occurred. The port screw of the ship holed the tug below the turn of the bilge. YTM-538 sank basically upright, in 41 feet of water, on the south side of the channel entrance to the Mayport Naval Station Basin. A hazard to navigation, the YTM had to be cleared for shipping.

Harbor Clearance Unit Two (HCU-2) was assigned the task of raising the tug. It completed the task in less than three weeks, making maximum use of salvage assets available in the Mayport area. This operation was the second major salvage effort of HCU-2 during 1970. It followed closely after the successful righting and refloating of the destroyer escort hulk, ex-USS REUBEN JAMES, at Dahlgren, Virginia.

INITIAL PREPARATIONS

Assignment of Key Personnel

The Commanding Officer of HCU-2 was designated by Commander Service Squadron EIGHT (COMSERVRON EIGHT) as Officer-in-Charge of salvage operations. The Officer-in-Charge of Harbor Clearance Team One (HCT-1) at that time was assigned as Salvage Master. HCT-1 was the principal component of HCU-2 deployed to Mayport for the operation.

Assembling of Forces and Equipment

The Naval Station at Mayport made available the following craft, which were to be used extensively in the operation:

2 Floating Cranes (YD's)	**YD-89 and YD-204**
1 Open Lighter (YC)	**YC-1482**
3 Landing Craft, Mechanized (LCM's)	

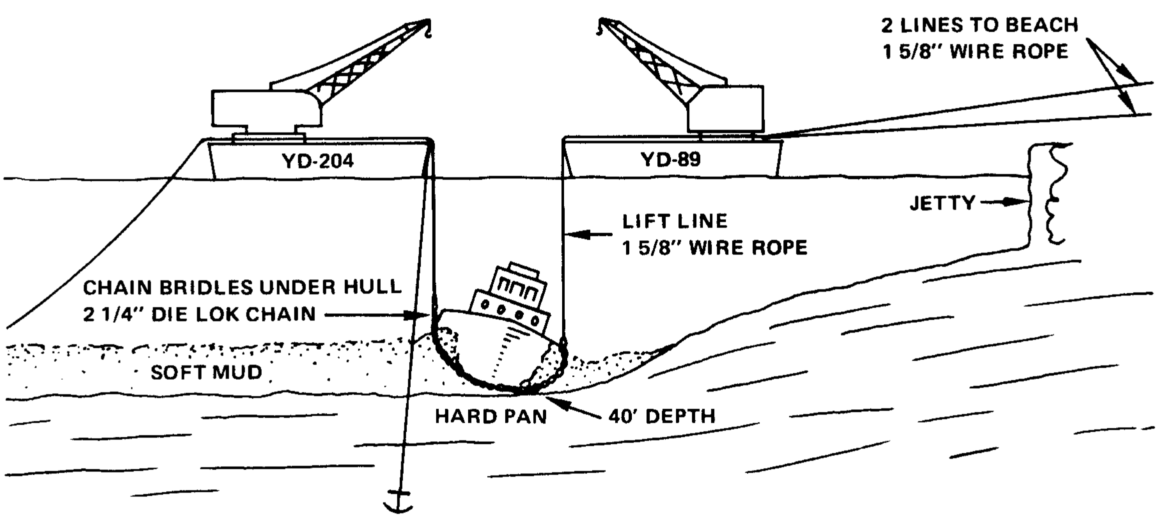
The YC, equipped with a mobile land crane, was to be used as the principal platform for diving and preparing the sunken tug for the lift. The two YD's would be employed primarily as platforms for the Clyde winches which would perform the actual lift of YTM-538 and secondarily to provide lift services for handling heavy equipment. YD-204, the larger, was rated at 50 tons, twice the rating of YD-89.

COMSERVRON EIGHT ships, operating near the Mayport area, were tasked to provide personnel and equipment in support of the salvage force. The USS ESCAPE (ARS-6) provided divers and diving equipment and key items of salvage equipment, notably four sets of beach gear, a Clyde winch, pumps, compressors, generators, and a welding machine. The USS SALINAN (ATF-161) provided technical assistance, including two salvage engineers, and working parties.

A second Clyde winch was airlifted from HCU-2's home port at Norfolk along with other critical equipment. The salvors also located some needed items in the Mayport salvage yard.

Diving Surveys

Diving surveys made on 19 and 20 July confirmed the feasibility of lifting the sunken tug. It was found to be in good condition, although the onrushing water had broken some doors. The YTM was resting in a mud cradle buoyed 45 feet forward and 10 feet aft with a 2-inch layer of silt covering the entire hull. It was listing 4 degrees to port. Doors, scuttles, and portholes were open. Current on the bottom was negligible.



The salvage plan featured the use of two YD's, each rigged with beach gear, as lifting platforms. Bulldozers on the beach backed YD-89. The YC barge was employed as a diving platform to prepare the hull for the lift.

POSITIONING OF LIFTING PLATFORMS

Clyde winches became critical items in planning as local craft were not rigged for heavy lifting. The salvage force obtained two winches and installed them on YD-89.

CLYDE WINCH ABOARD YD-89

THE SALVAGE PLAN

The salvage plan provided for the raising and refloating of the sunken tug in five phases. Principal features of the plan were as follows:

Phase I – Assemble personnel and equipment.
– Rig the YC and moor it at the salvage site.
– Strip the tug of unnecessary, easily removed weight and gear.
– Rig each YD with two sets of beach gear.

Phase II – Tunnel under the tug and rig lifting slings of 2 1/4-inch chain and 1 5/8-inch wire.
– Patch the hull and rig it for air lifting.

Phase III – Moor the two YD's over the tug for the lift.
– Set lifting slings tight and lash chain to bitts to prevent fore-aft movement.
– Blow tanks and spaces in the tug.
– Hoist the tug to the surface, deck slightly awash.

Phase IV – Refloat by pumping out with four 3-inch salvage pumps and eductors.
– Return tug to Naval Station.

Phase V – Return borrowed equipment and redeploy HCU-2 personnel and equipment to Norfolk.

Time Factors

Time was an important consideration in planning as the sunken tug was a hazard to shipping in the channel. Time periods for critical tasks, as estimated in the salvage plan and as actually accomplished, are as follows:

Task	As Planned	As Executed
Rigging and Mooring YC	19 – 21 July	19 – 21 July
Rigging YD's with Beach Gear	19 – 21 July	19 – 22 July
Rigging Tug for Lift	19 – 29 July	19 – 29 July
Positioning the YD's	25 July	25 July
Lifting the Tug	29 July	1 August
Refloating the Tug	29 July	1 August

The task force broke the mud suction on the sunken tug on 27 July, pulled it shoreward to clear the channel, and regrounded it. In addition, one of the YD's had to be moved out of harness on two occasions. These modifications accounted for the slight delay in completing the mission.

RIGGING AND MOORING THE YC

Staging of Equipment

Salvors commenced staging all gear needed for the initial rigging of the YTM-538 on the YC-1482, since this was the craft designated for all diving operations. Gear included all diving equipment such as generators, compressors, tanks, breathing apparatus and pumps, and equipment needed to ready the YTM.

Positioning the YC for Diving

Divers rigged the bow and stern anchor for the YC-1482, with the chain stopped off in a bight free for running. The stern anchor was dropped 180 feet from the bow of the YTM. The bow anchor was then carried out over the stern of an LCM. After the bow anchor was dropped, the LCM crew set the anchor by taking out all slack while pulling the crown wire until all chains were taut.

A kedge anchor was carried out shoreward to prevent the YC from setting over the top of the wreckage. The divers then attached a 6-inch nylon hawser to the head bitt and stern cleat of the YTM. This made the YC in a tight moor for diving operations.

STRIPPING THE YTM

With the YC barge firmly moored and rigged as a diving platform, extensive diving operations were undertaken to strip the sunken tug of removable gear. The object was not only to reduce topside weight but also to clear away loose items that might interfere with diving operations. The heaviest objects removed were the bow anchor and seven shots of 7/8-inch anchor chain. These were lifted to the surface with the mobile land crane aboard the YC. A wide variety of smaller articles were also removed.

RIGGING THE LIFT CHAINS AROUND THE TUG'S HULL

Two teams of divers worked concurrently to prepare the YTM for the lift. One team proceeded with the job of underwater patching while a second team concentrated on the task of tunneling under the tug's hull and rigging the lift chains. Tunneling was conducted under the stern at the quarter bitts and under the bow at the port and starboard bitts.

Tunneling Procedures

Tunneling under the bow section was first attempted with a submarine lance. This initial attempt failed because the lance proved to be too heavy and awkward to maneuver effectively around the contour of the hull. Accordingly, the salvage team set about fabricating a lighter lance. In the interim, the divers washed the mud away from the tug's bow fenders, using a falcon nozzle for this purpose. This effort succeeded in forming a tunnel under the bow fenders.

A wire rope messenger was then see-sawed under the keel, using the mobile crane aboard the YC barge for power. The messenger was stopped off when it was finally in place. The crane was then moved aft on the YC to a position over the quarter of the YTM-538, and tunneling proceeded at the starboard quarter. One diver, dressed in a wet suit, worked in the tunnel proper while a second diver, dressed in a shallow-water outfit, tended him from outside the tunnel.

Upon reaching the keel from the starboard side, the diver in the tunnel pushed the fabricated light lance under the keel. A braided nylon messenger had been attached to the lance. Then, as air was introduced, the divers tunneled from the port side until the messenger on the bitter end of the lance was reached. Over 3 feet of solid hard pan were encountered under the tug's hull before the lance was finally worked all the way through the tunnel.

Rigging the Chain Bridles

A 2 1/4-inch chain bridle was rigged under the bow section and secured to the forward bitts. A similar bridle was then rigged aft. A braided nylon messenger and wire rope were used to pull the chain for this bridle under the stern section. After reeving 7/8-inch chain connected to the 2 1/4-inch chain of the bridle, and rendering the chain under the hull, divers secured the bitter ends to bitts.

Shackle plates were then installed on all four bitter ends of the bridles, forward and aft. Then, after the two YD's were moored over the wreck, four 1 5/8-inch wire ropes were lowered to the tug's lifting points from the YD's, and connected to the bridles via the shackle plates. Each chain was lashed on its bitts with 2-inch braided nylon backed up with wire rope straps.

RIGGING THE HULL FOR AIR LIFTING

Calculations

Watertight integrity is comparatively low in harbor craft. The YTM-538 was no exception in this regard. Much underwater work would be required to make the hull watertight and prepare it for lifting. The salvage team calculated that it would be necessary to dewater the following spaces to create an air bubble adequate for lifting the tug:

Space	Capacity (ft^3)	Lift (tons)
Chain locker	200	6
Crew berthing	2016	62
Lazarette	800	24
After fuel tanks (2)	838	29
	Total air lift:	121 tons

The gross weight (light) of YTM-538 was 275 tons, whereas her underwater weight was 206 tons. Maximum ground reaction was 20 percent. A bubble of 15 tons could also be generated in the motor room using holes in the tug's side as access. A fuel oil lift of 6 tons was also provided for.

Patching and Plugging

Scuttles were ripped off from the chain locker, crew's berthing space and lazarette and modified for use as templates for pumping patches.

Vent strainers on the after fuel tanks were removed and replaced with pipe plugs. Valves and nipples were installed in place of tank caps so that appropriate sections could function as blow and spill pipes. The lazarette vent was plugged to seal off this space.

Modified patches were installed on the chain locker, chain pipe, and berthing compartment. Damaged spill valves were removed and welded. Initial air testing revealed numerous leaks from the patched spaces. The vent system in the berthing compartment had to be dismantled and its openings plugged to ensure the integrity of this space. Patching and plugging proceeded with the objective of sealing off the chain locker, lazarette, crew's berthing compartment and fuel tanks.

RIGGING AND POSITIONING OF YD'S

Mooring the YD-89

With the YTM rigged for the lift, the salvage teams made preparations to take YC-1482 out of its moor and move in the YD's. Salvors positioned the YD-89 inshore of the sunken tug. Bow and stern lines from the YC were then passed to the YD-89 and the YC slipped alongside. Two 300-foot pendants of 1 5/8-inch wire rope were connected to the stern bitts of the YD-89 and to two bulldozers on the beach near the jetty. The bulldozers anchored their position by digging their blades into the sand.

Positioning the YD-204

YD-204 was then maneuvered to a position off YD-89 and moored at the bow by passing anchor lines. Stern anchors were then carried out in the LCM's, and all mooring lines were tightened up. The vessels were thus secured in a tight moor over the sunken tug.

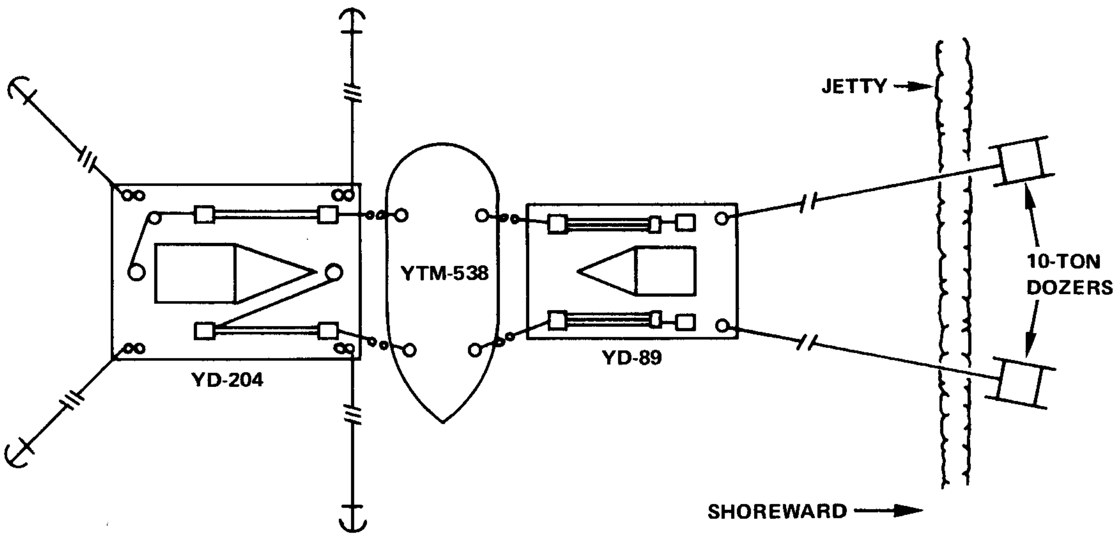
Rigging of Beach Gear

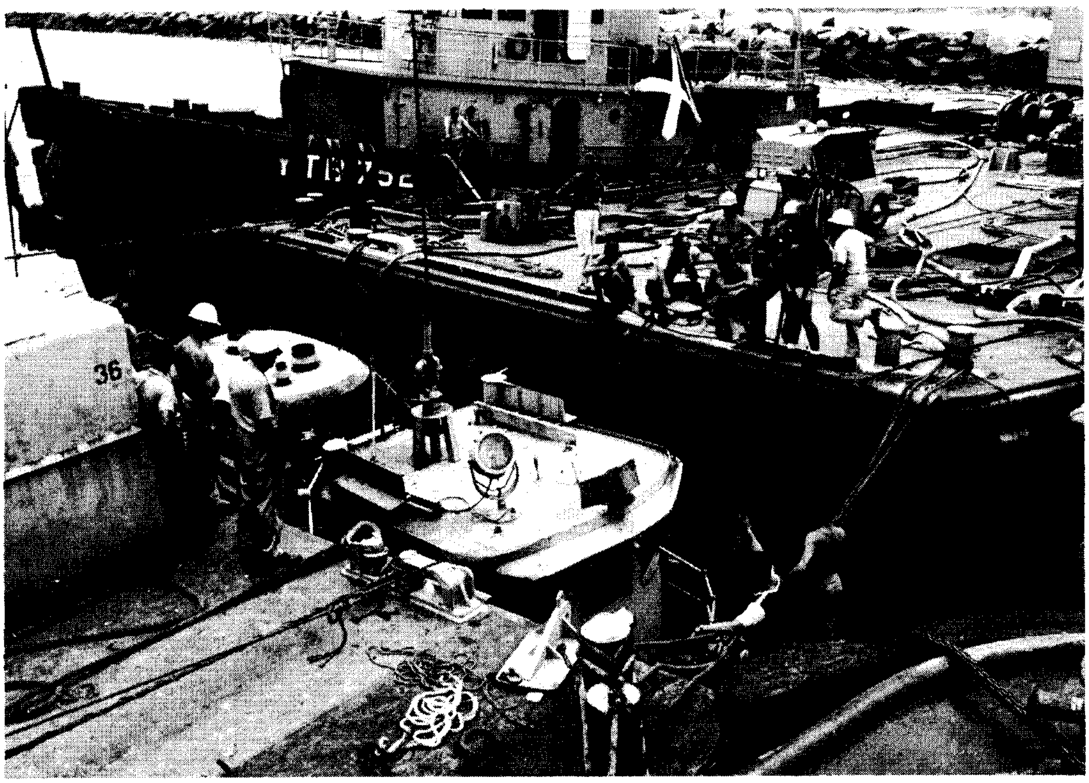
Rigging the two YD's proved to be a long and tedious job. They had not previously been rigged with the heavy, doubler plate padeyes normally required for beach gear applications. Installation of these padeyes required a major welding effort over a period of 4 days. Two sets of beach gear were rigged on each YD.

LIFTING OPERATIONS

First Lift Attempt – 26 July

With the two YD's in position over the wreck and beach gear set up to 15 tons of tension on each set, the task force moved quickly on 26 July to complete preparations for the first lift attempt. Spill valves were replaced and hoses were connected to the after fuel tanks. Pumping began from these tanks, the fuel being transferred to a sludge barge. Divers completed cementing of patches and installation of the lazarette patch.





Schematic indicates position of beach gear aboard the. two platforms. Doubler plate, heavy duty padeye had to be welded in place aboard each YD. Photo shows YD-89.

RIGGING OF YD'S FOR THE LIFT

Heaving around on the beach gear was started while these preparations were still in progress. The chain locker and lazarette were then pumped and the strain on the beach gear was increased to 60 tons per leg. The clutches on the Clyde winches aboard the YD's slipped at this point and the capstan on YD-204 stalled out as well.

In these circumstances, the tension was relaxed to 2 1/2 tons on each leg of beach gear. Divers proceeded to inspect the patches and it became evident that numerous leaks existed. Accordingly, the salvors secured blowing air and relaxed the beach gear to zero pull.

Second Lift Attempt – 27 July

Operations were suspended briefly when it became necessary to move the YD-204 out of its harness into the open channel to make way for shipping. However, it was restored to its harness early on 27 July and operations were renewed for a second lift attempt.

The salvage master decided to flood the forward voids of the YD-204 in order to provide additional counterbalance to the lifting forces. A harbor tug used its fire pumps and fire hoses to perform this task for the salvage team. The tug moored alongside the YD, completing the job in short order. Filling the voids increased the forward draft of the YD about 3 1/2 feet.

Eductors were rigged in each outboard void and 3-inch pumps in each inner void. Adjacent spaces were checked for leaks. The task force then set up all beach gear to 10 tons per leg in preparation for a tidal lift at 1300, the next time of low tide.

Tension on each beach gear leg was increased to 25 tons at 1300 and all pumps were started to dewater the voids. The two bulldozers backing YD-89 on the beach began taking strain at the same time. This combination of forces succeeded in breaking the mud suction on the bottomed tug. Strain on each set of beach gear reached 40 tons in the process. It was reduced to 30 tons after the chain locker and lazarette had been pumped.

With the bottom suction broken, the bulldozers were able to pull the YTM a distance of about 75 yards in order to clear the channel. The tug was then regrounded in its new position. The starboard lift line (1 5/8-inch wire rope) parted during this process. All beach gear was accordingly relaxed and repairs were made to this line as well as to the 5/8-inch wire from the starboard Clyde winch.

Preparation for a Third Lift Attempt

The salvage force lost the services of YD-204 for a 4-day period at this point. Mayport Naval Station had another work commitment of higher priority for this craft. It was slipped out of harness on 28 July, its lift line and moors being transferred to the YD-89. YD-204 was made available again on 31 July and restored to harness late that day.

Using the delay to good advantage, the salvors accomplished a series of improvements in preparation for the next lift:

1. A cementing detail sealed the chain locker and vent.

2. The air conditioners and ducting in the crew's berthing compartment were removed and all external vents were patched and cemented.

3. A lazarette patch was installed after surveys indicated that air was working through the internal hull.

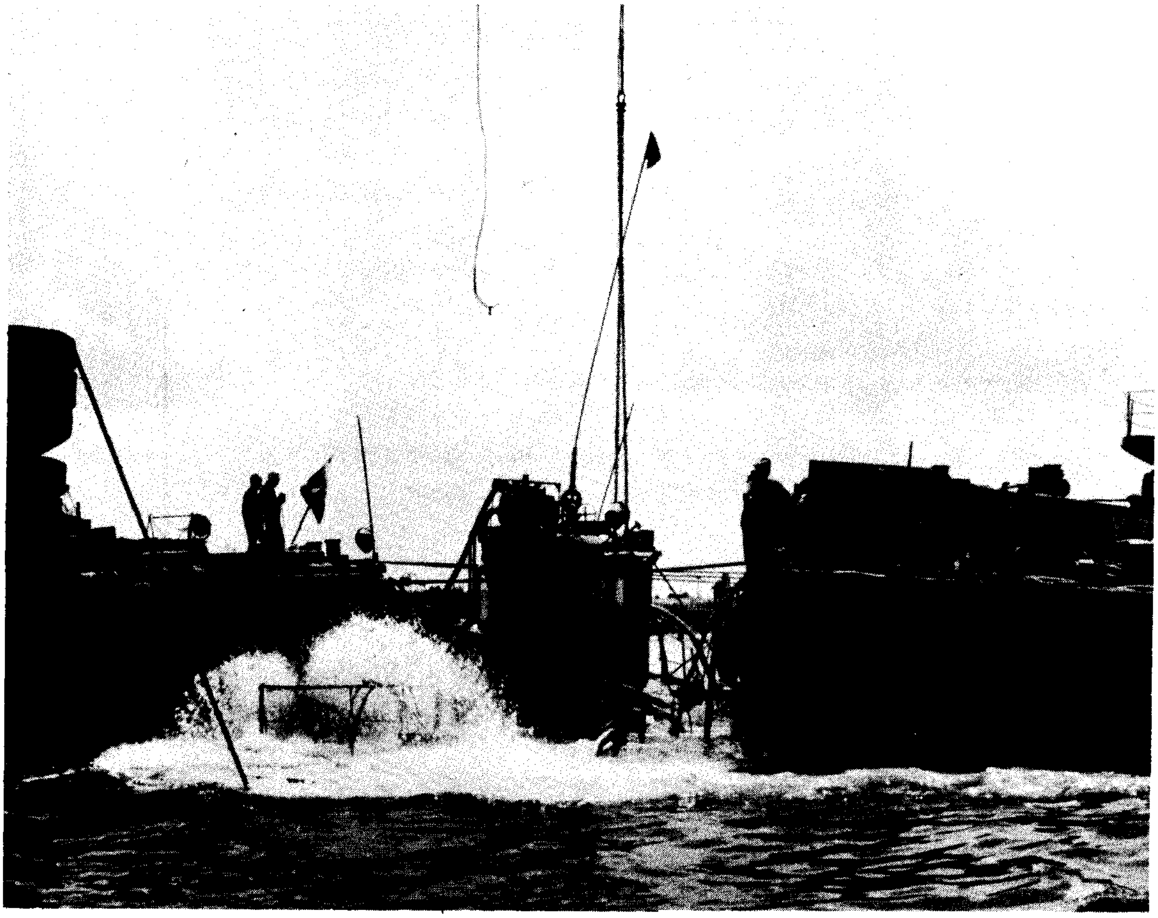
Other patching and cementing were accomplished as divers detected new openings or leaks in the vital spaces. All spaces were test pumped. Divers reported that all were finally tight, with no leakage observed.

Final Lift – 1 August

With YD-204 back in harness and all four legs of beach gear again connected, the salvage force turned to at 0200 on 1 August for the next lift. The forward voids of both YD's were flooded and pumps were rigged for dewatering.

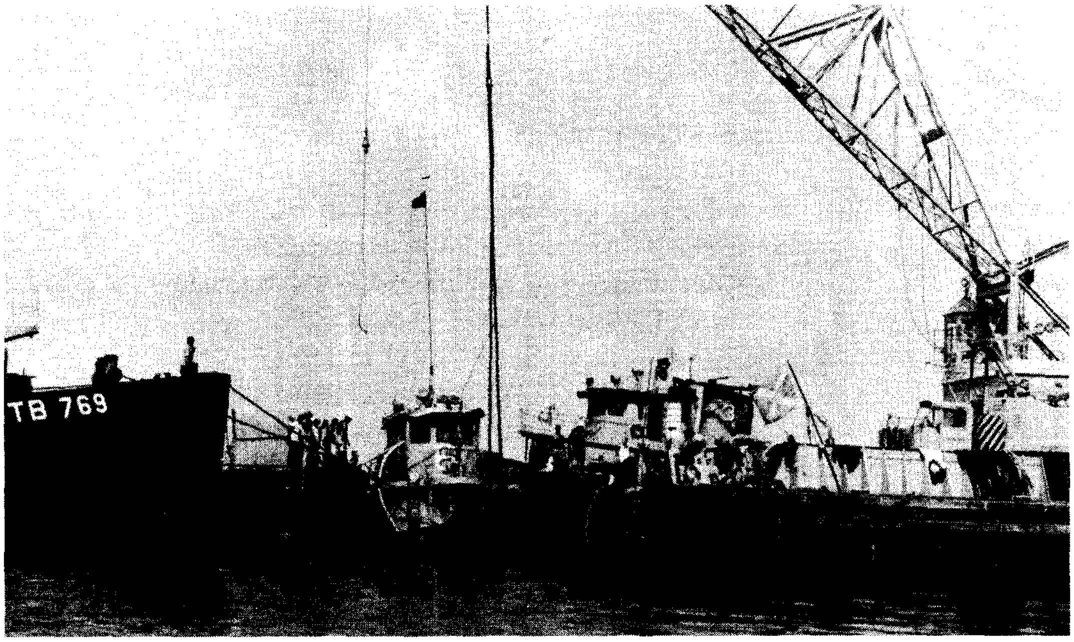
As the voids were being dewatered, strain on each leg of beach gear was increased to 25 tons. This force lifted the YTM about 5 feet off the bottom. All spaces were then pumped, reducing the tension to 10 tons. Strain on the beach gear was then reset at 25 tons.

Divers rigged a weak sling on the tug's head bitt and the sling was then connected to the crane hook on YD-204. Tension on the beach gear was again reduced. Then, as a heavy strain was renewed, the YTM-538 started up to the surface. In spite of all the spilled spaces, the tug came up very heavy. It surfaced at 1100.



Tug breaks surface as heavy strain is taken on beach gear. Sunken YTM came up heavy even though hull had been largely dewatered.

THIRD LIFT ATTEMPT PAYS OFF



Salvage force refloated the YTM after the lift, set water-tight boundaries and patched holed area. Large harbor tugs (YTB's) then towed it to Atlantic Marine Railway.

TUGS JOIN SALVAGE NEST AS YTM IS REFLOATED

REFLOATING THE TUG

The task force proceeded immediately to refloat the surfaced tug. All lift gear was set taut. Eductors and 3-inch salvage pumps were rigged on the tug's deck for further dewatering of the hull. A hole was cut in the top of the engine room's natural vent to provide access for suction hoses.

Patches were then systematically checked. When it became clear that the patches were holding, tension was gradually relieved on all beach gear. The vessel floated, without apparent difficulty.

COMPLETION OF OPERATIONS

With the tug afloat, the salvage force set up watertight boundaries and stripped designated spaces of all remaining water. Divers installed underwater patches on the holed area in the motor room space that had resulted from the collision. The area was 10 feet long and 1 1/2 feet wide. It proved difficult to patch, however. The seal broke on three different occasions as the motor room space was being dewatered. Plywood and J-bolts, backed with foam mattresses, were used as patching materials.

Attempts to patch the motor room were secured on 2 August. The patches were left in place and a pumping watch was established in the motor room, pending transfer of the YTM to drydock. The lifting rigs and dewatering equipment were dismantled. YD-204 was relieved. It returned to port while YD-89 remained in place at the salvage site.

The next day, 3 August, large harbor tugs (YTB's) were brought in to tow the refloated YTM-538 to the Atlantic Marine Railway. With the tug safely on the railway, the salvage force cleaned up, returned all equipment, and redeployed to home bases.

CONCLUSIONS

Working conditions for this salvage operation were ideal in certain respects. The tug was close to shore. Salvage resources were readily available from the fleet and from the Naval Station. The seas and weather posed no difficult problems. It was far from an easy job, however. The Officer-in-Charge of salvage operations and the Salvage Master welded together a remarkably efficient salvage team in a matter of a few days and proceeded to raise and refloat the tug efficiently and expeditiously.

This operation, as was the case with the righting of the REUBEN JAMES, required the application of a substantial number of salvage techniques. These included:

1. Beach gear was rigged on two YD's for lifting and holding the sunken hulk.

2. Four anchor moors and two bulldozer moors were used to lock the YD's in their lift positions.

3. Air, eductors and pumps were employed to lighten hulk in the bottom.

4. Rigging of heavy lifting slings by tunneling under the wreckage was accomplished.

5. Bulldozers on the beach helped to anchor the salvage nest. They also moved the sunken tug shoreward.

6. A YC barge, with land crane, was employed as the diving platform for rigging the tug for the lift.

SEARCH AND RECOVERY

OF

SOLAR ECLIPSE INSTRUMENTATION

PACKAGE OFF THE VIRGINIA CAPES

The NavalResearch Laboratory had programmed this rocket to provide the most extensive photographic coverage of a solar eclipse yet achieved. Loss of its instrumentation package in the deep ocean precipitated a unique search and recovery operation.

NASA LAUNCHING OF CAMERA-CARRYING ROCKET FROM WALLOPS ISLAND RANGE OFF THE VIRGINIA COAST

SEARCH AND RECOVERY OF SOLAR ECLIPSE INSTRUMENTATION PACKAGE OFF THE VIRGINIA CAPES

INTRODUCTION

A camera-carrying rocket was launched from the Wallops Island facility of the National Aeronautics and Space Administration (NASA) on 7 March 1970 in an experiment to provide extensive photographic coverage of an impending solar eclipse. The camera pods aboard the rocket formed part of a scientific instrumentation package assembled by the Naval Research Laboratory (NRL). The rocket was commanded to return to earth following the eclipse. The 400-pound instrumentation package was lost upon impact, however, apparently sinking in some 6,000 feet of water 75 miles east of Norfolk, Virginia.

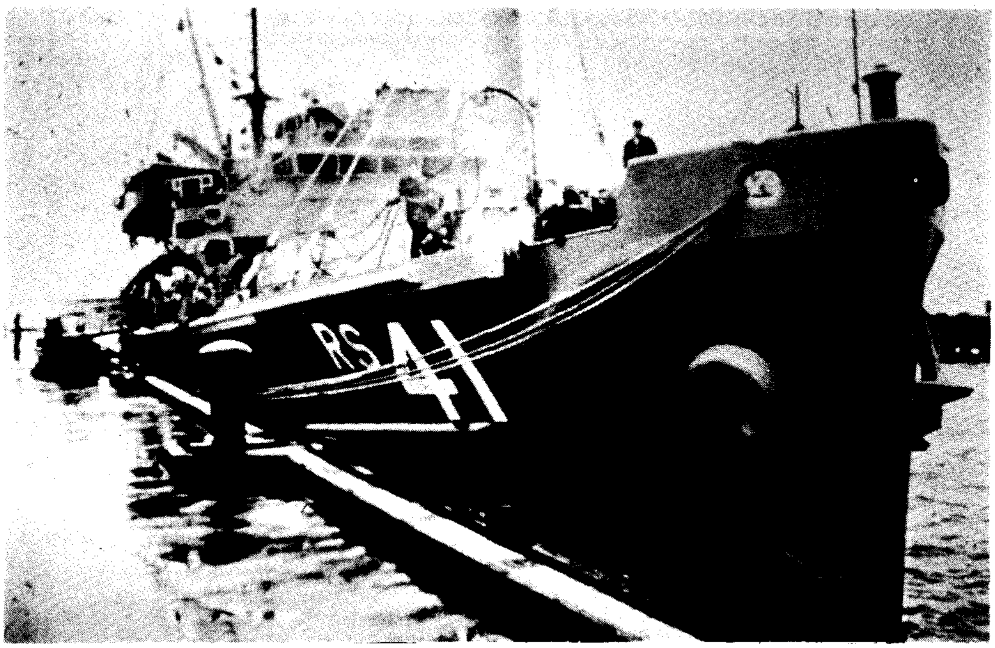
NASA and NRL requested the Supervisor of Salvage to attempt to recover the lost instrumentation package. The film of the solar eclipse was of great potential value to the scientific community, warranting a major recovery effort even though the chances of success appeared low in view of the small size of the package, its uncertain location, and the great depths in the impact area. The Supervisor of Salvage combined resources from the operating forces, Naval laboratories and commercial companies in a successful, highly coordinated search and recovery operation, featuring the Navy-owned, newly developed underwater recovery vehicle, CURV III.

ASSIGNMENT OF FORCES

The Supervisor of Salvage convened a conference on 12 March 1970 to discuss the feasibility of recovering the rocket's camera section. Available U.S. Navy and commercial deep recovery location and retrieval assets were examined and recovery techniques were discussed. Possible search datum points were determined based on a thorough examination of navigational tracking data, rocket impact predictions, pinger data, impact velocity and slant-range.

Selection of Recovery Vehicle and Platform

The Supervisor of Salvage determined that the Cable Controlled Underwater Research Vehicle (CURV III), equipped with sonar and underwater television and having a depth capability of 7,000 feet, was the most suitable. Consideration was also given to use of the submersibles, ALUMINAUT and DOWB.



This versatile fleet salvage ship proved to be an effective at-sea platform for controlling and supporting CURV III's underwater search and recovery operations.

USS OPPORTUNE (ARS-41)

The selection of an at-sea platform for the CURV system was made following the initial planning conference. It was concluded that the most cost-effective platform would be a fleet salvage ship (ARS). Accordingly, arrangements were made with the Commander Service Squadron EIGHT (COMSERVRON EIGHT) to provide the USS OPPORTUNE (ARS-41) as the command, control, and support ship for the operation.

Other Assignments

The Supervisor of Salvage tasked Ocean Systems, Incorporated (OSI) to provide management support, technical consultation and the precision navigation necessary to assist in the timely accomplishment of the task.

COMSERVRON EIGHT assumed overall operational responsibility for conduct of the operation, provision of supporting ships and craft, and logistic support ashore. NASA also participated, providing the supporting services of USNS RANGE RECOVERER and helicopter support for datum marking.

CURV III - CABLE CONTROLLED UNDERWATER RESEARCH VEHICLE

Characteristics of the System

CURV III is a cable controlled, free swimming unmanned submersible with a 7000-foot depth capability. The vehicle itself weighs approximately 4,000 pounds. Various types of ships can serve as the support platform since all topside control consoles can be packaged in a single control van which can be deployed with the vehicle to a ship of opportunity. The system's 7,000 feet of control cable are coiled in two basketlike containers. A spare parts van is also included in the topside equipment.

The system's principal search capabilities are a CTFM sonar mounted on the bow and two television cameras. The television cameras can pan 360 degrees and tilt through 180 degrees. They are supported with a floodlight system. A documentation system for still pictures, consisting of a 35 mm camera and an accompanying strobe light, is connected with the underwater television system.

The vehicle can do useful underwater work using a tool assembly that projects forward from the bow. A manipulator claw, mounted on the assembly, engaged the solar eclipse instrumentation package after it was located. It can be replaced with other types of tools and lifting devices as required for a particular task. CURV III also has other types of presensors aboard, such as an altimeter, depthometer and compass.

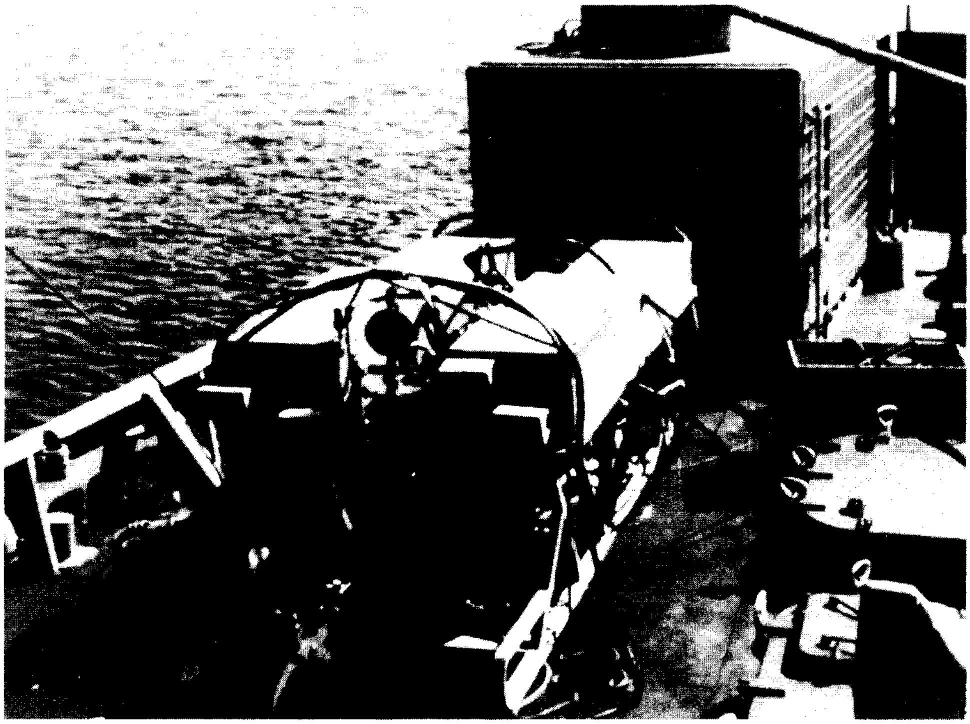
Control personnel in the topside van use three 10-horsepower propulsion systems aboard the vehicle to maneuver it underwater. One of them, mounted in the center, is used exclusively for vertical control. The vehicle, itself, floats with about 10-25 pounds of positive buoyancy provided by blocks of solid syntactic foam arrayed along the top of the frame. When operating on the bottom, the vertical thruster is used to drive the vehicle down, counteracting the positive buoyancy. The wash is, therefore, up and away from the vehicle, thus giving the cameras an unobstructed view.

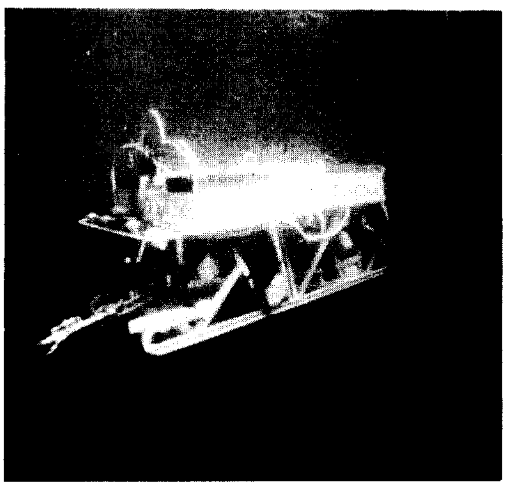
Advantages

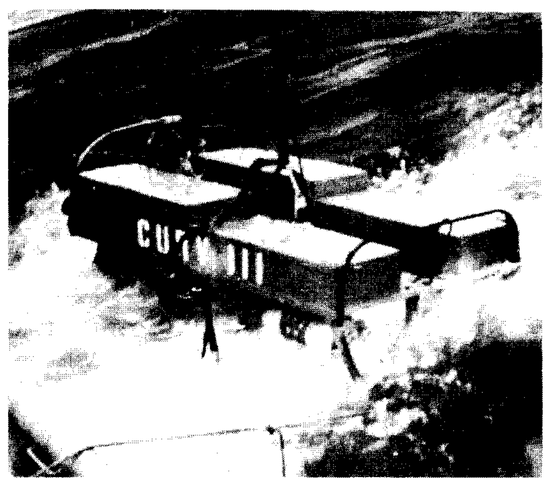
CURV III offered several advantages which made it ideally suited for the search and recovery task:

1. Bottom time is limited only by the endurance of the topside personnel in the control van operating the equipment.

2. The system eliminates the inherent problem of relying on someone else's description of an object. Observers can stand behind the operator and see the object on the television monitor. Problems relating to object recovery are clearly seen.







CURV vehicle and control van aboard OPPORTUNE in upper photo. Sonar and TV camera are mounted at bow on vehicle's upper frame. Manipulator projects forward from bow and has various tool assemblies. Claw tool for grasping solar eclipse package is shown in upper photo.

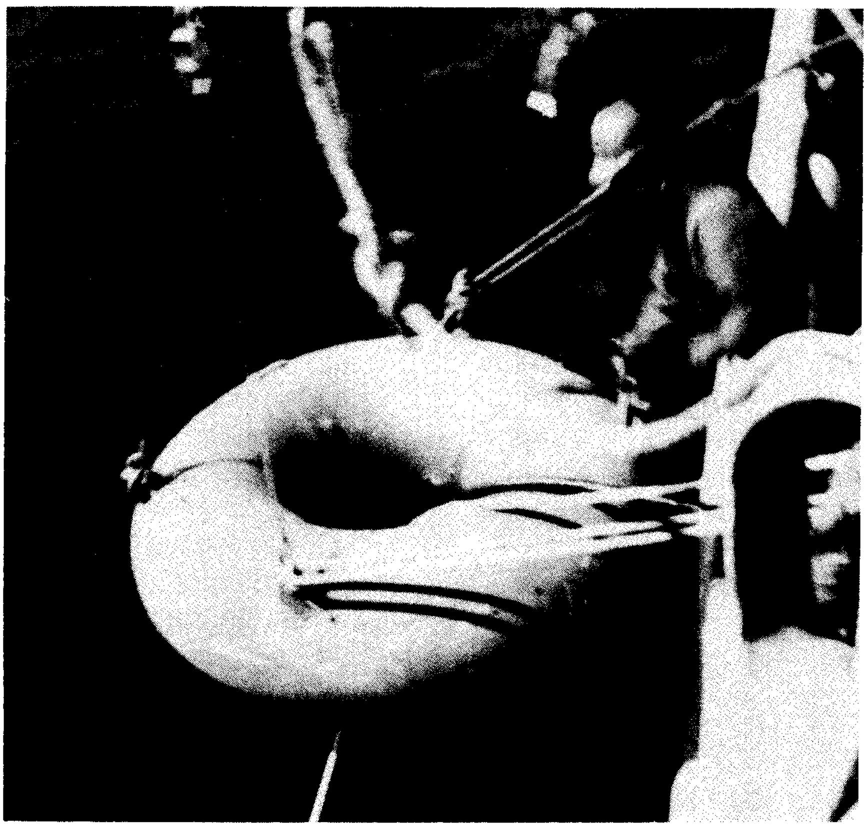
CURV III - CABLE CONTROLLED UNDERWATER RESEARCH VEHICLE

3. Still pictures can be taken in sequence for later reference. A video tape recorder can also provide a permanent record.

4. The vehicle can be equipped with devices for clasping and lifting objects such as the solar eclipse instrumentation package.

Construction and Application of the Cable Guard, "DONUT"

In its developmental employments off the coast of California, CURV III had routinely operated from a special support platform, a converted YFNX barge with two cycle propulsion thrusters for dynamic station-keeping. The Wallops Island deployment was the first opportunity for the system to operate at great depths from a ship such as OPPORTUNE where the ship's thrusters had to be used for station-keeping. Accordingly, special equipment had to be designed to protect the CURV's cable from being sucked into the ship's screws.



NURDC personnel fabricated this device with sections of piping and filled it with cement. Suspended in the water, it stabilized the CURV's control cable, keeping it clear of the ship's propellers.

CABLE GUARD "DONUT" IMPROVISED FOR THE OPERATION

Personnel of the Naval Undersea Research and Development Center (NURDC) fabricated a simple device for this purpose which soon became known as the "DONUT". It consisted merely of large diameter pipe sections with 180-degree bends, welded together and filled with about 3,800 pounds of cement. The concept was to suspend the DONUT over the side of the ship in about 50 feet of water, holding it with straps hanging fore and aft. The CURV's control cable and recovery line would feed through the hole in the center of the device. Using the DONUT, it was possible to keep the two lines tending straight down and away from the stern of the ship, keeping them from fouling the propellers. The tremendous mass formed by the cement helped to stabilize the lines even with the ship moving at slow speeds as it maintained station.

Deployment of CURV III to Norfolk

The CURV III development project is being conducted under the technical direction of the Naval Undersea Research and Development Center, San Diego, California. NURDC personnel were conducting experimental operations with the system at sea off Long Beach, California when the requirement was levied for the solar eclipse package recovery attempt. The entire system was withdrawn from at-sea operations, prepared for transportation, airlifted to Norfolk in two C-141 aircraft, loaded aboard OPPORTUNE, deck-checked and made ready to sail in less than five days from receipt of orders to deploy.

CURV'S SEARCH TECHNIQUE

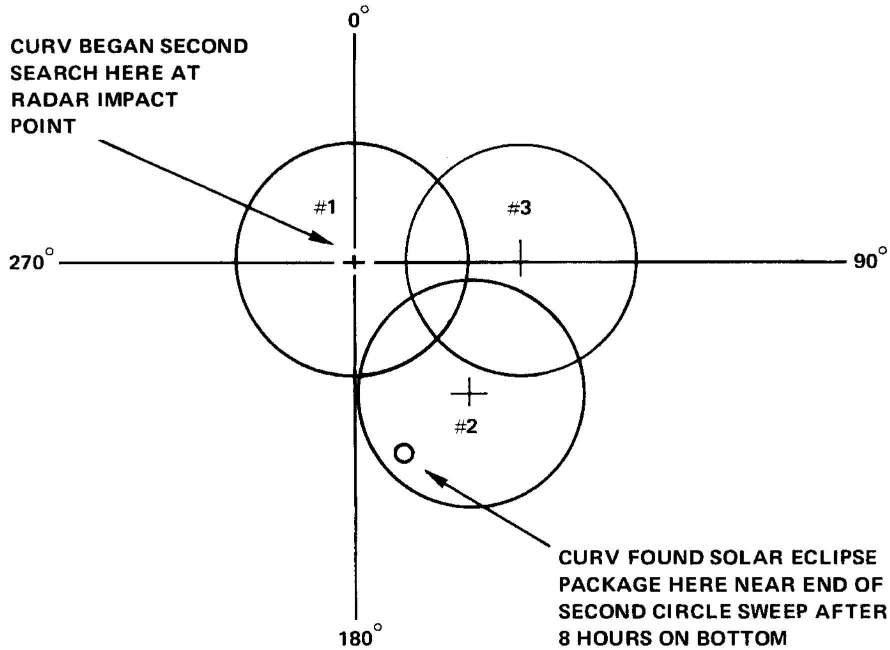
Implanting a Sonar Target

A sonar target is dropped from the support platform prior to deploying CURV. The target in this case was simply an anchor to which were attached several glass spheres and a pinger. The glass spheres provide an active target for the CURV's sonar while the pinger is a good reference for the passive portions of the sonar.

The vehicle is then deployed into the water and lowered to the bottom. Descent through the 5,800 feet of water in this operation took about two hours. The vehicle uses its CTFM sonar to close on the target and establishes its first search position on the bottom at the target location.

Covering an Initial 600-Foot Circle

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.



CURV uses sonar to locate potential targets within each circle and then investigates each target at close range with its television system.

CURV SEARCH PATTERN FOR SECOND AND SUCCESSFUL RECOVERY ATTEMPT

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.

Subsequent Search Circles

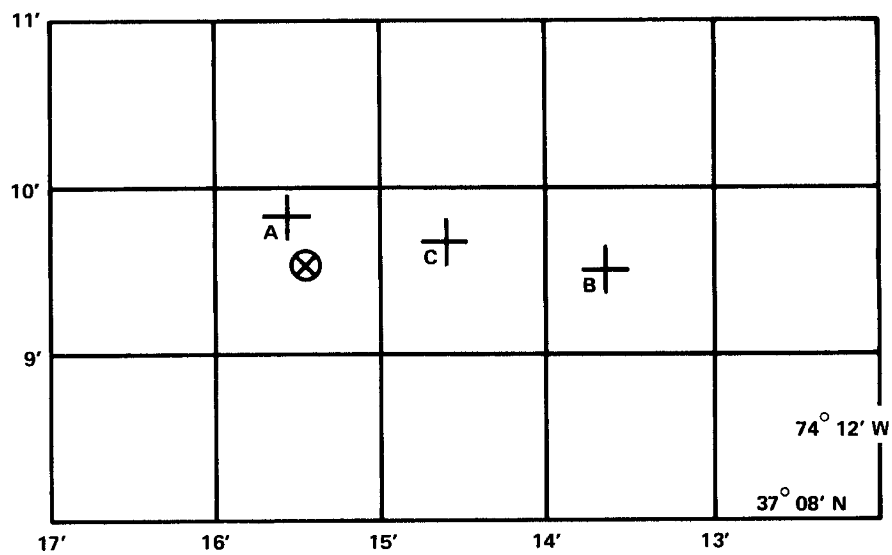
After completing its initial circle, the vehicle is maneuvered back to its original search position, closing again on the sonar target. It is then deployed to a new search position, using its active sonar and compass to mark range and bearing from the first position. The search pattern is then repeated. 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.

INITIAL SEARCH PROBLEM - WHERE TO LOOK?

The NASA rocket had been programmed to deploy a drogue parachute to carry the instrumentation package gently to the surface. Flotation gear would then maintain the package just below the surface while a water-activated 37.5 KC pinger would mark its location for recovery forces. The parachute failed to deploy in this instance. The package plummeted downward into the water and sank.

Two Assumed Impact Points

Analysis of the search problem revealed two critical items of information that could be used to establish a search datum point. One was the assumed, free-fall impact point of the package as extrapolated from radar plotting. NASA radar had tracked the falling camera pods to an altitude of 7,000 feet where radar contact was broken. The downward flight path was almost vertical. A probable impact point was extrapolated from these factors.



A – RADAR-EXTRAPOLATED FREE-FALL IMPACT POINT.

B – PINGER LOCATION AS CALCULATED FROM SIGNAL RECEIVED BY NASA RECOVERY VESSEL.

C – MID-DATUM POINT SELECTED FOR FIRST RECOVERY ATTEMPT.

⊗ – LOCATION OF PACKAGE WHEN FOUND BY CURV OPERATING FROM POINT A.

SEARCH DATUM POINTS AS COMPARED TO OBJECT LOCATION WHEN FOUND BY CURV

The other item was a possible impact location based on a signal from the 37.5 KC pinger mounted aboard the camera pod. A NASA recovery vessel had received the pinger signal. Its location was calculated relative to the recovery vessel's position which was determined through a LORAN fix. The pinger was a water-activated device intended to mark the location of the floating package for recovery forces. Since only one signal had been heard, and by only one vessel, the calculated location could not be considered fully accurate.

Attempts to Locate the Pinger

The task force deployed several vessels into the general area in an attempt to locate the pinger. USS SALINAN (ATF-161), working with the special locating equipment provided by NURDC, made the first effort. The equipment consisted of a very long pod lowered into the water to a hydrophone which was very sensitive to the sound source of the lost pinger. No results were achieved. A submarine, working in coordination with a NASA range recovery vessel and aircraft, also tried to make contact. These efforts did not succeed either, although the submarine did turn up one contact which was subsequently evaluated as being false.

Selection of Search Datum Points

The two probable impact points were about two miles apart. The search problem thus posed by this available data was a formidable one. It was not unlike an effort to find a piece of buckshot on a football field at night with just an ordinary flashlight.

In the ensuing operation, CURV III made two deep dives to locate the instrumentation package. For the first dive, which was unsuccessful, a search datum point was selected about midway between the radar-extrapolated impact point and the calculated pinger location. The radar-extrapolated impact point was selected for the second dive which proved to be successful. This search datum point was refined and verified prior to the dive by having helicopters drop smoke pods from the last reported position of the falling instrumentation package.

SYSTEM CHECK-OUT, 17 MARCH

OPPORTUNE got underway late on 16 March. Most of the next day was spent in station-keeping training and in conducting a 1000-foot check-out dive of the CURV system. Actual operations to locate the package commenced on the evening of 17 March.

Station-keeping

A RAYDIST navigation system had been contracted for by OSI and installed aboard OPPORTUNE to assist in station-keeping. This is a precision system which enables the ship to accurately position itself over the impact point and to maintain its position within 20-40 feet at all times. The degree of closeness to the impact point depends primarily on the skill of the Officer of the Deck in following the "XY" track plotter. The greatest distance away at any one time was not more than 150 yards. As the operation progressed, the distance was reduced to 20-40 feet as skill was acquired in using the plotter.

OPPORTUNE proved to be a very adequate vessel for station-keeping. Its twin screws were able to hold position in very rough weather. Smoke pots and flotation gear were deployed to mark the datum point. The RAYDIST system worked effectively. It was able to repeat positions within about 30 feet and the Officer of the Deck could turn the vessel from the actual radius plot.

Check-out Dive

The check-out dive, made at 1,000 feet, was conducted during the afternoon of 17 March. All systems worked well. The dive provided an opportunity to shake down OPPORTUNE's crew in handling CURV as well as a technical check by the system's controllers. The cable guard, DONUT, was employed for the first time on this check-out dive and it appeared to work satisfactorily.

FIRST SEARCH AND RECOVERY ATTEMPT

First Dive Fails

CURV dove at 2300 on 17 March for its first effort to locate and recover the lost instrumentation package. It spent 16 hours on the bottom, covering two search circles without success, although various targets were established by sonar and classified with the television system.

After 16 hours on the bottom, shorts began developing in the system. Intermittent at first, they soon caused inadequate television reception and an erratic compass. The seas were building up to 5-6 feet and rain and winds up to 20 knots were being encountered. In these circumstances it was decided to bring the CURV back up and recover it without delay.

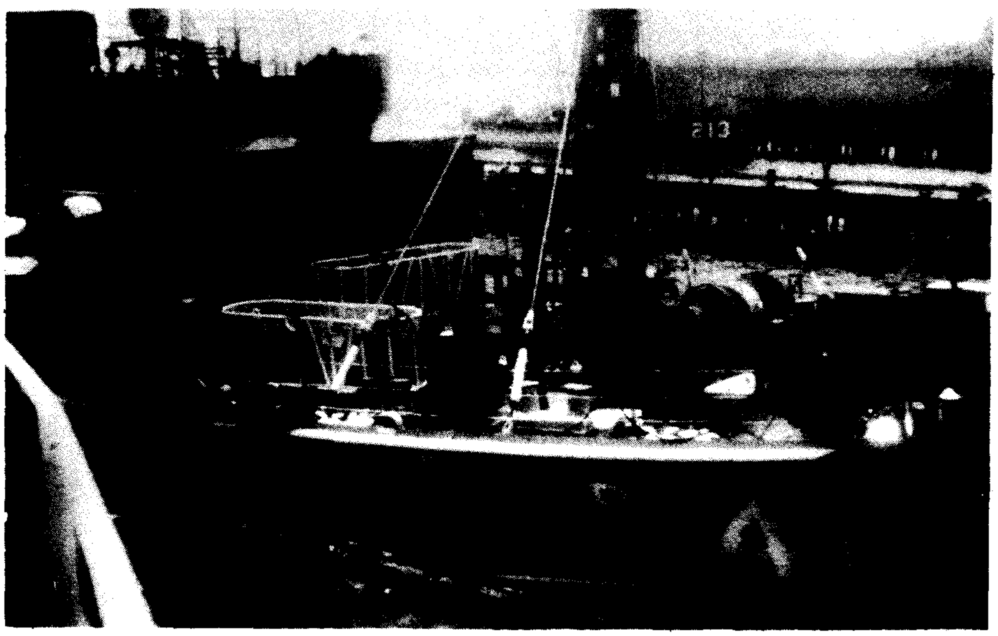
Recovery and Return to Port

Recovery was accomplished during the early evening of 18 March, being hampered by the unfavorable seas and weather and the clutter of CURV equipment on the stern of the OPPORTUNE. The vehicle was accidentally swung against the CURV van during the recovery, damaging the hydraulic claw assembly and cracking the syntactic foam in a few places. The task force returned to Little Creek, Virginia that night to make repairs and reevalutate the search problem.

SECOND SEARCH AND RECOVERY ATTEMPT

Preparations

The task force remained in port two days. Repairs to the CURV vehicle were accomplished quickly. The electrical shocks were traced to a 400-volt ground on a rented generator with dirty insulation. During this period, the two baskets, holding CURV's 7,000 feet of control cable, were shifted from the stern to the forward deck area of the OPPORTUNE. This change was made to reduce the clutter and provide more efficient working space on the fantail.



The two baskets, providing 7,000 feet of cable, took up substantial deck space. Note "U" frame for cable handling, mounted near bow.

CONTAINERS FOR CURV CONTROL CABLE ABOARD OPPORTUNE

The control cable was fairleaded through a 10-inch snatch block, hanging from a "U"-shaped frame over the roller, back along the rail (held by stoppers) to the CURV vehicle on the fantail. Deploying the cable from the bow area also was simpler in that the DONUT cable guard did not have to be used because of the extended distance between the cable and the ship's propellers.

Selection of a Different Datum Point

Time became critical at this point in the operation. NASA and NRL officials had estimated that the instrumentation package could probably remain in the water not more than two weeks before the information carried in the package deteriorated. Almost two weeks had already elapsed and the task force had only a little time left in which to locate and recover the package.

The task force reevaluated the situation and, in light of the urgency involved, discarded the search datum point used for the first attempt. It decided to renew operations from the point of projected free-fall impact of the rocket package. The thrust of the circular search patterns could be primarily westward from this point toward the reported pinger location and the first datum point.

Second Dive Succeeds

The task force got underway to the new datum point early on 21 March, arriving on station late that afternoon. The RAYDIST navigation system fix was verified by radar from Wallops Island. A helicopter dropped smoke pods to mark the datum position and confirm its accuracy. CURV entered the water at 1635 and was on the bottom at a depth of 5,850 feet, starting its search at 2000.

CURV was well into its second circular search pattern at 0400 when it picked up a target on sonar which, upon television inspection, turned out to be the instrumentation package. Control personnel attached CURV's claw to the package at 0515 and lifting operations began shortly thereafter.

Recovering CURV and the Instrumentation Package

The weather had turned bad by the time CURV broke the surface some five hours later. Winds were 20-24 knots and seas were running 10-12 feet. The control cable was transferred from the bow to the stern area where the hoisting equipment for picking the vehicle from the water was located. About 600 feet of cable had buoyed up, further complicating the handling problem.

The surfaced vehicle was on the leeward side of OPPORTUNE initially. The ship's propulsion was killed as divers began the task of rigging lines to the package, still held by the CURV's claw. The ship drifted into the floating vehicle and before control could be regained, the vehicle went underneath the OPPORTUNE surfacing again 300 feet on the opposite side. The CURV's control cable became snarled on the ship's propellers which, fortunately, were not turning. The cable worked itself loose before any damage could ensue.

OPPORTUNE then maneuvered downwind of CURV. The vehicle was placed at a depth of some 40 feet about 50 feet from the ship. Control personnel applied the vehicle's propulsion systems to maintain it in this position as divers went about the difficult work of attaching retrieving lines to the instrumentation package. They completed this task at 1208. The claw was then released from CURV and brought aboard with the package. Exceptionally careful seamanship was required to bring the camera pods aboard without damaging them in the heavy seas. The recovered package was immediately wrapped in black paper as it was extremely sensitive to the rays of the sun.

With the package recovered, steadying lines were made fast, the OPPORTUNE's boom hooked on, and the CURV hoisted aboard. The vehicle had been in the water over 21 hours on this second and successful dive. All systems were still working satisfactorily when it was brought aboard. The task force then got underway for the return trip to Norfolk, Virginia, its mission accomplished.

Seaman working in heavy weather handle the recovered package gingerly as it is brought aboard the OPPORTUNE.

PRIZE PACKAGE – THE SOLAR ECLIPSE INSTRUMENT POD

CONCLUSIONS

The operation was imaginatively planned and carefully executed in all important respects. Following, as it did, the recovery of the Deep Research Vehicle, ALVIN from 5,051 feet and the retrieval of SNAP-7E, an acoustical beacon, from 16,000 feet, this operation provided yet another indicator of the U.S. Navy's capability to find and recover lost objects in the deep ocean. The water depth in this instance was 5,850 feet with recovery made even more difficult by the small size of the solar eclipse instrumentation package and the rough seas in the operating area of the Virginia Capes.

The technical performance of the CURV III system was impressive, notwithstanding the electrical shorts that cut short the first dive after 16 hours. The malfunction was traced to a dirty generator, one which had been rented by NURDC personnel as they deployed the system from California. Apart from this difficulty the system performed as expected, proving itself to be reasonably rugged in the rough seas. The adjustments made in the deck arrangements and locations of CURV's topside equipment after the first unsuccessful dive improved control and deck handling substantially.

There appear to have been two mistakes in judgment during the operation. The first concerned the selection of the initial search datum point. The radar-extrapolated free-fall impact point seemed to be the most logical point available. Yet it was rejected initially in favor of a mid-point datum which represented a compromise among the best available data. The second dive confirmed the accuracy of the radar-extrapolation.

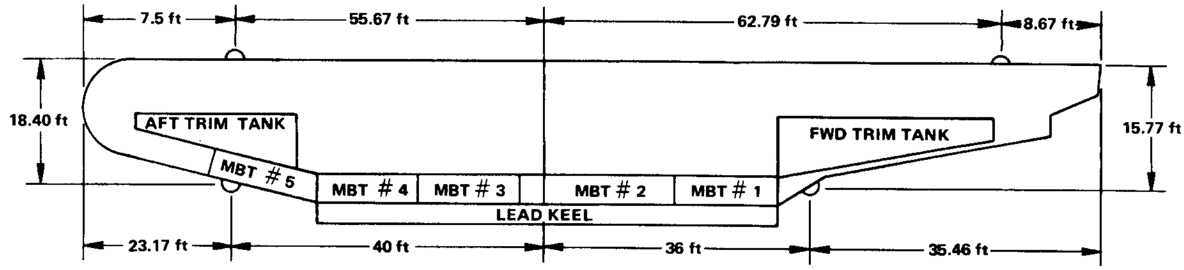
The other mistake lay in surfacing the CURV vehicle on the leeward side of the recovery ship. The probability of the OPPORTUNE drifting into and, in effect, over the CURV vehicle was evidently not foreseen. It was apparently thought that the CURV control personnel could maneuver and position the vehicle to keep it free of the OPPORTUNE until it could be hoisted aboard.

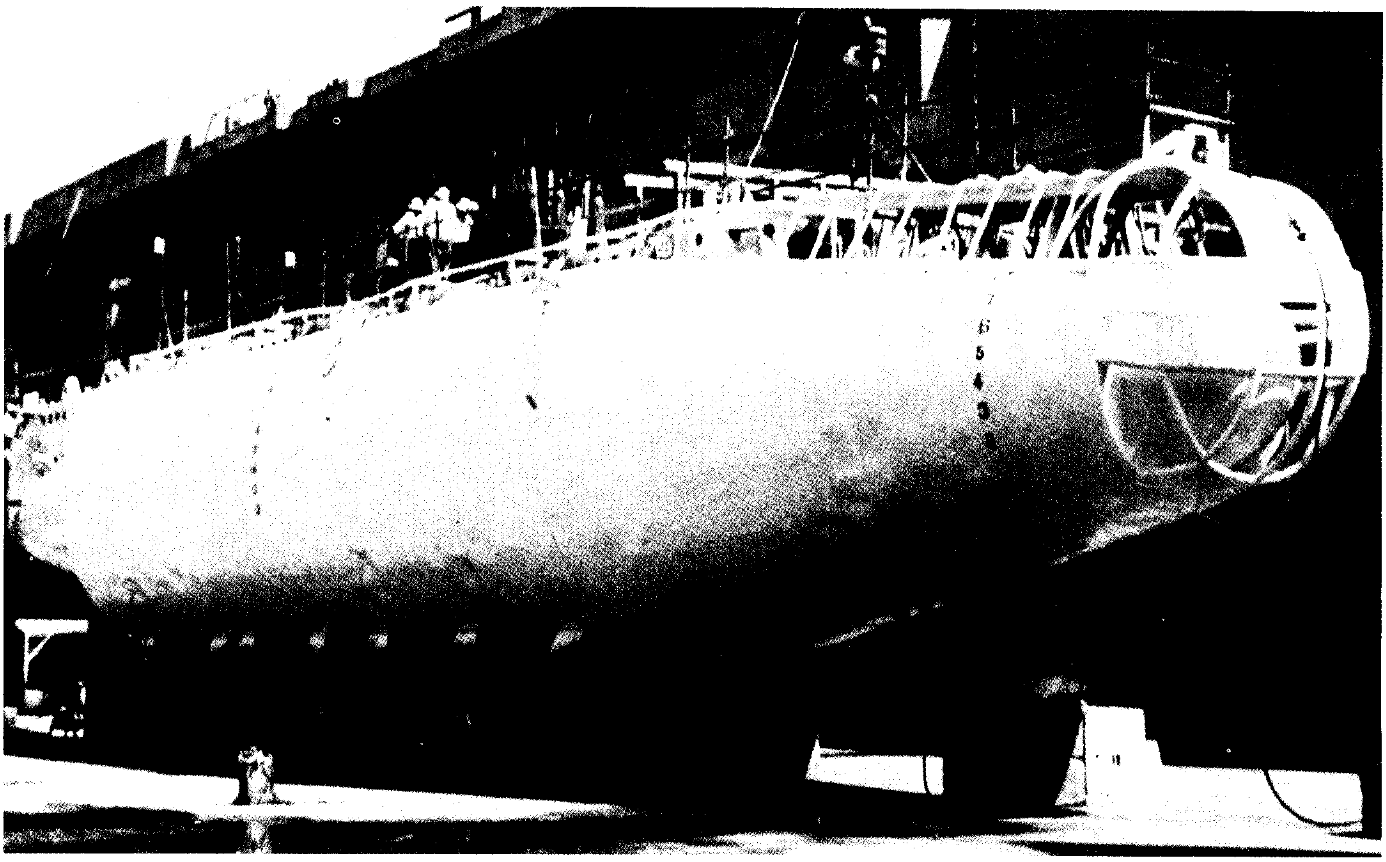
However, these mistakes were minor by comparison with the overall achievement of the search and recovery force. Consider the factors involved. The task force was assembled from both coasts and from a wide variety of Naval and civilian sources within a matter of days. Principal reliance was placed on a developmental system being employed operationally for the first time at depths of almost 6,000 feet. The instrumentation package was located and recovered in less than a week of active search. These factors, coupled with the object's small size, the great depth and the unfavorable weather, add up to a remarkably successful search and recovery operation.

SQUAW — SUBMERGED MOORING

OF

A MODEL SUBMARINE HULL





SQUAW, shown here at the Naval Shipyard, Long Beach, California, is a model experimental submarine hull. Mooring operations were conducted in November 1970 to implant the 135-foot long hull off San Diego for use as a sonar training target.

SQUAW BEING READIED FOR MOORING OPERATION

SQUAW–SUBMERGED MOORING OF A MODEL SUBMARINE HULL*

INTRODUCTION

The SQUAW, a model experimental submarine hull had been implanted in a subsurface moor off San Diego, California in 1965 for use as a sonar training target. The hull surfaced in 1970 when the moor failed. Consultations with the Pacific Fleet confirmed the need for continuing use of the SQUAW as a sonar target and led to a commitment by the Supervisor of Salvage to undertake a mooring operation.

The ensuing operation, completed within a 7-day period, entailed the use of a drop system for implanting the moor. Four mooring legs were lowered first and secured to the SQUAW. The hull was then submerged. Two inner vertical legs with heavy counterweights maintained the hull at its prescribed depth. Two outer legs, assuming an underwater catenary contour configuration, restrained horizontal movement. The resulting moor, which positioned the SQUAW 300 feet below the surface in water depths of 3,492 feet, is calculated to hold the hull for 5–10 years.

INITIAL PLANNING

The plan for the mooring operation was developed in a coordinated effort involving many different commands and agencies. Mr. Earl Lawrence, Representative of the Supervisor of Salvage, developed the basic mooring plan and list of materials. The initial plan was then refined and support requirements were established in a series of conferences with fleet command and appropriate agencies ashore.

Technical and Logistic Support

Key technical and logistic support were provided as follows:

Public Works Center, Naval Station, San Diego – Preparation of SQUAW and logistic support.

Naval Shipyard, Pearl Harbor – Fabrication of equipment.

*For the complete report, see THE SQUAW, NAVSHIPS 0994-011-2010.

Naval Ship Undersea Research and Development Center, San Diego – Instrumentation and oceanographic surveys.

Naval Shipyard, Long Beach – Engineering services and SQUAW drydocking.

Assignment of Operational Forces

Commander Service Group ONE (COMSERVGRU ONE) assumed operational responsibility for the effort. CDR J.W. Warren, from SERVGRU ONE, stationed aboard MOLALA, was Senior Officer Present Afloat (SOPA) for the operation.

The mooring plan, as developed, envisioned the coordinated employment of three ocean tugs to lay the mooring legs, transport SQUAW to the site and moor it. The following three ships were assigned, all playing key roles in the operation:

2 – Fleet Ocean Tugs

USS CHOWANOC (ATF 100) – CO, LCDR P.W. Wolfgang
USS MOLALA (ATF 106) – CO, LT K.C. Roberts

1 – Auxiliary Ocean Tug

USS KALMIA (ATA 187) – CO, LCDR F.R. Sandevlin

CONCEPT AND CONFIGURATION OF THE MOOR

The Mooring System

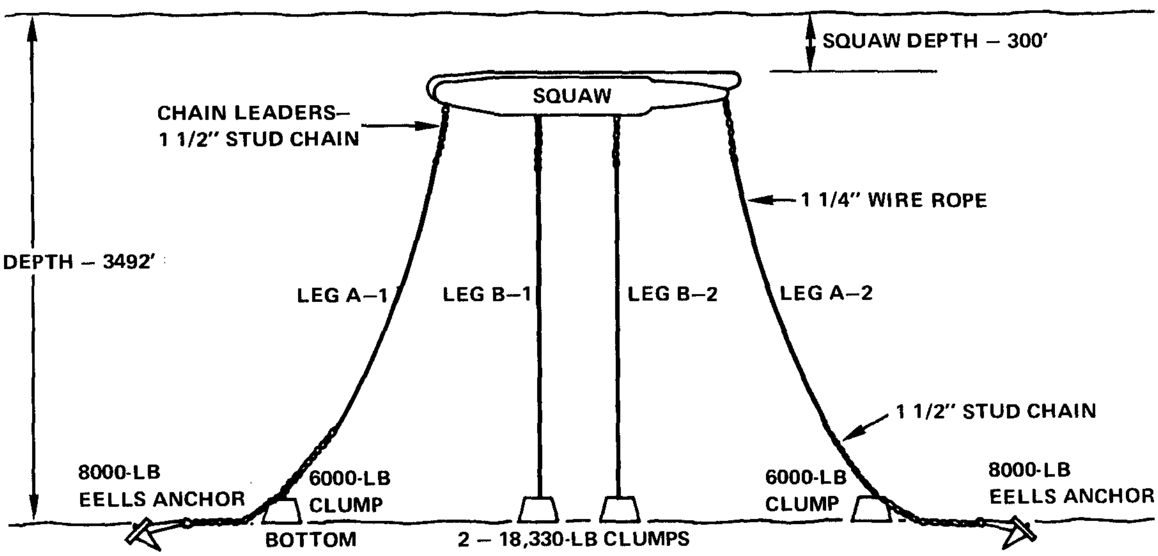
Planners foresaw at the outset that huge amounts of equipment would be required to deploy the large mooring system involved. Accordingly, they decided to use a drop system for implanting the moor. The drop system was efficient for moors of this scale and also ensured maximum safety in handling equipment, particularly in rough seas. Safety remained a paramount consideration, not only in developing the concept for the moor, but also throughout the actual conduct of operations.

Design Calculations and Considerations

The effects of ocean currents on the mooring legs were negligible at the mooring site off San Diego. This meant that the outer mooring legs would assume the configuration of a weighted catenary. The catenary in this case would be a compound one, as the leg would be made up of chain and wire-rope. Calculations of vertical forces could be made by summing the weight of the chain and the wire rope in the catenary. Tension could be computed by vector addition of vertical and horizontal forces.

The Naval Shipyard, Long Beach developed the necessary calculations for the composition and configuration of the mooring legs and for the establishment of necessary tolerances. Computations were affected by such factors as ship storage capacities, equipment capabilities and characteristics, and the provision that wire rope used in the legs be kept clear of the bottom at all times. A significant parameter in this regard was the recommendation of the Supervisor of Salvage that surplus mooring materials be used wherever possible in order to reduce costs.

The structure of the SQUAW hull was still another important design consideration. SQUAW has five main ballast tanks which can be used to control ascent and descent movements. The pressure hull provides buoyancy. Two trim tanks, one forward and one aft, and the lead keel of the hull can be used to adjust ballast as required. The SQUAW also had four rugged padeyes welded to its hull for previous mooring operations which, upon inspection, were judged to be adequate for the new effort.



Heavy clumps anchoring the vertical inner legs restrain the hull from surfacing. Outer legs, forming an underwater catenary, are also anchored securely, restraining horizontal movement of the hull.

CONFIGURATION OF SQUAW MOOR

The required net buoyancy of the hull was computed by summing the vertical reactive forces at the surface and submerged positions. All ballast tanks were assumed to be 100 percent full before deballasting. Weight increases due to factors such as possible water-logging of the hull from prolonged periods of submergence were not included. Data obtained from previous moorings of the submarine hull were used as appropriate.

Instrumentation and Other Aids

Various measuring devices indispensable to the operation were utilized to obtain information and record data and to maintain constant monitoring of changes that occurred. Accuracy required in crucial and critical moments dictated the use of such instruments as tensiometers and footage indicators for measuring cable tension and length. Recording capacities of these particular devices were 100,000 pounds. In addition to the foregoing, a depth recorder was used to produce a bathymetric chart of the mooring area.

Of equal importance were the many activities associated with communication, navigation, and distance measurements. Means were provided by which all ships in the task force could at any time quickly determine their relative and absolute positions and the distance between them. Ocean currents were investigated (surface, midwater, and bottom) to determine direction and magnitude, and ocean bottom characteristics were studied and examined. Accurately positioned buoys served to guide and aid ship movements and provided visual reference when vessels maintained their stationary positions.

Composition of the Outer Mooring Legs

The outer mooring legs, to be attached to the bow and stern of the SQUAW, were designated A-1 and A-2. Each was made up in the same manner, consisting of the following principal components, in ascending order from the bottom:

1. 8000-pound Eells anchor and 6000-pound clump.

2. 270 feet (3 shots) of 1 1/2-inch stud chain connecting the Eells anchor and clump.

3. 450 feet (5 shots) of 1 1/2-inch stud chain connecting the clump to the wire rope which formed the leg's longest component.

4. Two 2850-foot lengths of 1 1/4-inch wire rope connected by marrying an open socket with a closed socket.

5. 90 feet (1 shot) of 1 1/2-inch stud chain connecting the leg to a padeye on the SQUAW's hull. This length served as a chain leader, resisting destructive motions of the hull.

The foregoing five principal components formed each outer mooring leg in its final configuration. Two other components were used temporarily for specific purposes. One was a 4000-foot crown line made up of 1 1/4-inch wire rope. The crown line, connected to the Eells anchor and a surface marking buoy, was used to lift the anchor and apply tension on the leg for establishing the desired catenary.

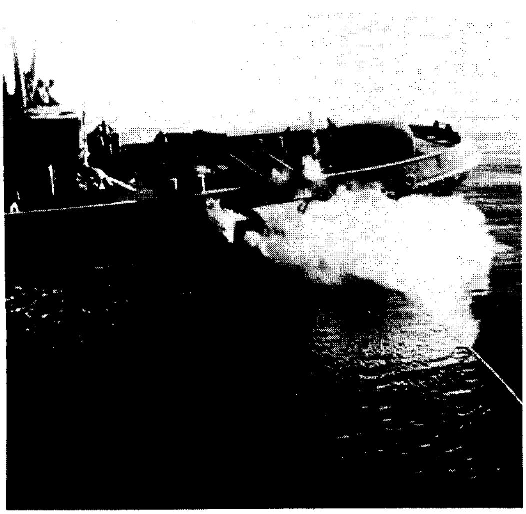
The other temporary components were a MK-4 surge buoy and a 500-foot pendant of 1 1/4-inch wire rope. The surge buoy supported the leg temporarily until it was dropped to the bottom. The pendant was connected by 2-inch bolt shackle to the ground ring which formed the juncture of the chain leader and wire rope on the mooring leg. This pendant was used to raise and lower the legs during the installation process.

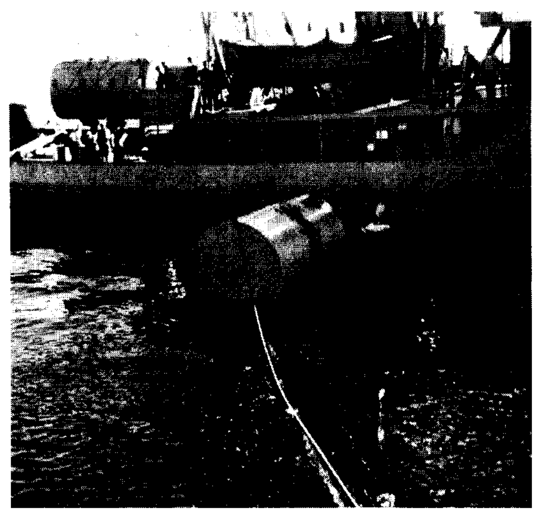
Composition of the Inner Mooring Legs

Both inner moorings legs, B-1 and B-2, were made up in the same manner. The principal components of each leg were as follows:

1. An 18,330-pound clump provided the counterweight for maintaining the SQUAW suspended from the bottom depth of 3,492 feet at the prescribed mooring depth of 300 feet.

2. 90 feet (1 shot) of 1 1/4-inch stud chain connected the clump to the wire rope which formed the longest component of the leg.





The huge surge buoys were used extensively throughout the mooring operation to help control the lowering of clumps, anchors, and the SQUAW itself.

KALMIA DEPLOYING MK-4 SURGE BUOYS AT MOORING SITE

3. One 3000-foot length of 1 1/4-inch wire rope.

4. A chain leader of 1 1/4-inch stud chain connecting the wire rope to the SQUAW's hull. The length of this chain leader was computed after the mooring legs had been lowered.

In addition to these four principal components, the task force used a MK-4 surge buoy and a 500-foot pendant on each inner mooring leg. These items were temporarily attached to the inner leg in the same manner and for the same purpose as on the outer legs. They served to help control the inner leg during the lowering process and the transfer to the SQUAW.

PHASES OF THE MOORING OPERATION

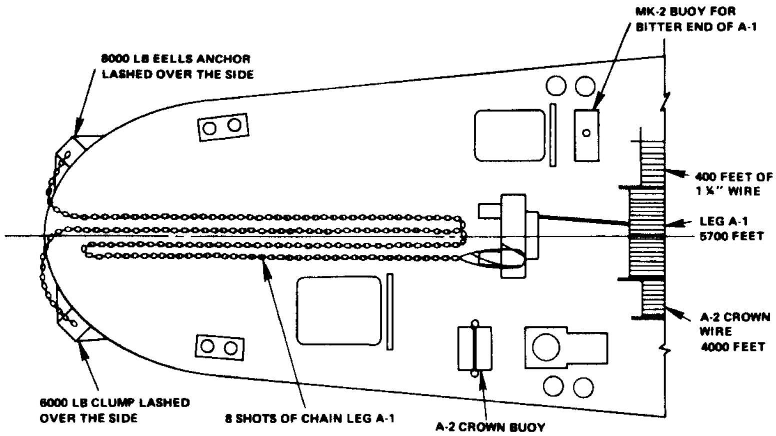
The mooring plan was developed as a series of operational phases, each one to be undertaken in a methodical, logical manner by applying successive step-by-step procedures. Each phase was outlined in a detailed schedule of events and designed to merge smoothly into the following phase.

The principal phases of the operation were specified as follows:

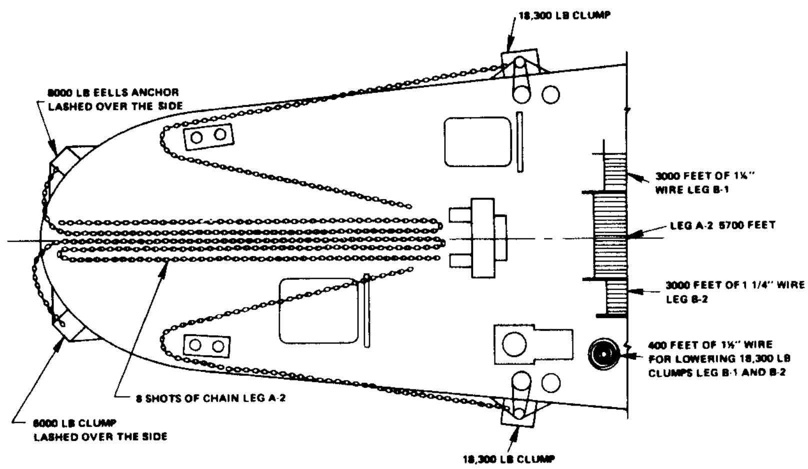
Loading and Rigging of Ships
Lowering the Outer Mooring Leg, A-1
Lowering the Outer Mooring Leg, A-2
Lowering the Inner Mooring Leg, B-1
Lowering the Inner Mooring Leg, B-2
Transferring all Mooring Legs to SQUAW
Flooding Ballast Tanks and Correcting Catenary
Retrieving Surface Buoys

LOADING AND RIGGING OF SHIPS

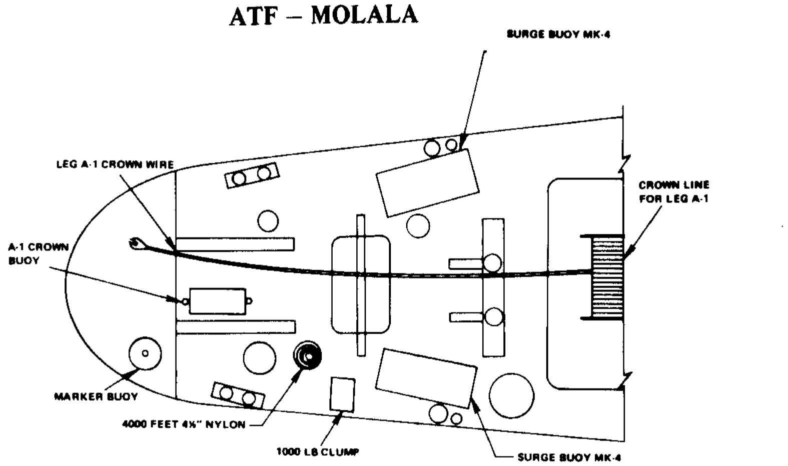
Ship loading and rigging were designed so that the three tugs of the task force could work efficiently in pairs to prepare the moor and implant it. The two ATF's, CHOWANOC and MOLALA, carried the principal components of the four mooring legs. The ATA, KALMIA, carried the crown line for leg A-1 and the two huge MK-4 surge buoys initially. After helping CHOWANOC with the lowering of the first anchor leg, A-1, KALMIA returned to port, picked up SQUAW and towed it back to the mooring site.



ATF – CHOWANOC

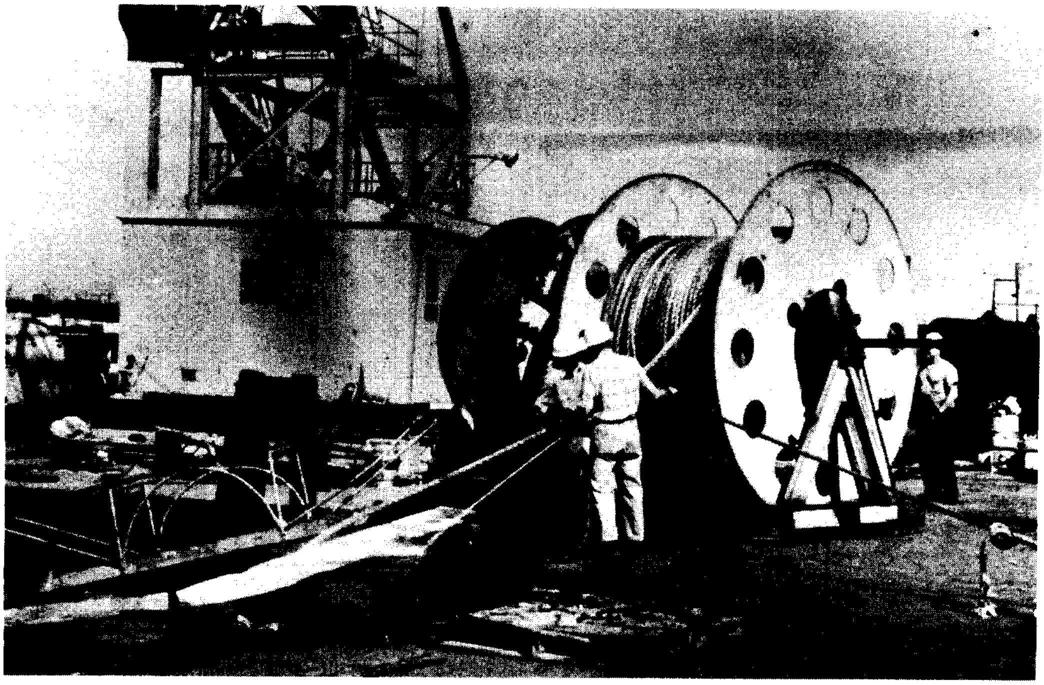


ATF – MOLALA



ATA – KALMIA

LOADING OF ATF'S AND ATA FOR SQUAW MOOR



The task force needed the towing drums aboard CHOWANOC and MOLALA for stowing and rigging the anchor legs of the moor. Tow wire normally stored on these drums was removed and placed on power reels.

ATF'S 2-INCH TOW WIRE STORED ON POWER REELS

Loading of CHOWANOC and MOLALA

Each ATF carried the principal components of one outer mooring leg. These components were rigged in a similar manner aboard each tug. The Eells anchors and 6000-pound clumps were lashed over the side near the bow, the chain was laid out on deck, and the wire rope was stored on the towing drum. CHOWANOC carried leg A-1 while MOLALA carried leg A-2.

The loads aboard the two ATF's differed in two important respects. MOLALA also carried the principal components of both inner mooring legs, B-1 and B-2. The heavy (18,330 pounds) clumps were lashed over the side secured to quarter bitts, ready for lowering. The tug's wing drums were used to store the wire rope for these legs. Provisions were made to transfer this wire from the wing drums to the tug's towing drum for the lowering process. CHOWANOC, on the other hand, carried the buoy and wire rope for the crown line of leg A-2, storing the latter on one of its wing drums.

Loading of KALMIA

The ATA was rigged to support CHOWANOC in the task of lowering leg A-1. KALMIA carried the buoy and wire rope for the crown line of leg A-1, storing the wire on its towing drum. She also carried the MK-4 surge buoys which were to be used in lowering the various mooring legs. The MK-4 buoys were mounted on skids so that they could be launched directly over the side without the necessity of lifting them.

LOWERING THE OUTER MOORING LEGS

Lowering Leg A-1

CHOWANOC and KALMIA, working together. accomplished the first principal task. that of lowering leg A-1. Prior to doing so. KALMIA layed a positioning buoy to mark the site and also made a fathometer survey.

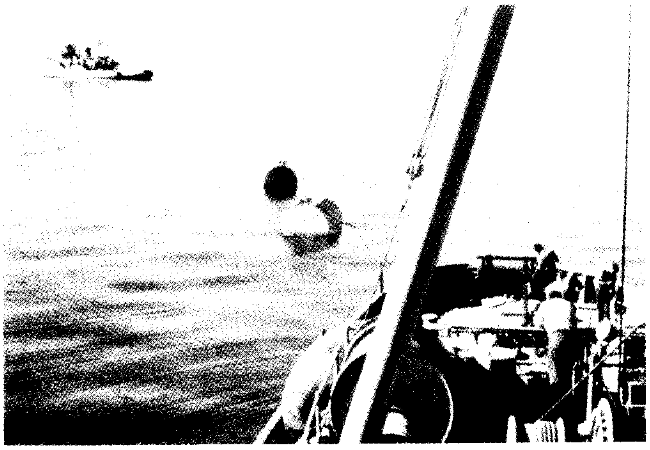
The two tugs lowered the outer mooring leg in a series of discrete steps that had been carefully worked out in preoperational planning. KALMIA initiated the process by transferring the two surge buoys and the crown line for leg A-1 to CHOWANOC. CHOWANOC then lowered the Eells anchor and the 6000-pound clump, supporting each with a surge buoy. Chain for leg A-1 was then payed out and its weight transferred to the towing drum wire.

CHOWANOC and KALMIA then proceeded to pay out the 5,700 feet of wire rope for leg A-1 and the 4,000 feet of wire rope for its crown line. With the wire fully payed out. UDT personnel then severed the lines to the two surge buoys with explosive cutters. the Eells anchor and 6000-pound clump then settling to the bottom. KALMIA then stretched them out, retrieved the two surge buoys and delivered them to CHOWANOC for the next lowering effort.

Lowering Leg A-2

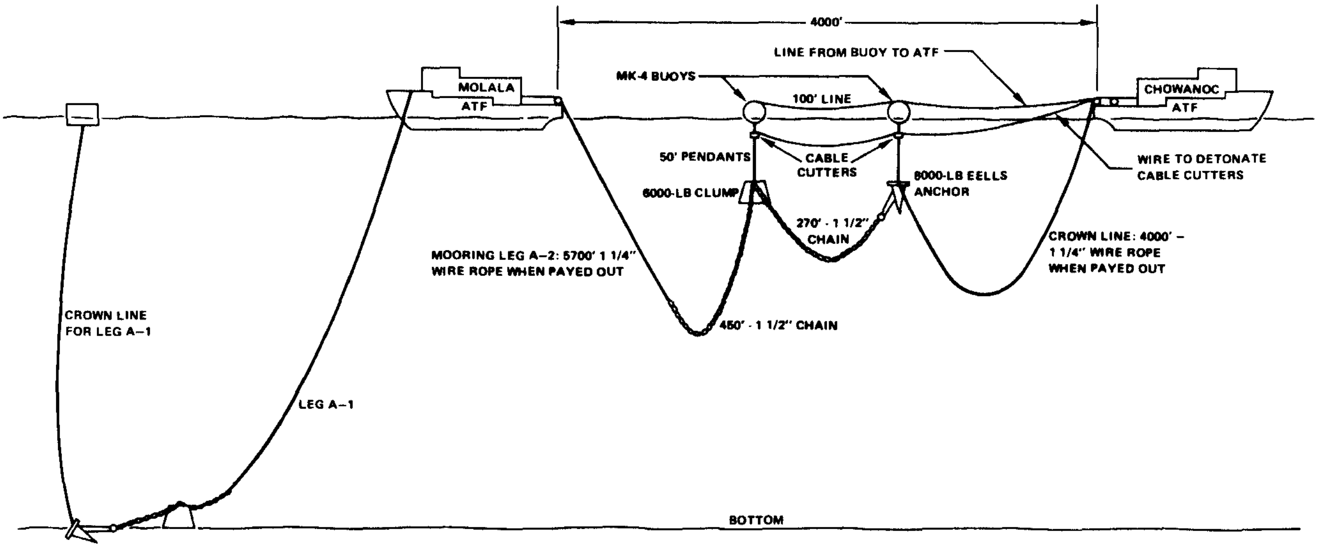
With the first leg laid successfully. MOLALA and CHOWANOC teamed up for the task of lowering the second outer mooring leg. A-2. MOLALA was carrying the principal components of this leg while CHOWANOC was carrying the wire for its crown line. Both ships followed the same steps that CHOWANOC and KALMIA had applied on lowering leg A-1.

Both CHOWANOC and MOLALA installed tensiometers on the mooring legs. CHOWANOC went on a downwind heading, took a strain, and observed tensiometer readings until leg A-2 was on the bottom.



CHOWANOC and KALMIA pay out wire rope for mooring leg and crown line as UDT personnel prepare explosive wire cutters for severing the pendants connecting surge buoys with suspended anchor and clump.

LOWERING OF MOORING LEG A-1 NEARS FINAL STEP



MOLALA deployed the Eells anchor and clump first, suspending them from the MK-4 surge buoys. MOLALA then payed out the wire for the mooring leg while CHOWANOC payed out the crown line. UDT personnel then cut the buoys loose, dropping the weights to the bottom. CHOWANOC and KALMIA had applied the same procedures in lowering leg A-1.

ATF'S IN PROCESS OF LOWERING LEG A-2

LOWERING THE INNER MOORING LEGS

Change in Sequence, B-2 Lowered First

The task force had originally planned to lower leg B-1 first followed by B-2. However, the 3000-foot length of wire for leg B-1 was fouled and damaged in removing it from the MOLALA's wing drum and had to be replaced. Accordingly, MOLALA proceeded to lower leg B-2 first. The lowering procedures for both of the inner mooring legs were similar to those that had been applied in lowering the outer legs.

In lowering leg B-2, MOLALA first connected the 18,330-pound clump to a surge buoy, using a 60-foot pendant for this purpose. The wire for leg B-2 was then connected to the clump using a miller swivel and 1 1/2-inch chain. The clump was then lowered until the buoy supported its weight. MOLALA then floated the buoy forward to the bow area and proceeded to pay out the remainder of leg B-2.

UDT personnel then placed cutters on the 60-foot pendant and fired them, releasing the surge buoy and allowing leg B-2 to settle on the bottom.

Lowering Leg B-1

In view of the damage to the wire rope aboard MOLALA, CHOWANOC went back into port to pick up a spare 3000-foot length of 1 1/4-inch wire rope. She returned with the required line the next day, ready to assist MOLALA in the task of lowering leg B-1. MOLALA first attached a 60-foot pendant to the second MK-4 surge buoy. CHOWANOC then came alongside, moored, and passed the anchor end of leg B-1 to MOLALA. Leg B-1 was then shackled to its 18,330-pound clump using a miller swivel and 1 1/4-inch chain as on leg B-1.

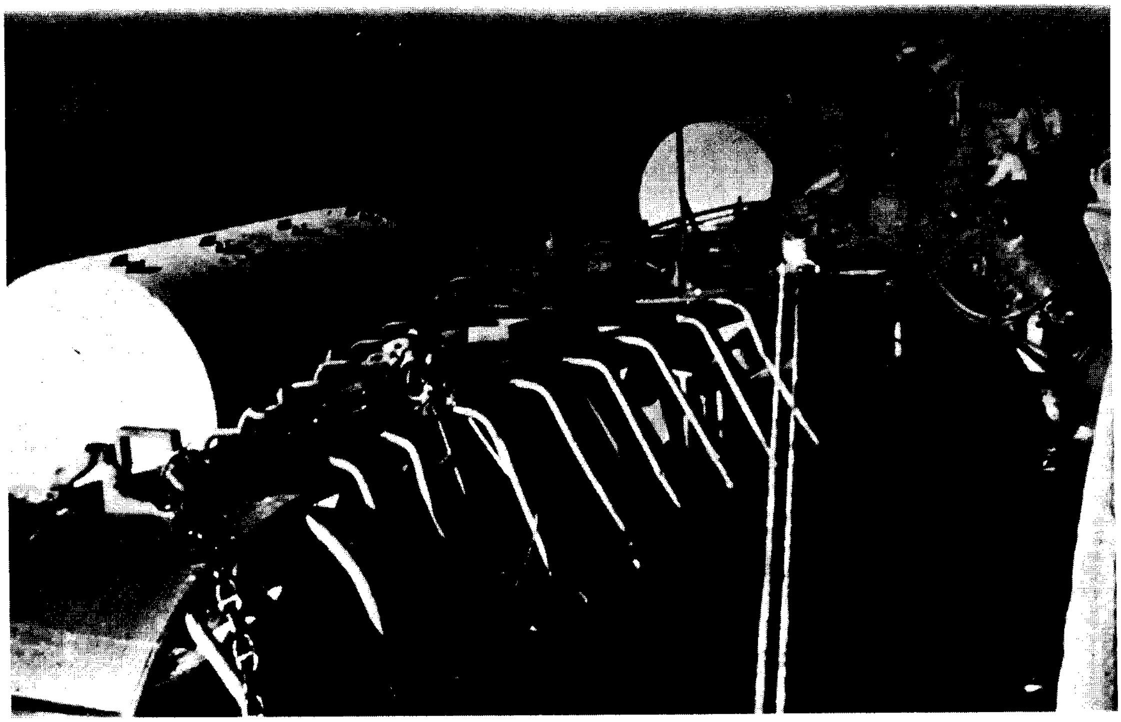
MOLALA next lowered the clump into the water until the surge buoy supported its weight. CHOWANOC payed out the remaining 3,000 feet of wire and then passed the "big ring" (7 1/2-inch inner diameter) on its bitter end to MOLALA where it was secured to the deck. UDT personnel then severed the buoy and clump, allowing leg B-2 to settle to the bottom.

TRANSFER OF MOORING LEGS TO SQUAW

KALMIA brought SQUAW alongside MOLALA for the transfer of mooring legs. The ATA also maintained control of the two surge buoys pending their attachment to SQUAW.

The plan for transferring the four mooring legs called for attaching them to the SQUAW's hull with chain leaders (pendants of 1 1/2-inch chain). MOLALA cut the pendants for the inner legs, B-1 and B-2, adjusting their length so that the 18,330-pound clumps on the anchor end of these legs would maintain SQUAW 300 feet below the surface when the model submarine was properly ballasted.

Each leg was then attached to its chain pendant, connecting it to the SQUAW. MOLALA used a 500-foot length of 1 1/4-inch wire rope to bear the weight of each leg as it was lowered beneath the SQUAW. This line was cut when SQUAW had the weight of each leg and was supporting it. The four mooring legs were transferred to SQUAW in the order B-1, B-2, A-2, and A-1, using these procedures.



With mooring legs and surge buoys attached, seamen from MOLALA and KALMIA make last minute adjustments to SQUAW's rigging.

FINAL PREPARATIONS FOR IMPLANTING THE MOOR

MOLALA proceeded to moor alongside SQUAW after leg B-2 had been transferred. She then assisted KALMIA in attaching the two MK-4 surge buoys to the submarine hull. Following the transfer of all four legs, MOLALA removed the rubber fenders from the submarine hull and both ships cleared the side of the SQUAW. Thus, with all mooring legs in place, SQUAW was ready to be submerged.

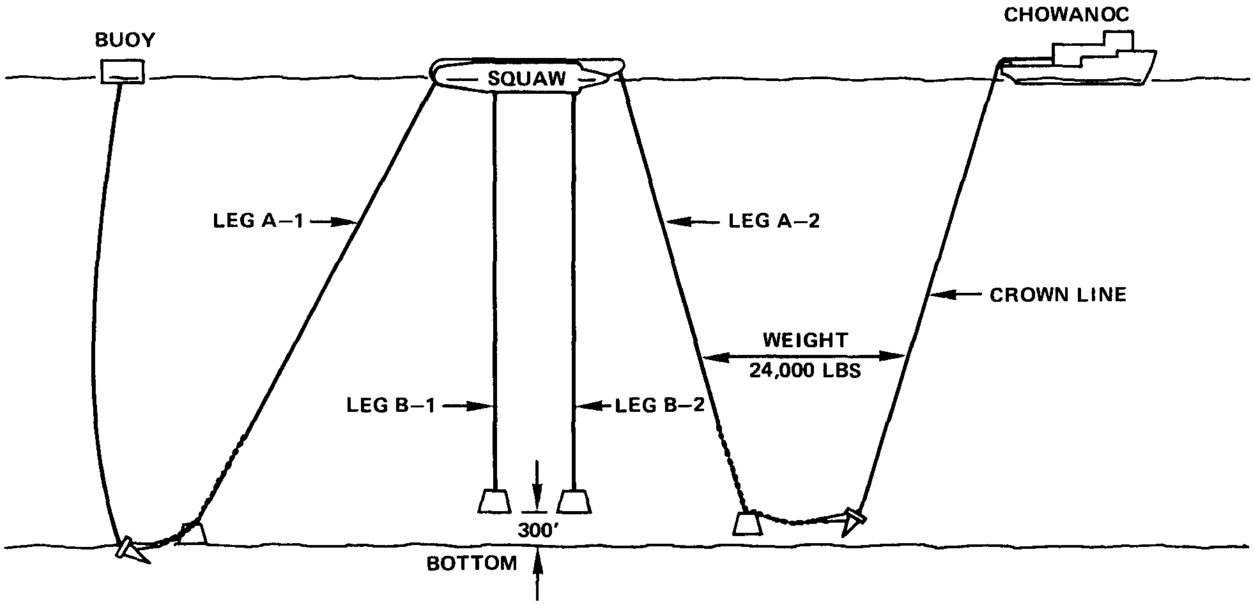
FLOODING BALLAST TANKS AND CORRECTING CATENARY

As MOLALA and KALMIA were in the process of transferring the mooring legs and attaching the surge buoys to SQUAW, CHOWANOC retrieved the crown buoy for leg A-2 and took the crown line for this leg aboard, attaching it to its towing drum. Meanwhile, rubber boats were deployed to the SQUAW with personnel aboard for opening the hull's ballast tanks on signal.

CHOWANOC then lifted the Eells anchor and 6000-pound clump of leg A-2 off the bottom and proceeded to take the necessary pull on this leg to reach the predetermined tension that had been calculated to submerge SQUAW to its 300-foot depth. The signal was then given to open SQUAW's flood valves.

SQUAW did not reach its prescribed depth on this first attempt. It remained only partially submerged. The lack of exact light ship weight in the initial computations had led to a miscalculation of the amount of ballast required to submerge the hull.

The problem was solved quickly. CHOWANOC reduced the tension on leg A-2 allowing SQUAW to resurface. The ballast requirements were recomputed and MOLALA used 2 1/4-inch chain to provide weight on the submarine hull for adding the additional ballast. CHOWANOC repeated the process of taking strain on leg A-2 and, on this second attempt, the SQUAW submerged readily to its required 300-foot depth with catenary corrected. CHOWANOC then tripped out of the mooring leg, A-2.



CHOWANOC takes strain to predetermined mooring tension. Flood valves are then opened and SQUAW submerges. CHOWANOC moves northeast until SQUAW reaches 300-foot depth, stops and lowers anchor and clump back to bottom.

SUBMERGING THE HULL AND CORRECTING CATENARY

With the SQUAW now at the correct depth and firmly moored, it remained only to sever the two surge buoys from the hull to complete the mooring task. UDT personnel did this in short order. The task force then retrieved all buoys and remaining gear, took navigational fixes to identify the position and headed for port, its mission accomplished.

CONCLUSIONS

Achievement of the objective was realized as planned. The SQUAW was moored at the specified design depth within the time period allotted and without any major setbacks or mishaps.

The operation did reveal the importance of crew training and the need to allocate adequate time for this purpose prior to the operation. Crews of the two ATF's and the ATA were not fully experienced in handling the large quantities of special rigging and towing gear required for the operation.

The drop system should be considered in planning the deployment of large mooring systems as it lends itself particularly well to the safe and expeditious handling of large amount of mooring equipment, even in rough seas.

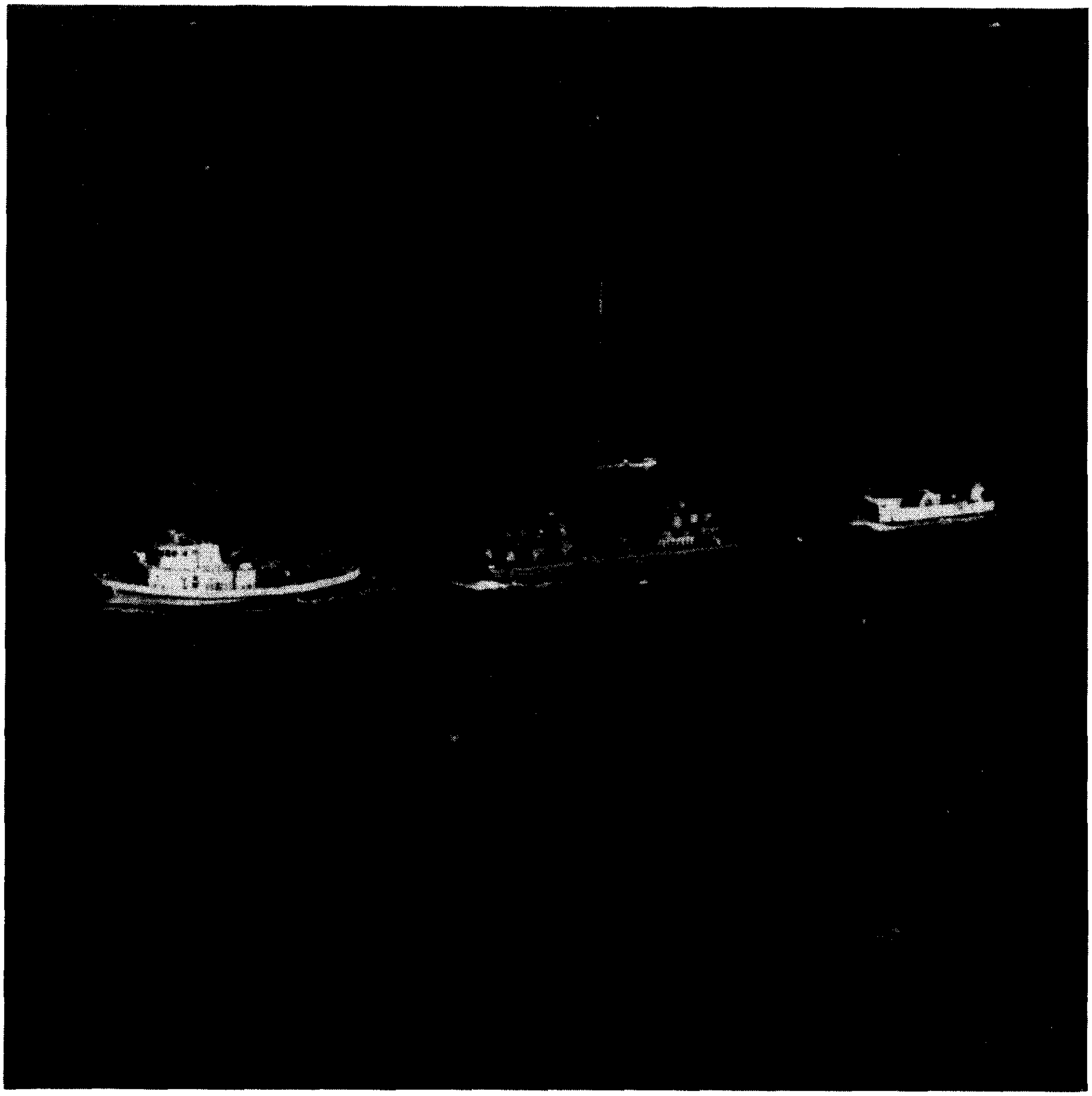
Lack of precise information on the causes of failure of the previous system hampered planning for the design of a new moor. The recovery of any mooring system after long use should be followed up by an inspection to isolate causes of failure and record appropriate documentation.

IMPLANTMENT

OF

HYDROPHONE ARRAY TOWER

OFF BLOCK ISLAND, RHODE ISLAND



The barge, YC-1429, was sunk off Block Island to function as a platform for the hydrophone array tower in a Naval Underwater Sound Laboratory project. The task force used deck-loaded salvage pontoons to help control the barge during the implantment operation.

BARGE-TOWER UNDER TOW TO IMPLANTMENT SITE

IMPLANTMENT OF HYDROPHONE ARRAY TOWER OFF BLOCK ISLAND, RHODE ISLAND

INTRODUCTION

The barge, YC-1429, with a 110-foot high, normal mode hydrophone array tower installed, was intentionally sunk in 104 feet of water off the entrance to Great Salt Pond, Block Island, Rhode Island in November, 1970. The USS SUNBIRD (ASR 15), supported by a harbor tug, YTB-793, and a diving tender, YDT-1, from the submarine base, New London, Connecticut provided required support services.

DESCRIPTION OF THE BARGE

The barge, of welded steel construction, was divided into six watertight compartments formed by four athwartship steel bulkheads. Two deck hatches, one on the port side and the other on the starboard side, provided access to each compartment. Barge deadweight was 115 tons. When the barge was ballasted with 85.5 tons of water, its average freeboard was 77 inches, mean draft was 26.5 inches, and displacement was 200 tons.

PLANNING AND PREPARATIONS

Planning

The concept of operations and the preliminary plan for the sinking was developed by the personnel of the Naval Underwater Sound Laboratory, (NUSL), New London, Connecticut. Throughout the planning, informal liaison was maintained with staff members of the Commander, Submarine Flotilla Two, the commanders and staffs of the USS TRINGA (ASR 16), the USS SKYLARK (ASR 20), and the Office of the Supervisor of Salvage.

The initial plan contemplated that the barge would be towed by a Navy tug to a preselected location and sunk in approximately 90 feet of water. Subsequently the tower, previously assembled at the NUSL pier, would be transported to the site, suspended by a floating derrick or an ASR boom. Upon arrival, it would be downhauled to the sunken barge where Navy divers would make it secure to the barge's deck.

Modifications to the Barge

Preparation for the sinking included modifications of the barge to accept and support the tower, and to assure control of the barge during sinking. The latter modifications consisted of providing means to secure salvage pontoons to the barge, sealing the hatches to the forward and aft compartments, and installing four 1 1/2-inch vent valves on each of the four sealed hatches. Two 10-inch flood holes were provided, one on the port side and one on the starboard side of the fore and aft compartments.

Results of Trial Installation

A "dummy run" installation of the tower on the barge was conducted alongside the NUSL pier, using the yard derrick to lift and position the assembled tower, during September, 1970. The trial, while verifying the soundness and design of the tower and the fit of the tower to the barge, disclosed that extremely precise and difficult coordination between the derrick operator and the riggers aboard the barge was demanded. In view of the demonstrated requirement for precise coordination of movement and the fact that the sinking and implantment was to be accomplished during mid-November, when unpredictable but normally bad weather would be encountered, it was concluded that the planned method of implantment would be much more difficult than anticipated.

Developing Alternate Plans

Recognizing the difficulties that would probably be encountered, two alternate plans were developed. Both were predicated on towing the barge, with the tower erected and secured in place, to a location within reasonable proximity to the selected site, and sinking it as rapidly as possible in shallow water. The shallow water sinking offered distinct advantages including reduced vulnerability to bad weather, improved visibility and longer work periods for the divers, and better communications between personnel on the surface and the divers. The plans differed only in the means of movement of the barge from the shallow water location to the selected implantment site. One called for towing the barge underwater, suspended by pontoons. The other envisioned skidding the barge along the bottom.

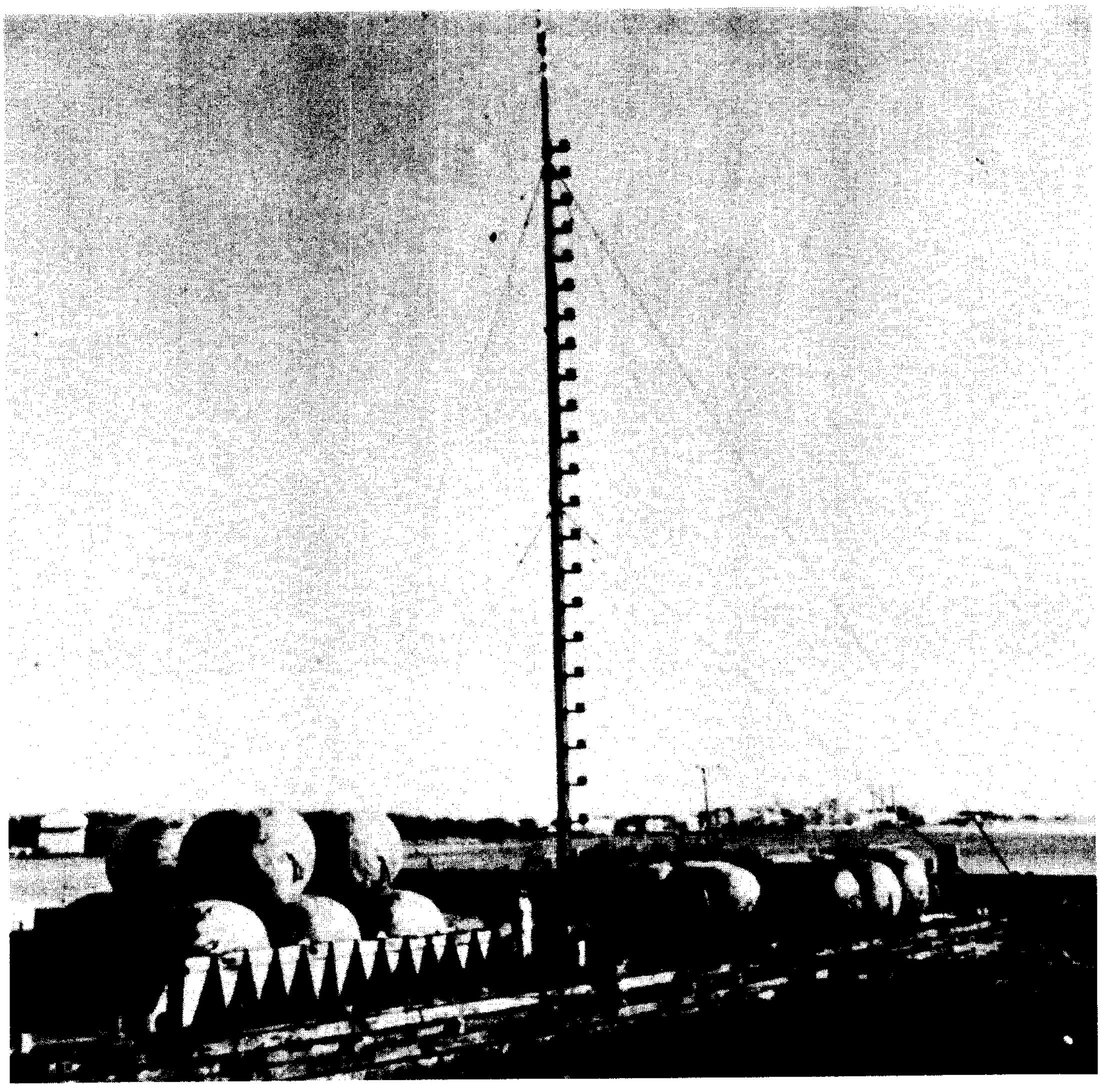
Implantment Plan

After consultations with representatives of the Supervisor of Salvage, an implantment plan was adopted that featured the following elements:

1. The tower would be erected and installed on the barge at the NUSL pier.

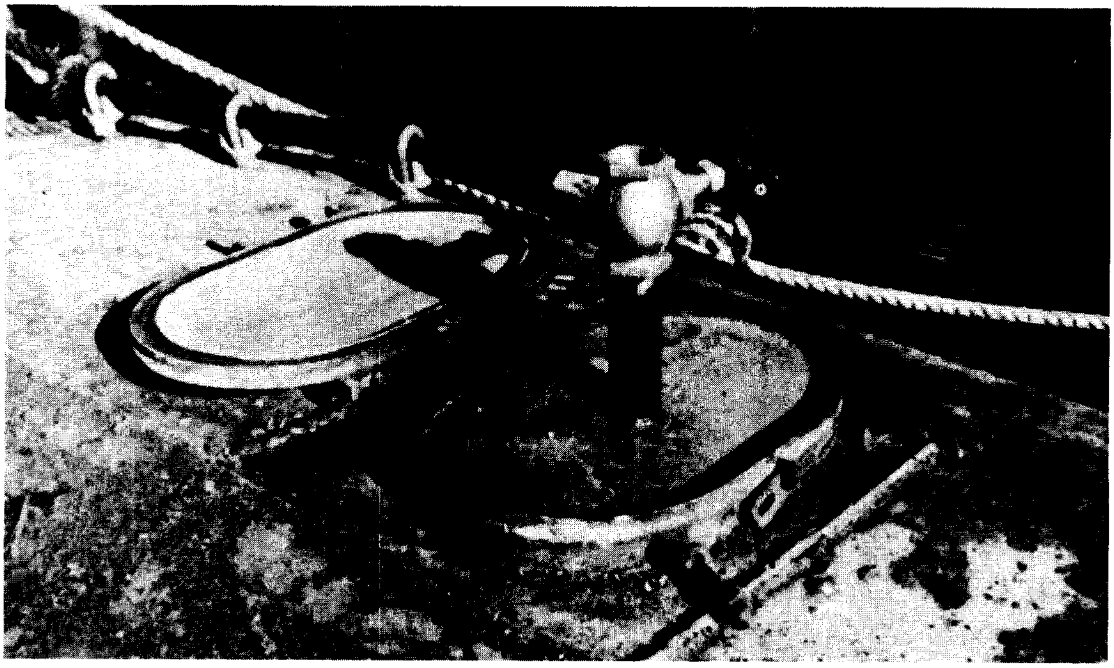
2. A 10-ton reel of shore cable, married to the tower, would be loaded on a 60-foot LCM to be provided by NUSL.

3. The barge tower, with salvage pontoons attached and deck-loaded, and the LCM would be towed by a tug to the selected shallow water location and sunk by divers from the ASR and the YDT.



The barge was outfitted at the Naval Underwater Sound Laboratory pier prior to the operation. An outrigger was needed to provide necessary stability for tower rigging. Note the huge size of the salvage pontoons compared to the personnel on the deck of the barge.

BARGE WITH TOWER RIGGED AND PONTOONS DECK-LOADED



Vent valves were installed on the sealed hatches to the barge's compartments. The task force opened valves, allowing air to escape and permitting controlled flooding of selected compartments during sinking of the barge.

VENT VALVE INSTALLATION ON DECK OF BARGE

4. The sunken barge, with the salvage pontoons supporting some of the weight of the barge-tower, would be towed along the bottom and anchored with 3000-pound anchors at the final implantment site.

5. The shore cable would be laid from the LCM to the beach where it would be attached to a crawler tractor and pulled across the 200 yards of beach and dunes to the NUSL field station.

Arrangement of Salvage Pontoons

Upon completion of all required modifications and the installation of the tower on the barge, the task force turned its attention to the task of installing the salvage pontoons. Twenty-three salvage pontoons, each 7 feet in diameter and 10 feet long, were installed in two tiers. The lower tier consisted of 14 pontoons, eight of which were on 6-foot tethers, the remaining six on 10-foot tethers. The upper tier consisted of nine pontoons attached by 34-foot slings to nine of the lower tier pontoons.

The two-tier arrangement was designed so that, as the barge moved into deeper water, the upper tier would begin to provide effective buoyancy as the sunken barge passed the 60-foot depth. That buoyancy would compensate for buoyancy lost as a result of compression of the lower tier pontoons by the increasing pressure to which they would be subjected as the depth of submersion increased. Sixty feet had been calculated as the critical point beyond which a condition of negative buoyancy would obtain. Two small inflatable markers, each with 250 pounds of buoyancy, were secured to the end of each tower outrigger to enhance the roll stability of the barge as it passed through the neutrally buoyant state.

SINKING AND IMPLANTMENT

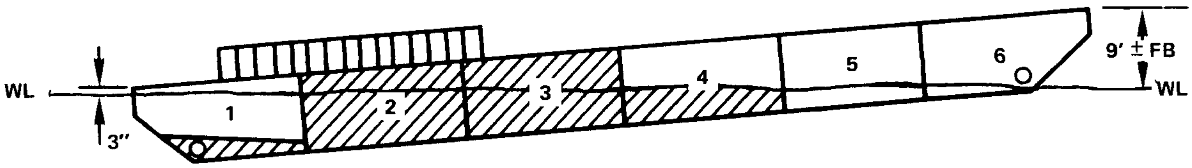
Preparations for Sinking

On Monday, 16 November, the USS SUNBIRD and the YDT-1 were on site, prepared to put divers overboard to survey the bottom track along which the barge was to be towed. However, bad weather prevented the divers entering the water and the survey was postponed until first light the following morning. By 0800, 17 November, when the YTB-793 arrived with barge and LCM in tow, divers had marked the sinking site and were conducting the bottom survey.

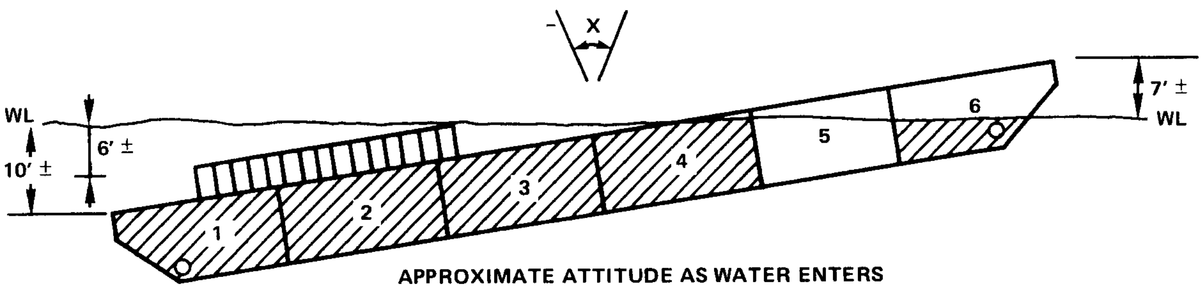
The barge was cut loose from the tug and then maneuvered by the tug into position for sinking, where it was placed in a 1-point moor secured by a 3000-pound anchor. A 3/4-inch wire rope secured the anchor to the tug. The anchor position was marked by a marker buoy attached to the crown line.

As the bottom survey had revealed the presence of 5- and 6-foot boulders strewn along the planned path, a second survey for an alternate route was conducted while the barge was being prepared for sinking. Preparations for sinking included lengthening the hawser and shore cable connecting the barge and LCM to 200 feet; attaching floats to keep the cable afloat and minimize the chances of its becoming fouled on the bottom or under the barge during towing; and removing all excess gear from the barge. In addition, since the barge would now be sunk to a depth of only 42 feet, the nine pontoons comprising the upper tier were removed as they would not be needed until the barge went below 60 feet.

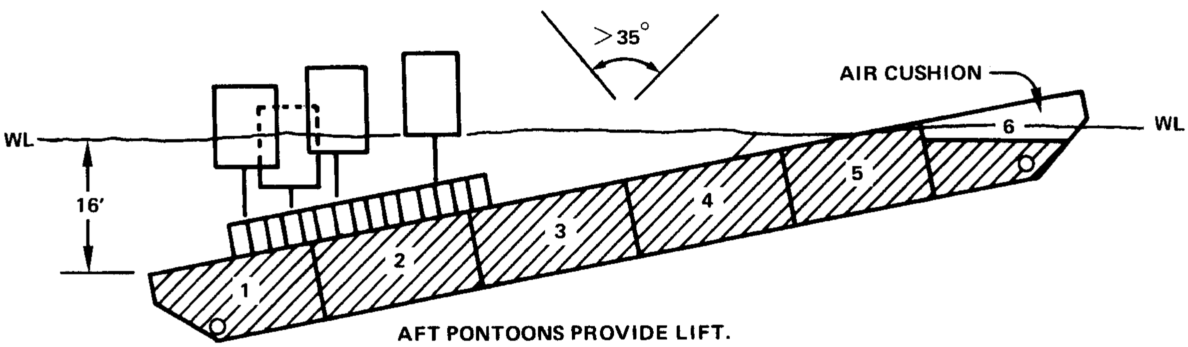
By early afternoon, 17 November, the bottom survey was completed and an obstacle-free route along the bottom was located and marked. The YDT-1, which served as the work platform for all diving operations, was put on a bow anchor with her stern tied up to the barge. Vent valves to the fore and aft barge compartments were closed and two 250-gpm pumps, located on the after deck, commenced pumping sea water into the barge's compartments.



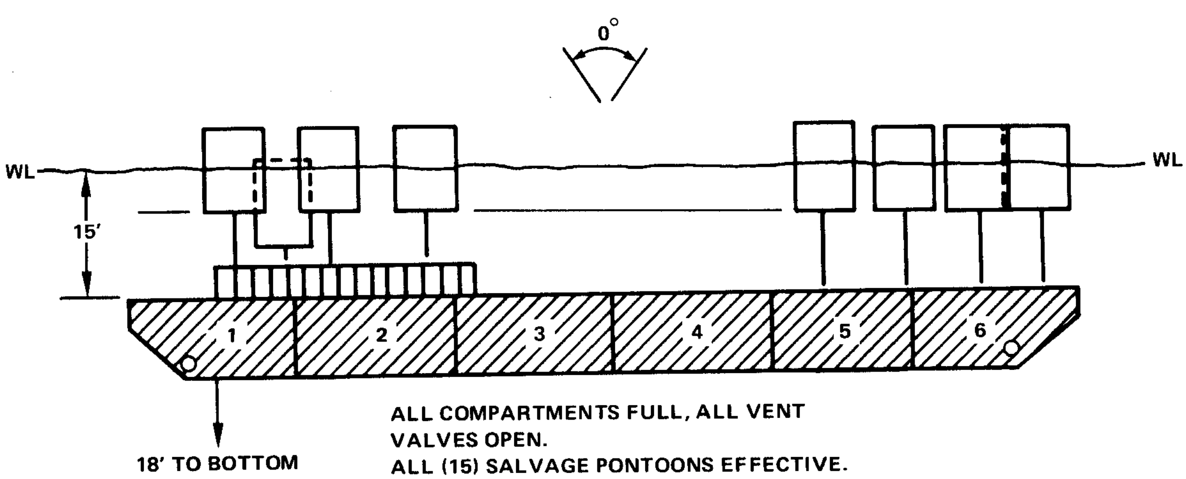
2 1/2 COMPARTMENTS FULL.
STERN COMPARTMENT VENT VALVES CLOSED.



APPROXIMATE ATTITUDE AS WATER ENTERS
6TH COMPARTMENT, STARBOARD FLOOD HOLE.
AFT VENT VALVES OPEN, FORWARD CLOSED.



AFT PONTOONS PROVIDE LIFT.
AIR CUSHION, PORT, COMPARTMENT 6.
FORWARD VENT VALVES CLOSED.



ALL COMPARTMENTS FULL, ALL VENT
VALVES OPEN.
ALL (15) SALVAGE PONTOONS EFFECTIVE.

SEQUENCE IN SUSPENDING BARGE 15 FEET BELOW SURFACE

Sinking the Barge

The planned sequence of filling the compartments and sinking the barge was:

1. Fill compartments 2 and 3 and one-half of compartment 4.

2. Open vents and flood compartment 1. Stern then sinks until supported by aft pontoons.

3. Complete filling of compartment 4 and fill compartment 5.

4. Open vent valves and flood compartment 6. Bow then sinks until supported by forward pontoons.

5. Vent stern pontoons. Barge settles to bottom stern first.

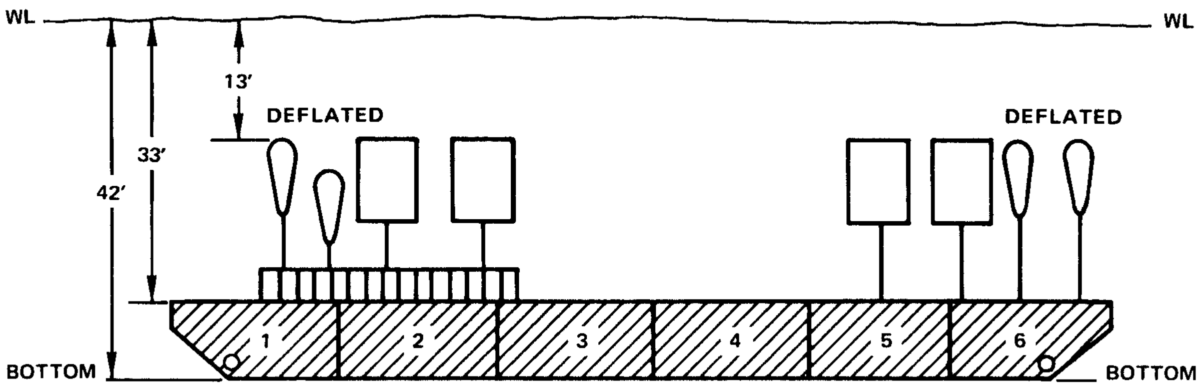
6. Vent forward pontoons. Bow settles to bottom.

As compartment 2 was filled, a decision was made to modify the lower tier of pontoons by relocating the stern centerline pontoon to a position just aft of the starboard stern bulkhead, bringing the total number of pontoons employed to 15.

Following the modification of the lower tier pontoon arrangement, pumping was resumed and continued until compartments 2, 3, and 1/2 of compartment 4 were filled and the barge was afloat with about 3 inches of stern freeboard and 9 feet of bow freeboard. With pumping discontinued, and 2 1/2 compartments filled, the pumps were moved forward to complete filling compartment 4. Pumping was resumed and the stern compartment vent valves opened allowing the sea water to rush through the stern flood holes. With the simultaneous actions of pumping water into compartment 4 and flooding compartment 1 (stern), the barge settled by the stern as planned. However, it also developed a starboard list. With water continuing to flood uncontrollably into the stern compartment and the list steadily increasing, a critical stability problem soon developed. Water in the partially filled fourth compartment shifted to the starboard (lower) side, compounding the list and causing the stern compartment to fill unevenly. Water poured to the starboard side while the air rushed to the port side. As the filling and flooding continued, the barge settled by the stern. Its freeboard steadily decreased until all freeboard was effectively lost.

The loss of freeboard and the continuing increase in starboard list soon submerged the open starboard hatch of compartment 4. As water rushed through the open hatch filling the compartment, settling increased, the remaining starboard bow freeboard was lost and water commenced flooding through the starboard bow flood hole. Both forward vent valves being closed, air in the compartment was expelled through the port flood hole which was still above the water line. As the sixth (bow) compartment flooded, all remaining starboard freeboard was lost and water was soon pouring into the fifth compartment through the open starboard deck hatch. Sinking and listing continued until the port bow flood hole submerged, trapping sufficient air in the compartment to support the bow, and the stern had sunk deep enough to permit the aft pontoons to support the weight of the stern. When all sinking and listing had stopped, the barge was listing 30-40 degrees to starboard. The stern deck was 16 feet below the surface and the forward bow quarter, held by the air trapped in compartment 6 was above the surface. With all motion stopped, a diver boarded the barge and opened the forward vent valves, permitting the trapped air to escape and the bow to sink until sufficient buoyancy was provided by the forward pontoons to hold the weight of the bow, thus leveling the barge.

With the barge stable and suspended 15 feet below the surface by the 15 salvage pontoons, it was decided that, although it was already dark, the barge would be put on the bottom for the night. Divers swam to the partially submerged pontoons, opened the vents on the two aft-most and the bow centerline pontoons, thereby, reducing the number of fully inflated pontoons to 12. The 20 percent reduction in buoyancy provided by these 12 remaining pontoons, while allowing the barge to settle a few feet, proved sufficient buoyancy to prevent the barge from sinking to the bottom. Divers returned to the barge and deflated four additional pontoons, two at the bow and two at the stern. The barge slowly settled to the bottom, stern first. At the close of the day's operation the barge was resting on the bottom at the 42-foot depth, eight fully inflated pontoons arrayed above it. It was secured by the 3000-pound anchor and 200-foot hawser and shore cable to the LCM, which also had an anchor out.



Barge has 15 pontoons here, all lower tier. Sketch shows 8 pontoons in section view. Seven pontoons are deflated.

FINAL SUBMERGED POSITION OF BARGE AT 42-FOOT DEPTH BEFORE TOW TO IMPLANTMENT SITE

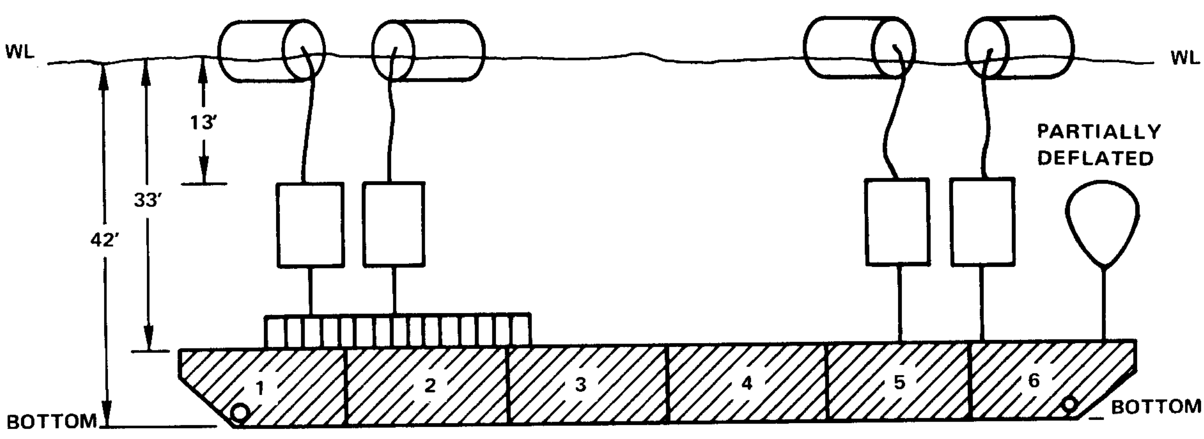
TOW TO IMPLANTMENT SITE

Adjustments to Pontoons

As the final sinking operation had demonstrated that 12 pontoons would support the barge, it was concluded that either the pontoons provided greater buoyancy than advertised, or the barge was lighter than calculated. Accordingly, the first order of business on 18 November was to determine the actual number of pontoons required to lighten the barge sufficiently for skidding to the implant site. Air hoses were run from the YDT-1 to the submerged pontoons and divers began fully inflating the forward pontoons, one at a time, until, with 5 pontoons inflated, the bow broke from the bottom and surfaced. From this it was postulated that 10 pontoons would provide sufficient flotation to raise the barge, while 9 would provide sufficient buoyancy to position the barge properly for skidding. It was decided to leave only 9 pontoons in the lower tier and the bow was returned to the bottom where divers removed the 6 excess pontoons from the lower tier and reinstalled 4 pontoons to reform the upper tier. With all 13 pontoons in place, 1 bow centerline (partially inflated), 2 forward port, 2 aft port, 2 forward starboard, and 2 aft starboard comprising the lower tier, and 4 comprising the upper tier, the bow was only slightly negatively buoyant while the stern was about 10 tons negatively buoyant.

Towing is Successful

By dusk all preparations for the tow were complete. Visibility and visual navigation being difficult because of increasing darkness, the SUNBIRD anchored offshore in position to provide navigation assistance to the YTB-793 around the rocks to the implantment site. With all preparation complete, the YTB-793 took a strain on the tow line, steadily increased the turns on the main shaft, until, at 130 RPM, the barge broke loose from the bottom. Its

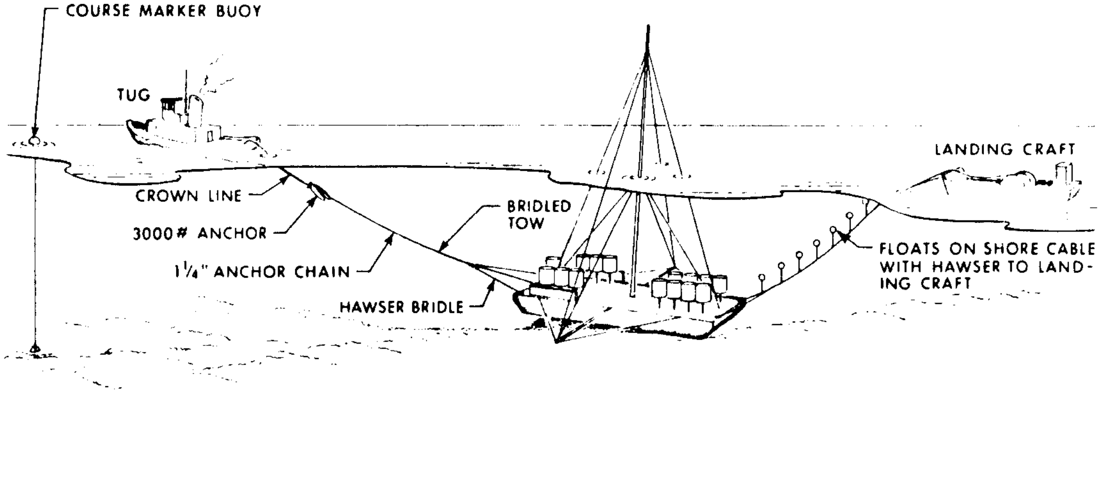


Task force rigged 13 pontoons for tow on two tiers: 9-lower; 4-upper. Sketch shows 9 of the 13 pontoons in section view.

PONTOON ARRAY FOR TOW TO IMPLANTMENT SITE

bow broke the surface before the shaft RPM could be reduced. The YTB-793 was directed to stop and the barge settled back to the bottom. The YTB-793 then made a second attempt, this time increasing shaft RPM gradually and more slowly. At 80 RPM shaft speed, the barge started to move slowly and was soon gliding effortlessly along the bottom. Shaft speed of the YTB-793 was reduced to 50 RPM for the mile tow around the rocks to the implantment site and the barge continued to move slowly at 3-5 knots.

The tow continued smoothly and without incident. As calculated, the upper tier of pontoons become effective at the 60-foot depth, compensating for the loss of buoyancy, due to compression of the lower tier pontoons. The SUNBIRD provided a new course once the barge was safely past the rocks. The YTB-793 slowly executed a 90-degree turn to the new course and continued the tow until the barge reached the design depth for the barge-tower, at a point 360 yards short of the chosen implantment site and at the bottom depth of 104 feet. As the critical elements of the implantment were tower height, orientation, and attitude, not barge location, the tow was halted. Divers descended to the upper pontoon tier where the four upper tier pontoons were vented and deflated. The barge, with about 60 tons of negative buoyancy, was secured on the bottom for the night.



The task force sunk the barge initially in shallow water about one mile from the implantment site. The barge was then "skidded" along the bottom to the site using the towing rigging shown here and pontoons to provide buoyancy.

BARGE PREPARED FOR SUBMERGED TOW

MOORING AND FINAL POSITIONING

On the morning of 19 November, following an unsuccessful attempt by the LCM to lay the shore cable to the beach, the YDT-1 was moored to the barge-tower and divers set to work reinflating the four upper tier pontoons in preparation for turning the barge approximately 180 degrees to align the acoustic projectors with the receiving hydrophone 20 miles away. With all pontoons inflated and the YDT-1 freed from its moor, the YTB-793 picked up the crown line and anchor, rigged the towing hawser and pivoted the barge without difficulty to a heading of 280 degrees T, well within design tolerance.

The YTB-793 again put the crown line and anchor overboard and the YDT-1 was again moored to the barge. Divers began the task of removing all pontoons from the barge. Due to time limitations because of the working depth, the removal went very slowly and was not completed until after dark.

On Friday, 20 November, the two remaining 3000-pound anchors were put on the bottom securing the sunken barge-tower in a 3-point moor. Divers removed all remaining nonessential gear from the barge deck and made a final inspection of the barge, tower and guys. All work was completed by that afternoon and the task force returned to the port.

CONCLUSIONS

Because of the complexity of the sinking and implantment, the operation provided a unique and invaluable training and performance exercise for the participating personnel.

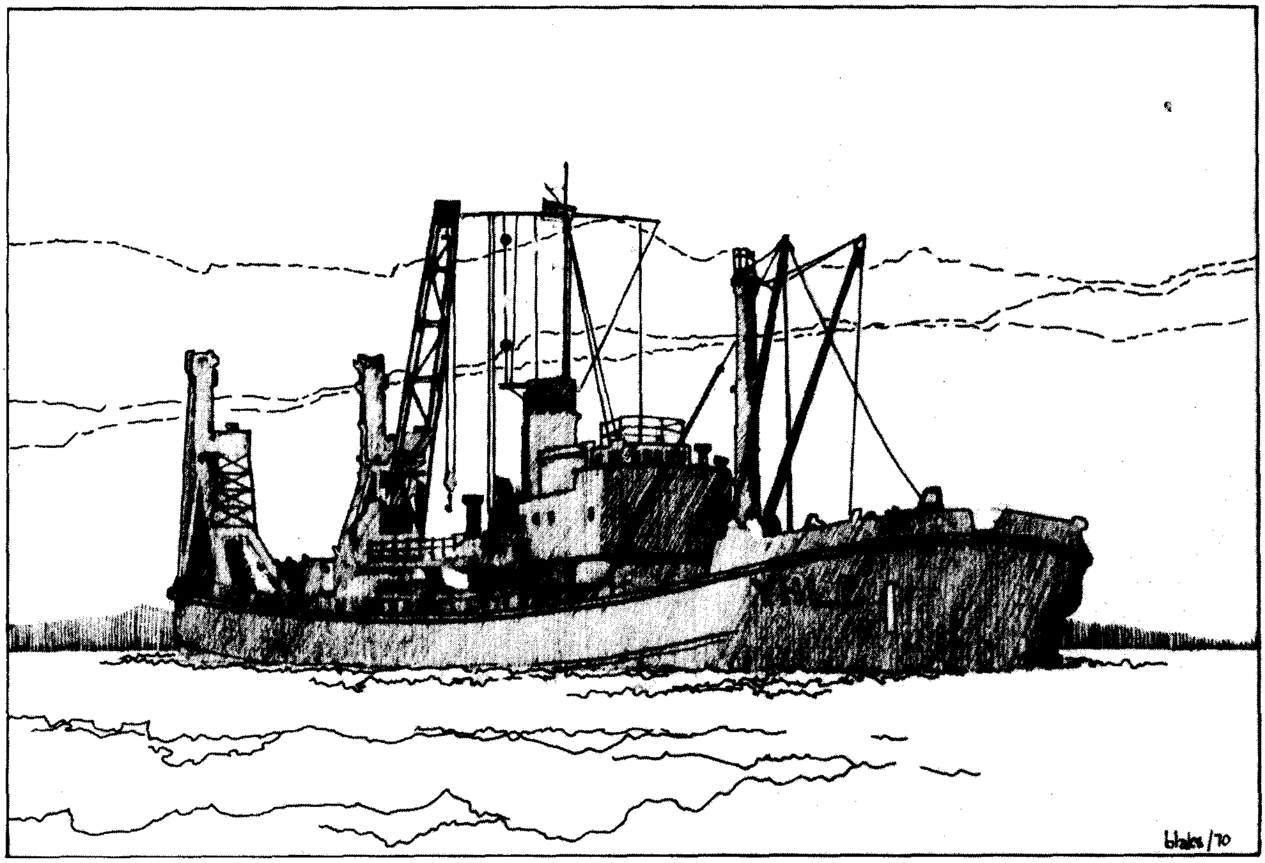
The technique used to sink and implant the barge-tower, i.e., preassembling the system, sinking it in shallow water, and skidding it to the implantment site, is practical and effective. However, details of the method such as pontoon location, which, in this instance was far from ideal, must be refined if the operation is to be accomplished with maximum effectiveness and safety.

SALVAGE OPERATIONS

OF

HARBOR CLEARANCE UNIT ONE

IN VIETNAM



These craft are the largest salvage craft in the world with a tidal, ballast lift of 2,400 tons.

**THE HEAVY SALVAGE LIFT CRAFT (YHLC)
SHOWN IN ARTIST'S CONCEPTION**

SALVAGE OPERATIONS OF HARBOR CLEARANCE UNIT ONE IN VIETNAM

INTRODUCTION

The increased scope of military operations in Vietnam during 1965 brought with it a quantum jump in requirements for salvage services resulting from groundings, collisions, breakdowns and enemy action. The need for salvage services was particularly acute along the coastline and on Vietnam's many inland waterways. The U.S. Navy responded to the need by commissioning Harbor Clearance Unit One (HCU-1) on 1 February 1966 with the dual mission of river and harbor clearance and salvage.

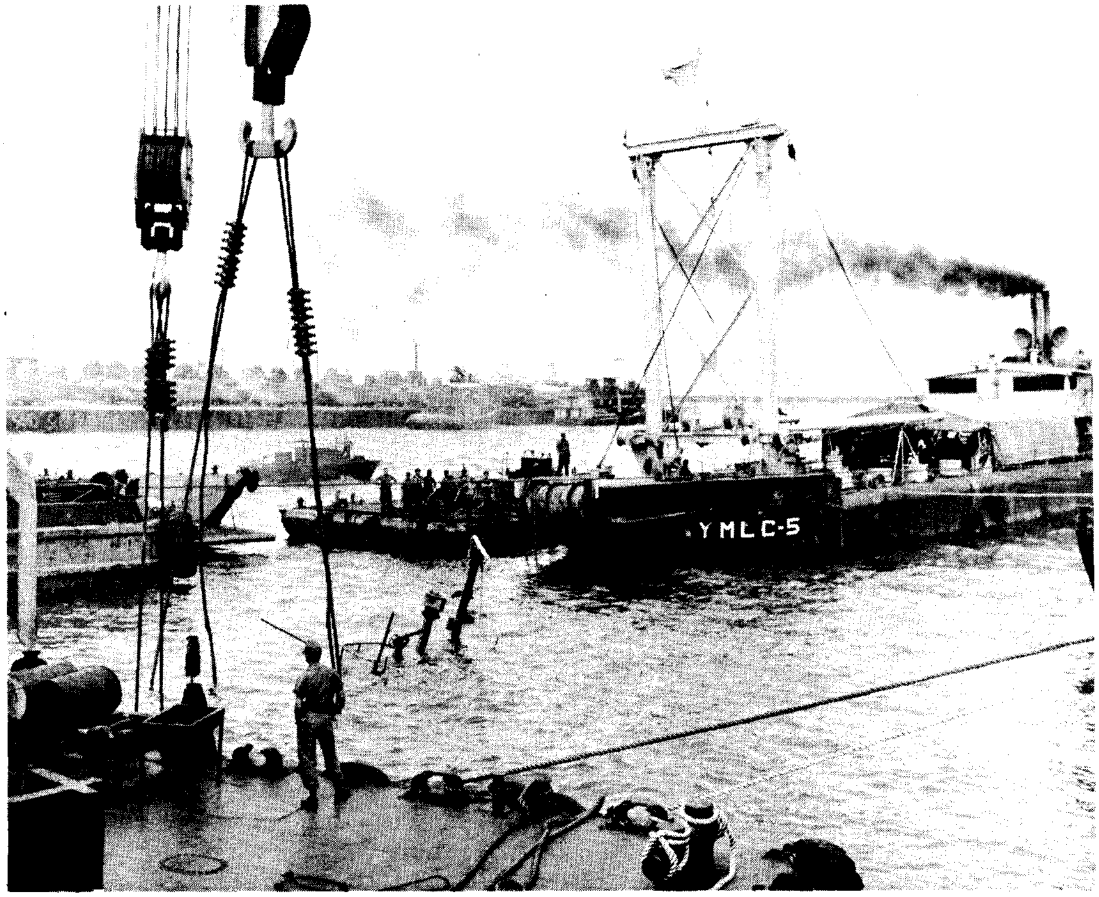
HCU-1 bore the brunt of in-country salvage work for over 5 years, operating deep in the Delta and ranging up and down the coastline. The year 1970 marked the beginning of the end of its salvage services in this conflict as elements of the unit withdrew with other U.S. Navy forces and the Vietnamese Navy assumed increased responsibility for salvage operations. By the end of 1970, HCU-1 had turned over most of its craft and equipment to the Vietnamese and had reduced the number of its personnel in the Western Pacific to less than 50 percent of its peak commitment of 27 officers and 275 enlisted men.

CONCEPT OF HCU OPERATIONS

Background

The concept of harbor clearance units, with equipment designed for salvage work in shallow and restricted waters, was developed originally in World War II. Key ports were often closed by air attacks, submarine raids and sabotage and special measures were invoked to clear away the widespread damage and reopen them for shipping. Although the damage inflicted by the Viet Cong and the North Vietnamese was hardly of the same scale, it was nonetheless a major factor in limiting the use of coastal and inland waterways for critical military transportation. For example, in 1970, there was an average backup of 25 craft waiting for salvage.

The concept applied by the U.S. Navy in forming HCU-1 was to form a series of small, relatively independent, highly mobile teams that could deploy to the salvage site rapidly and take immediate action. Commitment of HCU-1 to in-country salvage in Vietnam brought with it a concurrent benefit in that it freed Service Group Three, with its salvage ships (ARS's) and fleet ocean tugs (ATF's), to concentrate on offshore salvage work in the theater.



YMLC-5 builds up steam for lifting a tug at Qui Nhon. HCU-1 operated a family of light, medium and heavy lift craft in its Vietnam salvage operations.

THE MEDIUM SALVAGE LIFT CRAFT (YMLC) HARD AT WORK

Mobility and Lifting Capability

Mobility and lifting capability were the cornerstones of HCU-1's operational concept. Mobility was required to ensure quick access to shallow, restricted waters. A significant lift capability was necessary because, by their very nature, most jobs called for lifting a sunken craft and moving it to a safe haven, the undesirable alternative being destruction in place. These two requirements were met by outfitting the unit with a family of versatile lift craft. Most were small, highly 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 make a major contribution to the salvage effort in Vietnam.

SALVAGE CRAFT OF HCU-1

HCU-1 Workhorses:

CSB - Combat Salvage Boat
YLLC - Light Salvage Lift Craft

YLLC-1 lifts wrecked LCM-6 up onto the shore of the Song Vam Co Dong near Ben Keo during one of its many SALVOPS in 1970. Note 8-ton salvage balloons to keep bow afloat.

YLLC – VERSATILE LIGHT SALVAGE LIFT CRAFT

The YLLC, a converted Landing Craft Utility (LCU) and the CSB, a converted Landing Craft Mechanized (LCM) were the two craft most extensively employed by HCU-1 during the height of its salvage operations in Vietnam. At its peak strength, the unit operated three YLLC's and four CSB's. These craft, because of their versatility and suitability for small scale salvage work, were among those turned over to the Vietnamese Navy as the United States withdrew its salvage assets from Vietnam in 1970.

The CSB "Baby Giant" is the most active salvage craft in Vietnam. Fitted with an A-frame and other special lift equipment, it is highly maneuverable and especially suited for riverine salvage work. The CSB has a 10-ton lift capacity which covers a wide range of small craft and objects. Typically, HCU-1 deployed this craft with a salvage crew of four to six men.

The YLLC, also A-frame equipped, has a lift force of 25 tons. However, it is also capable of a 100-ton ballast bow lift. It has a much greater capability for sustained salvage work than the CSB, being outfitted with shops for cutting and welding, and berthing and messing facilities. Its shallow draft and amphibious landing capability make it accessible to many restricted water areas that are denied to other salvage vessels. These features make it a versatile craft, capable of quick and flexible response.

Both the CSB and YLLC often worked in tandem, the A-frame derricks on each craft being the primary lifting device in a wide variety of small scale salvage operations. Like the CSB, HCU-1 normally manned each YLLC with a salvage team tailored for the job at hand.

Other Lift Craft

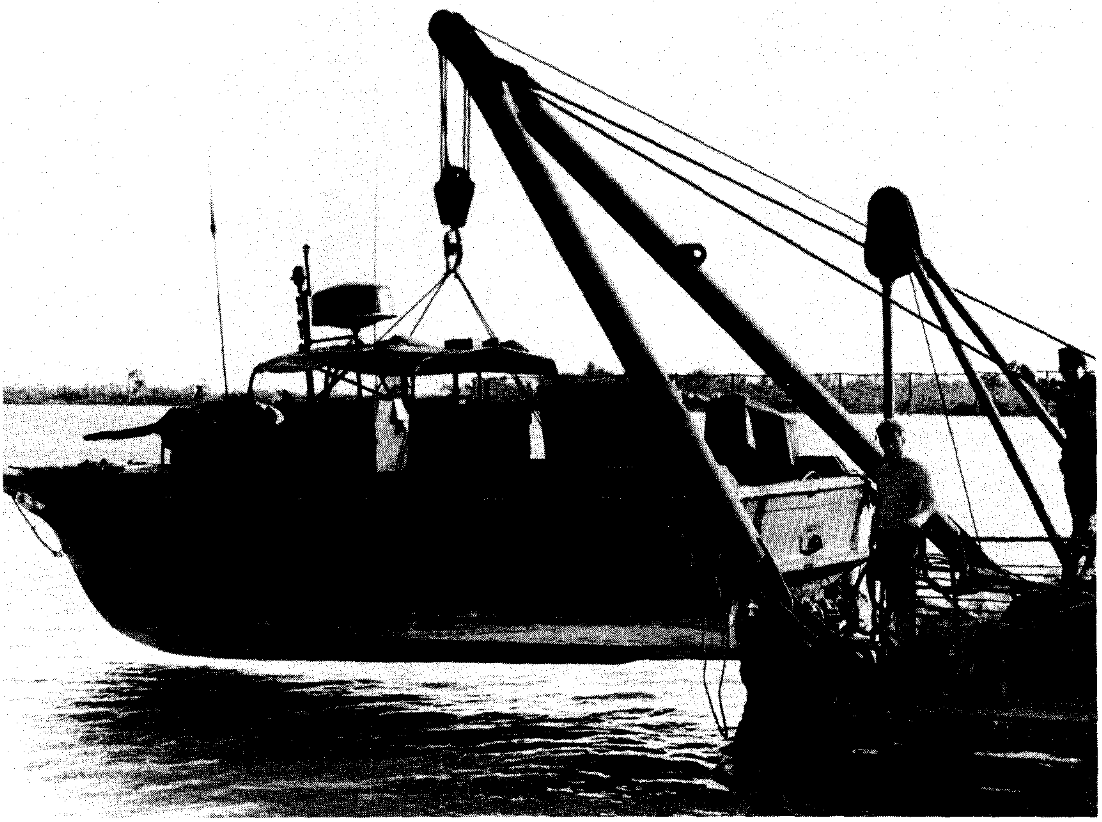
YHLC - Heavy Salvage Lift Craft
YMLC - Medium Salvage Lift Craft

The U.S. Navy had no heavy or medium lift craft available in the Western Pacific as large scale operations began in Vietnam during 1965. It procured two YHLC's from the West German Navy and four YMLC's from the British Navy to meet the operational demands of the Vietnam conflict. These craft were, for the most part, maintained at Subic Bay and deployed to Vietnam only when a major salvage task required their special lifting capabilities. These craft were made available for HCU-1 salvage operations as the need arose, and were husbanded by HCU-1 personnel at Subic when not in use. Two of the medium lift craft were returned to British custody as the scope of U.S. involvement in Vietnam declined.

Other HCU-1 Salvage Craft

At the peak of its strength, HCU-1 also had available to it these craft:

1 **YRST - Salvage Craft Tender**
2 **YDB - Yard Diving Boat**



The CSB, "Baby Giant" among salvage craft, easily lifts a patrol boat from the river bottom.

CSB – COMBAT SALVAGE BOAT APPLIES ITS LIFT CAPABILITY

In addition, HCU-1 made repeated use of LCM's that had been converted into diving and salvage workboats. They were particularly valuable as diving platforms in small operations and as propulsive forces to aid in towing a refloated craft to a repair base. Typically, an HCT from the unit would deploy to a salvage site with one or two LCM platforms to support a CSB or YLLC as required. ATC's (Armored Troop Carriers) were also used extensively as support platforms and for towing.

TYPES OF SALVAGE OPERATIONS

General

HCU-1 was based at Subic Bay, Republic of the Philippines throughout the period 1966–1970. About 40 percent of its personnel were continuously deployed in-country on a rotating basis. For specific salvage assignments, the normal technique was to task organize the necessary personnel skills and equipment into Harbor Clearance Teams (HCT's). 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.

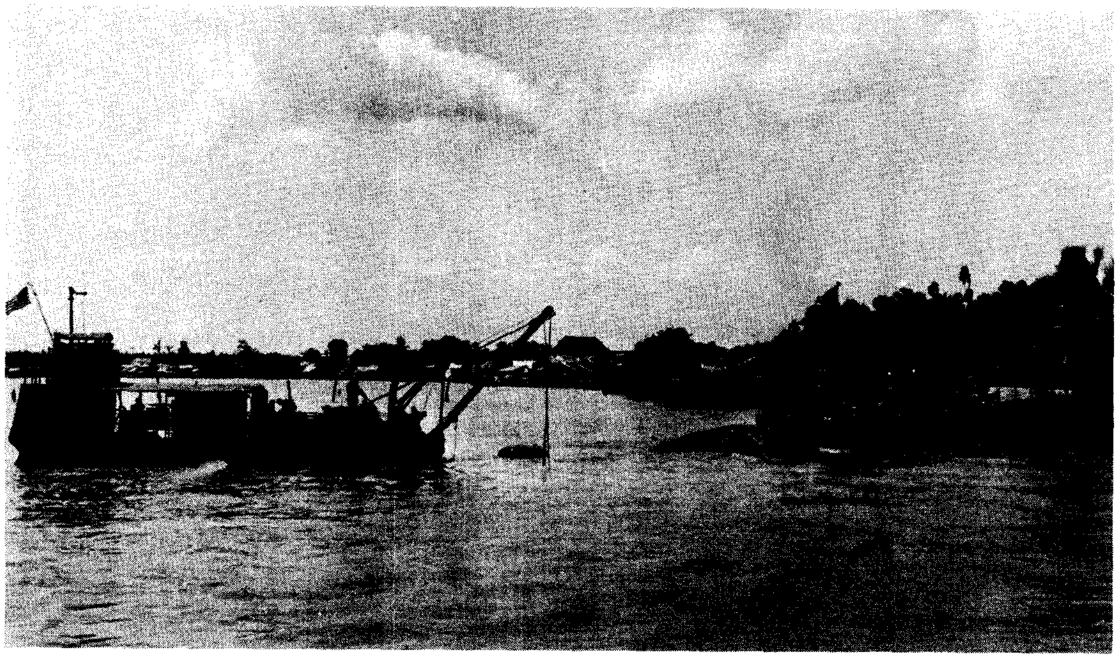
Operations in the Delta

Of all the sites of salvage activity, none was busier or more dangerous than an area deep in the Delta that came to be called Solid Anchor or Sea Float. The vulnerability of the area and the frequency of Viet Cong attacks required HCU-1 to maintain a detachment there with a light lift craft (YLLC). The area itself was a tidal river whose banks were largely controlled by the Viet Cong. Currents in the river ran as high as 6 knots with less than an hour's slack water. With enemy attacks almost a daily occurrence, continuous salvage operations were necessary just to keep the backlog of work down to four or five stranded and sunken craft.

Variety of Operations

A review of 43 "minor" operations conducted by HCU-1 throughout Vietnam during 1970 indicates the scope and variety of salvage work undertaken by the unit. Teams of HCU-1 lifted the following vessels, refloating them and towing them to safe havens as appropriate:

6 Troop Carriers	**2 Helicopters**
5 Barges	**1 Tug**
10 Landing Craft	**1 Minesweeper**
6 Patrol Craft	**3 Other Types**



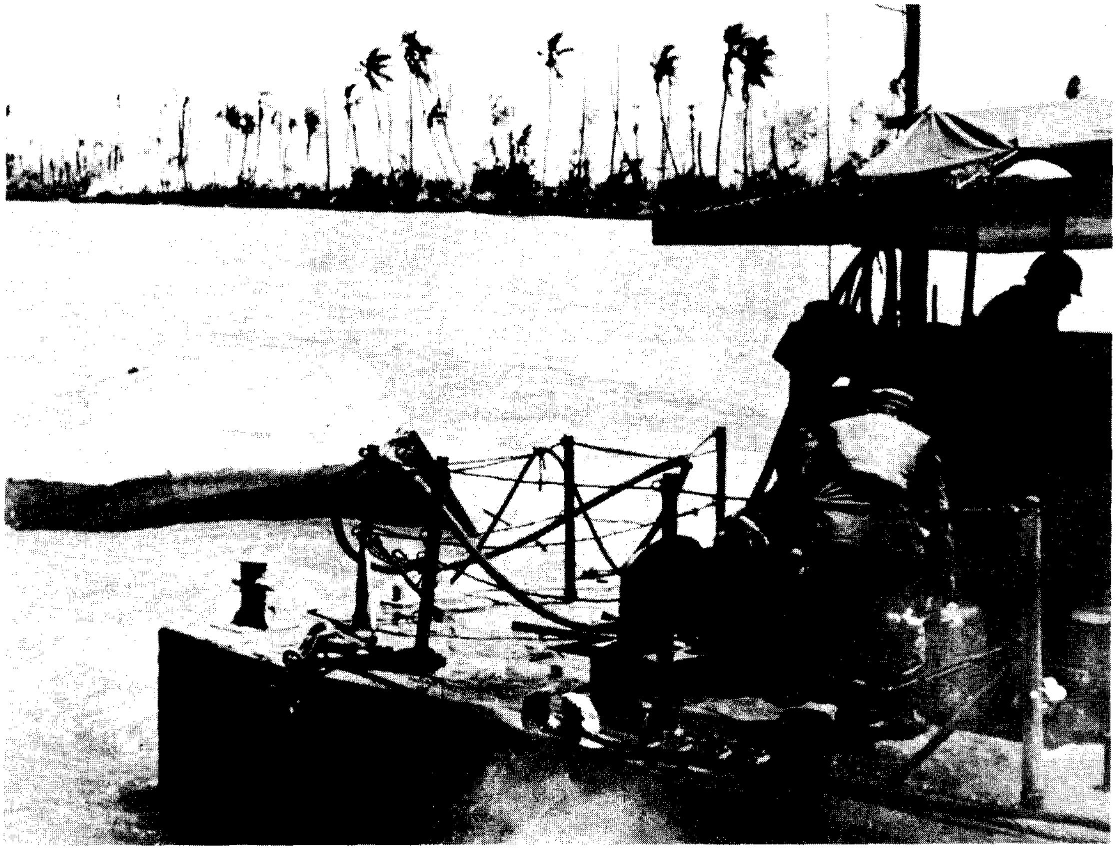
Combat Salvage Boat (CSB) lifts sunken craft with aid of LCM. Salvors often moved sunken craft such as this one close to shore for patching, dewatering and refloating.

A-FRAME IN SALVAGE MEANS FLEXIBILITY AND CAPABILITY FOR LIFTING

An assortment of other objects were salved, ranging from railway bridge spans to sunken trucks and howitzers. These objects, as well as the sunken craft, were the product of hostile action in over 50 percent of the cases. Sapper mines were particularly destructive, creating holes of 3-8 feet and causing rapid flooding and capsizing. Capsized hulls had a tendency to burrow deeply into the mud bottom, thereby complicating the salvage task.

The majority of salvage situations involved working in depths of about 20 feet. The inland waterways of Vietnam are famous for their strong currents. These currents hampered diving work and made the maneuvering of salvage craft and salvage nests difficult. Fortunately, the crews of sinking craft succeeded in beaching them in many instances, simplifying the ensuing salvage task.

Craft which were not sunk by hostile forces sometimes sank at their moorings due to leaky shaft packing, exhaust boot leaking or excessive storm damage. A few salvage



Viet Cong fire interrupted this HCU salvage operation near Ben Tre. Helicopter gunships provide suppressive fire as salvors prepare to resume work.

HCU-1 SALVOPS UNDER HOSTILE FIRE

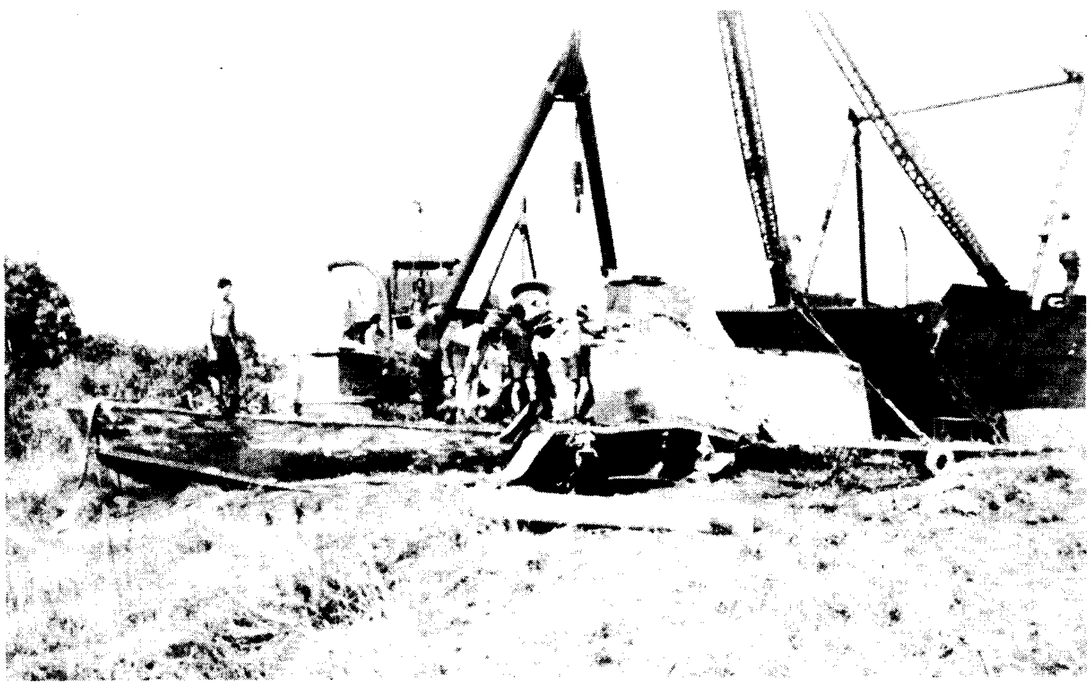
CSB, foreground, and LCM provide the tow while support craft of Vietnamese Navy provide escort protection. Salvor is manning port gun aboard CSB.

SALVAGE NEST TOWING SUNKEN TROOP CARRIER TO REPAIR BASE

situations involved items or objects which had been damaged, or sunken for at least one to two years. In these incidents, the item or object salved became heavily covered with mud, making salvage lift operations more challenging.

Salvage Techniques

All but a few of the 43 salvage tasks reviewed required a lift of some sort. The techniques included lifts with derricks and/or balloon floats, dewatering with eductors, patching or plugging and refloating sufficiently for towing to the nearest naval base or facility for permanent repairs. The primary lifting device was the A-frame derrick on the CSB and YLLC types. The proper placement and securing of the salvage craft in position were critical to almost every lift. Each situation had to be handled as an individual salvage operation in spite of the similarities of items salved.



CSB (on left) and YLLC prepare to lift stranded craft from the river bank. CSB and YLLC, used individually and in combination, were the two most active salvage craft in Vietnam.

CSB AND YLLC PROVIDE "1-2" SALVAGE PUNCH ON INLAND WATERWAY

The righting of inverted hulls which had burrowed into the mud and the correct rigging of pulling or lifting bridles caused the salvors to test their ingenuity and skills to the limit. On some occasions, while towing a refloated inverted hull, the salvage craft had to tow backwards to prevent the damaged craft from driving under and grounding. This greatly reduced towing power and eventually, due to excessively strong currents, the craft required parbuckling to set it in an upright position to complete operations successfully.

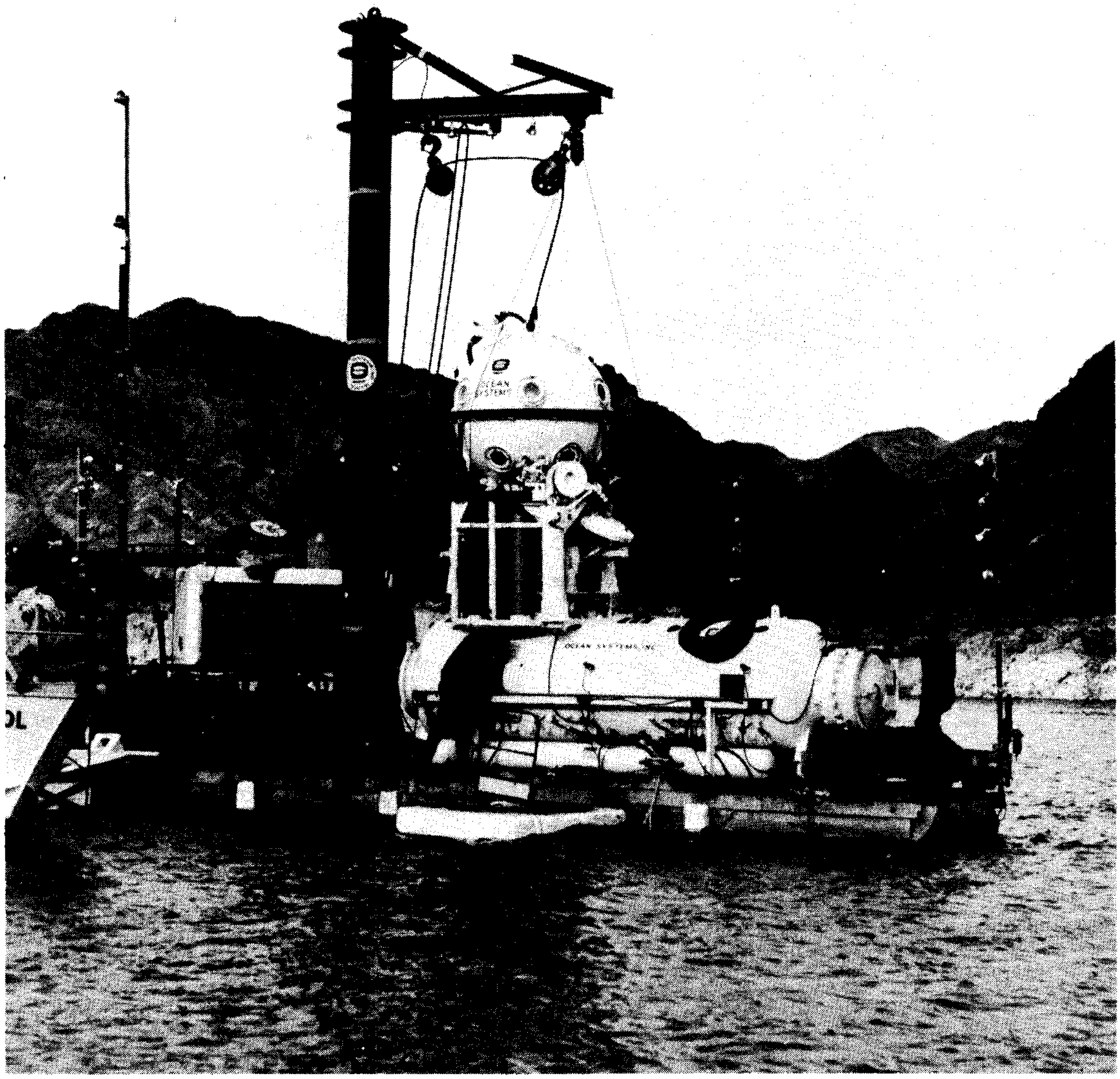
In practically every service craft salvage operation, salvors were able to make only temporary hull repairs. Due to the extensiveness of hull damage and the material condition of power plants, salvaged service craft had to be held in a lifting bridle and towed for several miles to a repair base. Many techniques included a salvage nest with salvage lift craft forward and aft or one on each side to keep the salvaged craft from going under. Salvors frequently employed lift balloons as a technique to restore lost buoyancy. The balloon helped keep the damaged craft afloat and relieve the severe stresses on lift equipment, particularly during salvage nest towing operations.

UNDERWATER

SEARCH AND RECOVERY

OF

AIRCRAFT IN LAKE MEAD, NEVADA



Search and recovery of a Cessna U-206 aircraft featured the use of ADS-IV, the commercial deep diving system of Ocean Systems, Incorporated. The Supervisor of Salvage committed this system to the operation because the downed aircraft was in 400 feet of water, precluding the use of shallow diving techniques.

AIRCRAFT SEARCH AND RECOVERY OPERATIONS IN LAKE MEAD, NEVADA

UNDERWATER SEARCH AND RECOVERY OF AIRCRAFT IN LAKE MEAD, NEVADA

INTRODUCTION

On 25 November 1970 an amphibious Cessna U-206 aircraft, carrying Commissioner Theos J. Thompson of the Atomic Energy Commission, crashed into Lake Mead, Nevada. Only the pilot escaped. Commissioner Thompson and two other passengers were lost, presumably trapped in the plane as it sank to the bottom.

Because of the great depth involved, immediate search and recovery efforts with conventional, shallow water diving gear would have been futile and, therefore, were never started. The aircraft had gone down in the Boulder Canyon area about 10 miles from Hoover Dam, one of the deepest parts of Lake Mead. The water depth was estimated at about 400 feet. The onset of the early Nevada winter was already threatening to produce storms and icy temperatures, so salvage operations had to begin quickly, if they were to succeed.

The Supervisor of Salvage, U.S. Navy tasked Ocean Systems, Incorporated (OSI) to assist the Atomic Energy Commission and the National Park Service in recovering the plane and the bodies of its victims. The recovery was accomplished in a unique, highly successful operation featuring the employment of OSI's commercial deep diving system, the ADS-IV, airlifted from Florida to Lake Mead for this purpose.

INITIAL SEARCH EFFORTS

Circumstances of the Crash

The plane, operated by the National Park Service, was engaged in low altitude reconnaissance of the canyon walls surrounding Lake Mead. According to the pilot, it was flying at about 25 feet when a sudden downdraft forced it into the lake. The aircraft struck the water, breaking one of its amphibious pontoons and flipping over on its back. It sank almost immediately. The pilot succeeded in exiting the plane and ascending to the surface where he was picked up by the ECHO, a recreation cruise boat in the vicinity.

Weather in the general area was temperate, although it could change quickly. Frontal storms passing through could cause severe surface conditions on the main lake. However, the impact area within Boulder Canyon was fairly well sheltered and initial on-scene work was not seriously affected. The average water temperature was 52 degrees.

Immediate Reaction of Local Forces

The operator of the ECHO had the presence of mind to fix the general location of the accident by making visual observation of bearings and distances from prominent land features. His information in this regard proved to be invaluable in initiating the subsequent search operations. National Park Service personnel began to search the area shortly after the crash, using one of their lake boats with the side-scanning sonar devices as well as still cameras. Park Rangers marked the search area with buoys and took fathometer readings. Recovery procedures were constrained due to the lack of suitable work platforms at Lake Mead for use by salvage forces.

These initial efforts were not successful. Although the crash location was reasonably well defined, the sonar search picture remained in doubt due to the uncertain bottom topography, aircraft size, and the proximity of the canyon walls. The shoreline was within 2,000 feet on both sides and the rocky canyon walls sloped sharply downward and inward toward the crash site.

ASSEMBLING THE SALVAGE FORCES

Preliminary Activity

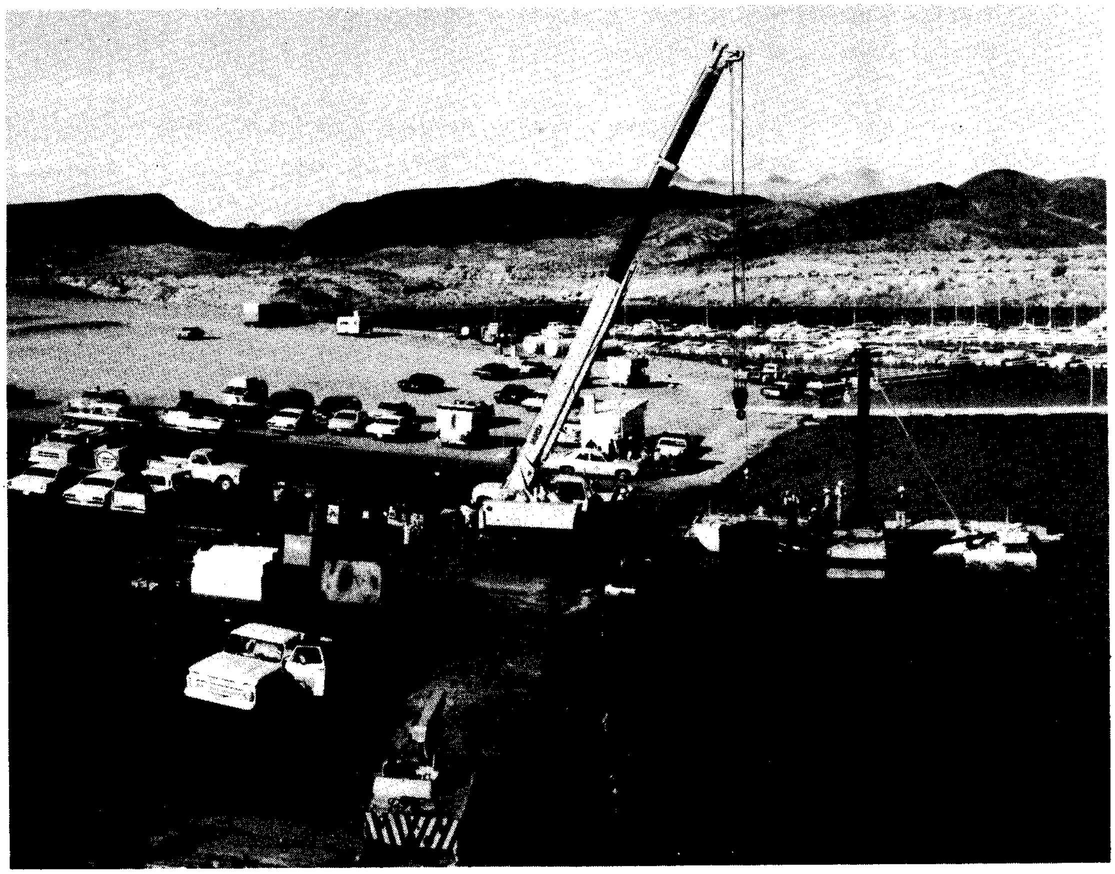
It became apparent within a few hours following the accident that a major, coordinated effort would be required to undertake the search and recovery operation. The Manager of the Nevada Operations Office of the Atomic Energy Commission, promptly set about the task of assembling the forces and support equipment. The Supervisor of Salvage, responding immediately to a request for assistance, committed Ocean Systems, Incorporated, to the operation on the morning following the accident. The Operations Manager for OSI arrived on the scene on 27 November to assume tactical direction of the salvage effort.

Forces Involved and Specific Assignments

OSI was tasked to perform the search and recovery operations using its Advanced Diving System (ADS-IV), which would be flown in by the U.S. Air Force from West Palm Beach, Florida, to Nellis Air Force Base, and from there transported by land to Lake Mead. Diver teams and equipment, a diving supervisor, and an underwater TV camera would also be provided for the operations.

AEC sub-contractors were charged with the responsibility of constructing a suitable working platform for the ADS-IV diving system and for providing sonar devices and underwater still camera equipment. In addition, communications services and equipment transportation would be handled by the AEC. Attention, of course, would be focused on the fabrication of the working platform since early commencement of full-scale salvage activity would depend on its rapid completion.

The National Park Service would contribute patrol boats, water transportation to and from an operational base on the shores of Lake Mead, and mooring and datum marking services as requested. Assistance would also be forthcoming from the Nevada Fish and Game authorities who would furnish a patrol boat and a fine-line fathometer for water depth profile runs.



Crane swings cube-shaped flotation cell into position. Platform was assembled by marrying a lifting davit to a 35-foot barge and rigging them with flotation devices.

CONSTRUCTION OF WORKING PLATFORM FOR THE ADS-IV AT CALLVILLE BAY MARINA

ELEMENTS OF THE PLAN

Search and Recovery Approach

The recovery of the bodies of those lost in the crash was the primary objective of the operations. Of secondary importance was the reclaiming of the aircraft wreckage. To effect recovery, the following approach would be taken:

Sonar search
Underwater TV camera confirmation of contacts made
Utilization of ADS-IV system for recovery attempts
Towing of wreckage to land base

While awaiting the arrival of the ADS-IV system and the completion of the construction of the working platform, search for the bodies and the wreckage would continue using sonar techniques. When and if a definite sonar signature was obtained, visual confirmation of the contacts would be made, if feasible, by means of the underwater TV camera. It was anticipated, however, that mud on the bottom might limit visibility.

Recovery attempts would follow using the ADS-IV. This system, composed of two major units, namely, a diving bell and a deck decompression chamber, would be ideally suited for the water depths and conditions existing in the impact area. The bell, which could hold two divers, allowed an added advantage to its underwater search capability in that the divers could be locked out, if necessary, to conduct a more thorough survey of the vicinity being covered. Thus, use of the ADS-IV in this case would increase the chances for success tremendously. Support equipment for the two major units included items such as an electric plant, hose box, air bottles, compressor, winch, and control house.

Establishment of Base Camp

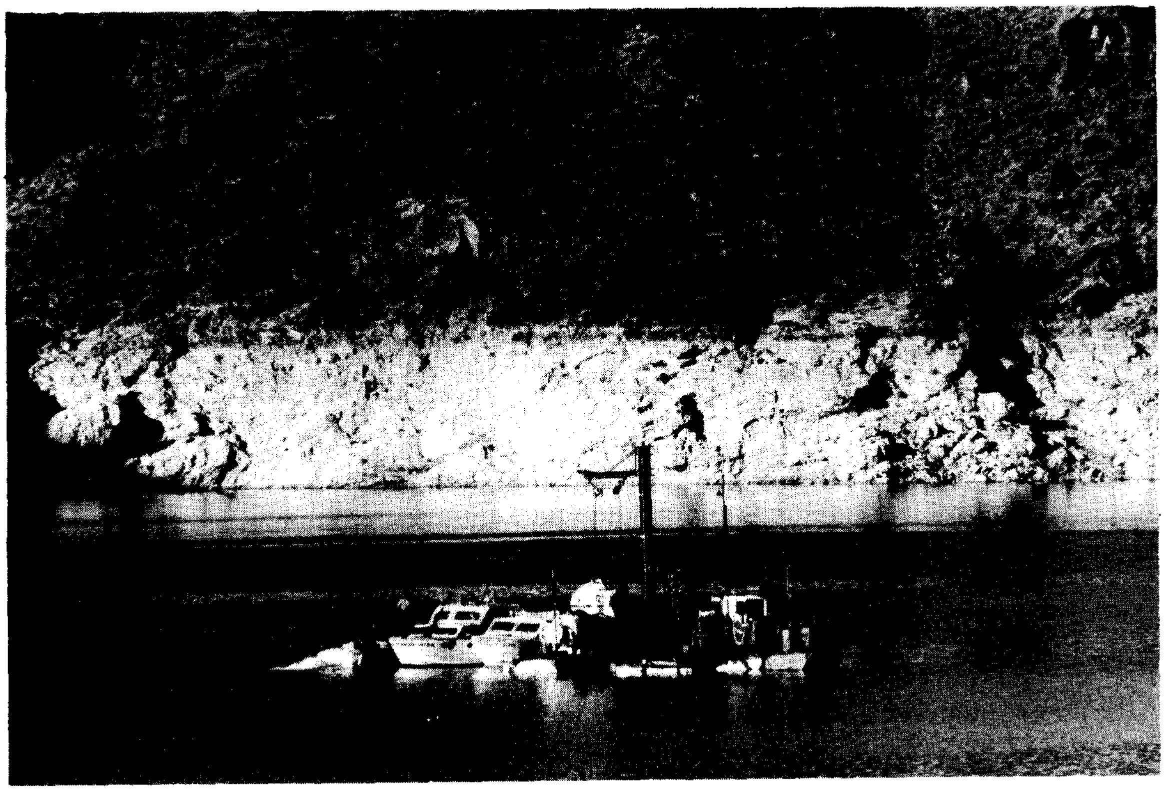
Base camp for the operations would be established at the Callville Bay Marina on the shores of Lake Mead, some six miles from the crash scene and about 40 miles from Las Vegas, Nevada. Major preparations at the site would include the fabrication of a working barge for the ADS-IV and the marshaling of all forces and equipment needed for the operation. All aspects of the operation were to be coordinated from this base camp.

CONDUCT OF OPERATIONS

27-30 November – Initial Search Activities

Sonar search and grapnel dragging during this period did not result in any significant contacts. The underwater TV camera was used in some instances, but heavy concentrations of suspended silt at the bottom of the lake made identification of any objects almost impossible. Fine-line fathometer readings within the marked search area were taken by the Nevada Fish and Games personnel as an aid in providing precise depth information for subsequent search efforts.

Fabrication of the working barge, including construction aboard of a lifting davit for the ADS-IV diving bell, proceeded at the base camp. The initial contingent of OSI diver personnel arrived on the scene and immediately prepared to assume their duties while awaiting the arrival of the ADS-IV. Long-range and local arrangements were set up for equipment transportation and loading.



Canyon walls, sloping downward into the lake, made bottom topography rough and uneven, hampering the use of surface sonar devices.

SEARCH AND RECOVERY OPERATIONS UNDERWAY AT IMPACT SITE IN BOULDER CANYON

1-5 December – Search Efforts Intensify

The complete ADS-IV diving system arrived at the Callville Bay base on 1 December and was hoisted on the working barge. Mounting and positioning of equipment commenced in earnest. The lifting davit was placed on the barge and load tested. As an added safety measure, a hydraulic ram was installed on the davit boom to assure greater freedom of movement in controlling the suspended bell.

Equipment installation on the barge was completed on 3 December, and on the following day the barge was towed to the crash site and moored in the marked search area. Mooring was accomplished by running two legs to anchors ashore and two more legs to Danforth anchors on the lake bottom. A total of five ADS-IV bell observation dives followed. Each dive produced no sightings or contacts, principally because of a heavy 20-foot silt layer suspended above the lake bottom which reduced visibility to zero. In the meantime, sonar readings strongly indicated that the wreckage was in the vicinity covered by the ADS-IV dives.

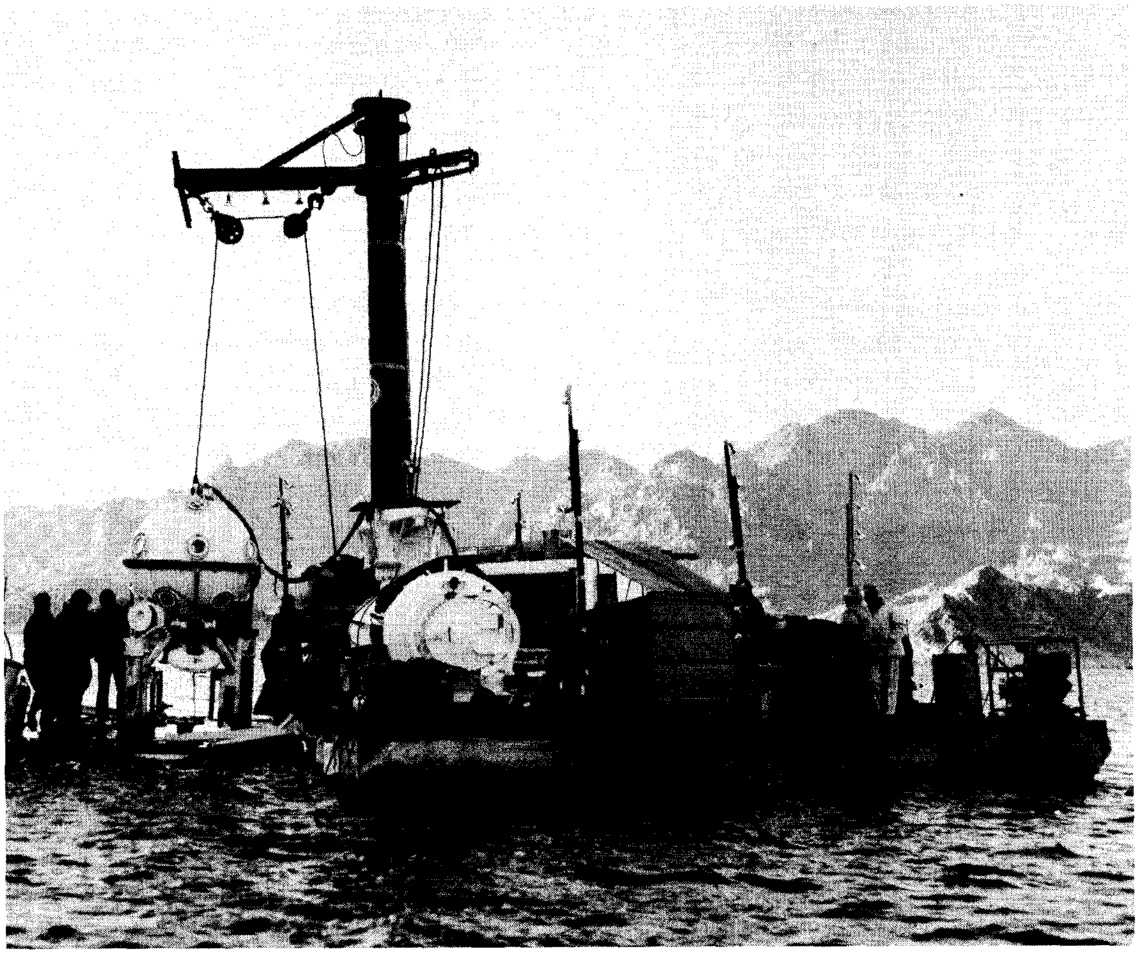
6 December – Wreckage Located

On 6 December the ADS-IV bell was lowered to the lake bottom again. Mounted to its outer shell were two sonar transducers, attached there at the suggestion of one of the sonar engineers at the scene. It was felt that in this way, movement of the diving bell could be directed more accurately toward the wreckage. The diving bell would be moved toward any strong sonar indications by repositioning the barge at the surface.

Use of sonar transducers on the diving bell succeeded in effecting contact with the aircraft. As the diving bell was moved slowly along the lake bottom, sonar recordings indicated that it was heading in the right direction. When it reached a point about 11 feet from the suspected location of the wreckage, a decision was made to lock out a diver for a circle line search, since visual sighting from within the bell was almost impossible because of the heavy silt. Shortly after exiting from the bell, the diver found the aircraft and attached a surface tag line to it. The bell, with diver, was then lifted to the surface and onto the barge.

7-8 December – Recovery Operations

Immediate preparations were made to lift the wreckage from the bottom. Lift slings were fabricated and a surface recovery wire from the davit was attached to the diving bell. A diesel powered, barge-mounted shore anchor air tugger would be used as the lifting winch. A U-206 aircraft, similar to the one which crashed, was flown to the scene to familiarize the recovery crew with the structural features as an aid to determining the best possible lifting arrangement.



After initial observation dives failed to locate the plane, the recovery force attached two sonar transducers to the ADS-IV diving bell and used sonar to home the bell in on the target.

TASK FORCE PREPARES TO LOWER ADS-IV DIVING BELL WITH LIFTING DAVIT

Lift operations commenced at 1300 on 7 December. A lock-out dive was made in which slings were attached to lift points on the aircraft without difficulty. Divers then reentered the bell and ascended to the surface. With diving bell on the barge and divers in the deck decompression chamber, a slow, careful bottom-breakout of the aircraft commenced which brought the plane to within 100 feet of the surface. Ascent ceased at this point as scuba divers were sent down to inspect the plane. Poor visibility, due to insufficient light, prevented a visual look at this depth. Diver inspection was repeated at the 30-foot level where the bodies of Dr. Thompson and his aide, Lt. Colonel Rosen, were discovered inside the plane and recovered. The body of the third passenger could not be found.

The aircraft was then re-rigged for final lift (it was upside down and had to be righted). Final lift, at about 1730 hours, brought the plane to the surface where it was dewatered and hoisted onto a small pontoon float and lashed down securely. A decision was reached not to continue searching for the third body. The working barge and the pontoon float were then towed to Callville Bay where the wrecked aircraft was unloaded onto a low-boy truck and transported to a National Park Service warehouse in Boulder City, Nevada. Demobilization of forces and equipment was completed in the following two days.

CONCLUSIONS

Three major factors influenced the conduct of the operations: the 400-foot water depth, near-zero underwater visibility, and the canyon walls surrounding Lake Mead. Lack of visibility seriously hampered the underwater search capabilities of the ADS-IV diving bell and forced discontinuance of the use of both the underwater still camera and TV equipment. Surface sonar was adversely affected by echo reflectivity from the canyon walls. Even in deep-tow application, sonar output power had to be reduced to cut out the "cross-talk."

Despite the limitations imposed by the aforementioned existing physical conditions, an almost totally successful operation was carried out. The installation of sonar transducers on the ADS-IV diving bell, and their subsequent use in the underwater search efforts, effectively offset the loss of the other underwater search equipment. Contact and location of the aircraft was achieved by this means, and thus, recovery of the wreckage was made possible.

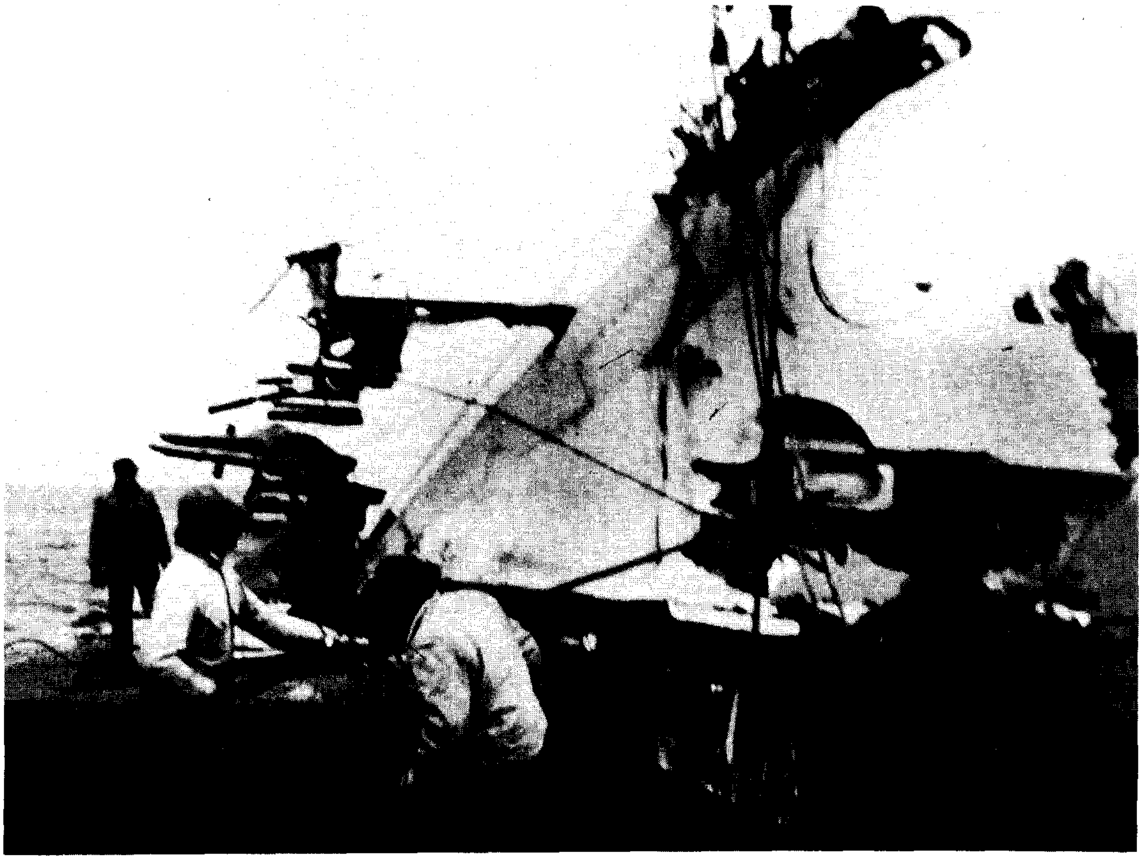
SUMMARY

OF

DOWNED AIRCRAFT

SEARCH AND RECOVERY

OPERATIONS IN 1970



Recovery of small debris as well as large portions of fuselage may be vital for accident investigation purposes.

CONTINUING SALVAGE TASK – THE SEARCH AND RECOVERY OF DOWNED AIRCRAFT

SUMMARY OF DOWNED AIRCRAFT SEARCH AND RECOVERY OPERATIONS IN 1970

INTRODUCTION

This article summarizes the services provided by the Office of the Supervisor of Salvage in connection with operations to locate and recover six different downed military aircraft. The recovery of an amphibious Cessna U-206 which crashed into Lake Mead, Nevada, in November 1970, has been the subject of an individual article presented previously in this 1970 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 salvage and recovery operations can get underway. Together, the search and recovery of these downed aircraft reflect the scope and diversity of services required to conduct operations of these types.

Each of the following operations is summarized in this article.

OPERATION	DATE OF CRASH
Search and Recovery of U.S. Air Force F-4D Phantom in San Pablo Bay, California	12 January
Recovery of U.S. Navy F-4J Phantom in Patraikos Bay, Greece	6 March
Search for Texas Air National Guard F-102 Delta Dagger in Gulf of Mexico	24 March
Recovery of U.S. Navy F-4J Phantom in Currituck Sound, North Carolina	24 April
Recovery of U.S. Navy A6A Intruder from Lake Chesden, Virginia	21 August
Recovery of U.S. Navy A6A Intruder from Eagle Lake, Mississippi	20 September

SEARCH AND RECOVERY OF U.S. AIR FORCE F-4D PHANTOM IN SAN PABLO BAY, CALIFORNIA

Date:	12 January 1970
Location:	San Pablo Bay, California
Condition:	Lost in 10 feet of water
Task:	Search and Recovery

Background

This aircraft crashed into the waters of San Pablo Bay just after takeoff from Hamilton Air Force Base, California. The two airmen in the plane were lost in the crash. The impact was witnessed by civilians in fishing boats nearby who picked up some of the debris which surfaced. The water in the impact area was about 10 feet, with a mud layer of about 6 feet on the ocean bottom.

U.S. Air Force helicopters and aircraft and U.S. Coast Guard cutters arrived on the scene shortly after the crash and conducted an immediate search. Except for determining the crash location, no positive results were realized in this effort. Among the Coast Guard cutters making this initial search was the USCGC POINT CHICO, which took a series of navigational fixes based on the impact point indicated by those witnessing the accident. A tentative geographic location was thus established for subsequent search activity.

The President of the Accident Investigation Board at Hamilton AFB requested Navy assistance in locating and recovering the downed aircraft. The Supervisor of Salvage, responding to the request, provided the services of Ocean Systems, Incorporated (OSI) for the operation and designated a Supervisor of Salvage representative at the site.

Search and Recovery Plan

Recovery of the remains of the two airmen would take priority over recovery of wreckage. Divers would be used to accomplish this task. It was decided that a limited search would follow utilizing LCM's (landing craft, medium) to drag for wreckage in the vicinity designated by USCGC POINT CHICO. Any and all contacts would then be buoyed off and verified by divers. Meanwhile, more refined support in the form of side-scan sonar devices and an autotape navigation system would be mobilized for the effort. The several commands in the bay area would provide assistance as required.

OSI divers and equipment would be used in the initial search attempt, assisted by two LCM's, one from the Naval Inshore Operations Training Center, Mare Island, California, and the other from the U.S. Naval Air Station, Alameda, California. A YSD (seaplane wrecking derrick) from Alameda would serve as a working platform in the operation. These forces would be deployed by 14 January at which time search operations would commence. Further survey and study would continue concurrently with the search and recovery mission.

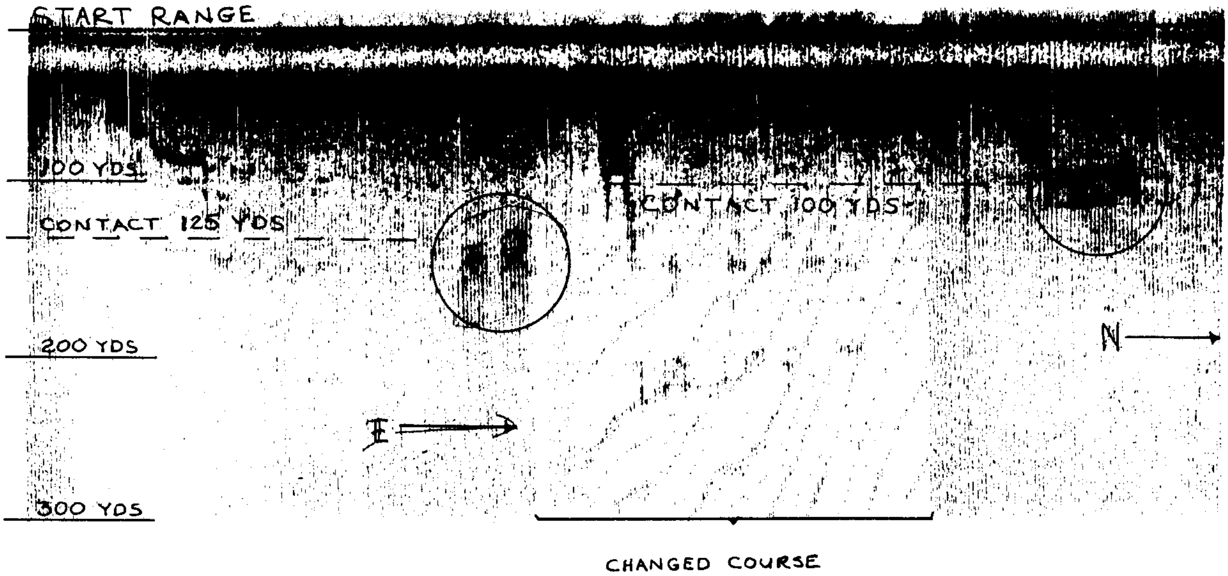
Conduct of Operations

The divers, the two LCM's, and the YSD assembled late 14 January around a search point buoyed off by POINT CHICO. Two random drag passes were made by the LCM's in the vicinity before darkness suspended further activity. Dragging operations, using sweep wire between the two LCM's and single drags hand-tended from the stern of each craft, continued on the next day. No contacts were made other than a large unidentified object which later proved to be an embedded old-fashioned anchor.

On 16 January, an additional LCM was acquired from the Murphy Pacific Marine Salvage Company for dragging operations. Utilization of three LCM's throughout the day plus intermittent diver inspections produced no evidence of the wreckage. The navigation and sonar systems (Cubic Autotape (DM-40) Electronic Position System, and Kelvin Hughes Transit Sonar, respectively) arrived that evening and were checked out, calibrated, and set up for use the next day.

Search operations continued on 17 January using grapnel drags and sonar. The first sonar pass indicated a debris pattern some 600 feet from the impact point originally marked by POINT CHICO. Diver investigations verified the sonar readings. Repeated dives followed which established the wreckage pattern, concentration, and spread (debris appeared to be within a 150-foot wide circle). Four buoys were emplaced to mark the corner limits, and wire drags were made along the borders of the area for peripheral debris.

Debris recovery began in earnest on 18 January and continued through 23 January using divers and travel net drag. Bodies of the two occupants of the aircraft were recovered. A "stand down" was put into effect on 23 January until an assessment could be made as to whether enough wreckage had been recovered to establish cause. On 24 January a decision was reached to continue operations using a derrick barge, crane, clamshell bucket, and washout pumps in lieu of the LCM's and the YSD. In addition, a 6 x 6-foot open-grid washout platform, constructed and welded on the barge, would be used for debris/mud washdown. Fine-grain recovery of the remaining wreckage could thus be achieved.



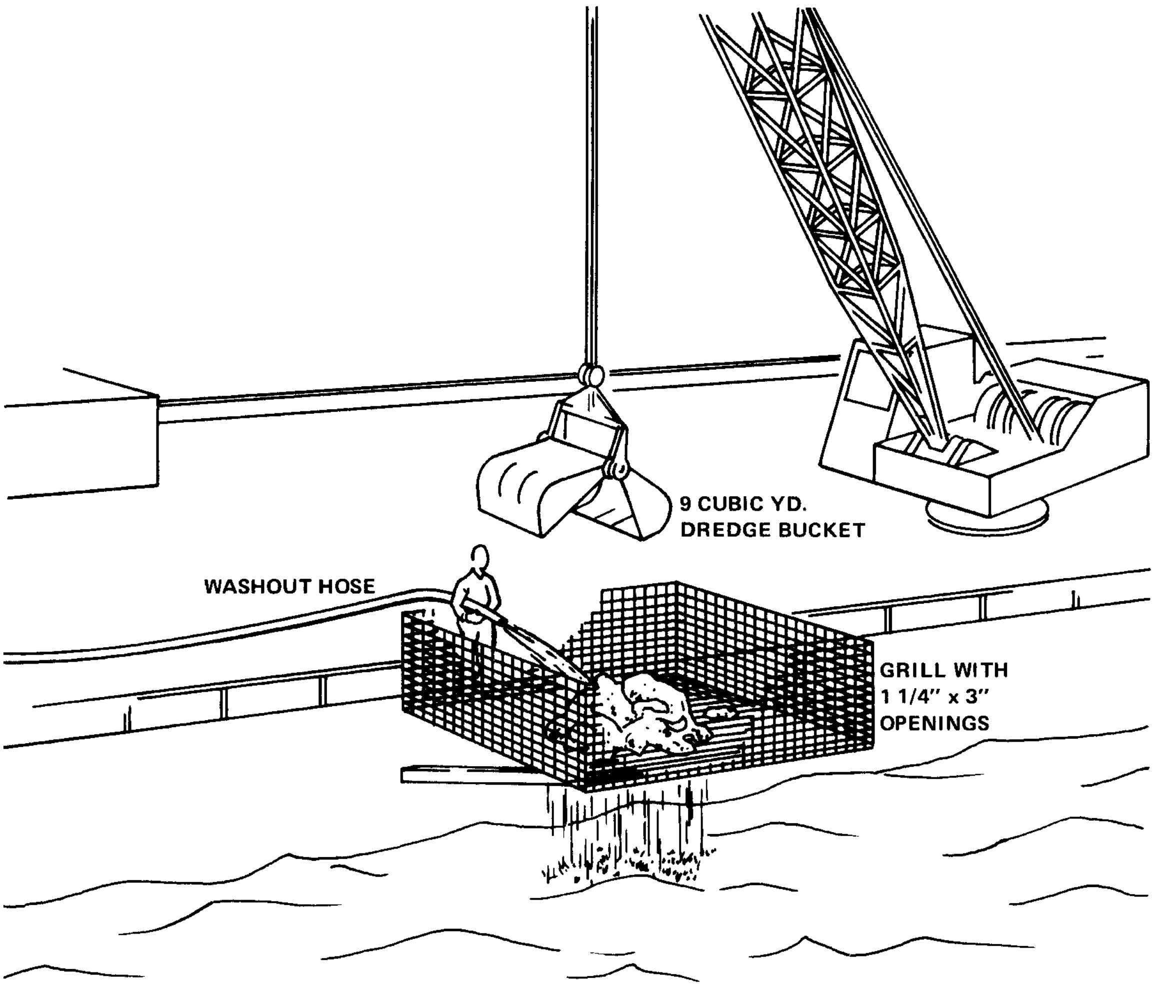
Kelvin Hughes Transit Sonar located the wreckage on its first sweep. This sonar is highly portable and especially suited for shallow water applications.

SONAR PATTERN OF AIRCRAFT WRECKAGE

Clamshell bucket dragging commenced on 26 January and was concluded the following day. Virtually all of the aircraft wreckage was recovered by the combined processes of dragging and digging. All wreckage was delivered to the U.S. Air Force via the Mare Island Naval Shipyard. Operations were terminated on 28 January.

Evaluation of Techniques and Equipment Employed

Search techniques using sonar and a navigation system were not used at the outset of operations as they were not available. The decision was made to proceed with drags and divers and to follow this with the sophisticated equipment if the initial on-scene search results so warranted. As events proved, these devices played a vital role in the subsequent follow-on search and recovery activity.



The task force used this method to recover aircraft debris after divers had recovered bodies of the plane's occupants. Debris was needed for accident investigation purposes.

CLAMSHELL DREDGING FOLLOWED BY SCREENING OF RECOVERED WRECKAGE

The sonar used was the Kelvin Hughes Transit Sonar which is especially suitable for shallow water applications. Operating at a frequency of 48 kHz and powered by 24 volts d.c., with ranges of 0–300 and 0–600 yards, this device showed its effectiveness in this operation by locating the aircraft wreckage on the first sweep.

The navigation system used was the Cubic Autotape (DM-40) Electronic Position System. It is powered by 12 volts d.c., operates at frequencies from 2900 to 3100 mHz, and has a range of 40 miles. The normal accuracy of this system at the 40-mile range is from one to three meters, depending on shore transponder locations and the shipboard interrogator antenna position. It is extremely precise, easy to read, and can be equipped with a position printer which will give instant recorded tape readings.

Two additional pieces of search equipment were sent to the crash scene but were not used. One was a high frequency sub-bottom profiler which was to be used if the wreckage was found to be buried deeply in mud. Another was a self-potential detection device which was to be substituted for the sonar if the latter did not produce sufficiently accurate acoustical patterns. This detection device is towed just under the water surface and measures the electrical potential generated by the rapid self-destruction of certain metals, such as magnesium, immersed in salt water.

Problems Encountered

Two problems affecting the operation were encountered. One was ship-shore communications. Many different combinations of ship-shore radar, walkie-talkies, etc., were used, but satisfactory communications were never established between the search site and Hamilton AFB (designated the official communications center for the operations). Imperfections in this regard did not hamper the search effort to any great extent.

The second problem dealt with operational access to Hamilton AFB. Original plans called for Hamilton AFB to provide various services, including daily air boat and small boat services, logistics and replenishment for on-scene craft, helicopter services, ground transportation support, communications, and shore berthing. The existence of a very shallow tidal canal between the base and the crash site prevented effective support so that staging had to be diverted to Mare Island about 10 miles to the north.

Conclusions

With the recovery of most of the aircraft wreckage and the bodies of the two airmen lost in the crash, operational objectives were met. Operations covered a 12-day period. In view of the presence of the two bodies in the wreckage, initial recovery techniques utilized diver services exclusively. Once the personnel had been recovered, full-scale dragging for debris commenced followed by clamshell recovery procedures. Of singular importance to the operations was the spotting of the debris by side-scan sonar devices at the outset of activity. The fact that debris was detected and verified on the very first sonar sweep made early full-scale dragging and recovery possible.

RECOVERY OF U.S. NAVY F-4J PHANTOM IN PATRAIKOS BAY, GREECE

Date:	6 March 1970
Location:	Patraikos Bay, Greece
Condition:	Wreckage in 75 feet of water
Task:	Recovery

Background

On 6 March 1970 an F-4J Phantom aircraft, attached to the attack aircraft carrier USS FRANKLIN ROOSEVELT (CVA-42), crashed in 75 feet of water approximately 200 yards off the northern shore of the city of Araxos, Greece. Explosive Ordnance Demolition (EOD) divers from the ROOSEVELT, and also the ammunition ship USS BUTTE (AE-27), were assigned to make a preliminary survey of the wreckage for the specific purpose of removing electronic components from the downed plane and rendering safe any weapons found.

The Commander of the Sixth Fleet directed the salvage ship USS PRESERVER (ARS-8) to recover the downed aircraft and to dispose of it as directed by the Commander, Fleet Air Force Mediterranean. Diplomatic clearance from the Greek government was obtained which allowed the PRESERVER to arrive at the crash site on 13 July 1970. Hellenic Navy assistance was requested for the operations, but was unavailable during the planned salvage time period.

Recovery Plans and Preparations

EOD diver observations following the crash showed that the aircraft was in several pieces, but all within a relatively limited area. Recovery of major component parts would be effected by lifting these to the surface by means of wire lift straps. Shipboard gear would then hoist them aboard. This method of recovery would be utilized if PRESERVER could be accurately positioned above the wreckage. In the event that this was not possible, major components would be raised to the surface by means of pontoon lift and then hoisted aboard. Since pontoon lifts were not normally carried aboard the PRESERVER as part of its salvage equipment, these were transported to the site from the ESSM pool at Livorna, Italy.

All forces and equipment were on hand at the scene on 13 July ready for commencement of the operations. Personnel aboard the PRESERVER were briefed by the EOD team as to the general underwater characteristics. In addition, the EOD team leader confirmed that all live ordnance had been rendered safe and that recovery operations could proceed without fear of this danger. Buoys had already been attached to various major components of the aircraft by the EOD team prior to the arrival of the PRESERVER.

Conduct of Operations

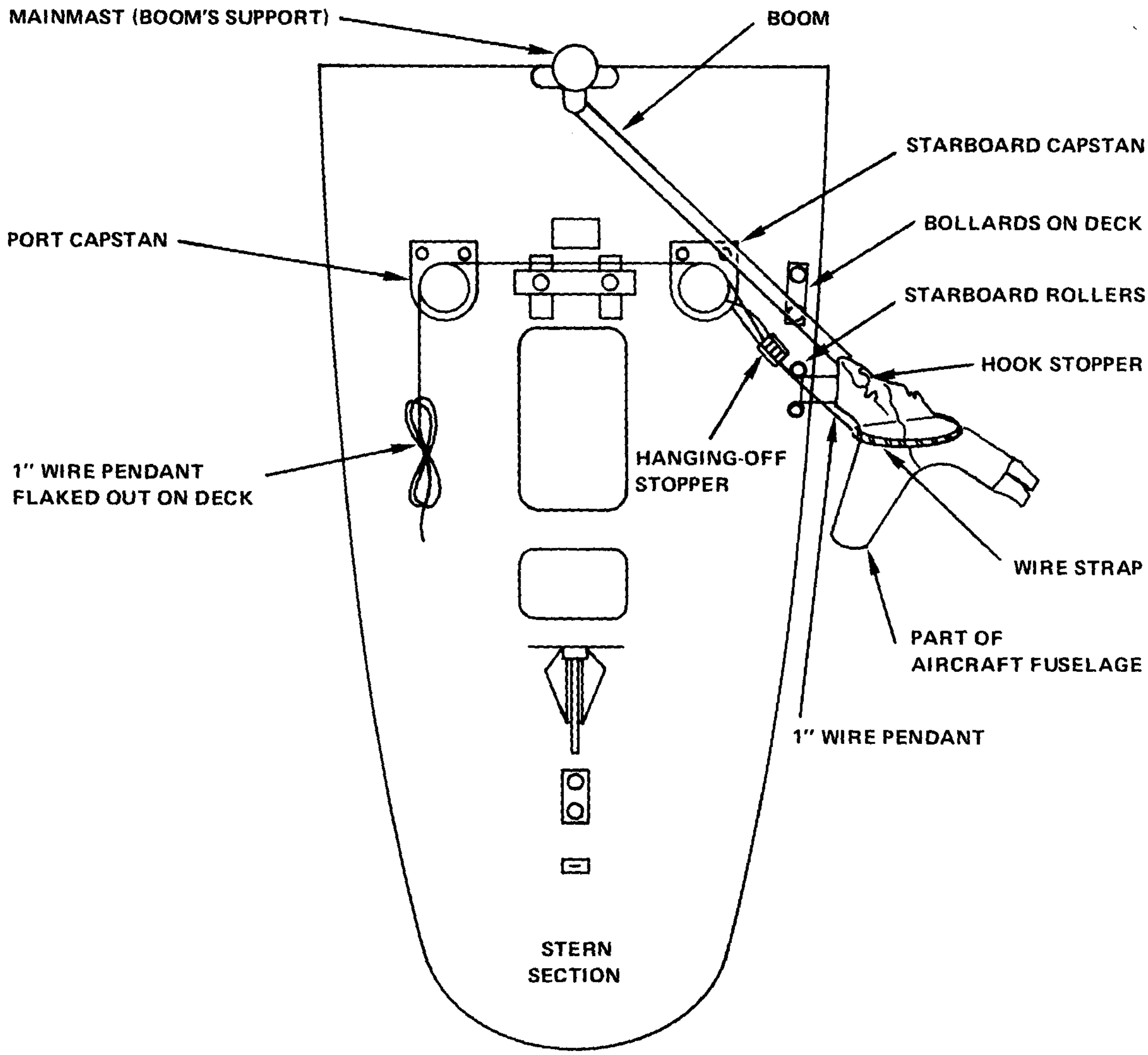
PRESERVER's divers, working out of a 35-foot workboat, began attaching 1-inch wire lift straps to the major component parts. This activity was halted shortly after the noon hour because of sudden strong winds which arose and which created dangerously high waves in the vicinity. Adverse weather conditions continued throughout the remainder of the day, making it impossible to resume the operations.

On the following day, inclement weather subsided, allowing full resumption of salvage operations. PRESERVER was positioned again over the wreckage. Divers secured a 1-inch wire pendant to the wire strap attached to the fuselage. The pendant was then run over the starboard quarter roller to the starboard capstan on the PRESERVER and across the deck to the port capstan in tandem. The fuselage was then lifted successfully to the surface, at which point the wire was secured with a 1-inch Carpenter stopper. The boom, with another 1-inch Carpenter stopper on the hook, was swung out to receive the fuselage. When this stopper was passed, the load was transferred from the capstan to the boom. The capstan wire was then cut and the fuselage was landed on the fantail.

As the work continued, salvage personnel succeeded in recovering other major components and small wreckage. To provide a greater degree of safety during retrieval of the larger sections of the aircraft, divers made modifications to the wire pendant used for this purpose. The 1-inch wire pendant was attached to a 4-inch double-braided nylon rope, the bitter end of which was buoyed off on the surface. The nylon rope was then brought to the ship where recovery procedures similar to those used in lifting and hoisting the fuselage were put into effect. The advantage, insofar as safety was concerned, was that divers would be relieved of working with heavy cables, or of hauling parts under extreme tension.

Termination of Recovery Operations

Six major components of the F-4J were recovered, plus small wreckage. Sections retrieved included the fuselage and right wing (less right wheel and nose section from leading edge of wing forward), the nose wheel assembly, the left wing and wheel, the nose section, the cockpit, and the tail section.



Wire holding the fuselage is secured first by the hanging-off stopper, placing the load on the capstans. The boom with another Carpenter stopper on the hook is then swung out to receive the load. The load is transferred when the hook stopper is passed and the wire is cut below the starboard capstan.

USS PRESERVER RIGGING FOR RECOVERY OF AIRCRAFT FUSELAGE

Salvage operations were completed prior to sunset on 14 July. PRESERVER, with all personnel and equipment aboard, departed Araxos, Greece, for Naples, Italy, the same evening. On 15 July, all aircraft sections and wreckage were jettisoned in 1700 fathoms of water in international waters. Jettisoning over the side was achieved with the same straps and pendants used in hoisting the aircraft parts aboard during the recovery operations. In jettisoning, the wire pendant was secured on deck and the load transferred from the hook to the hanging-off stopper. The hook was then tripped out and the 1-inch wire behind the handing-off stopper cut. The Carpenter stopper was then tripped out as the final step in the procedure.

Conclusions

Most of the aircraft was recovered in this 2-day operation. Lifting and hoisting procedures utilized allowed the maximum degree of safety possible for both personnel and the ship. In this regard, weights handled were always under positive control. At no time did a sudden transfer of weight occur during the recovery or jettisoning operations. This successful recovery operation, without injuries, setbacks, or costly delays, attests to the soundness of the recovery plan and to the competence of the salvage crews and their leaders.

SEARCH FOR
TEXAS AIR NATIONAL GUARD F-102 DELTA DAGGER
IN GULF OF MEXICO

Date:	**24 March 1970**
Location:	**Gulf of Mexico, off Texas**
Condition:	**Destroyed and lost in about 60 feet of water**
Task:	**Survey and Search**

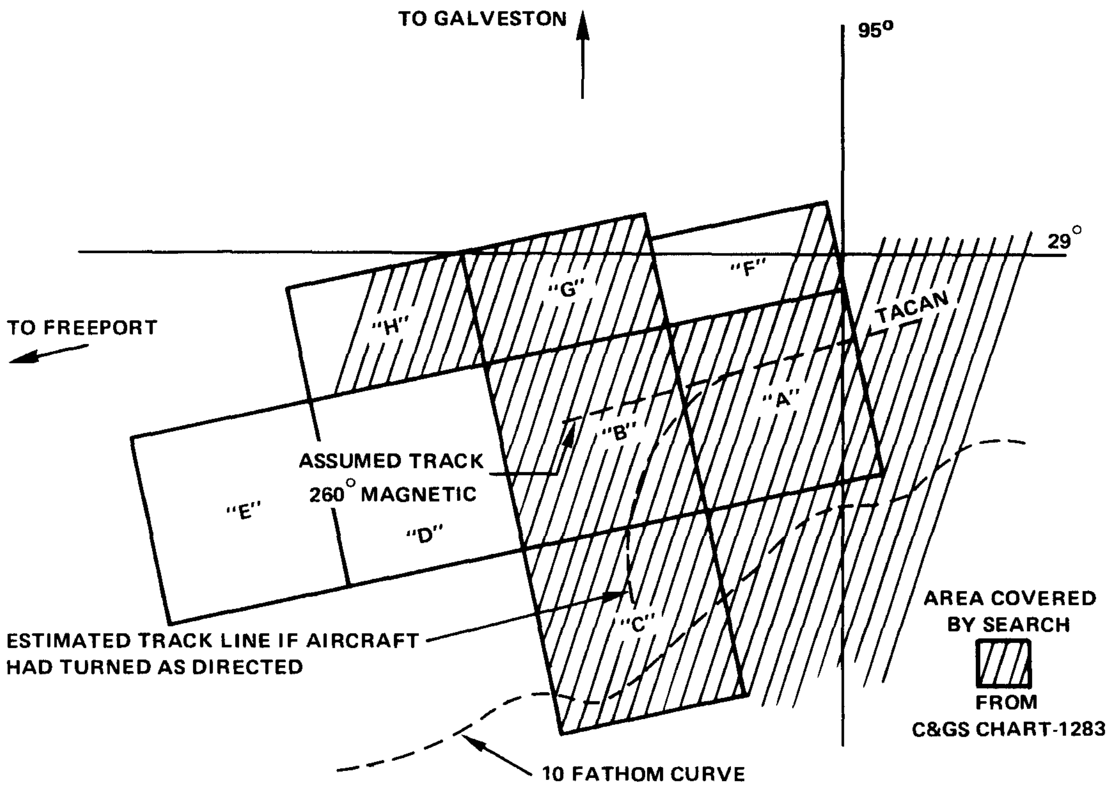
Background

This Texas Air National Guard (ANG) F-102 aircraft crashed while on night maneuvers over the Gulf of Mexico. The plane had just completed a practice radar attack pass on another friendly aircraft (both planes were from Ellington Air Force Base, Houston, Texas) when it suddenly disappeared from the radar tracking screen. Total loss of communications with the pilot accompanied the disappearance. The target plane immediately flew back over the probable impact area, but sighted nothing. A 4-day search for debris and/or signs of oil slicks by the U. S. Air Force and by surface and air units of the U. S. Coast Guard met with equally discouraging results.

In response to a request for assistance by the President of the Accident Investigation Board and the Safety Advisor, Texas ANG, the Supervisor of Salvage moved to provide technical support in the investigations. Ocean Systems, Incorporated (OSI) was directed to discharge this responsibility for the Supervisor. Survey and search procedures were developed to meet the demands of the situation and overall management and coordination were provided to assure efficient implementation of proposed plans.

Proposed Conduct of the Operation

The impact area could only be surmised in this case since loss of communications with the pilot following disappearance of the plane on the radar screen made it impossible to accurately determine the direction, speed, and altitude of the aircraft prior to the crash. A wide area would have to be searched to compensate for this lack of information. Assumed final aircraft trackings and estimated distances were plotted, based on a single TACAN line of bearing on an IFF beacon signal flashed prior to the crash. This signal could not be totally relied on since it could have originated from either one of the two aircraft. An order sent to the pilot to turn left was a related planning factor, although it was not known whether he had carried it out.



The sonar search covered almost 25 square miles. A TACAN line of bearing provided the only basis for identifying the impact area. The search did not locate the aircraft.

CONDUCT OF SONAR SEARCH FOR LOST F-102 AIRCRAFT

Search was to be conducted using dual side-scanning sonar and a Cubic Autotape precision navigation system. These techniques were considered most effective for broad coverage in water depths of 60 feet. The search area was set up in three 2 x 2-mile squares and designated areas "A," "B," and "C." Alternate areas "D" and "E," each also 2 x 2 miles square, were also provided in the event that no contact was made in the first three areas. USCGC POINT MONROE, an 82-foot cutter, would be used to test the sonar equipment prior to actual search operations and would also serve as a working platform if practice runs showed it to be suitable for this type of activity. Search would emanate from Freeport. Texas. the nearest port to the assumed impact area.

Survey and Search Activity

MONROE got underway for its test run on 1 April. Her performance proved unsatisfactory since she could not be operated slowly enough to allow effective use of the side-scanning sonar. In addition, deck working space was too limited. The fishing vessel, JAMES D, a 65-foot twin-screw craft with a large cabin and ample working space and with positive slow-speed control, was then hired from Dearborn Marine Service to replace the MONROE.

On 2 April, JAMES D, loaded with all gear, departed for search area "A." After completing four passes there, the autotape navigation system malfunctioned, making it necessary to return it to Freeport for repairs. Repairs could not be made, so a Decca Hi-Fin navigation system was substituted. On the following day, search resumed but was seriously hampered again when one scanning side failed. No contacts had been made by the end of the day.

Search of prime areas "A," "B," and "C" was completed by 9 April with negative results. Operations then shifted to newly designated areas "F," "G," and "H" to the north, but no contacts were made there either. The President of the Accident Investigation Board terminated the operation on 10 April. Demobilization of personnel and equipment was completed by 12 April.

Conclusions

A total of approximately 25 square miles was covered in the undertaking with negative results. Two of the 9 days at sea were not fully productive because of equipment breakdowns. The major problem affecting the operation was, of course, the absence of vital information needed to ascertain within reasonable limits the location of the F-102 when it went down. Given this lack of information, search area boundaries were set up to give the widest coverage possible under the circumstances.

RECOVERY OF U. S. NAVY F-4J PHANTOM IN CURRITUCK SOUND, NORTH CAROLINA

Date:	24 April 1970
Location:	Currituck Sound, North Carolina
Condition:	Wreckage in 6 feet of water
Task:	Recovery

Background

This aircraft crashed into the waters of Currituck Sound taking the lives of the two passengers aboard, the pilot and the radar intelligence officer. Impact occurred about 2 nautical miles from Corolla Light, North Carolina. Eyewitnesses reported the aircraft flying low over the water, then disappearing in a splash. No parachutes were observed prior to crash, indicating that the passengers went down with the plane.

U. S. Coast Guard craft and divers from Sea and Land (SEAL) Team Two, a unit of the Commander, Amphibious Force Atlantic (COMPHIBLANT), were dispatched to the crash site to recover the bodies and to reclaim confidential fire control equipment and explosives aboard the plane. The F-4J carried a MK 106 practice bomb, various pyrotechnics, and two rocket-equipped MK H-7 ejection seats. Coast Guard personnel and SEAL Team Two were unable to locate these items, or any other major components, in their coverage of the impact area. Before leaving the scene, the Coast Guard marked the area with a jerri can and a clorox bottle, the two buoys being aligned to point towards Corolla Light.

Commander Service Squadron EIGHT (COMSERVRON EIGHT) directed Harbor Clearance Unit Two (HCU-2) to recover the aircraft wreckage. Harbor Clearance Team One (HCT-1), a working team of HCU-2, was alerted to undertake the task.

Preparations for the Recovery Effort

HCT-1 departed Norfolk, Virginia, on 25 April for the Naval Air Station (NAS) at Oceana, Virginia, for early morning preliminary briefings with Navy Safety Center (NAVSAFCEN) personnel. Following these conferences, both groups proceeded to the crash site by convoy, arriving there early in the afternoon. Inspection and survey of the crash scene were not made since surface craft were not available for this purpose at this time. The personnel spent the rest of the day searching for a suitable base camp site. At the day's end, it was decided that land adjoining the Corolla Light property would be the most convenient location for the camp.

Support surface craft for the recovery operations would be furnished by Beach Master Unit Two, COMPHIBLANT, in the form of two Light Amphibious Resupply Craft (LARC's) and by HCU-2 in the form of one self-propelled Seaplane Wrecking Derrick (YSD-53). Both of these types of craft would be ideally suited for work in shallow waters ranging in depth from 1 to 6 feet.

At dawn on 26 April, while HCT-1 was awaiting the arrival of the LARC's, the Officer-in-Charge of HCT-1 and one of his divers attempted to locate the buoys previously placed over the impact area by SEAL Team Two. These were not found. Another HCT-1 two-man diver team followed and marked the area with a flotation balloon. The two LARC's arrived and all salvage assets and personnel were taken to the base camp near Corolla Light. The YSD-53 was not expected to arrive until late noon on 27 April.

The Salvage Plan

To assure the greatest possible coverage, a circle-line search of the impact area would be made by the HCT-1 divers utilizing the two LARC's as diving platforms. Recovered wreckage would be placed on the LARC's, transported to shore, and then transferred to NAS Oceana trucks. Sweep-chain dragging by the LARC's would accompany the circle-line search to clear the heavy growth of weeds and underwater plants infesting the area.

The YSD-53 would be anchored in the approximate center of the impact area and used as a support vessel during the diving operations. Large and heavy fragments found by the divers which could not be handled by the LARC's would be lifted and recovered by the YSD-53.

It was decided that because of the swampy nature of the impact area and the heavy undergrowth of weeds, the jackstay method of search, normally used in shallow water recovery of widely scattered wreckage, would not be used in this instance. There was no doubt in the minds of the HCU-2 and NAVSAFCEN planners that this method would be effective even under these conditions, but movement of gear would be impeded by the heavy undergrowth to the extent that it would cause a prohibitive extension of the contemplated operational time planned for the overall task.

Conduct of Operations

A search of the salvage area was undertaken by HCT-1 divers on 26 April, utilizing a LARC as a diving platform. Water depth was less than 6 feet. A few small pieces of wreckage were recovered, before darkness and inclement weather halted further efforts. Heavy weed growth hampered diver activity considerably.

Diving efforts continued on 27 April utilizing the two LARC's. No large aircraft pieces were recovered, although numerous small items continued to be retrieved. Human remains of the occupants were also found. An area of about 200 square yards was covered by the divers on this day.

By 1 May about 50 percent of the aircraft was recovered by the divers. Almost all of the wreckage was in small pieces. Divers were successful in recovering a portion of one engine. Occasional delays were experienced in the operation due to fog and rain, but these did not seriously hamper the search and recovery efforts.

Operations ended on 7 May with the recovery of about 65 percent of the wreckage. The only large pieces retrieved were portions of the two engines. Total weight of wreckage reclaimed was approximately 7,000 pounds.

Conclusions

An area of about 300,000 square yards was covered by the divers and the sweep-chain drag in a 12-day period. Despite problems encountered, such as the unusually heavy weed growth, widely scattered fragments of the aircraft, occasional inclement weather, and the relative remoteness of the impact site from land areas, salvage forces succeeded in recovering most of the wreckage. With regard to the loss of the two buoys originally placed in the impact area, it is suggested that in the future flotation balloons be used, with an identifying tag attached, to minimize the recurrence of such losses.

RECOVERY OF U. S. NAVY A6A INTRUDER FROM LAKE CHESDEN, VIRGINIA

Date:	**21 August 1970**
Location:	**Lake Chesden, Virginia**
Condition:	**Wreckage in 10 to 20 feet of water**
Task:	**Recovery of Wreckage**

Background

A Navy A6A Intruder aircraft carrying classified material crashed into Lake Chesden near Petersburg, Virginia, on the afternoon of 21 August 1970. The pilot parachuted to safety prior to the crash. No live ordnance was aboard. Aviation Squadron VA-176, stationed nearby, was immediately contacted to provide security forces at the site and the personnel needed to recover the classified material.

The Commander, Service Squadron EIGHT (COMSERVRON EIGHT) tasked Harbor Clearance Unit Two (HCU-2) to recover the aircraft. On 23 August, the Officer-in-Charge of Harbor Clearance Team One (HCT-1), a working team of HCU-2, arrived at the scene to survey the conditions and to determine equipment and personnel requirements for the operation.

Impact occurred off a cove of Lake Chesden, about 100 feet from a poorly defined shoreline (marshlands followed the shoreline contour) and in waters ranging from 4 to 10 feet in depth. A charted underwater old creek bed, dropping abruptly some 25 feet into the lake bottom, swung past the impact site some 100 feet further out into the lake. Nearby was Allen's Marina, a boat basin bordering on Virginia State Highway Route 623 and within easy reach of the impact site area. The owner of the marina allowed the use of his boats and other equipment in the salvage operations which followed.

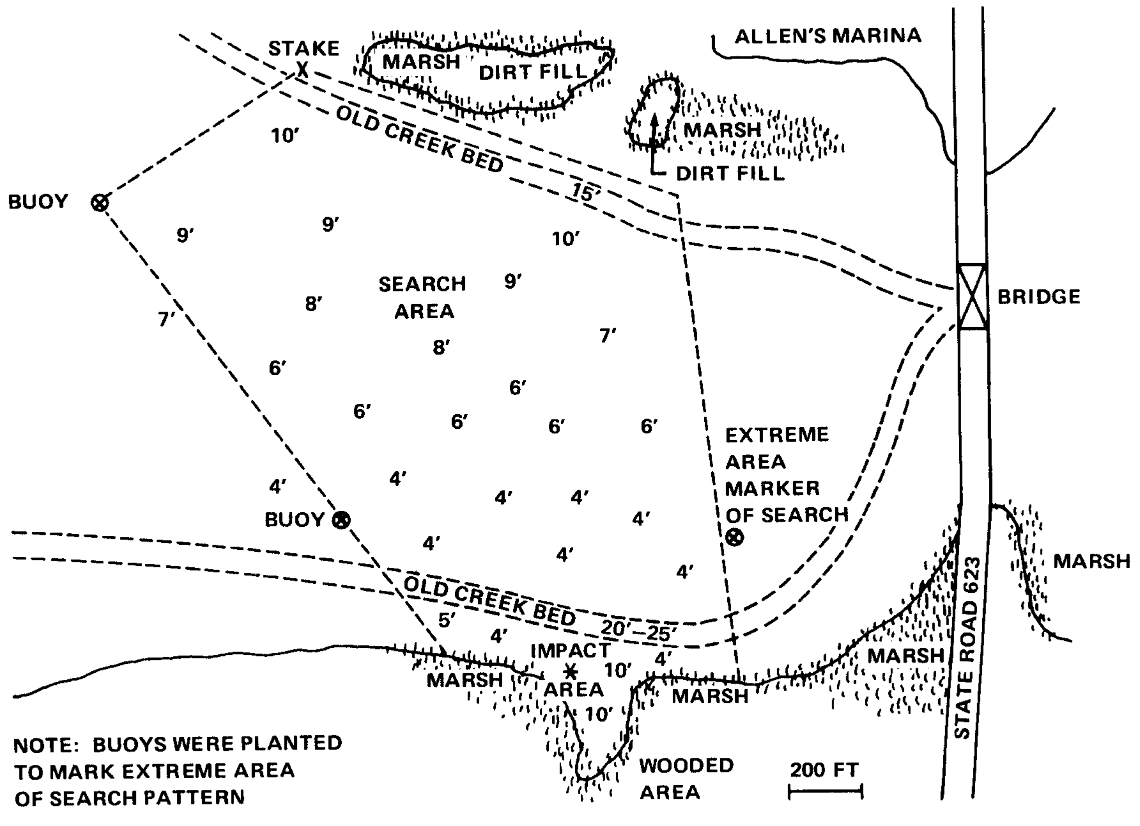
Recovery Plans and Preparations

The salvage approach was predicated on the physical conditions found at the impact site, namely, the relatively shallow waters in which the HCT-1 team would have to work and the close proximity of the aircraft wreckage to the lake shore. In addition, there was reason to believe that the wreckage was widely scattered, since debris which floated to the surface at the time of impact was reported to have appeared over a relatively broad area. In light of these conditions, the survey team decided to apply the following techniques and procedures for the recovery effort.

Scuba diver search for wreckage
Jackstay rigging for systematic search coverage
Small boat retrieval of aircraft fragments
Dragging and pulling of larger sections from lake by means of a cable attached to a portable winch on land

Since the general impact area was well defined, buoys would be set marking the field of search. Search and recovery efforts would emanate from a shore base, located as close as possible to the search area.

HCU-2 personnel and equipment arrived at the scene on 24 August and immediately set up a base of operations near the crash site. A section of guard rail surrounding the area was removed to allow entry and departure of vehicles. A 6 x 6 truck, with the portable winch installed on it, was placed in position for the forthcoming operations. Trailers were set up on higher ground and brush was cleared to allow room to assemble water-rigging gear for the scuba divers.



Aircraft wreckage was strewn throughout a swampy area. Divers, wading in some parts of the marsh, used jackstay rigs and circling lines to cover the area systematically.

MARSHY AREA OF LAKE CHESDEN, VIRGINIA SEARCHED BY HCU-2 DIVERS

Conduct of Operations

Diving operations commenced on 25 August off the Lake Chesden cove where most of the wreckage was lying. Two divers, using shallow water gear, were immediately successful in finding and recovering several aircraft parts, among these being one engine, the tail section, hydraulic parts, and various other small pieces. The engine and tail section were winched out by the 6 x 6 truck. Other fragments were brought to shore in small boats. By the end of the first day, approximately 15 percent of the aircraft had been retrieved.

Successful recovery of numerous aircraft parts continued through the next 5 days. Jackstay rigging proved invaluable as an aid in guiding the divers during their search efforts. For example, on 28 August, the jackstay rig was moved out of the confines of the cove to a position 200 feet offshore. Reference buoys were planted at each extreme boundary of the search area. The jackstay, made up of 1/8-inch polypropylene line, was then moved progressively to the left at 4-foot distances as divers completed each search and recovery run. When and if aircraft fragments were recovered, small boats would be on hand to transport them to the shore base. Divers were tended by a line from one of the boats to the jackstay, and a 3/4-inch shackle was spliced to the line for divers to move along the jackstay.

On 29 August, concentrated search efforts shifted back to the area near the shoreline. A wing section of the aircraft, which had been discovered a few days before and buoyed off, was rigged with eight flotation balloons and raised to the surface. It was then towed to the shoreline and pulled onto the beach by the portable winch. On the following day, a large section of the fuselage was also found, rigged with balloons, and recovered.

Salvage operations were terminated on 30 August with the recovery of about 90 percent of the wreckage. Buoys were removed and all equipment reloaded for return to home base.

Conclusions

The competent performance of HCU-2 personnel in this operation, from planning, to conduct of operations, to successful conclusion, merits high praise. The accomplishment of almost total recovery of widely scattered fragments and sections of the downed aircraft within a relatively short period of time reflected this competence and the soundness of the techniques and procedures that were used.

The use of jackstay rigs was particularly effective in helping the divers to search the area systematically and progressively. Using the rigs, the recovery force was able to canvas the area thoroughly in a short period with no lost motion or wasted effort.

RECOVERY OF U. S. NAVY A6A INTRUDER FROM EAGLE LAKE, MISSISSIPPI

Date:	**20 September 1970**
Location:	**Eagle Lake, Mississippi**
Condition:	**Wreckage in shallow water**
Task:	**Follow-up Recovery**

Background

This aircraft crashed into Eagle Lake some 50 feet from shore and in water depths of 3 to 4 feet. The force of impact drove the forward section of the fuselage into the mud bottom and scattered the remaining wreckage over a wide area of the lake. A 12-foot crater was carved out at the impact point.

Civilian divers were immediately engaged to recover as much of the wreckage as possible. By 30 September they succeeded in retrieving approximately 50 percent of the aircraft. Equipment used by the divers to effect recovery included a large crane and high pressure pumps, the former being used to lift heavy objects and the latter to force mud away from deeply embedded parts. Major items recovered included the port engine, three compressor stages of the starboard engine, electronic gear, and fuel flow instruments.

On 30 September, Commander Service Squadron EIGHT (COMSERVRON EIGHT) tasked Harbor Clearance Unit Two (HCU-2) to continue and complete the operation. Harbor Clearance Team One (HCT-1), a working team of HCU-2 consisting of an Officer-in-Charge and seven divers, departed the Naval Air Station, Norfolk, Virginia, for Vicksburg, Mississippi, on the same day via military airlift. The team arrived at its destination at 1730 that evening and secured for the night. On the following day, the group proceeded to the scene of the crash to survey and inspect the site conditions and to prepare for the operations.

Recovery Plans and Preparations

HCT-1 arrived at the crash scene on 1 October at about 0915 and immediately set up an offshore diving station. Shallow water diving rigs were assembled using portable air compressors with volume tank. Following an inspection of the impact site, it was decided to begin the recovery efforts in and around the crater where most of the larger remaining pieces of wreckage was believed to be embedded. The main concern would be the recovery of items such as the second engine, fuel controls, generators, and stern fuel system gate valves.

Recovery operations would proceed using a variety of shallow-water techniques. The basic plan called for scuba divers to search for, locate, and recover as much of the wreckage as possible. The jackstay method would be used by the divers to assure maximum coverage of the areas being searched. Small boats would transport to shore any recovered debris. Larger and heavier items would be retrieved by means of a mobile crane. In this connection, high pressure pump tunneling under these bulky objects would enable the divers to pass wire lift straps underneath them so that lift could be achieved.

The Army Corps of Engineers, Vicksburg, Mississippi, offered to cooperate in the endeavor by making available to HCU-2 a mobile heavy lift crane and high pressure pumps. Further assistance would be provided by the Corps during the progress of operations, if and when needed.

Conduct of Operations

Initial search and recovery activity was confined to the area in and around the 12-foot crater. Divers, using scuba equipment, found and recovered several small pieces of the aircraft. A major find was the second engine. This was deeply embedded in about 7 feet of mud. Diving operations continued throughout the day.

From 2 October through 4 October, concentrated efforts made to dig a tunnel under the engine did not succeed. Difficulties, in this regard, stemmed from delays caused by high pressure pump failures, and from heavy silt accumulations in the vicinity which hampered the work being carried out by the divers. Because of these impediments, tunneling activity ceased at 1200 on 4 October. Plans were then made to secure an airlift from the Army Corps of Engineers for subsequent tunneling efforts. Meanwhile, search for the remaining wreckage continued. A 200-foot jackstay was rigged using a 1/8-inch polyethylene line, salvage balloon floats, and cement block weights. This method of search proved to be effective. Divers continued to recover many more fragments of the aircraft.

On 5 October, HCT-1 rigged the airlift for resumptions of tunneling under the engine. In this connection, an "A" frame was installed on a small barge to assist in handling the gear. Use of the airlift, with washout nozzle married to the end, enabled HCT-1 personnel to successfully tunnel under the engine and to secure two wire straps. Twenty salvage balloons were then attached to the engine and filled with air from a low pressure system. The engine was lifted and recovered on 7 October by means of the mobile crane. Underwater search and recovery operations continued until 10 October, at which time all activity was terminated. About 80 percent of the aircraft wreckage had been recovered by both the civilian and the HCT-1 teams.

Conclusions

Recovery of most of the widely scattered wreckage and debris, including significant major items such as the two engines of the aircraft, reflected the competence of the personnel involved in the operations and the effectiveness of the techniques and procedures employed. Three factors influenced the conduct of the operations, namely, shallow waters, deeply buried objects, and widely scattered debris. Means employed to overcome the problems posed by each of these conditions proved to be more than satisfactory. In particular, application of the jackstay method of search was a major factor in providing more than adequate coverage of areas close to and beyond the crater dug out by the aircraft.