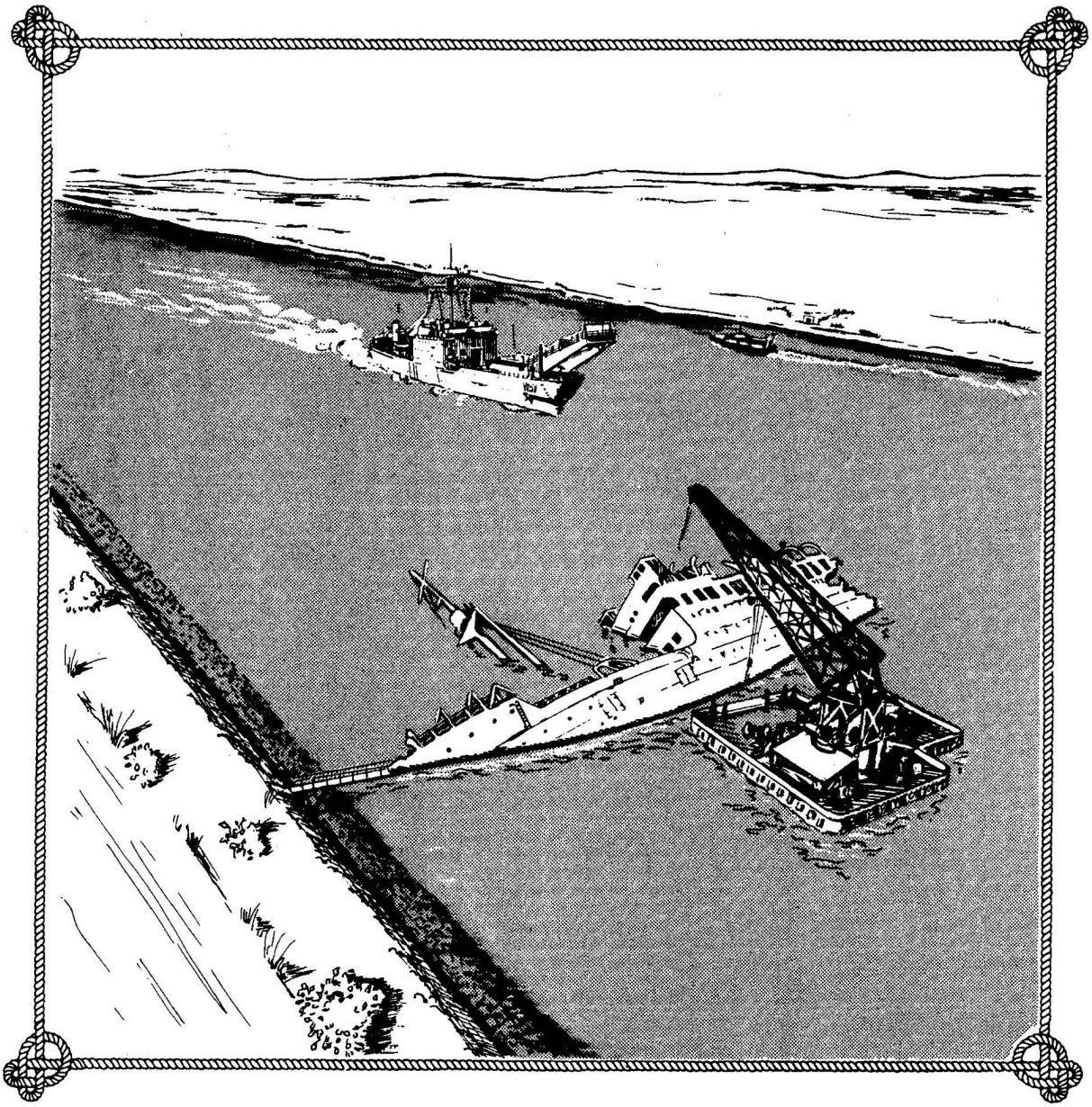
NAVSEA 0994-LP-012-6060

SALVOPS 74

A review of significant salvage operations conducted by U.S. Navy salvage forces and other salvage activities during 1974.



SUPERVISOR OF SALVAGE, U.S. NAVY
NAVAL SEA SYSTEMS COMMAND
WASHINGTON, D.C.

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

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NAVAL SEA SYSTEMS COMMAND
WASHINGTON, D.C. 20362

FOREWORD

Lessons documented by the record of operations conducted under the auspices of the Supervisor of Salvage in 1974 are particularly valuable from the point of view of harbor and channel clearance. Although water depths seldom exceeded 40 feet, a wide variety of problems associated with wreck removal were encountered while dealing with the 14 vessels covered by this report. In addition to these major undertakings, a variety of unique projects were accomplished.

- Supervisory personnel and equipment were dispatched to assist indigenous shipyards in Southeast Asia with the task of installing polyurethane flotation foam in riverine craft.

- USS MONITOR, lost for over one hundred years, was found, located electronically with precise coordinates, and proof of her identity was established by remote underwater photography.

- Emergency dewatering assistance was provided in two cases where vessels had experienced flooding.

- Numerous pinpoint search and recovery operations were successfully conducted for aircraft and special components.

The chronicle of salvage work, set forth annually in this SALVOPS series, is establishing a substantial background of case histories that will be of accumulative value to the salvage community. These reports are cross indexed in a variety of useful categories, as well as abstracted to facilitate reference for future use.

1 September 1978

ROBERT B. MOSS, CAPT., USNR
Supervisor of Salvage, U.S.N.

ABSTRACT

SALVOPS is the annual review of significant salvage operations conducted by the Supervisor of Salvage (SUPSALV), U.S. Navy. This includes operations of U.S. Navy salvage forces and those of contractor salvors working under the auspices of SUPSALV. The operations reported in this review are intended for general reading by those interested in the current state of the salvage art. The largest single type of work was devoted to clearance of wrecks from navigable waterways. The major effort was the operation to open the Suez Canal by the removal of ten large wrecks. A substantial effort also was mounted to remove the dredge MACKENZIE from Galveston Channel. The removal of YDT-9 from York Spit Channel in Chesapeake Bay, although made difficult by weather and current, was modest in scope. Two strandings were of concern: the tug USNS LIPAN was aided after deliberate grounding to deal with collision-flooding in the Strait of Juan de Fuca; and the 30,000-ton liner CARIBIA became a problem for the Navy when it was lost from a tow and broke up on the Apra Harbor breakwater, Guam. The fact that it was not blocking the channel had to be ascertained. The successful search and photography of USS MONITOR off Cape Hatteras was a unique operation, historically, for which SUPSALV provided support. The injection of polyurethane foam to protect riverine craft from battle damage in Southeast Asia was a technically interesting project. Useful oil pollution recovery work was undertaken at Avila Beach, California, after the USNS MERRELL's postcollision repair effort was interrupted by a storm off San Luis Obispo Bay. The usual summary of downed aircraft recovery operations also is set forth.

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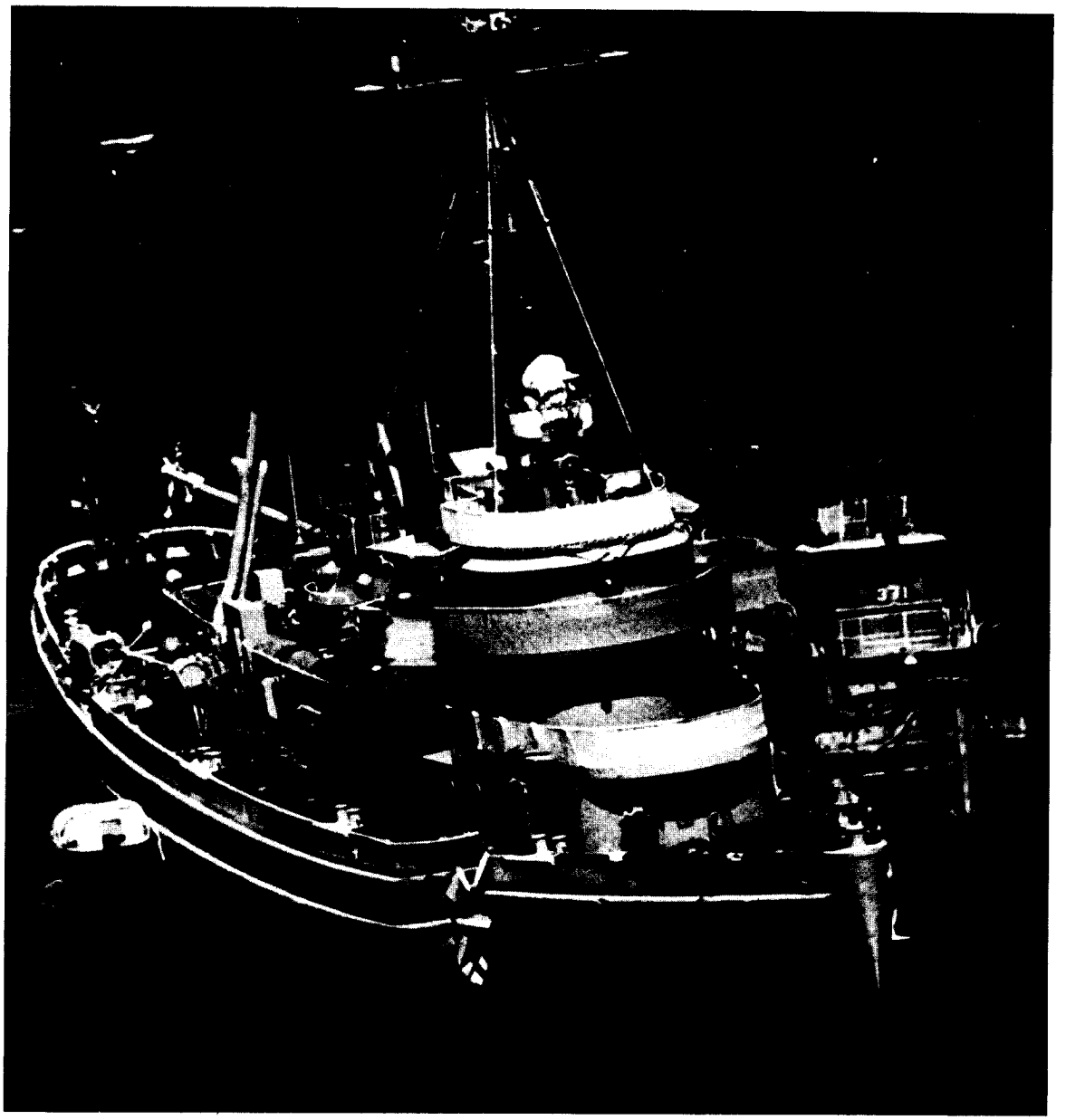
RETRACTION AND RECOVERY

OF USNS TUG LIPAN



WHILE TOWING A TUG, LIPAN COLLIDED WITH A TANKER

USNS LIPAN (T-ATF-58) was damaged in a collision with the tanker ATLANTIC PRESTIGE while towing the fleet harbor tug YTM-371 through the Strait of Juan de Fuca.

RETRACTION AND RECOVERY OF USNS TUG LIPAN

INTRODUCTION

On 3 August 1974, while transiting the Strait of Juan de Fuca with a small craft tow, the USNS fleet ocean tug LIPAN (T-ATF-58) collided with a tanker. There was no significant damage to the tanker, but LIPAN was severely holed to starboard below her pilot house, with five spaces open to the sea. LIPAN's crew abandoned ship while the captain and chief engineer proceeded to ground LIPAN several hundred yards offshore, to prevent sinking. The fleet ocean tug USS MOCTOBI (ATF-105) was dispatched to assist and retract LIPAN, and to provide tow to a repair yard in Seattle. MOCTOBI arrived on scene the next day and made a quick damage survey. Minor patching was undertaken and the gasoline barge YOG(N) was brought alongside to receive fuel-contaminated water pumped from LIPAN's flooded spaces. After two days of preparation, LIPAN was retracted easily on a flood tide and taken under tow. Because the gaping hole made LIPAN an unmanageable tow, she was permitted to proceed under her own power, limited to four knots to protect a soft external patch. LIPAN and her escort arrived safely in Seattle after a day and a half under way.

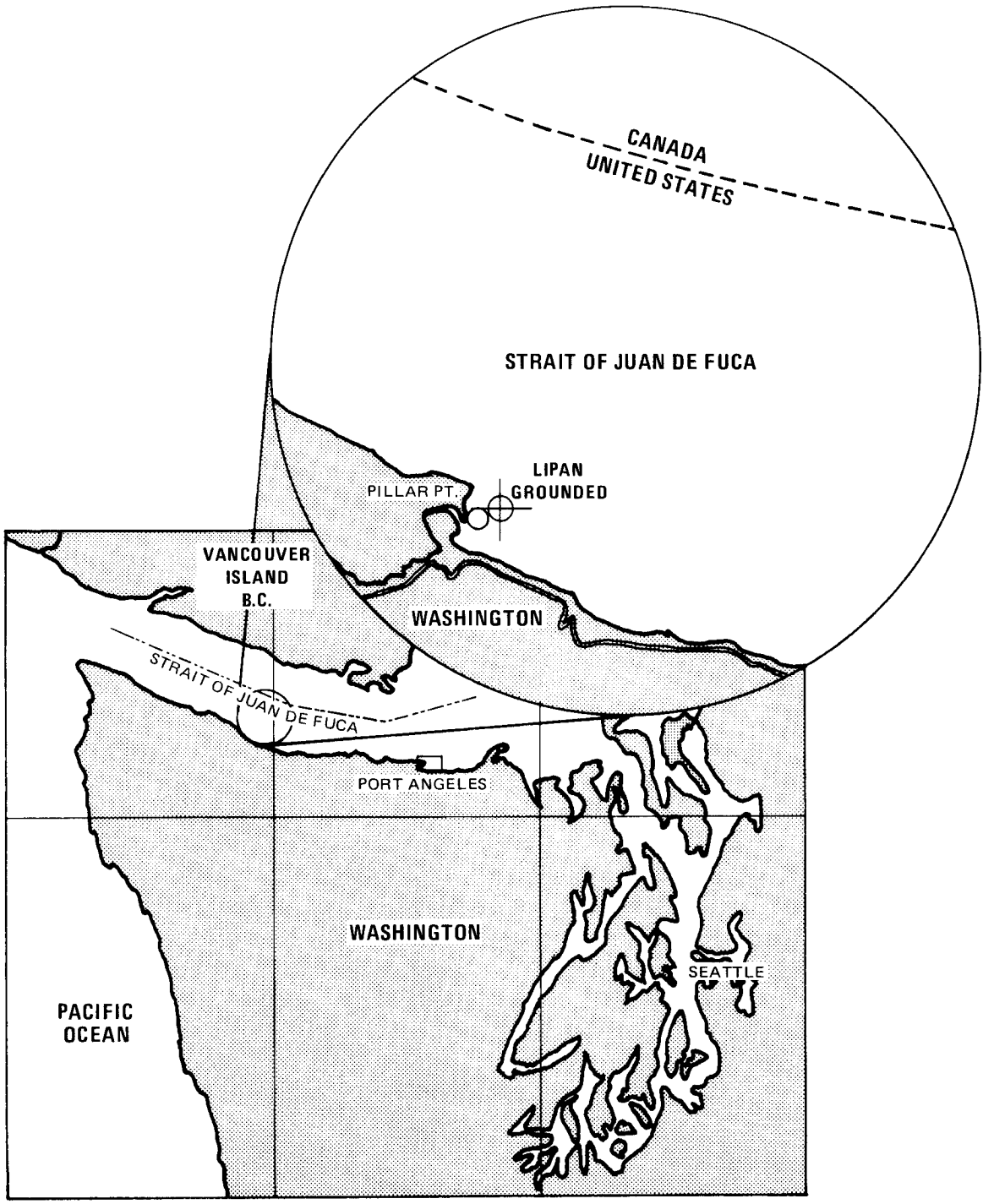
COLLISION AND DAMAGE

On 3 August, while transiting the Strait of Juan de Fuca with a medium harbor tug (YTM-371) in a stern tow, the USNS fleet ocean tug LIPAN (T-ATF-58) was involved in a collision with the tanker ATLANTIC PRESTIGE. Although the tanker received negligible damage, LIPAN was holed on her starboard side from frames 21 to 32 (slightly over 10 feet), from the main deck to two feet below the first platform deck, with the bulbous bow structure of the tanker causing severe distortion of LIPAN's hull below the waterline. Four compartments were opened to the sea: stateroom spaces, a storeroom, a watertank, and a cofferdam. LIPAN responded to the emergency by heading shoreward and grounding in shallow water off Pillar Point, near Pysht, Washington, in order to prevent foundering of the vessel before the damage and flooding could be stabilized.

SALVAGE AND RECOVERY

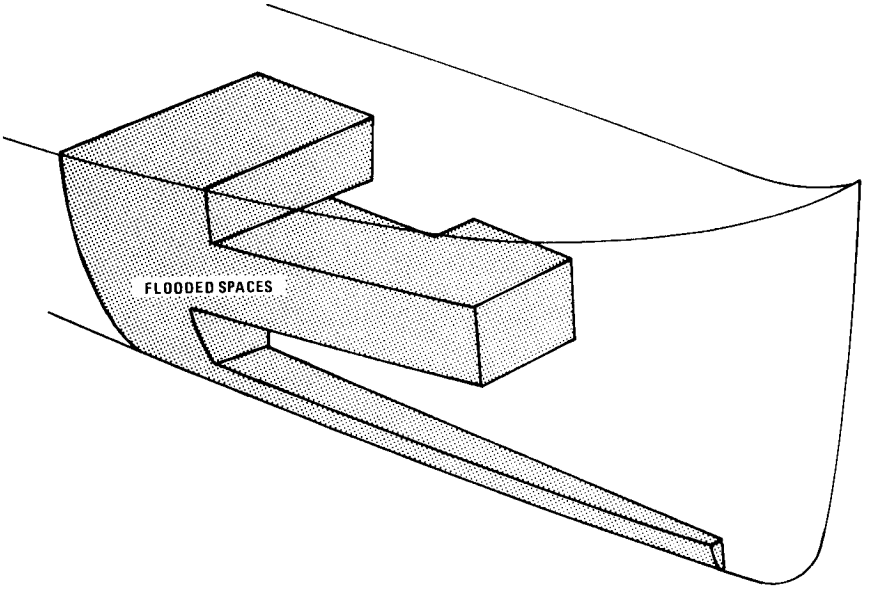
Initial Response

The following day, Commander, Service Group ONE dispatched the fleet ocean tug USS MOCTOBI (ATF-105), a sistership, to provide emergency salvage assistance for LIPAN. An hour later MOCTOBI was under way and arrived at LIPAN's location after steaming less than eight hours.



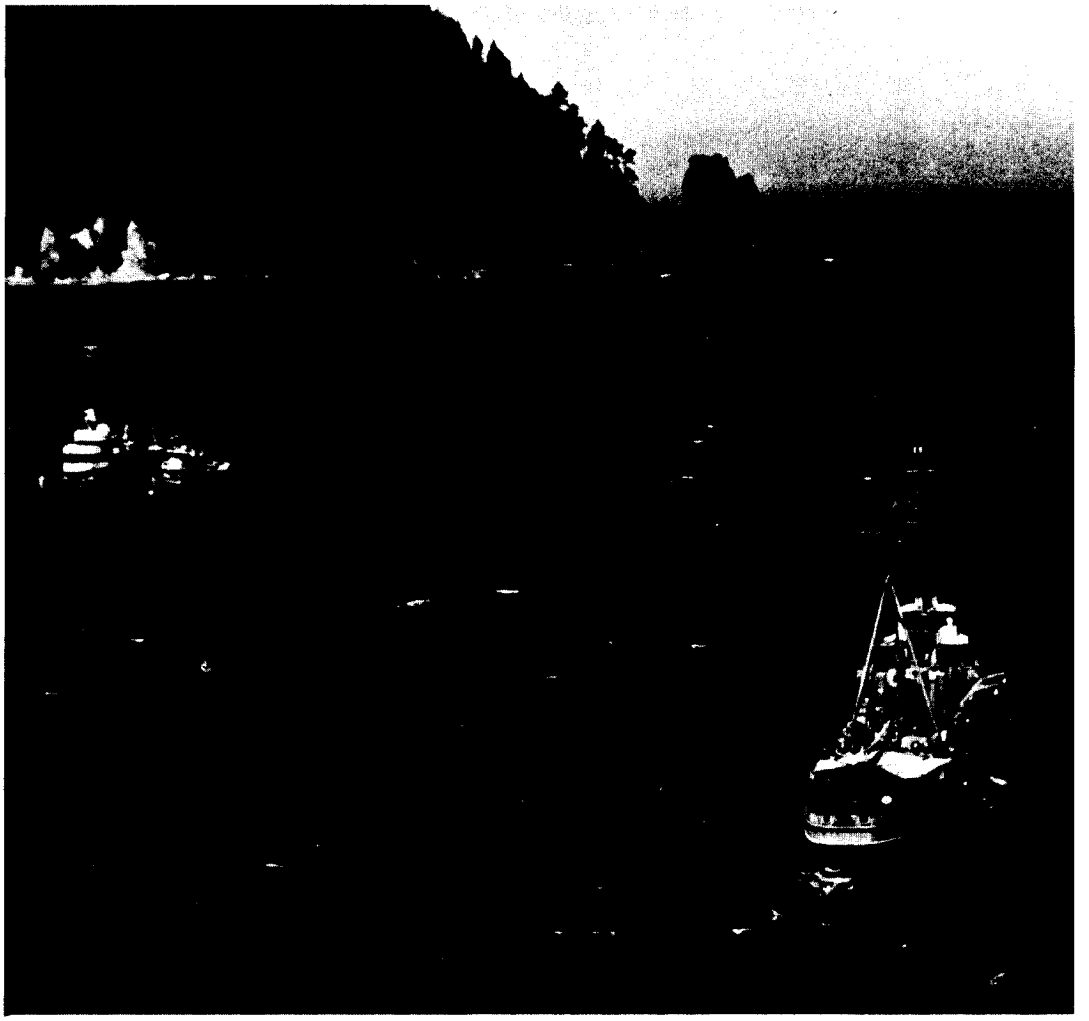
LIPAN'S COLLISION LED TO GROUNDING OFF PILLAR POINT

After collision with a tanker in the Strait of Juan de Fuca, severe damage to USNS LIPAN (T-ATF-58) led to grounding at Pillar Point, off Pysht, Washington, to prevent loss from sinking.



THE TUG LIPAN SUFFERED SEVERE DAMAGE TO STARBOARD

Lipan was penetrated at two levels, which caused extensive flooding in forward spaces.



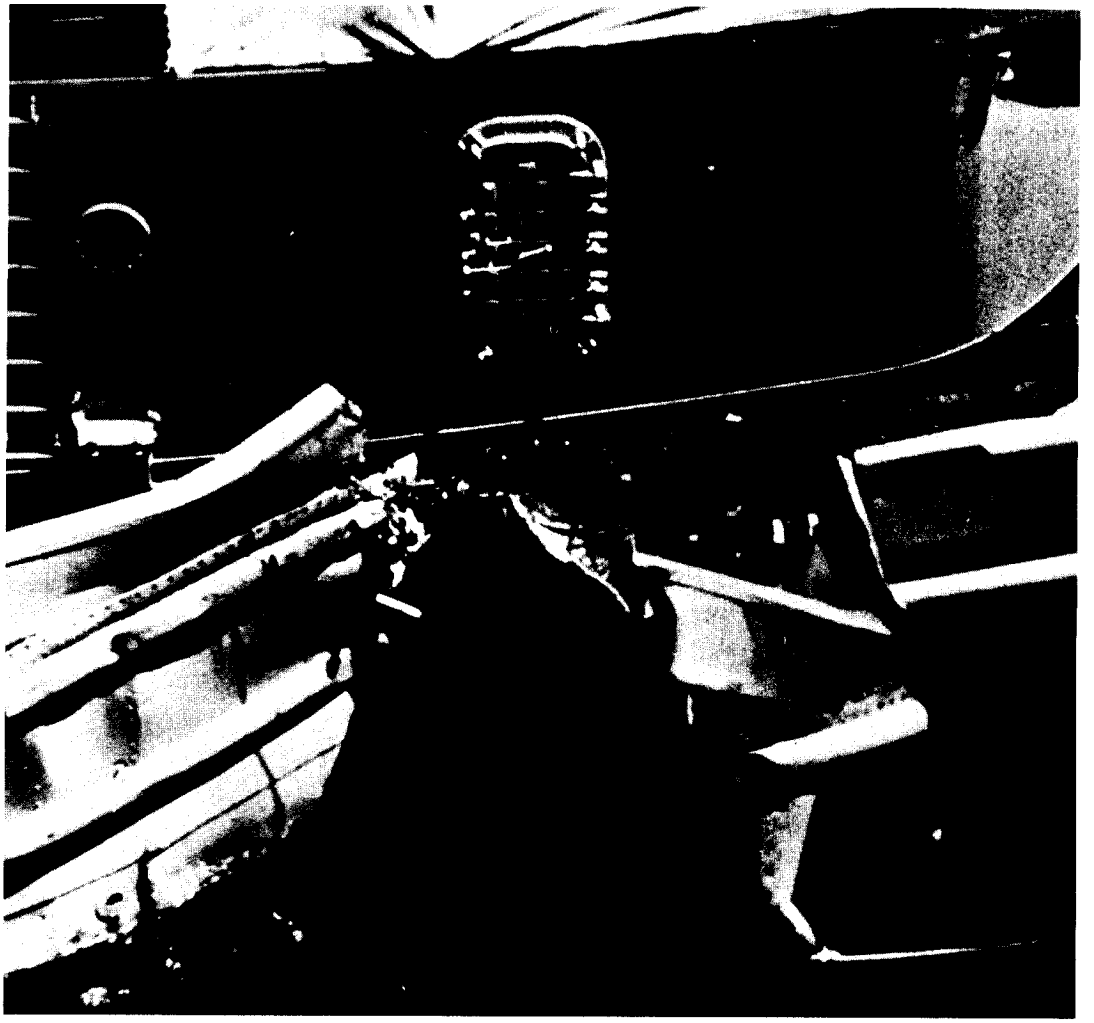
MOCTOBI WAS DISPATCHED TO ASSIST LIPAN

The fleet ocean tug USS MOCTOBI (ATF-105) arrived at Pillar Point to find LIPAN aground in shoal water, with her tow YTM-371 tied up alongside to port.

Damage Survey and Plans

LIPAN, a fleet ocean tug of the CHEROKEE class, is a 1,640-ton ship, 205 feet in length, with a beam of 39 feet. Her draft is 17 feet.

She was grounded in shoal water, with no apparent list, a few hundred yards offshore. Her tow, the YTM-371, had been brought alongside to port. There was fuel oil seepage from cracked rivets in the forward diesel fuel tank.



LIPAN'S DAMAGE PRECLUDED MAJOR PATCHING

Severe distortion of LIPAN's hull in the vicinity of the hole resulting from the collision prevented the installation of anything but concrete patches.

Temporary Damage Repair

Because of the severe distortion of LIPAN's hull under water in the vicinity of the hole produced by the collision, it was not deemed feasible to install a substantial patch. It was possible, however, to accomplish minor patching and plugging along the lower edge of the hole. This permitted removal of water from some of the flooded spaces. Since the water was contaminated with diesel oil from seepage from LIPAN's forward starboard fuel tank, it was necessary to bring a gasoline barge YOG(N) alongside before the water could be pumped out.

First Refloating of LIPAN

LIPAN's grounded position a few hundred yards offshore was on a southerly heading, bow-down by about three feet, in contact with the soft mud bottom. Retraction was planned for a favorable tide after dewatering. As it turned out, however, a favorable wind, a regionally typical high tide, and stowage of the heavy tow wire on LIPAN's fantail (preparatory to retraction) resulted in LIPAN's unanticipated ungrounding in the late afternoon of 4 August. As an indication of the extreme tidal ranges in this area, LIPAN at extreme low tide was now bow-up by three (3) feet, and still no list. At noon with flooding tide, LIPAN was permanently retracted, and with the YTM-371 alongside, moved to a deeper anchorage for repairs and dewatering.

Salvage Repairs

On the evening of 5 August, the commercial tug SEA QUEEN (Foss Launch and Tug Co.) made up to LIPAN's tow, the YTM-371, and took it under tow to Seattle. The next day, 6 August, was spent carrying out minor patching of LIPAN and commencing dewatering into the gasoline barge, now alongside. Oil containment was successful. On 7 August, major concrete patching operations were completed.

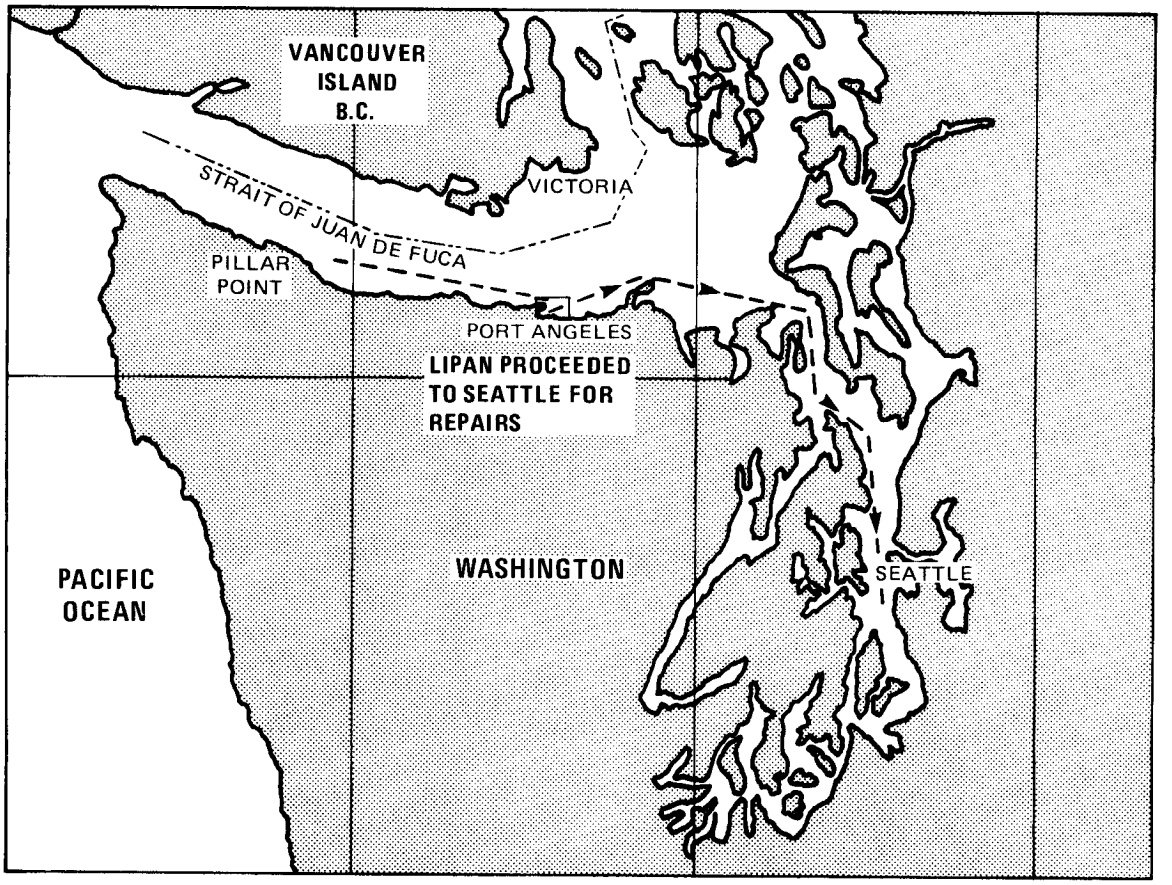
TOW AND FOLLOW-UP

Return to Seattle

Early in the evening of 7 August, MOCTOBI took LIPAN under a bow tow to proceed to Seattle. After two hours of difficult tow, it was decided that the hydrodynamics of torn plating was making LIPAN dangerously unmanageable, and she was cast off from MOCTOBI to proceed under her own power. First she was escorted into Port Angeles, Washington, to obtain pilots. Shortly after midnight, 9 August, LIPAN got under way with pilots and, escorted by MOCTOBI, proceeded to Seattle where she arrived at the Lockheed Shipyard shortly after dawn.

LIPAN's Towing Bridle

There still remained the task of recovering LIPAN's towing bridle, which could not be located in the thick kelp off Pillar Point before LIPAN's salvage could be completed. Accordingly, on 12 August, MOCTOBI proceeded to Pillar Point to recover this expensive piece of equipment. Extensive searching was necessary, requiring the employment of both motor whaleboat drags and divers. After a day's effort carefully covering the general area where the bridle was believed to have been jettisoned, it was finally located by divers and returned to the Military Sealift Command in Seattle.



UPON COMPLETION OF TEMPORARY REPAIRS AND DEWATERING, LIPAN GOT UNDER WAY FOR A SEATTLE YARD

Initially under tow, LIPAN proved unmanageable due to hull damage distortion. She then was escorted under her own power, first to Port Angeles for a pilot, and then to Seattle for repairs.

CONCLUSION

This relatively routine provision of salvage assistance to a fleet ocean tug points up several useful aspects of salvage operations for future consideration. Once again, minor patching and concrete techniques were employed as a field expedient to make a damaged hull temporarily seaworthy. The unmanageability of LIPAN as a tow, due to the hydrodynamic effects of a relatively large hole and surrounding hull distortion, should be remembered in rendering future assistance to small auxiliaries. Under circumstances of unsheltered water or where the damaged ship's power is lost, this could pose a more serious problem than it did with LIPAN. The premature ungrounding of LIPAN was due to the extreme tidal ranges of the Puget Sound region. It produced no problem with LIPAN, but such tides constitute a hydrographic element of significant proportions that can significantly affect salvage operations in the northern coastal waters of North America, Europe, and Asia.

BUOYANT FOAM SINK-PROOFING

IN SOUTHEAST ASIA

RIVER MONITOR (ASPB)

Both monitors and landing craft had polyurethane foam installed to provide permanent buoyancy in previously empty voids.

TYPICAL RIVER CRAFT IN SOUTHEAST ASIA WERE VULNERABLE TO ROCKET ATTACK

In Southeast Asia, river craft subject to rocket attack were injected with polyurethane foam as a damage control measure.

BUOYANT FOAM SINK-PROOFING IN SOUTHEAST ASIA

INTRODUCTION

During 1974, two projects were undertaken in Southeast Asia that further explored the usefulness of liquid-injected polyurethane foam to protect combat craft against battle damage. It was used to fill the voids of Cambodian and Vietnamese riverine craft as a means of preventing loss of buoyancy. This is an extension of the salvage technique for installing quick hardening flotation foam to add buoyancy in sunken or grounded vessels. In salvage, when the extent of hull damage precludes normal displacement of flooding by pumping or injection of air, the foam pumped in from a salvage vessel provides a contained mass of buoyant Freon bubbles. Although of negligible weight, the quickly hardening polyurethane foam adds a useful degree of structural strength as well.

Liquid foam injection is also a convenient method of providing and installing assured buoyancy in vessels before damage occurs. This report describes such use in Vietnam and Cambodia to provide watertight integrity for several types of craft engaged in hazardous river operations. These included LCMs, gunboats, and shield barges.

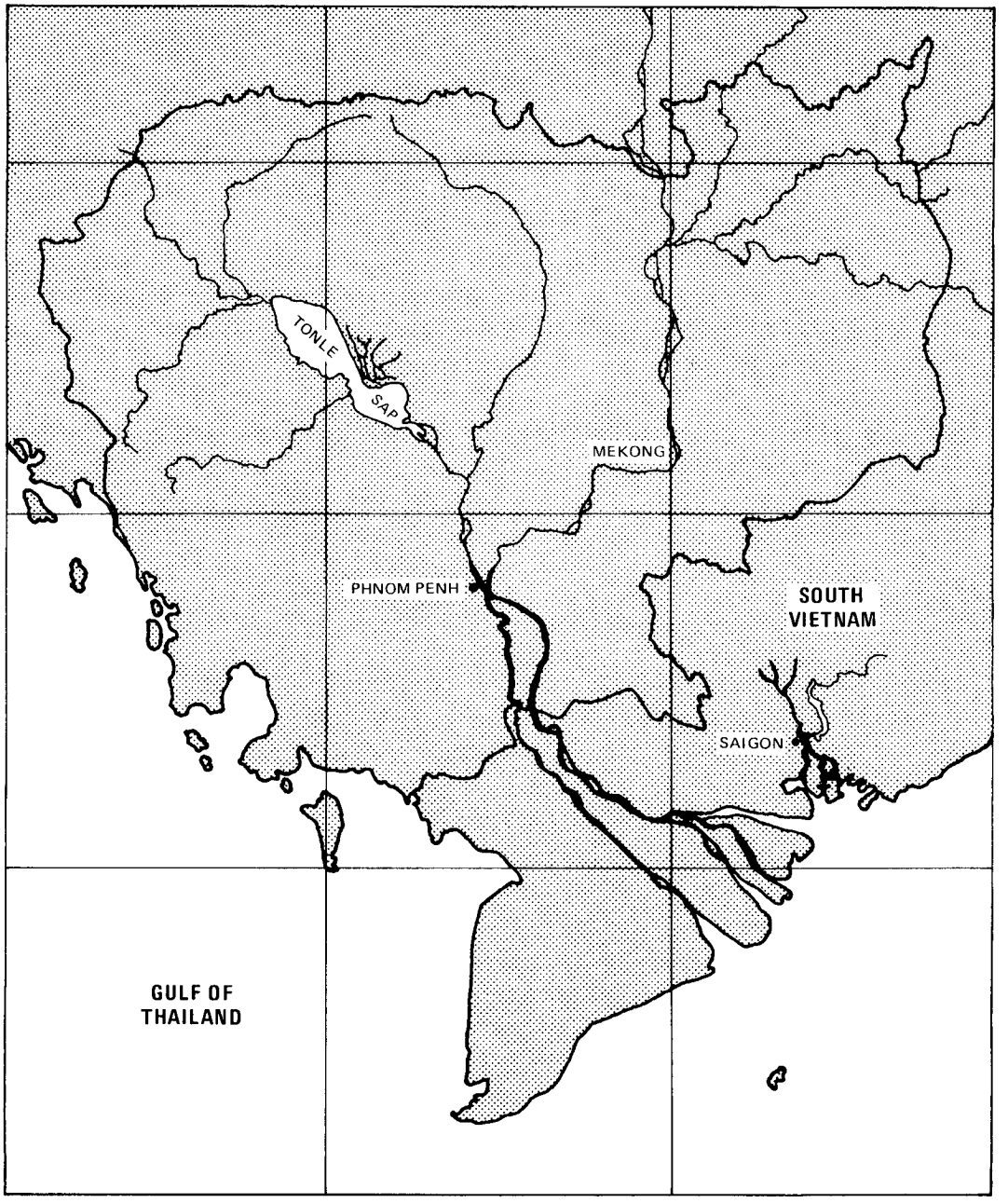
BACKGROUND

With the withdrawal of U.S. forces from operations in Southeast Asia, Communist insurgents continued to pursue their campaigns vigorously. The fight against them was left to indigenous forces dependent on U.S. supplies. In parallel with political efforts to eliminate U.S. aid at the source, Communist insurgents stepped up direct military attacks on supply lines. In particular, the sea supply routes up the river entrance to Saigon, and the longer trip up the Mekong River to Cambodia and Phnom Penh further upstream, were both important and vulnerable; and the extensive marshes and rice paddies of the region provided convenient bases and sites for guerrilla attacks on shipping. Supply convoys on this and other rivers of the region were the objects of successful attacks by artillery, mortars, rockets, small arms, and mines. The attacks constituted a serious threat to the logistic support of the indigenous units who were fighting to keep their country from being overrun. Additionally, they resulted in a substantial loss of equipment and supplies at a time when input from CONUS was being progressively cut back.

RIVERINE CRAFT AND TECHNOLOGY INVOLVED

In order to enhance the survivability under attack of the various craft involved in riverine traffic and operations in Southeast Asia, a variety of countermeasures had been evolved. These included various types of armor, compartmentation, sandbags, and projectile

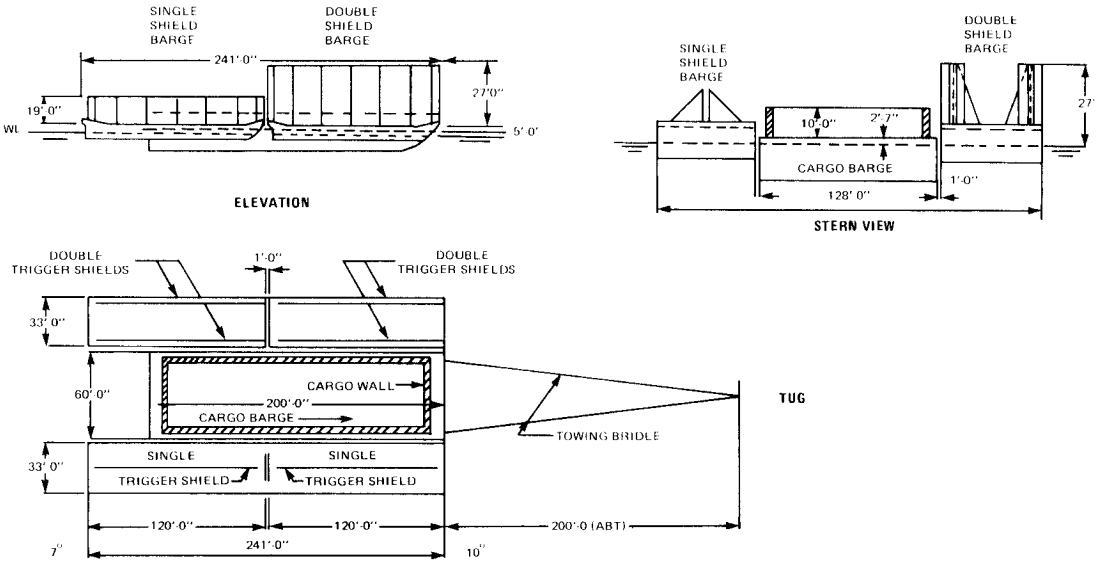
triggering shields. It also included the installation of polyurethane flotation foam in buoyant voids, with which Supervisor of Salvage effort was concerned as related in this report.



RIVER SUPPLY ROUTES IN SOUTHEAST ASIA WERE IMPORTANT AND VULNERABLE

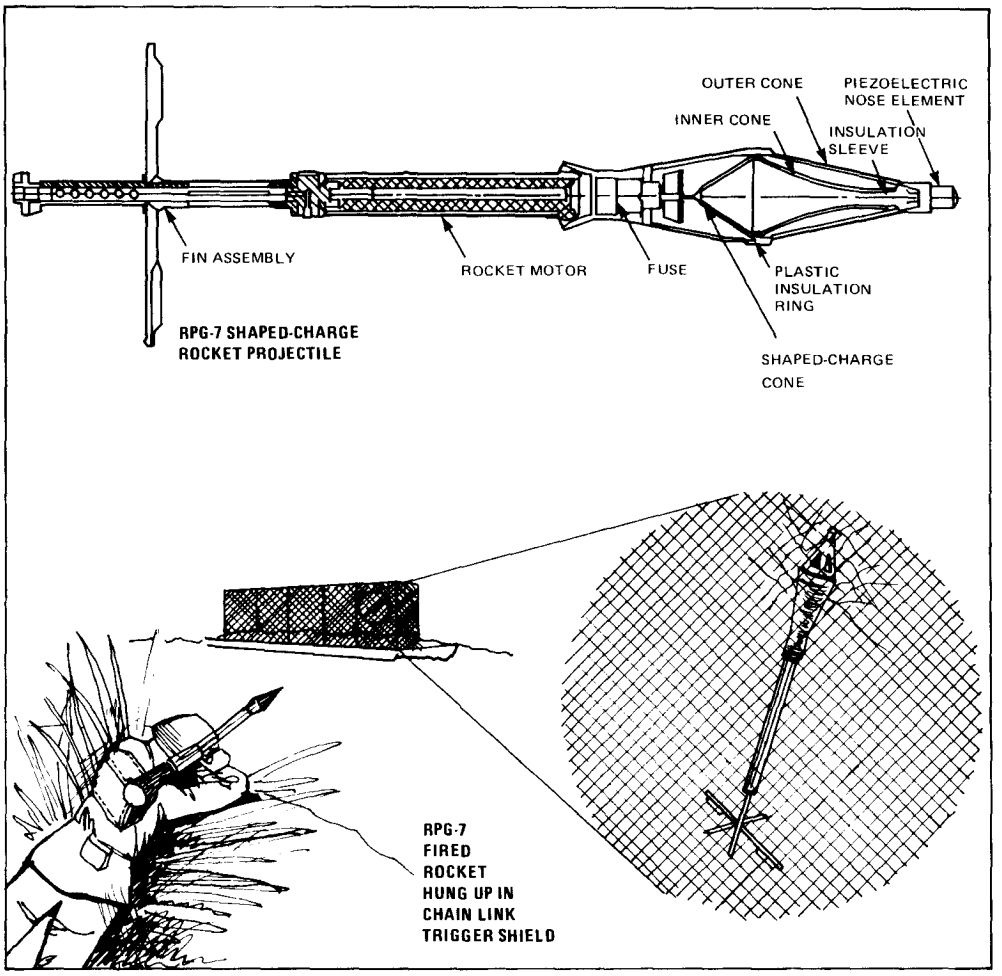
The extensive marshes and rice paddies provided convenient bases and sites from which guerrilla attacks on river shipping could be launched.

The first application of buoyant polyurethane during 1974 was for shield barges, in what was called Operation MOSQUITO NET. Shield barges had been recommended early in 1974 by the Technical Section of the Navy Division, Defense Attack Office, Saigon, for ballistic protection of cargo barges carrying explosive cargo. The 120-foot-long, flat shield barges carried a 19-foot-high, double-layer chain link fence. The barges were towed, one to each side, as shields for barges with explosive cargo. The chain link fence was referred to as the "trigger shield" because it was intended to trigger the detonating device, harmlessly and prematurely, of a rocket or artillery round fired at the protected barge. Frequently these screens also would completely deactivate shaped-charge rockets and prevent the detonation of approximately 50 percent of those rounds fired against them. This would happen when the nose fuse of a round failed to impinge on any screen wires until the round was well immeshed in the screen. The strands of the screen then crushed the walls of the standoff nose cone, short-circuiting the electrical firing mechanism, and the round became a complete dud. This left a residual problem of protecting the shield barges themselves. If their unprotected hulls were damaged, the resultant loss of buoyancy would either dangerously reduce the maneuverability of the tow, or would require jettisoning, leaving the barge with the explosive cargo exposed to hostile fire. Accordingly, in early July 1974, eight of sixteen shield barges were completed with foam-filled voids. These were deployed to the Mekong River as protection shields for cargo barges in convoy to Phnom Penh, Cambodia.



SCHEMATIC ARRANGEMENT OF SHIELD BARGE

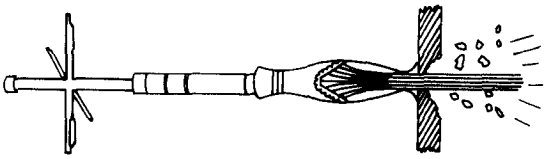
Both double and single shield barges are shown in a single tow, for illustration. This was not necessarily the normal employment.



SOVIET RPG-7 ANTITANK GRENADE LAUNCHER

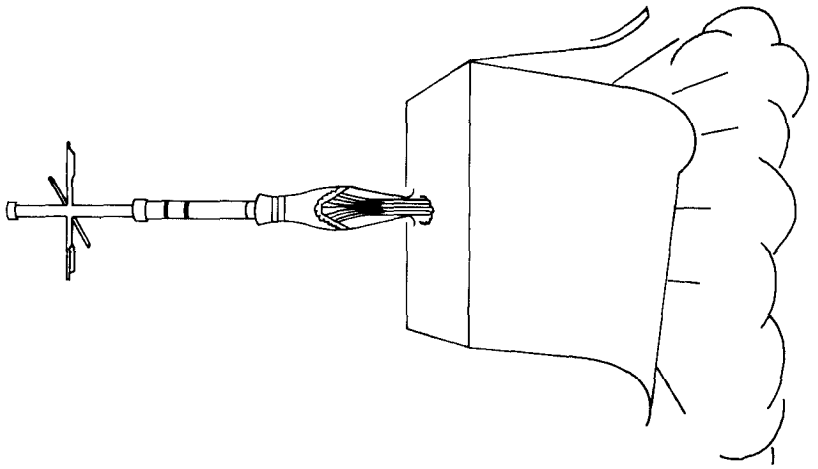
The grenade of this weapon is a typical shaped-charge munition with a concave shaped-charge cone that focuses the explosive blast into the target. Polyurethane foaming is a specific countermeasure. Chain link "trigger shield" fences were used to either detonate the rockets prematurely or to deactivate the firing mechanism from a short circuit induced by crushing the inner and outer nose cones together.

Polyurethane foam installation in buoyant voids has some unique damage suppression qualities against shaped-charge munitions fired by the Soviet RPG-7 antitank grenade launcher widely supplied to Communist forces. The foam is flexible and the Freon bubbles in it are compressible. This tends to confine the jet blast damage to its narrow focused path by reducing buildup of damaging explosive pressure within the void. In addition, the heat of the penetrating explosive melts the polyurethane immediately peripheral to the jet path. This melted plastic tends to sag into the hole again, closing the opening immediately after it has been made.



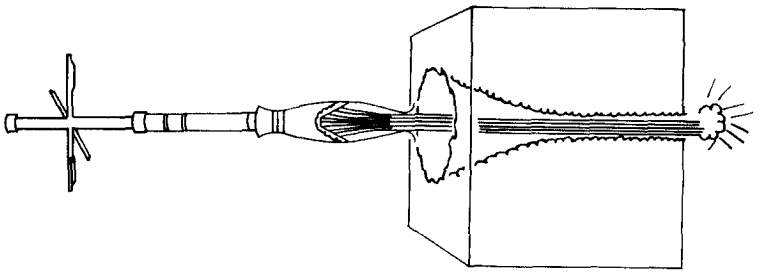
SHAPED-CHARGE MUNITIONS AGAINST ARMOR

Shaped-charge munitions, like the RPG-7 and the old U.S. bazooka, are designed to penetrate thick armor by using an explosive focusing principle known as the Monroe effect. It uses an explosive charge with a metal-lined, hollow cone of explosive facing the target. When the warhead detonates, the metal lining focuses the explosion, and then forms a small cone that burns through the armor, propelled by the focused explosion.



SHAPED-CHARGE MUNITIONS AGAINST SHEET METAL STRUCTURES

Shaped-charge munitions tear open thin metal walled voids from expansion of their explosive gas jet, injected by the focusing Monroe effect.

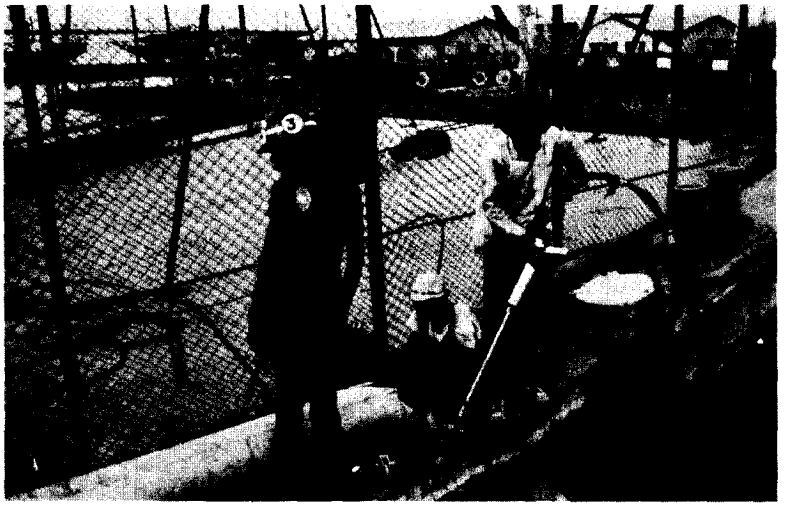


SHAPED-CHARGE MUNITIONS AGAINST FOAMED VOIDS

When shaped-charge munitions impact on voids filled with polyurethane foam, the foam tends to keep the explosive jet channeled, and then to close the penetration with melted foam debris.

POLYURETHANE FOAM INSTALLATION EQUIPMENT

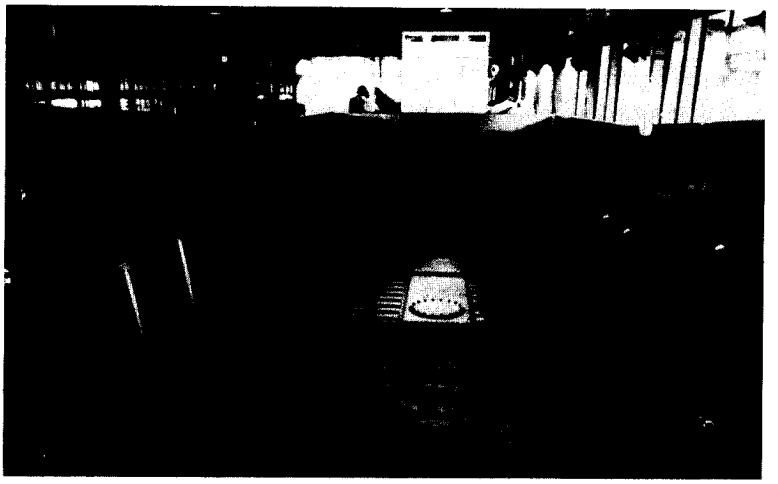
Material and equipment were supplied by SUPSALV and SUPSALV contractors to indigenous shipyards.



NATIVE WORKMEN INSTALLING FOAM IN A SHIELD BARGE

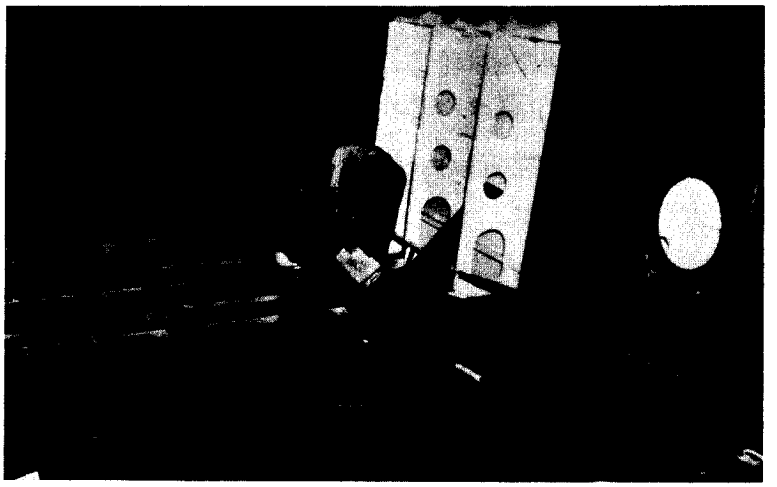
Liquid injection of polyurethane was performed by local labor under the direct supervision of representatives of SUPSALV and SUPSALV contractors.

The liquid installation of foam was performed by indigenous personnel at Saigon under the direct supervision of SUPSALV and contractor representatives. Material and equipment were supplied by SUPSALV and SUPSALV contractors, including the 120,000 square feet of foam used to fill designated voids on the barges.



CARGO WELL OF AN LCM-6

Manholes in the deck and on port and starboard bulkheads provide access to voids in which foam was installed.

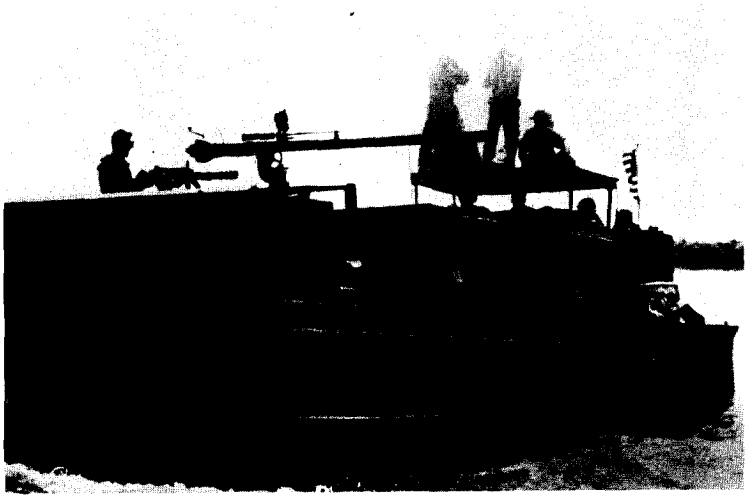


LCM-6 UNDER CONSTRUCTION

The open bulkhead manhole and uncovered bottom voids provide a view of the structure of the craft's inner bottom where polyurethane foam was injected.

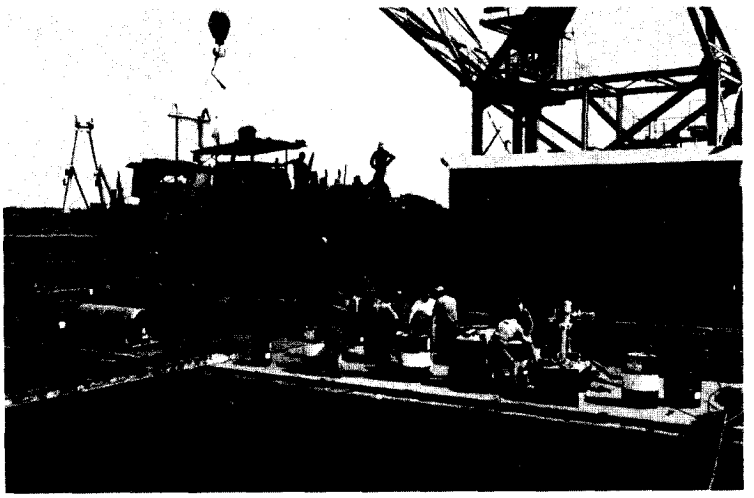
The second program in 1974 involved providing additional and assured buoyancy for LCMs and ATP/MONITORs in Cambodia. This work was undertaken in Phnom Penh at the Cambodian Navy Yard. Indigenous workmen again were used under the supervision of representatives of SUPSALV and SUPSALV contractors. SUPSALV again supplied the equipment and materials. Several measures were undertaken. For LCMs, foam was installed

in bottom and wing tanks. Sheet-steel stern and side foam-blisters were also designed to provide additional protection for LCM engine compartments. These blisters were installed by tack welding, and foamed in place. (An additional arrangement to provide foaming of the LCM lazarets proved impractical and was discarded.) Foam installation was provided for a total of 25 ATP/MONITORs, 15 LCM-6s, and 5 LCM-8s, requiring a total of approximately 45,000 cubic feet of self-extinguishing polyurethane foam.



ARMED LCM-6 SHOWING SIDE BLISTERS

Addition of foam-filled tanks around sides of rear and stern protected engine spaces against damage from rocket attack.

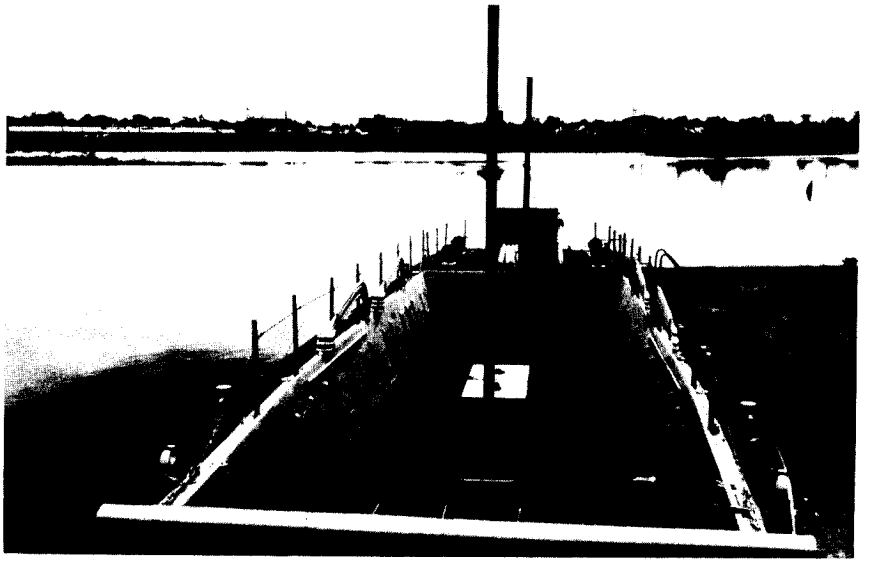


LCM-6 UNDERGOING FOAM INSTALLATION

It should be noted that side blisters on this particular craft are of an unfoamed standoff variety with a chain link trigger shield outboard.

LCM-8 OF THE TYPE PROTECTED BY FOAM

These craft, when equiped with foamed voids and blisters around the engine room, were considered unsinkable.



CARGO WELL OF LCM-8

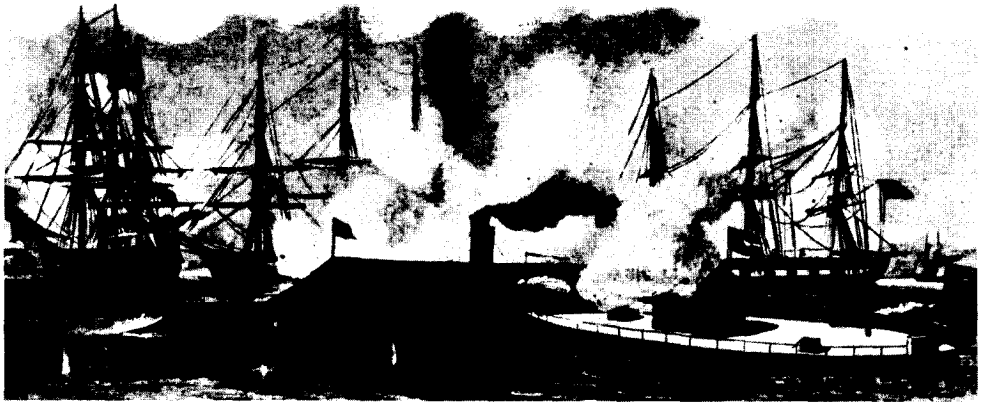
Access manholes to wing walls may be seen, as well as engine room, aft, around which the U-shaped blister structure, filled with foam, was installed.

CONCLUSION

As a result of damage assessment after attacks, it was concluded that foam protection of buoyant voids performed as expected and significantly contributed to reducing damage to riverine craft involved. An LCM-8 with inner bottom and wing walls foamed, and with a U-shaped foam-filled blister around the engine room and transom, was considered to be unsinkable. Blisters added to LCM-6s and ATP/MONITORs substantially reduced the main hull damage and, in the operations, only the associated unfoamed LCM-6s were ever reported sunk.

LOCATING AND PHOTOGRAPHING

THE WRECK OF THE MONITOR



USS MONITOR STANDS OFF THE CSS VIRGINIA (EX-MERRIMAC)

Rapidly contracted and built to meet the threat of the VIRGINIA, MONITOR saved the Union blockade squadron at Hampton Roads from the Confederate ironclad.

MONITOR WAS LOST IN A STORM OFF CAPE HATTERAS

Less than a year after stopping the VIRGINIA at Hampton Roads, MONITOR was lost while in tow to a new blockade station.

LOCATING AND PHOTOGRAPHING THE WRECK OF THE MONITOR

INTRODUCTION

The famous naval encounter of the Civil War between John Ericsson's innovative naval weapon system, USS MONITOR, and the Confederate VIRGINIA, an armored battery extemporized on the hull of the ex-USS MERRIMAC, is a major benchmark in naval history. The diminutive but efficient MONITOR fought the VIRGINIA to a draw, inflicting heavy damage. The VIRGINIA withdrew and the only serious threat to the naval blockade of the Confederacy was eliminated.

Marine salvage interest in the MONITOR results from the fact that her innovative and effective engineering for combat was not quite matched in seaworthiness. MONITOR foundered from uncontrollable flooding in a violent night storm off Cape Hatteras the following December, and was lost– a missing historical symbol of American naval tradition and technology.

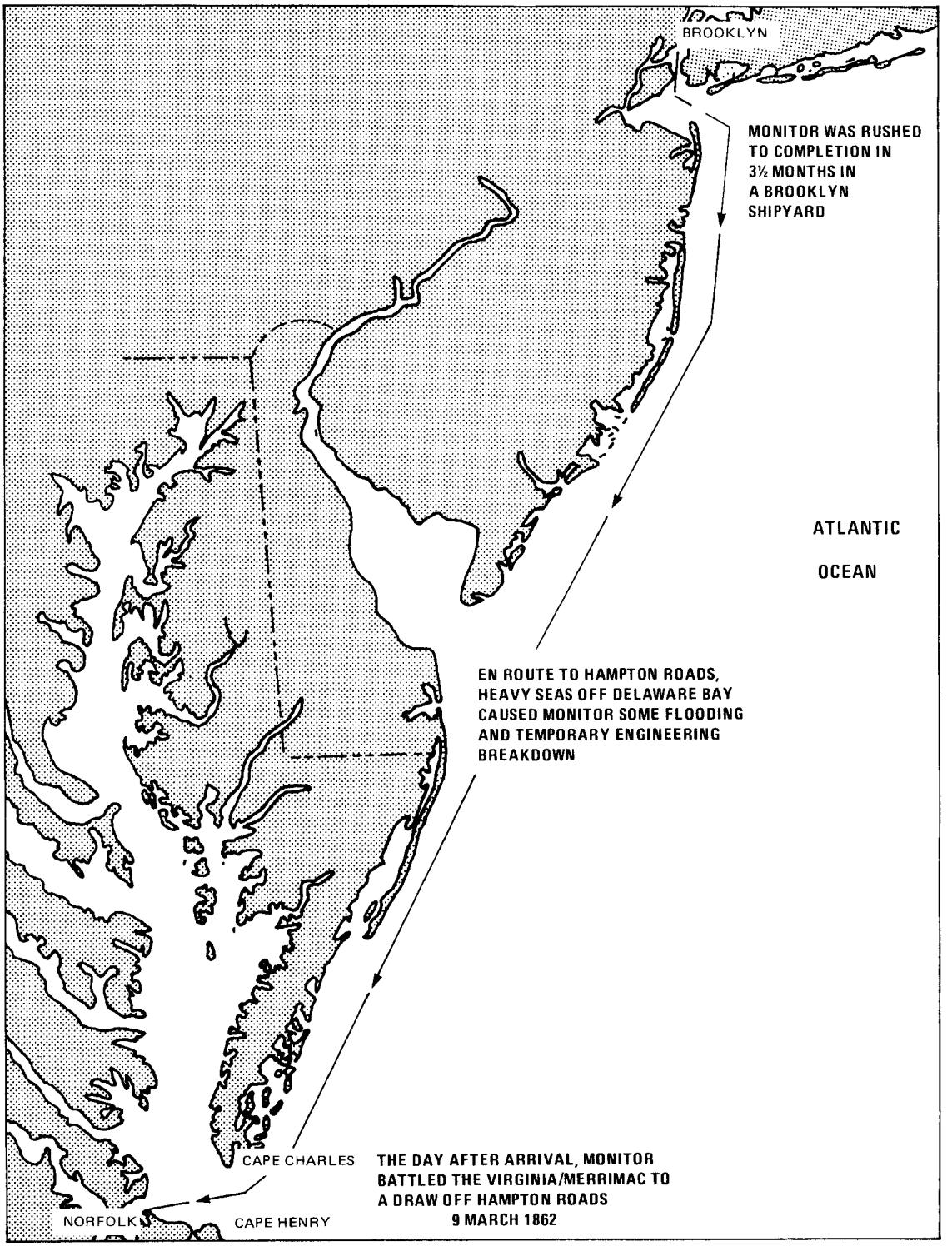
In 1973 and 1974, a coordinated effort involving a number of private and government agencies culminated in underwater photography by the Navy clearly established the resting place of MONITOR's hull in the shifting sands of Diamond Shoal off Hatteras.

Success, of course, did not just happen. It resulted from coordinating the need for testing underwater reconnaissance equipment with the dedicated efforts of a number of naval historical and archeological activities, long focused on the lost MONITOR. This interest brought the goal of locating the MONITOR to the attention of the Navy, and provided the necessary research background information. SUPSALV's need for exercising ALCOA SEAPROBE on underwater reconnaissance targets, such as the MONITOR, made available this latest ocean engineering technology for the job. In March 1974, an expedition with the interested parties embarked on ALCOA SEAPROBE and located and photographed MONITOR from stem to stern. Long sought evidence of the location and condition was thus provided – over 102 years after the MONITOR was lost.

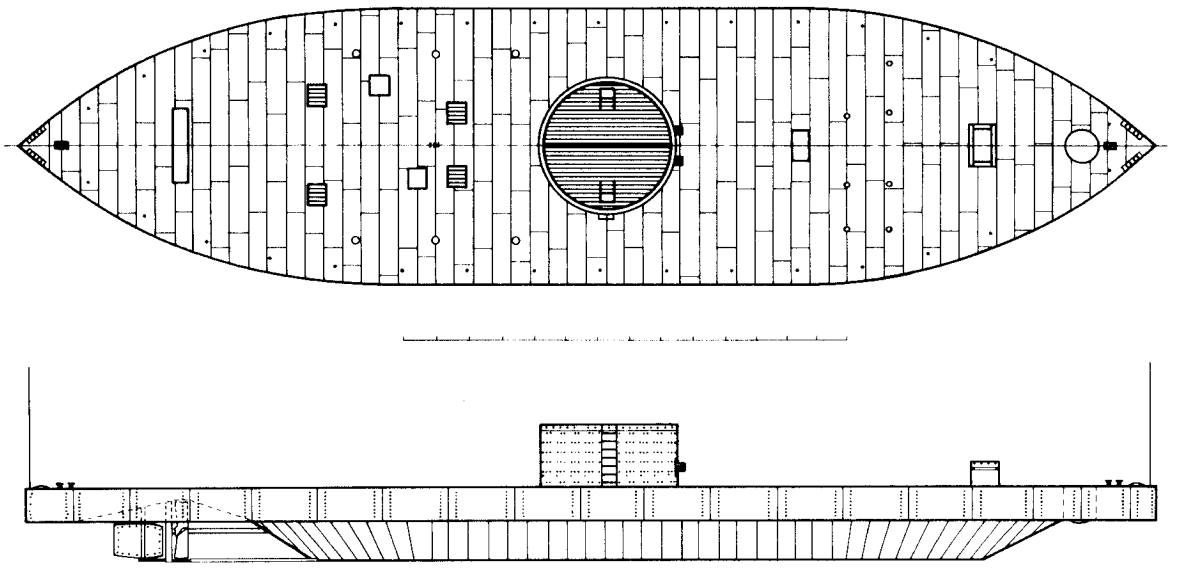
BACKGROUND

Characteristics of MONITOR

MONITOR was an amalgam of the inventive genius of John Ericsson and the emerging iron and steel technology of America's northeast. MONITOR's construction was rushed at a



MONITOR'S INITIAL DEPLOYMENT



USS MONITOR

MONITOR was designed by the immigrant Swedish engineering genius John Ericsson. The unconventional ship constituted an efficient protected weapon system with a number of innovations to optimize the use of material and machinery of the era for use in inland waters. President Lincoln was one of the first to recognize the potential of Ericsson's bold design.

Greenpoint shipyard in Brooklyn, N.Y., on the basis of rumors regarding the building of the VIRGINIA – a threat to the ships of the Union blockade. She arrived on station at the close of the very day VIRGINIA had embarked on an effective sortie against the Hampton Roads flotilla: she had rammed and sunk the USS CUMBERLAND, destroyed the USS CONGRESS with hot shot and incendiary fire, and badly savaged the USS MINNESOTA, before retiring to Sewells Point for the night. The next morning, the VIRGINIA stood out again to finish off the MINNESOTA and have at the rest of the Hampton Roads flotilla. The little MONITOR emerged from the Union formation to epitomize a David and Goliath encounter. Compactness was a design feature of MONITOR, with little above the waterline but a low armored deck and a single armored turret to house twin 11-inch Dahlgren guns. The displacement of her 124-foot hull put her engineering plant and living spaces safely behind submerged armored sides. For four hours this efficient weapon system pounded away at the VIRGINIA, and taking, in turn, the worst that her enemy had to offer. VIRGINIA finally withdrew, on the verge of heavy damage. MONITOR was a little dented but essentially unscathed. The threat to the blockade ships was defeated.

Loss of the MONITOR

The evidence seems to suggest that MONITOR's foundering resulted from several factors. Loss of caulking in her turret's roller path led to severe leaking.* Shallow-draft bilges exposed the coal-fired grates of her boiler to flooding, which reduced both the fires and boiler pressure to the pumps. These factors combined in a chain reaction, New Year's evening 1862, as MONITOR was being towed by the side-wheeler USS RHODE ISLAND. She was being deployed south from Hampton Roads to a new blockade station at Wilmington, North Carolina, to deal with another Confederate ironclad at that port. When the RHODE ISLAND, with MONITOR in tow, was 10 to 12 miles southeast of Cape Hatteras, a fierce southeast gale struck. MONITOR's turret base caulking was opened up by the pounding seas and her bilges became heavier by the minute. As MONITOR settled, her negligible freeboard reduced, she became a sea anchor. The southeast gale swung the RHODE ISLAND, on the towline, to a heading tending toward the dangerous lee shore. This situation was all the more hazardous to the RHODE ISLAND, having now to cope with the dangerous currents in this notorious Graveyard of Ships. Engineering plants were primitive and inefficient in early days of the age of steam. The brave skipper of the MONITOR, aware of the danger himself, ordered the tow to be cut and the MONITOR abandoned. Boats from the RHODE ISLAND had rescued only part of the MONITOR's crew when the lantern on her turret disappeared beneath the sea.

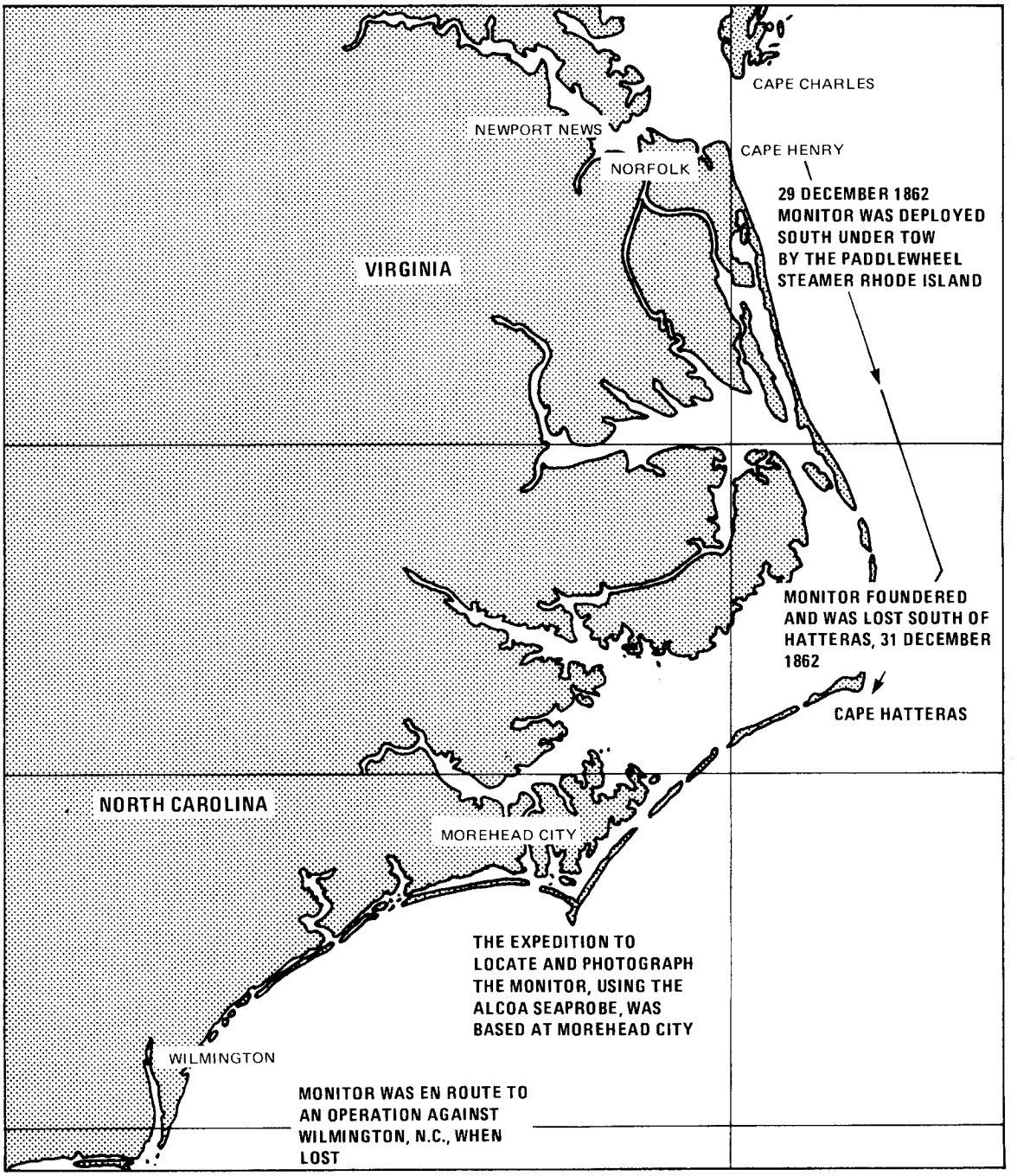
SEARCH PREPARATIONS

Preliminary Research

The Navy's interest in the MONITOR was rekindled and investigation began to move in effective directions as a result of an historical research project conducted by midshipmen at the U.S. Naval Academy. Their findings identified a 10-square-mile rectangle, 20 miles south of Cape Hatteras, as the likely search area for MONITOR. The advice of the Naval Ship Research and Development Center, Annapolis (NSRDC), was sought and NSRDC, impressed by the quality of information produced by this research project, sponsored an airborne magnetometer search, testing a new cryogenic system. Eleven magnetic contacts were detected that were judged to be wrecks. One of the contacts coincided in position with a site explored the previous summer (1973) by a Duke University group headed by Mr. John G. Newton and Dr. Harold E. Edgerton of the Massachusetts Institute of Technology (and EG&G sonar). The efforts of the earlier expedition had resulted in a remarkably well-resolved sonar picture and a few closed circuit TV glimpses of a capsized hull, all of

*Ironically, evidence indicates that the caulking was a Navy modification. Ericsson's design called for a flush-fit turret base that, while not waterproof, was sound enough to minimize leakage in even the worst seas. The modification seems to have involved jacking up the turret enough to insert caulking. While this "SHIPALT" was drier in moderate seas, it proved fatal in the Hatteras storm that washed out the caulking.

which showed characteristics unique to MONITOR. Nevertheless, comprehensive reconnaissance and photography were required to produce validating evidence and to verify the contact as the long-lost MONITOR.



MONITOR'S FINAL DEPLOYMENT

PLANNING CONFERENCE

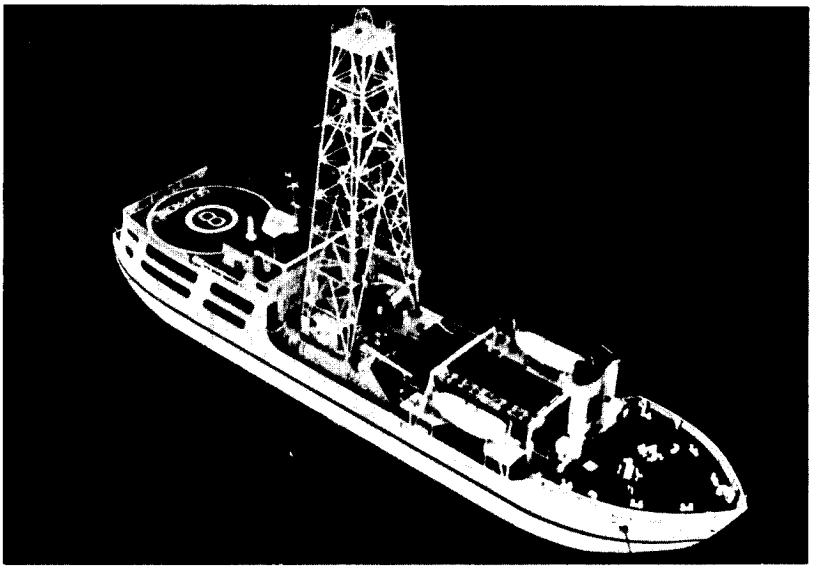
The various activities interested in MONITOR first held a coordinating and planning conference at the Naval Research Laboratory in Washington, D.C. The research team of U.S. Naval Academy midshipmen presented the corroborating data from the aerial magnetic wreck reconnaissance. This supported the wreck identification provided by the Edgerton and Newton expedition on EASTWARD. The Supervisor of Salvage was represented at the meeting and undertook to provide the services of ALCOA SEAPROBE, using the MONITOR as the target of needed tests of ALCOA SEAPROBE's bottom search photoreconnaissance capabilities.

ALCOA SEAPROBE

General Characteristics

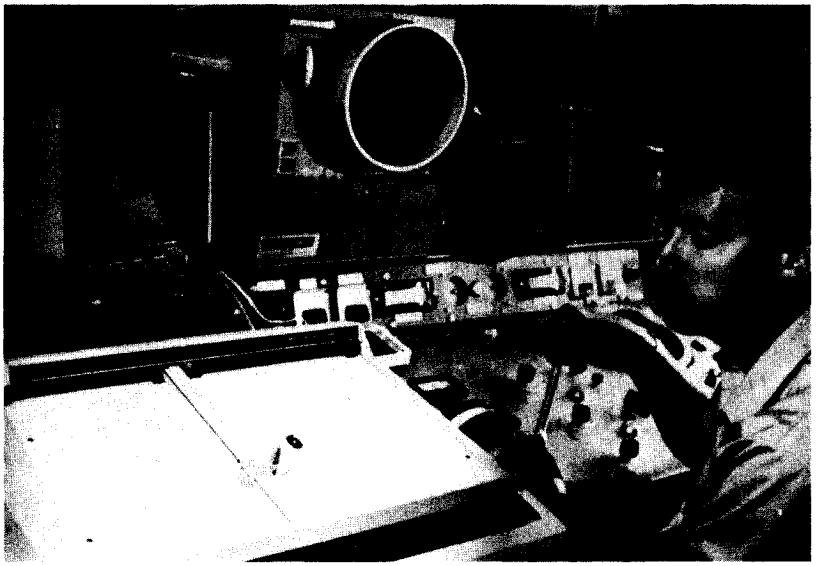
The R/V (Research Vessel) ALCOA SEAPROBE is a 243-foot all-aluminum vessel designed for oceanological exploration and a variety of underwater work using advanced technology. The ALCOA SEAPROBE is sufficiently unique to merit tabulating some of her basic characteristics:

Length	243 feet
Beam	50 feet
Draft	14 feet (Propeller depth)
Displacement	1,700 tons
Speed	10 knots
Range	6,600 miles
Endurance	45 days
Main Power	Two 880 kW diesel-electric generators
Auxiliary Power	Two 250 kW diesel-electric generators
Propulsion	Two Voith-Schneider cycloidal omnidirectional propulsion units
Auxiliary Deck Equipment	Two 5-ton cranes Oceanographic winch-interchangeable drums
Ship Control	Decca ship control consoles on bridge and in search/recovery control center



ALCOA SEAPROBE

ALCOA SEAPROBE's underwater reconnaissance and photographing capabilities proved to be the needed element in establishing the MONITOR's location.



ALCOA SEAPROBE'S CONTROL CENTER

This console was used to control and manipulate the instrument pod containing cameras and closed circuit TV. The pod at the end of the drill-pipe string suspended from the ALCOA SEAPROBE swept across the seafloor at the correct height to view and photograph the remains of the MONITOR.

Primary Ship Construction Material	5456-H117 aluminum plate 5456-H111 aluminum extrusions

ALCOA SEAPROBE is a dynamically positioned working platform. The ship can be very accurately navigated for precise area-searches, and can hold a pinpoint position in the open ocean against winds and currents with the aid of the following systems:

- Ocean-bottom-mounted acoustic reference systems
- Land based, precision short-range and medium-range radio locating systems
- Radar positioning relative to land-based or moored reference points
- Worldwide positioning systems employing satellites and/or VLF Omega
- Two Voith-Schneider cycloidal omnidirectional propulsion units

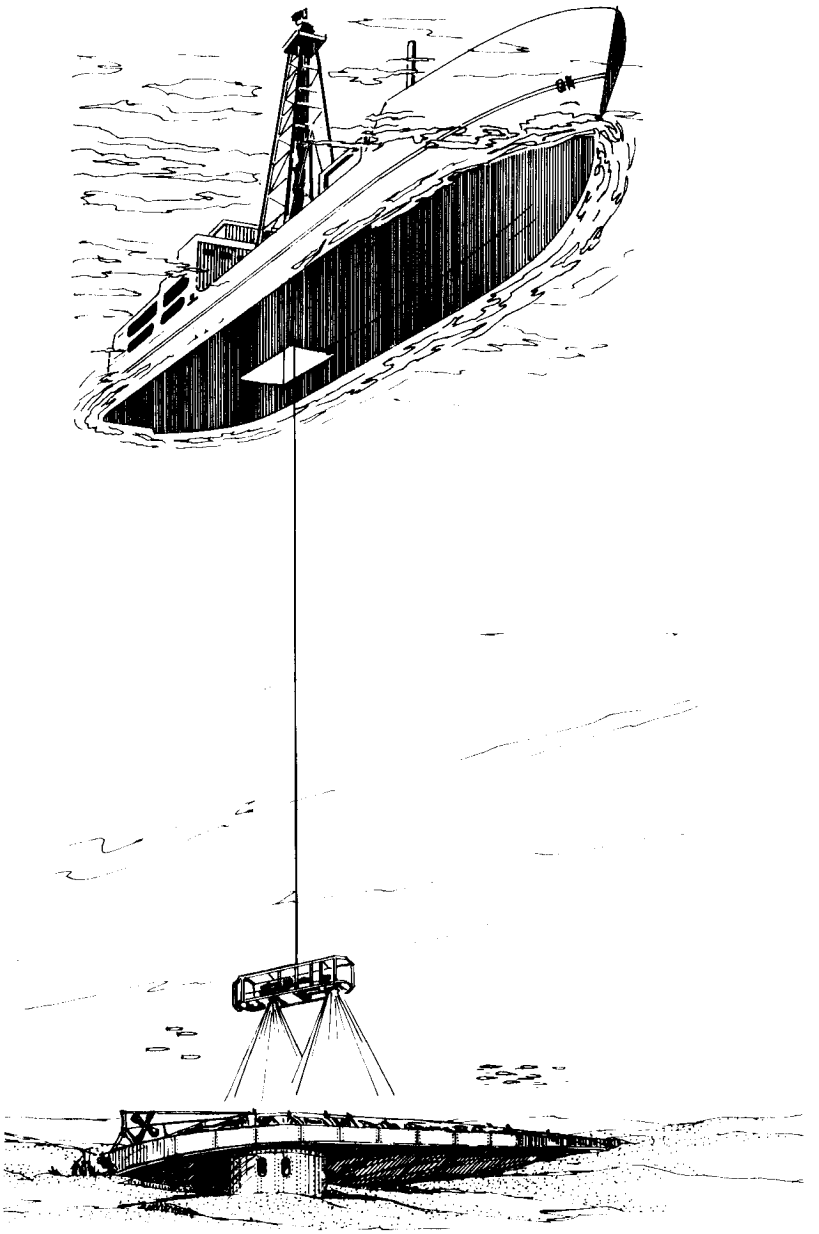
Deep Ocean Capabilities

The working end of the ALCOA SEAPROBE system is located at the end of a pipe string made of 60-foot segments of aluminum drill pipe threaded together to reach the ocean depths required. Using the semirigid pipe system, ALCOA SEAPROBE deploys a search, identification, and sensor package in close proximity to the ocean floor. This system is designed to permit accurate control of the sensor package, relative to the ship's working platform, and with regard to the seafloor or objects on it.

Depending upon the task at hand, sensor systems are deployed for fine-grain bottom search and examination, target identification and marking, or oceanographic sampling and measurement. Recovery devices ranging from multipurpose grappling claws to coring tools are available for lifting objects or cores to the surface. A cable affixed to the exterior of the pipe provides the necessary electrical power, telemetry control signals, and data transmission circuits between the shipboard control consoles and the sensor systems probing the deep ocean. All these components are remotely controlled from an operating center aboard the ALCOA SEAPROBE.

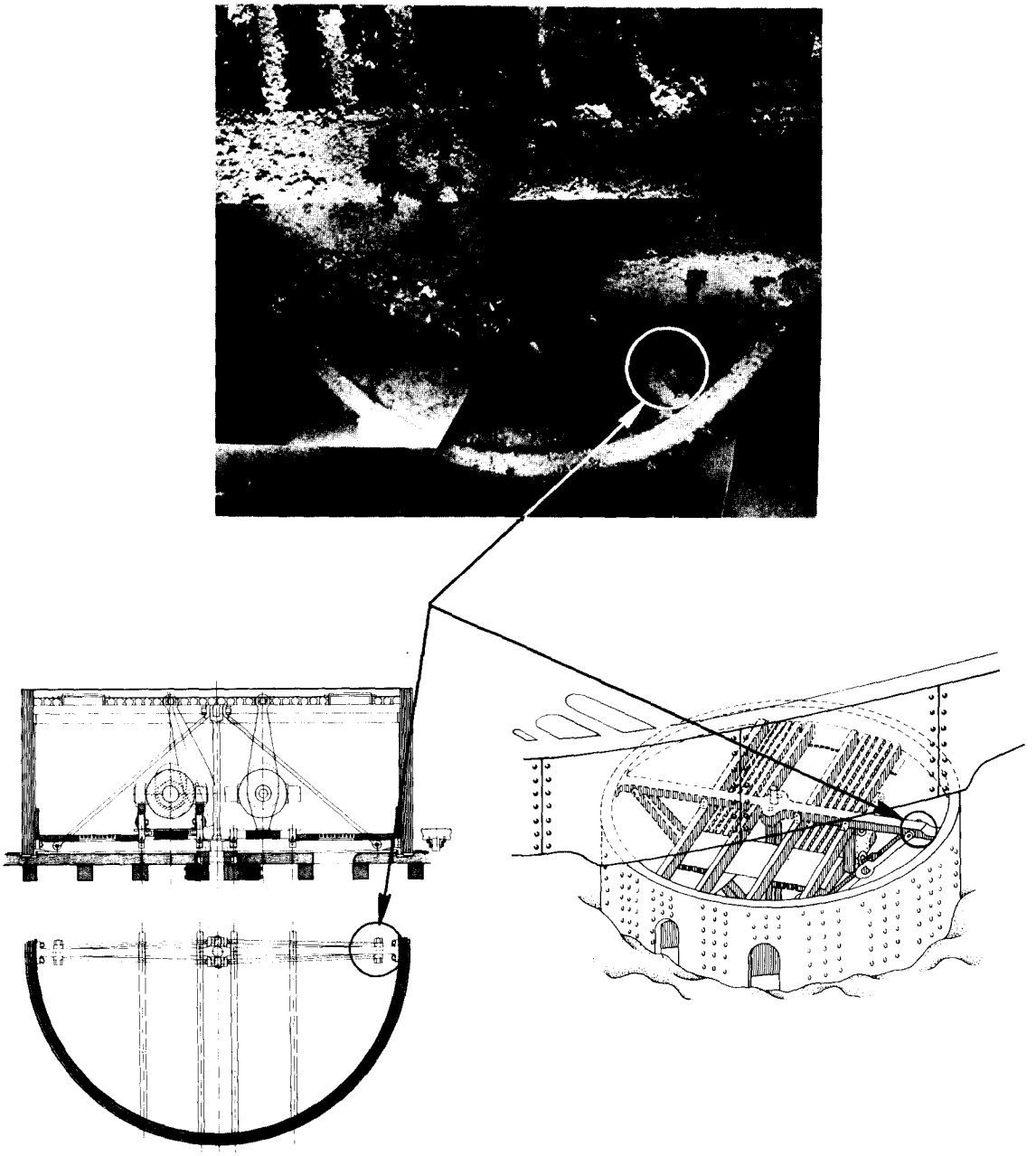
Underwater Search and Inspection

A thruster system at the working end of a pipe string provides precision control and positioning of sensor packages, recovery mechanisms, viewing or recording systems, and



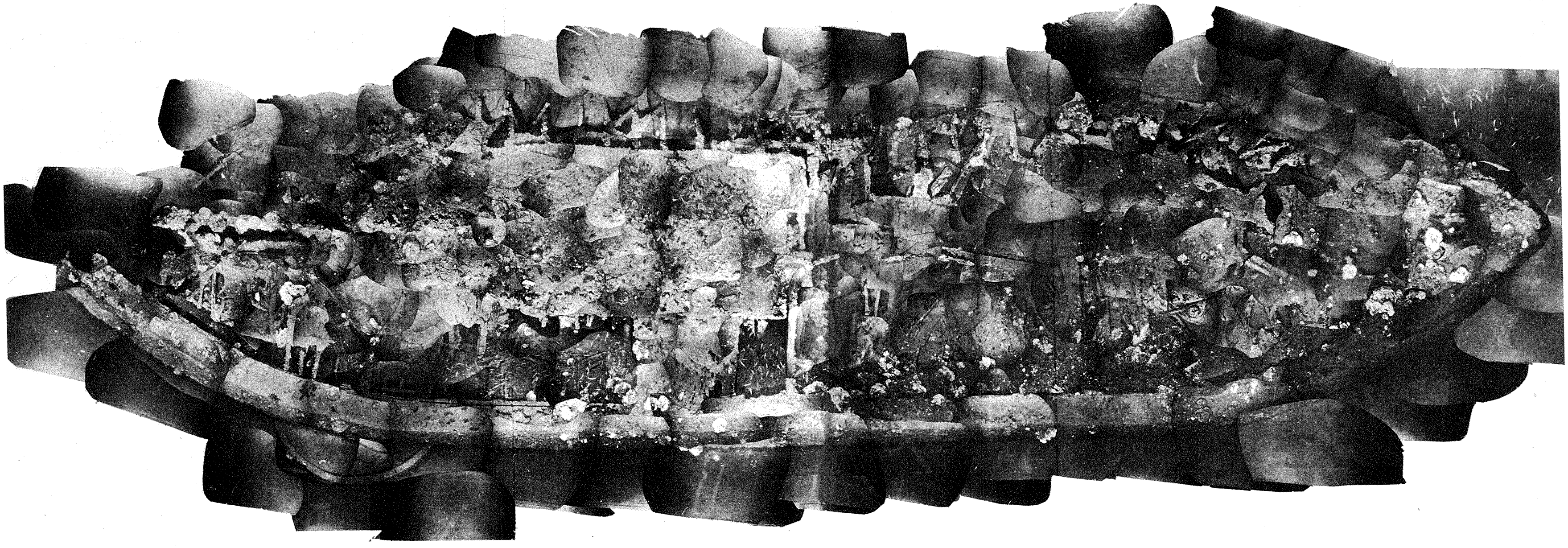
ALCOA SEAPROBE

The semirigid aluminum pipe string exploits the many years of oil industry experience to provide a semirigid depth probe. The probe can carry a variety of tools, including closed circuit TV and underwater cameras, which are operated from the ship's control center.



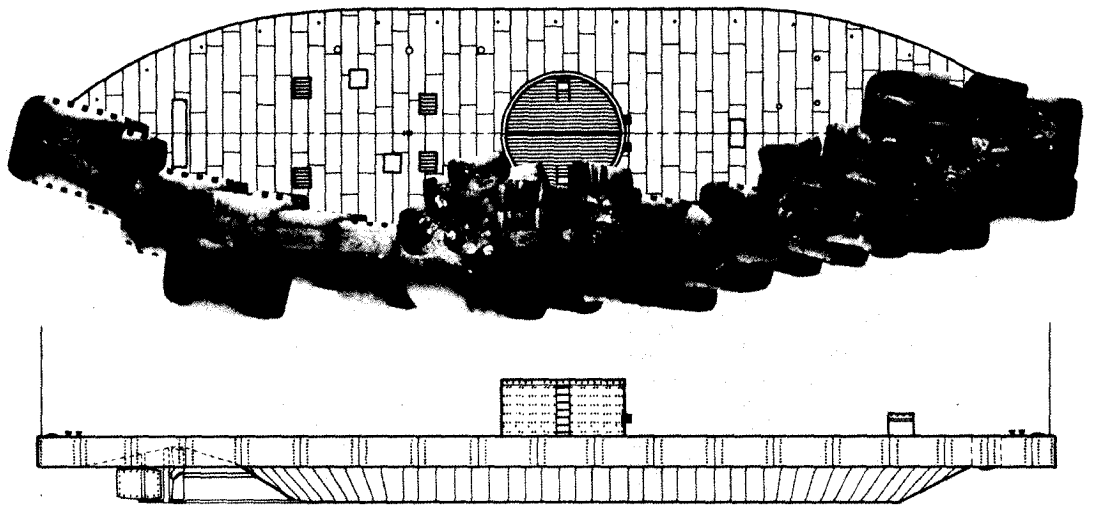
MONITOR'S TURRET

Artist's interpretation at right shows detail seen in both the underwater photo, above, and the original design plan, left. The turret floor diameter beam and the attachment bolt for the diagonal support turnbuckles are shown in all three figures.



UNDERWATER PHOTOMOSAIC OF USS MONITOR.

This composite was reconstituted by the Naval Intelligence Support Activity by using aerial photo interpretation techniques. It required several weeks of careful work assembling hundreds of frames of underwater strip photography obtained from the search and reconnaissance operations by SUPSALV.



CONSTRUCTION OF MONITOR'S PHOTOMOSAIC

real-time television examination of deep ocean objects. The basic search "pod" deploys side-scan sonar to sweep a 2,400-foot path along the seafloor. The pod is configured with forward-looking sonar, television, still camera, target illumination systems, and a droppable acoustic beacon to use in marking specific target locations. Additional sensors, detectors, and other special devices may be added to the pod to meet the requirements of specific missions.

OPERATIONS OFF HATTERAS

Preliminary

The ALCOA SEAPROBE operation was conducted at the beginning of a deployment to Europe from her home port of Fort Lauderdale. En route, she put in to Morehead City, North Carolina, where MONITOR expedition members from the Navy, Duke University, the State of North Carolina, the National Geographic Society, and others embarked. This joint expedition got under way the evening of 31 March, and arrived in the Hatteras area early the next morning. The operation plan called for evaluation of a sequence of sites identified by previous expeditions and magnetometer findings, following a priority of probable likelihood.

Reconnaissance

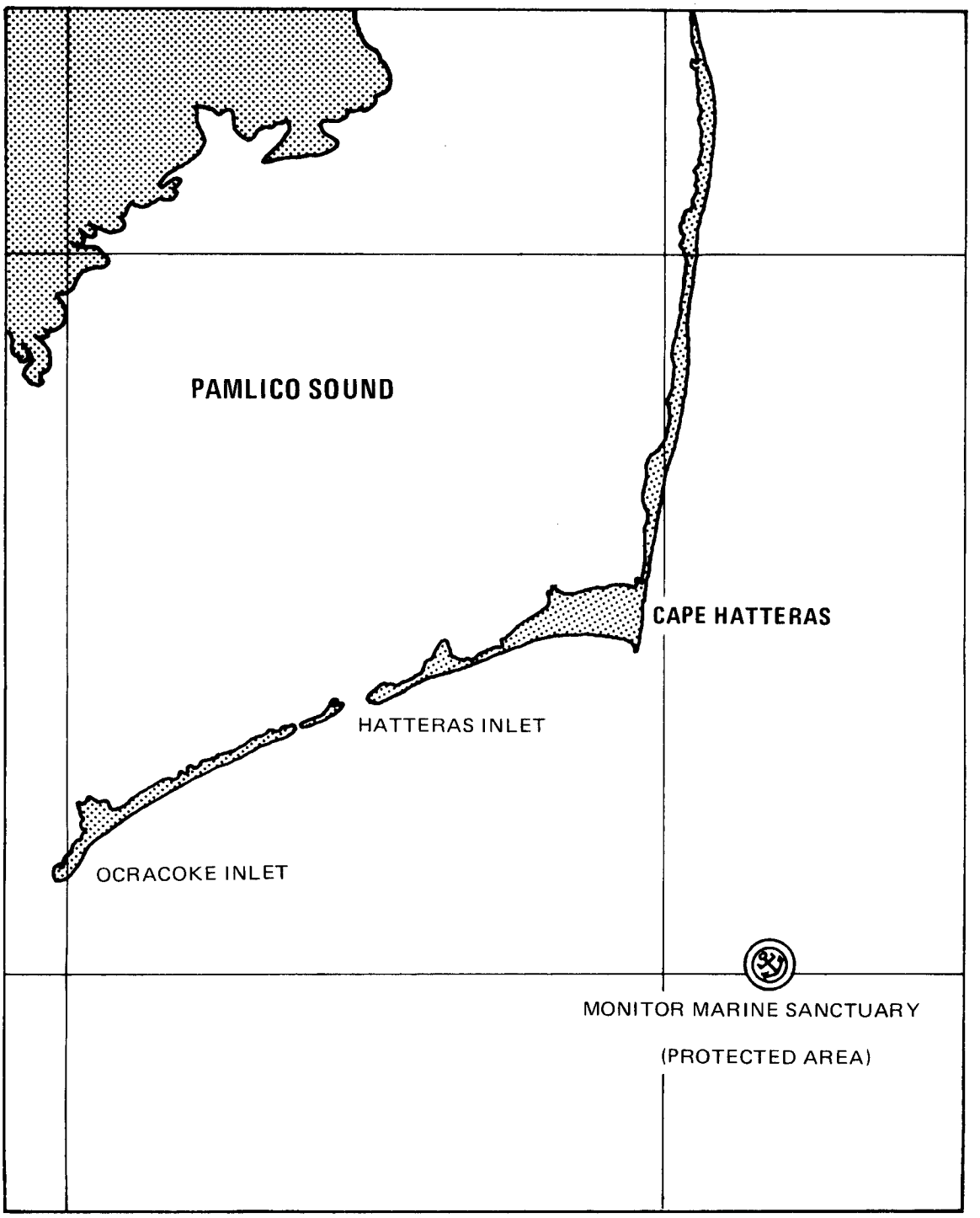
By 0818, ALCOA SEAPROBE was over Site #1 (35°00.1'N, 75°24.5'W) with a fathometer indication of a bottom feature 18 feet high. Without the Del Norte precision microwave navigation system, which remained unavailable the first two days, the remainder of the morning was spent in unsuccessful sonar search in parallel passes at 100-foot intervals progressing from the assumed wreck position. Finally, at 1407, a target was picked up on the side-scan sonar, which was confirmed upon lowering the pipe-string pod with closed circuit TV. The hulk of the MONITOR was seen resting bottom-side up on the ocean floor in 210 feet of water, oriented on an east-west axis. Roughly a fourth of the turret was visible protruding beyond the armor belt, where it must have been sheared off the deck when MONITOR hit the bottom that stormy night in 1862.

Photography

The position thus confirmed, 15-1/2 miles south-southeast of Hatteras light, the 35mm camera in the pod was activated and runs were commenced to record film sequences suitable for assembly into a photomosaic. These runs, guided by closed circuit TV, were continued until after midnight when the film supply was exhausted. Subsequent photographic runs were also conducted later on 2 and 3 April, for a total of over 2,000 photos. Two more days were spent in unremunerative reconnaissance of two more sites. The SEAPROBE expedition then came to an end, but the Navy's contribution continued for several more months. The 2,000 photographs were skillfully assembled at the Naval Intelligence Support Activity at Suitland, Maryland, into a complete and fully identifiable photomosaic of the hull and turret of MONITOR as they lay in the sand of Diamond Shoals. It shows (1) bow and stern shapes, (2) direction of the plating, (3) the distinctive armor belt, (4) peculiar diagonal braces used in the construction, (5) shape of the skeg and extended propeller shaft, (6) overall size and shape of hull, and (7) the flat bottom. In addition, the turret dimension including armor thickness agree with two specifications copied from original engineering drawings preserved at Stevens Institute in Hoboken, New Jersey.

CONCLUSION

The very effective TV video tape and 35mm photographic coverage provided by modern deep ocean technology was crucial in providing definitive evidence of MONITOR's existing location and condition. In view of the expense of such operations, the Supervisor of Salvage was pleased that the occasion to do this work occurred at a time when test requirements for the ALCOA SEAPROBE system coincided with a requirement for reconnaissance of MONITOR. It seemed appropriate for the Navy to be able to provide this assistance to again bring to light this important and symbolic relic of the technological fighting Navy, which now lies protected by law, as a national relic, in the sands off Hatteras.



LOCATION OF MONITOR WRECK

The remains of MONITOR.

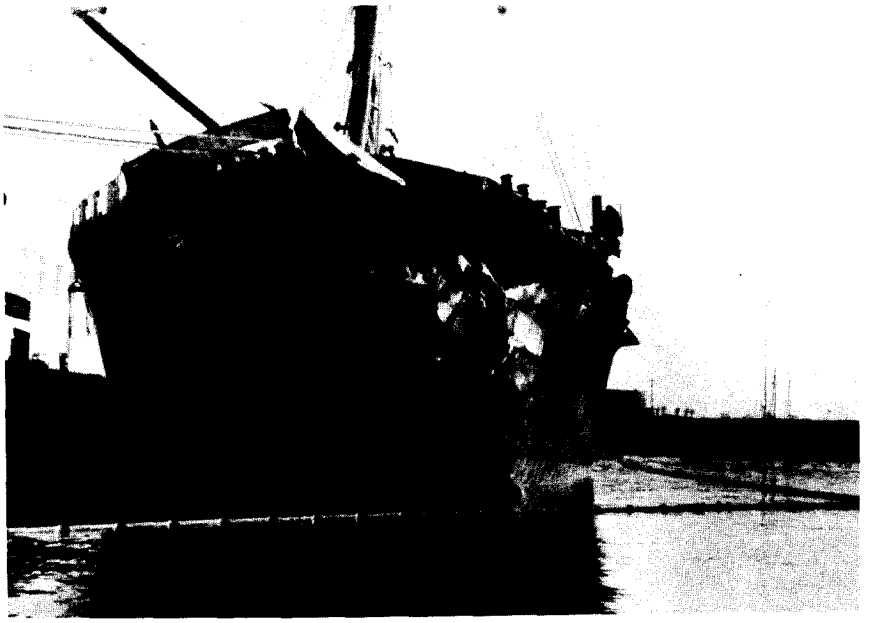
TOW, REPAIR,

AND OIL SPILL RECOVERY

FOR USNS PVT. MERRELL

MERRELL WAS LEFT DEAD IN THE WATER

The bow of the PEARL VENTURE penetrated MERRELL, port side aft, into holds 4 and 5.



PEARL VENTURE, ALSO DAMAGED, MADE PORT UNDER HER OWN POWER

The Liberian bulk carrier suffered heavy bow damage but was able to proceed to Los Angeles for repairs.

TOW, REPAIR, AND OIL SPILL RECOVERY FOR USNS PVT. MERRELL

INTRODUCTION

Early on 29 December 1973, in a light fog, USNS PVT. JOSEPH F. MERRELL (T-AK-275) and the Liberian tanker SS PEARL VENTURE collided off Cape San Martin, California. MERRELL was penetrated on the port side aft, causing severe structural damage, which allowed approximately 16,000 gallons of heavy fuel oil to escape into the sea. PEARL VENTURE pulled free and despite damage, proceeded to Los Angeles. MERRELL remained dead in the water.

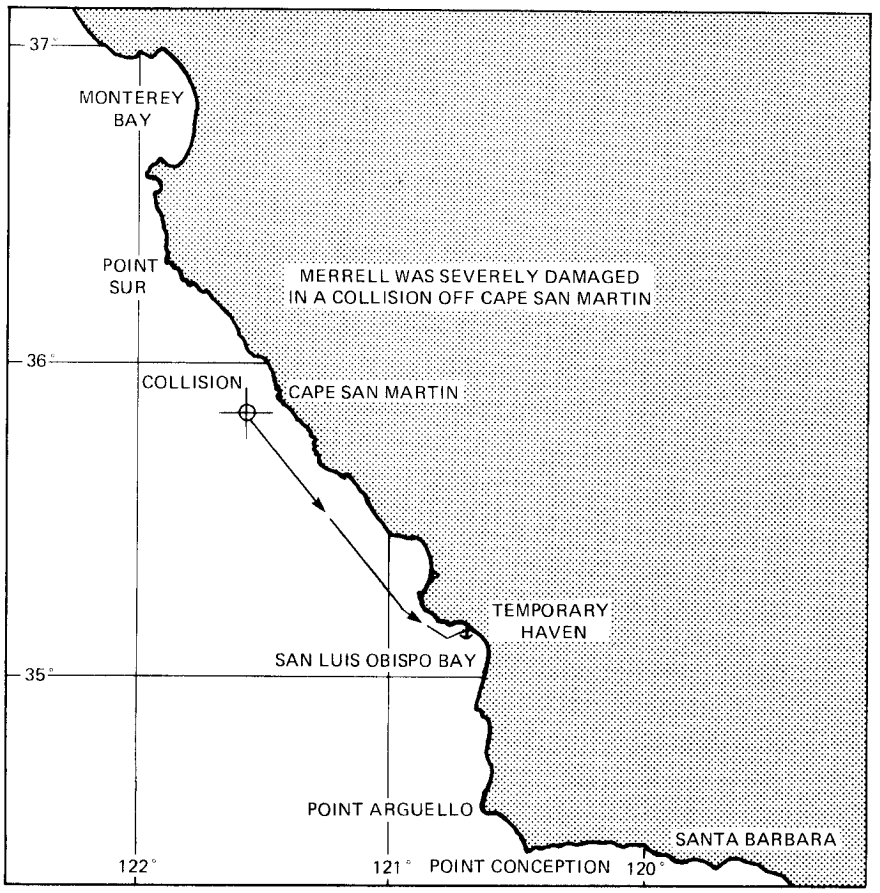
The Supervisor of Salvage Representative, West Coast (SUPSALVREP) directed the Murphy Pacific Marine Salvage Company to assist in both oil spill abatement and salvage efforts. Murphy sent their ocean salvage tug M/V GEAR to the scene, and directed a salvage master to proceed to the MERRELL, at sea, with the SUPSALVREP.

To supervise tow of the crippled MERRELL to a temporary haven, the salvage master and the SUPSALVREP boarded MERRELL early the following morning. The M/V GEAR took MERRELL in tow and proceeded down the coast to San Luis Obispo Bay, where MERRELL was anchored. Weather became increasingly adverse. Oil containment boom placed around MERRELL to confine escaping fuel oil was torn loose. As soon as the weather abated, a new boom was installed and major effort began to clear the area of oil, and to prepare MERRELL for tow to Port Hueneme.

Underwater inspection indicated the structural strength of MERRELL sufficient for tow, but it was decided to improve MERRELL's righting moment and relieve strain on damaged strength members by ballasting the forward holds. On 12 January, GEAR took MERRELL in tow to Port Hueneme, and custody was transferred to the Military Sealift Command (MSC).

THE COLLISION

During the early morning hours of 29 December 1973, in a light fog, USNS PVT. JOSEPH F. MERRELL (T-AK-275) and the 7,000-ton Liberian bulk carrier, SS PEARL VENTURE, collided approximately 10 miles southwest of Cape San Martin, California. The bow of PEARL VENTURE penetrated the after port side of MERRELL into holds 4 and 5. It also badly damaged the MERRELL's after fuel tanks beneath these holds, releasing some 16,000 gallons of Bunker C fuel oil into the sea. Although the bow of PEARL VENTURE was badly damaged, she proceeded to port at Los Angeles under her own power. MERRELL remained dead in the water at the scene of the collision, trailing a slick of Bunker C fuel.

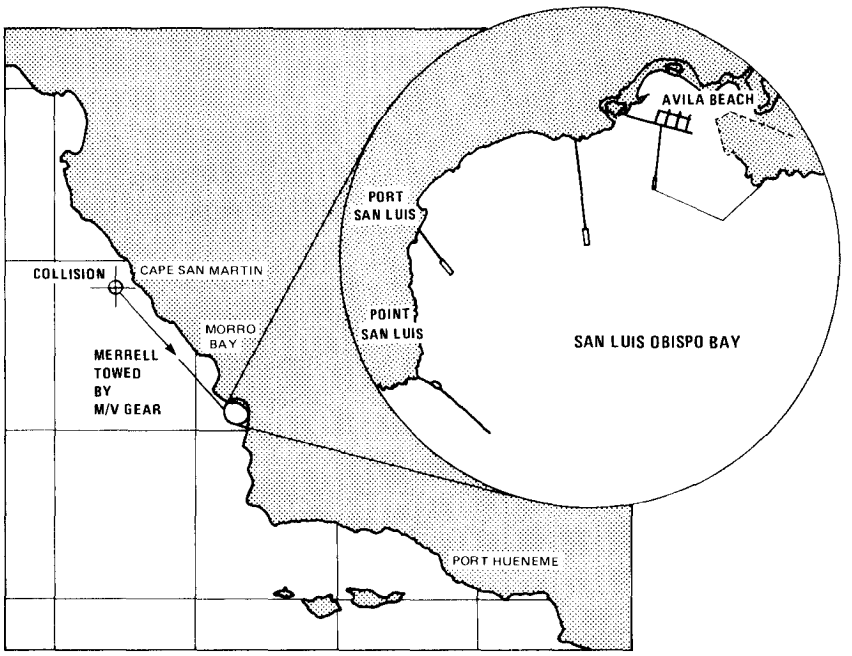


MERRELL'S COLLISION AND TOW

MERRELL was severely damaged in a collision off Cape San Martin. She was left dead in the water and the M/V GEAR was sent to tow her to an anchorage in San Luis Obispo Bay for temporary repairs.

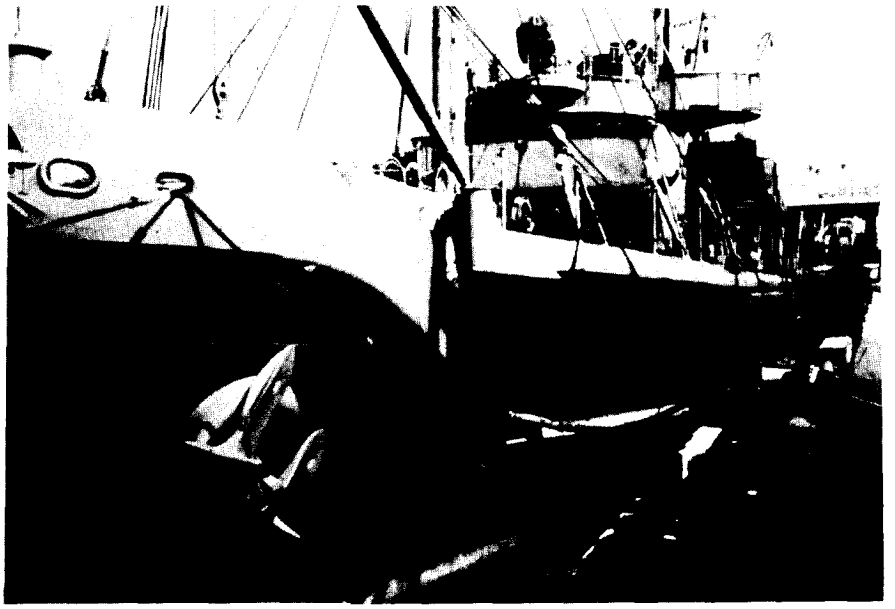
SALVAGE RESPONSE

Early the morning of the collision, upon being alerted by the Commander, Military Sealift Command, Pacific (MSCPAC), the Supervisor of Salvage Representative, West Coast (SUPSALVREP) directed the Murphy Pacific Marine Salvage Company (MYPAC) to mobilize all available resources to deal with the salvage and with the oil spill abatement. SUPSALVREP also directed MYPAC to provide a salvage master to accompany him to board MERRELL at sea. MYPAC dispatched their salvage vessel M/V GEAR from Long Beach and a pair of Clearwater skimmers from San Francisco to the scene. GEAR is the former ARS-34, on bare-boat charter from the Naval Sea Systems Command (OOC), nanned with experienced MYPAC salvage technicians and mariners.



MERRELL HAD TO BE TOWED TO TEMPORARY HAVEN

The damage to MERRELL necessitated tow to an anchorage in San Luis Obispo Bay for damage inspection and repair.



M/V GEAR TOOK MERRELL UNDER TOW

Murphy Pacific dispatched their salvage ship GEAR to tow MERRELL from Cape San Martin to San Luis Obispo Bay.

GEAR got under way promptly but was slowed somewhat in transit by a heavy northwest sea and swells, accompanied by 20- to 30-knot winds commencing during early evening hours. GEAR finally fetched up on MERRELL about dawn. SUPSALVREP and the MYPAC salvage master were already at the scene aboard the M/V ARCADIA and soon boarded MERRELL, despite the heavy wind and sea. Plans had originally been considered to tow MERRELL to San Francisco for repairs, but as information was developed, it became apparent that this would not be prudent. Both structural damage and loss of stability resulting from flooding made the tow of over a hundred miles too risky. It would also widely disperse the slick of leaking fuel oil already spreading several miles downwind, fortunately southward away from shore. Accordingly, GEAR was ordered to tow MERRELL to the nearest suitable haven for interim repairs – San Luis Obispo Bay, about 50 miles further south along the California coast.

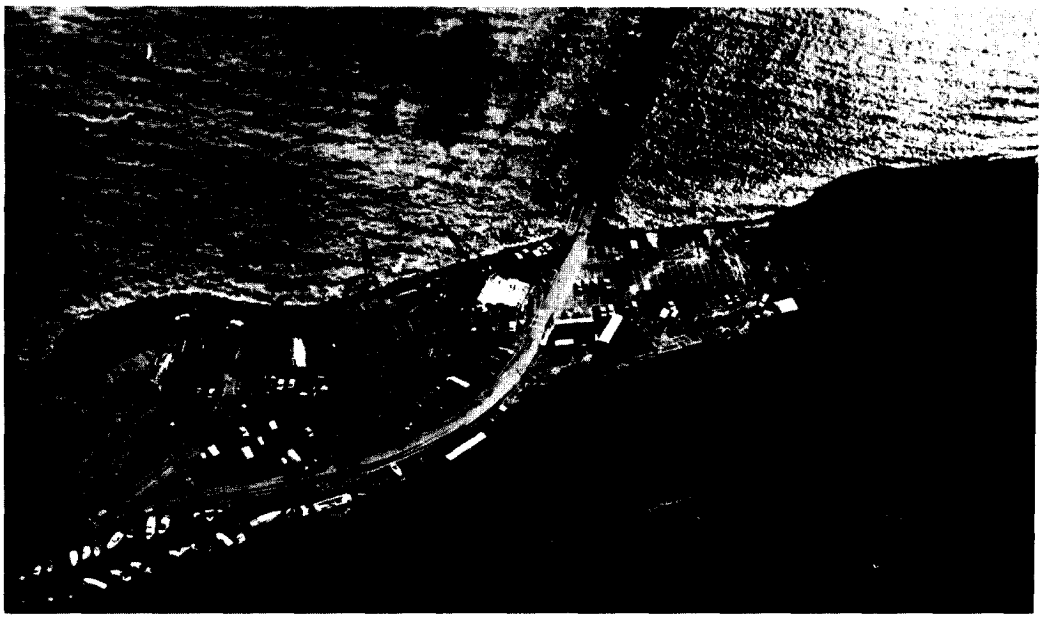
GEAR then came close aboard MERRELL and passed a messenger line with which a tow cable was hauled aboard and made fast. With 1,500 feet of tow cable paid out, on 30 December at 0800, GEAR with MERRELL in tow got under way at slow speed. The seas subsided somewhat, which permitted shortening the tow, to facilitate positioning MERRELL in an anchorage off Avila Beach late the next morning.

By now, the original spill from MERRELL, extending downwind some eleven miles and about a half-mile wide, started to break up into patches. It became apparent that the patches were in the process of dissipating through evaporation and emulsification, under the action of wind and sea. Accordingly, it was not necessary to employ the open sea skimmers as originally intended.

INITIAL OIL SPILL RECOVERY OPERATIONS

As soon as MERRELL was anchored off Avila Beach in San Luis Obispo Bay on the afternoon of the 31st, SUPSALVREP, the Coast Guard Pollution Control On-Scene Coordinator, and the MSCPAC representative began inspecting MERRELL's damage and oil leakage to determine what interim repairs were needed prior to further towing. They were assisted by divers from GEAR who surveyed underwater damage. They found a hull crease to starboard at frame 145 extending to the keel, a four-inch crack on the flat keel, and the propeller knocked out of alignment.

Meanwhile, spill containment boom, three oil recovery skimmers, three Coast Guard cutters, tugs, a commercial oil disposal barge, a Navy self-propelled fuel barge (YO), and other pollution control resources had been sent to Port San Luis on the western lee of San Luis Obispo Bay. There, the boom was faked down, ready for use upon MERRELL's arrival. It was then deployed, both around MERRELL as well as within her torn-open number 4 and 5 holds, where heavy Bunker C fuel oil was oozing up from the damaged number 5 deep tank beneath. Despite three concentric enclosures of boom, oil was leaking at about 100 gallons per hour in the 10-foot seas.

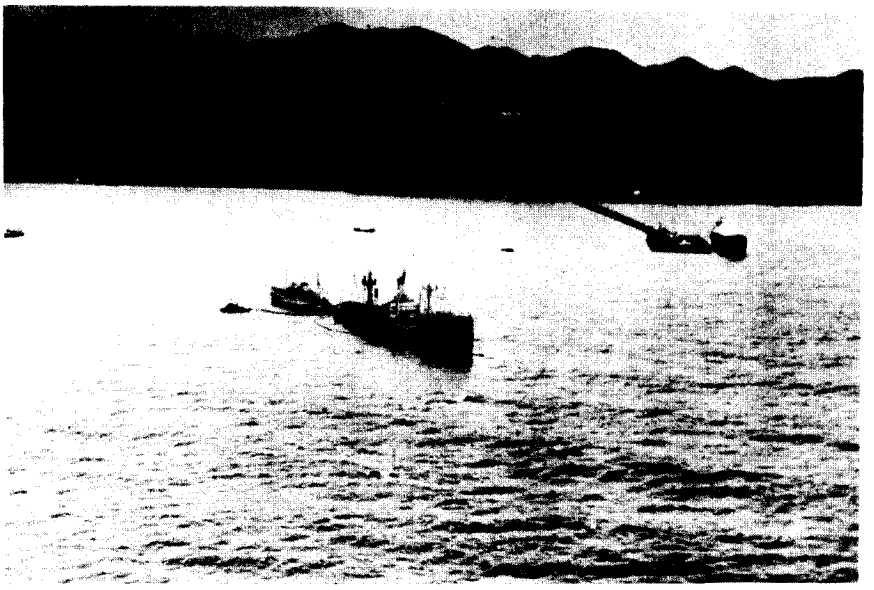


POLLUTION CONTROL RESOURCES ARRIVE AT AVILA BEACH

Murphy Pacific Marine Salvage Company was directed to transport oil containment boom, cranes, boats, barges, and other equipment to Avila Beach, San Luis Obispo Bay, to await MERRELL.

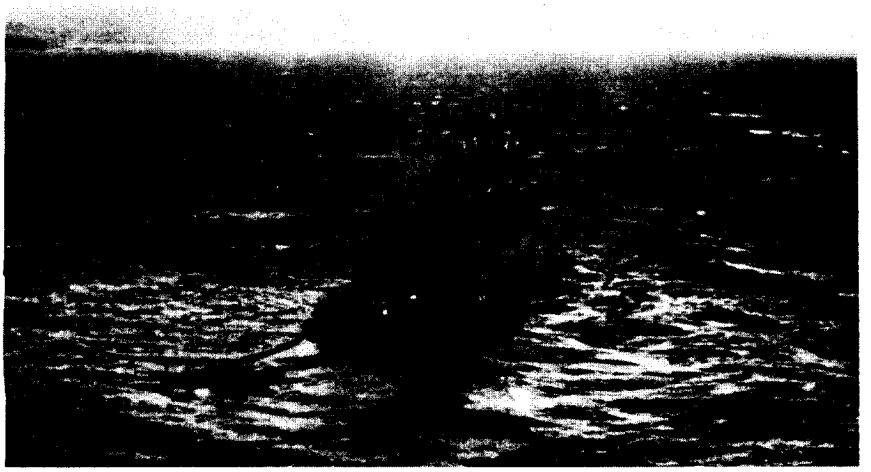
OIL CONTAINMENT BOOM AT AVILA BEACH

Close-up of the boom on the pier landing as faked down before launching for deployment.



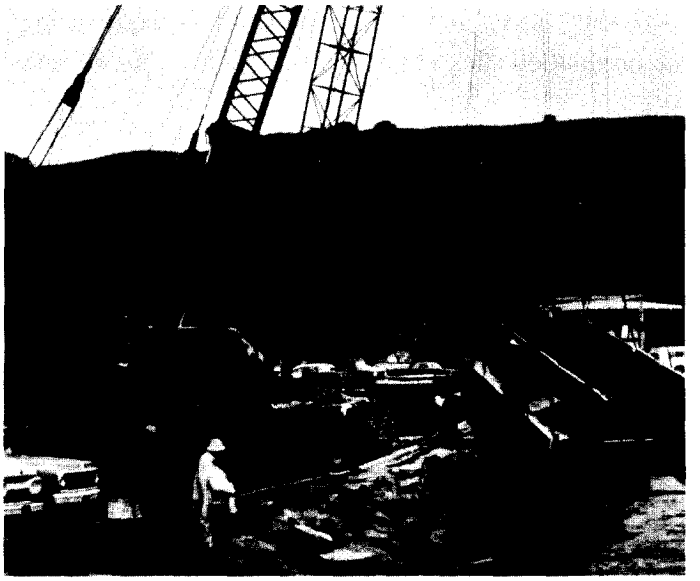
DEPLOYING OIL SPILL CONTAINMENT BOOM FOR MERRELL

The small tug is engaged in towing the boom around MERRELL while GEAR is setting up a two-point moor.



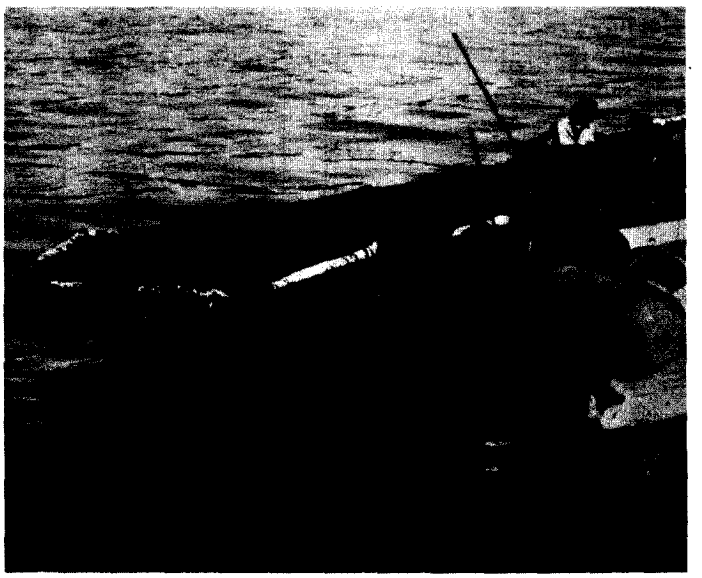
MERRELL'S BOOM CLOSES IN AS WEATHER WORSENS

Increasing wind and seas in San Luis Obispo Bay pull on the spill containment boom and bring it close aboard MERRELL.



HUSKY SKIMMER UNLOADED INTO WATER

Skimmers were transported by flat-bed trucks to Avila Beach where contractor's cranes put them into the ocean for cleanup operations around MERRELL's containment boom rig.



SKIMMER COLLECTING OIL FROM CONTAINMENT BOOM

Only the stern of the skimmer can be seen, adjacent to collected fuel oil in a bight of MERRELL's boom. Oil is being pumped into fuel drums from the skimmer.

A Coast Guard and a Marine Corps helicopter were being used to conduct reconnaissance on the original oil slick at sea and in the San Luis Obispo Bay area.

On 31 December, transfer of oil from MERRELL to the Standard Oil motor barge RECOVERER commenced. By then almost all the original spill at sea had dissipated and as yet none of the local spill from MERRELL had washed ashore. But on 1 January, despite the commencement of skimmer operations, oil began polluting the Pismo Beach area to the southeast, and U.S. Navy personnel from NAS Lemoore, commenced assisting in cleanup.

Next day, 2 January, efforts were intensified in and about the MERRELL to cut off the pollution at its source. All likely damaged tanks were emptied of fuel and pressed with water ballast to further purge all oil. The SUPSALV Harding and Huskey skimmers arrived that morning and recovery of oil, dunnage, and other trash being contained within the booms around MERRELL was given top priority. A thousand feet of boom was added to the original installation, and with a skimmer operating inside the boom, seepage was contained. The high capacity Harding skimmer was particularly effective. By link-up with the successive concentric booms, it worked its way into the MERRELL, capturing the trapped oil as it went. The Harding was coupled with MYPAC Barge 201, which was held to the port side of the skimmer using the MYPAC tug ELLEN MURPHY. The capacity of this barge was required for 1,500 barrels of oil and 40 cubic yards of trash recovered during the day. Navy, Coast Guard, and civilian contract personnel were cleaning up the beach area, using dump trucks, a front-end loader, and a grader. Two more skimmers were working offshore. All the beach work was progressing satisfactorily with, in particular, no loss of wildlife noted, and ninety percent of the beach cleanup was completed by evening.

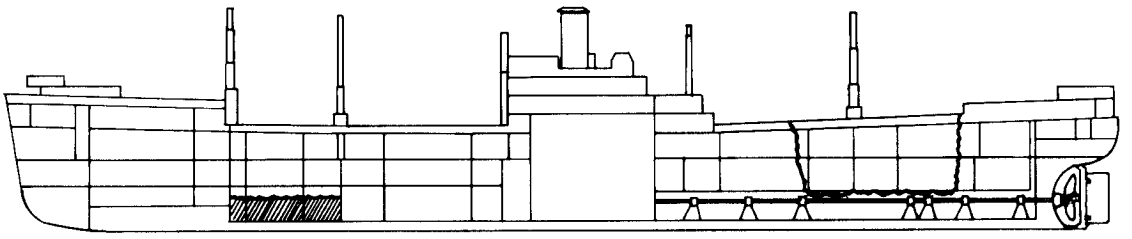


DIAGRAM OF MERRELL'S DAMAGE

In addition to the 65-foot hole cut into holds 4 and 5 port side aft, divers reported a hull crease to starboard extending to the keel, a four-inch crack on the flat keel, and the propeller knocked out of alignment. While MERRELL had enough structural strength for the tow to Port Hueneme, 1,000 tons of sand was placed in number 2 hold to increase the metacentric height and relieve strain on strength members in the damaged areas.

INITIAL SALVAGE WORK

Divers from GEAR, in undertaking a thorough underwater inspection, not only discovered that the flat keel was fractured, but also provided information as to which of MERRELL's compartments were damaged, flooded, or intact. These facts were developed and passed to a naval architect at the scene and to NAVSEC on 2 January. The concensus was that MERRELL had enough structural strength to withstand tow to Port Hueneme, but that her stability needed improvement by placing additional ballast in a forward hold. This would increase her metacentric height, as well as relieve strain on remaining strength members in the damaged area. Calculations indicated that 1,000 tons of sand placed in number 2 hold would accomplish the desired result, and accordingly, 1,000 tons of sand was ordered. It was further recommended that a centerline separator bulkhead be installed in number 2 hold to more narrowly position the ballast. This would optimize the locus of its stabilizing effect. Construction of the separator bulkhead commenced on 5 January. A derrick barge had previously been ordered from San Diego to be used for the removal of loose cargo from number 4 and 5 holds. Number 4 hold contained several large mooring buoys and three 8000-pound anchors; number 5 hold was choked with debris of all kinds floating on at least a foot of oil.

There were 11 dives made during the salvage operations, each averaging about 45 minutes. The dives were made for underwater inspection, clearing of boom and lines from various small vessels' propellers, and for clearing debris and oil boom from number 4 and 5 holds.

DISASTER STRIKES

Storm forecasts from the Fleet Weather Control at Monterey indicated that the successful coordination of effort was working against time. The Harding skimmer and Barge 201 required only time to complete collection of the remaining oil and debris alongside MERRELL and within its pierced number 4 and 5 holds. The work continued throughout the evening until 10-foot swells developed and forced the skimmer operations to shut down.

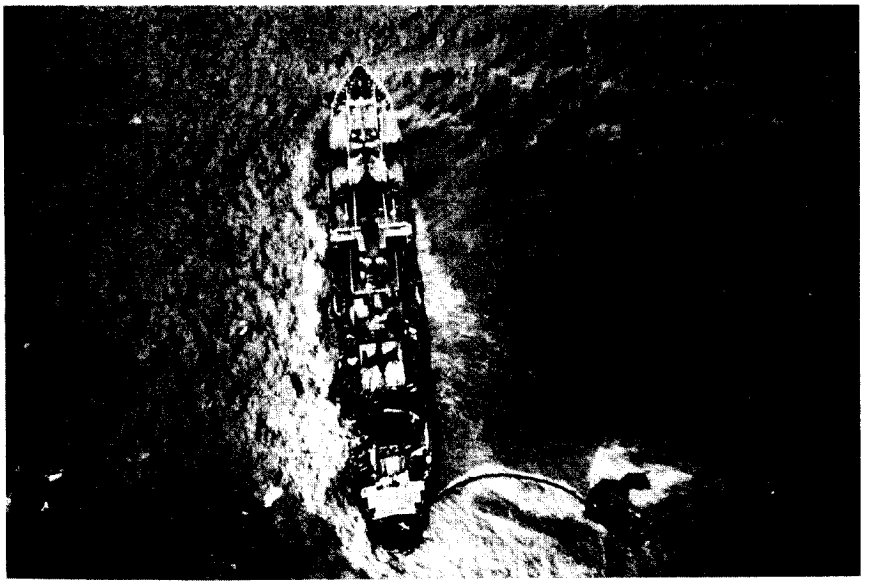
The weather continued to worsen into the early hours of 4 January, with 30-knot winds and rough seas. Preparations to move MERRELL closer inshore for better working conditions were canceled and instead, GEAR, in a series of sequences, used its beach gear to put MERRELL into a taut three-point moor. The Harding skimmer and Barge 201 were moored to oil company buoys, but the barge broke free and was blown onto the beach along with two skimmers. Worst of all, the oil containment boom, completely exposed to wind and seas, was torn away, allowing large amounts of the contained oil to wash free. This converted the once successfully-proceeding spill recovery into a severe spill. The fact that beach cleanup could and did continue through the storm was scarcely relevant. For some time, pollution worsened even as the work continued.

OIL WASHED ONTO AVILA BEACH BY THE STORM

The successful emplacement of containment boom around MERRELL had scarcely been completed when 30-knot winds and high seas tore it away and converted a successful spill recovery into severe pollution.

OIL SPILL RECOVERY CRAFT REACHED BY STORM

The MYPAC barge and the Navy oil recovery skimmer ashore on Avila Beach after the storm. MERRELL lies anchored offshore in the background.



OIL CONTAINMENT BOOM AROUND MERRELL WAS BLOWN AWAY

The glaze of escaped oil can be seen on the water around MERRELL, as well as the skimmer redeploying the boom.

SOME CONTAINMENT BOOM ENDED UP INSIDE MERRELL

The storm's force blew a considerable amount of boom, along with oil and debris, into the opening in MERRELL.

RECOVERY FROM STORM DAMAGE

With the abatement of stormy weather on 5 January, the salvage party returned to MERRELL. The Navy YO was moored alongside and began receiving bunker oil from MERRELL's number 5 deep tank. Containment boom again was rigged around MERRELL. The installation was ably enhanced by the Coast Guard Cutter BLACKHAW, which put down mooring to secure the boom well clear of MERRELL's hull. This assured effective working space for the skimmer to pick up the oil within the containment area.

The oil that leaked up into the torn-open number 4 and 5 holds posed a special problem. It was being held by some lengths of containment boom pushed into the hold by the storm of 4 January. It was necessary to remove the boom to get at the oil, and the MERRELL's cargo boom could not do the job because of limited reach and impeding wreckage. The derrick barge sent to the scene was brought alongside while the wreckage was being cut away. Then, using a clamshell to lift out portions of boom while tugs pulled out other sections, the holds were freed. This effort required two days of work. The retrieved containment boom was sent ashore for cleaning or shipment to disposal. Then, DUKW amphibious trucks and the Harding skimmer went to work on the oil in holds 4 and 5, clearing it after two days work once all boom had been removed. While the spill recovery work was in progress, MERRELL's starboard anchor was recovered from underfoot, moved clear of the oil boom, and hauled out to seven shots to put MERRELL in a taut four-point moor. This was partially a precaution against possible additional bad weather, and was useful in reducing the surge in swells which somewhat hampered the assisting barge derrick.

Ashore, although the parting of MERRELL's oil containment boom had freed all the trapped oil, the freed boom and the counterclockwise current circulation in San Luis Obispo Bay fortuitously combined to restrict the oil spill to a beach area between the Port San Luis wharf and the Union Oil pier. This enabled beach cleanup to be focused on this area. Oil, kelp, and debris were recovered by hand for the most part. The grade from the road to the beach precluded using heavy equipment so oil, kelp, and debris were loaded into 55-gallon drums that were hoisted from the beach using a 100-foot crane. The drums were then loaded on flat-bed trucks for hauling to disposal sites.

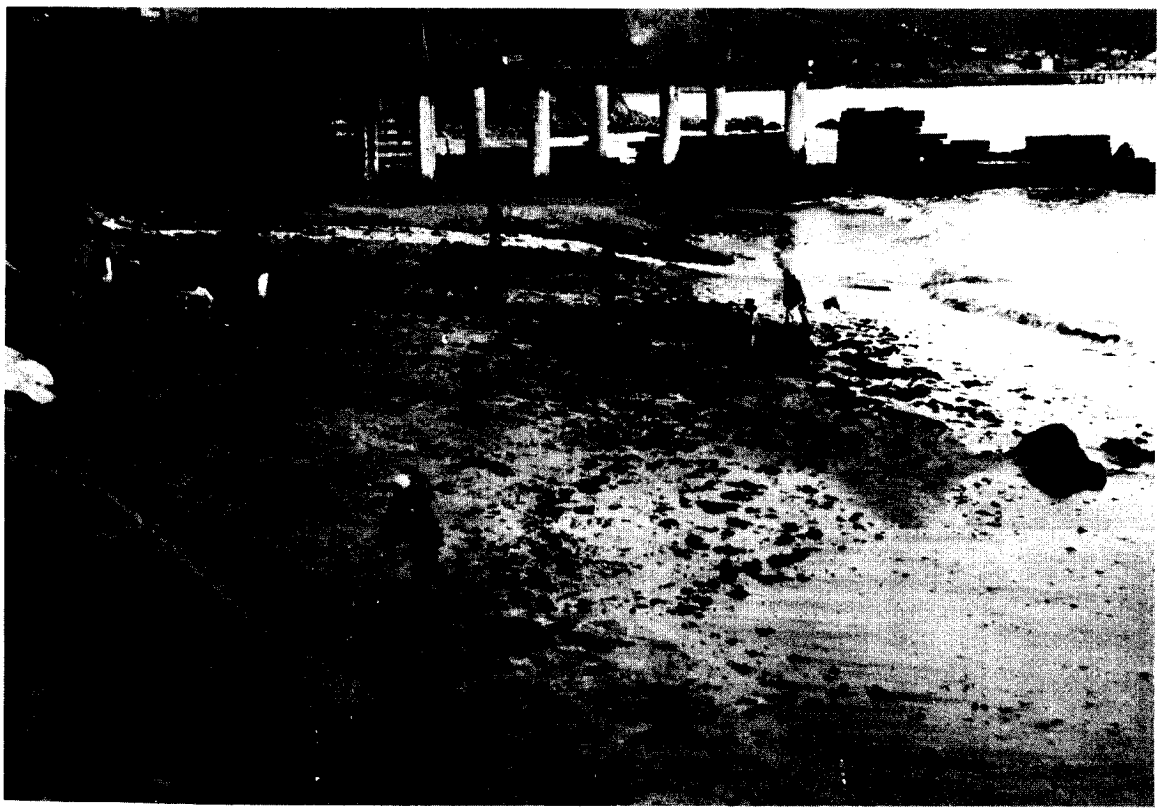
The two skimmers were hauled off the beach by combined efforts of a tug and a DUKW. The refloating of MYPAC Barge 201 required some ingenuity. It had to be emptied of recovered oil, emulsion, and water, which was complicated because of the viscosity of the oil and the 100-foot head up which it had to be unloaded from the beach. The problem was solved by stepping a sequence of portable diesel and gasoline pumps emptying into vacuum trucks. In this fashion, all 1,500 barrels were offloaded in two days. Once lightened, Barge 201 partially refloated by itself, and was easily pulled off the beach by a DUKW.

BEACH OIL POLLUTION AT ITS WORST

Workers attacking petroleum pollution at the shoreline at Avila Beach.

BEACH CLEANUP COLLECTION POINT

Beach sand and debris soaked with petroleum were collected in 55-gallon drums.



BEACH CLEARANCE TAKES EFFECT

Cleaning beaches of oil pollution is hard, dirty work, but hand labor is the only way at present to do the job.

It is worth mentioning that thrifty citizens would appreciate the careful attention to costs practiced by the On-Scene Commander. Plans were made and followed carefully to phase out the operations of expensive pollution recovery personnel, craft, and equipment expeditiously as work was completed. Military personnel were employed to the full extent practicable. The sand ballast needed for MERRELL was purchased with a prudent eye to price and transportation costs. In the end, suitable (and cheaper) sand and gravel aggregate was barged from the Los Angeles area. Only a small amount of more expensive, locally trucked sand was used to fill additional ballasting requirements quickly. The weather continued to bring heavy rain but work continued. Even when conditions afloat had precluded any effort but seakeeping, except for a few hours at the height of the storm, work ashore continued around the clock. During darkness, illumination was provided by Navy SeaBees as well as commercially rented portable generators and floodlights. The work progressed well with decreasing amounts of oil showing on the beaches with each high tide.

PREPARATION FOR FINAL TOW

After all the free oil in MERRELL's holds 4 and 5 was transferred to the YO, 16 tons of cargo was shifted forward from number 4 hold. Salvage crews removed loose, torn metal from her sides, shored the shaft alley door, and screw-jacked MERRELL's shaft through 90° to assure that the shaft was not broken. The barge with sand-gravel aggregate arrived early on the 9th. The loading of the aggregate, as ballast forward, commenced at noon and was completed by 1800, with approximately 750 tons located in number 2 hold. An additional 250 to 300 tons of sand was ordered locally and delivered to the beach at 0800 on the 10th. Assisted by a Bobcat tractor put on the barge to trim the load, loading was completed in a few hours. The barge then moved back to the MERRELL to finish the ballasting. Here the Bobcat tractor was again employed, this time within number 2 hold to grade the aggregate more quickly against corners and outer bulkhead. Operations continued through the night, including replacement of the tractor with a crawler when its drive chain broke, and by 1030 on 11 January, work of leveling the ballast was completed. Thereafter, three mooring buoys, a channel buoy, two 6,000-pound anchors, and all wreckage cut from number 5 hatch area were loaded into number 2 hold. That afternoon, divers completed a shaft locking device, and towing gear was broken out and installed in MERRELL. After a final inspection by the salvage party on the morning of the 12th, a towline from the M/V GEAR was made fast.

TOW TO PORT HUENEME

M/V GEAR got under way from San Luis Bay to Port Hueneme with MERRELL at the end of 1,500 feet of tow wire rigged to her starboard anchor chain, with two and a half shots of 2-1/4-inch chain out. The tow rode easily in a small southeast sea and swell accompanied astern by YTB-823 and YO-200. GEAR proceeded at 6.3 knots, with four engines on line, until shortly after midnight when fog began to develop, which required slowing. As Port Hueneme was approached, fog became heavy, speed was further reduced, and the tow was shortened to 400 feet. Harbor pilots boarded MERRELL and speed was reduced to steerageway while awaiting lifting of the fog bank. At noon, the tow proceeded slowly to the harbor entrance. Two Navy harbor tugs made up to MERRELL as she passed the sea buoy, and shortly thereafter, the tow was broken to permit the tugs to proceed into port with MERRELL. Two hours later she was made fast, port side to Wharf 4, Port Hueneme, for further disposition by Military Sealift Command. (Ultimately, further repair was found uneconomical, and MERRELL was striken from Navy rolls.) M/V GEAR completed operations with return to San Luis Bay to recover her two beach gear legs, and then proceeded back to home port at Berth 37, San Pedro, California.

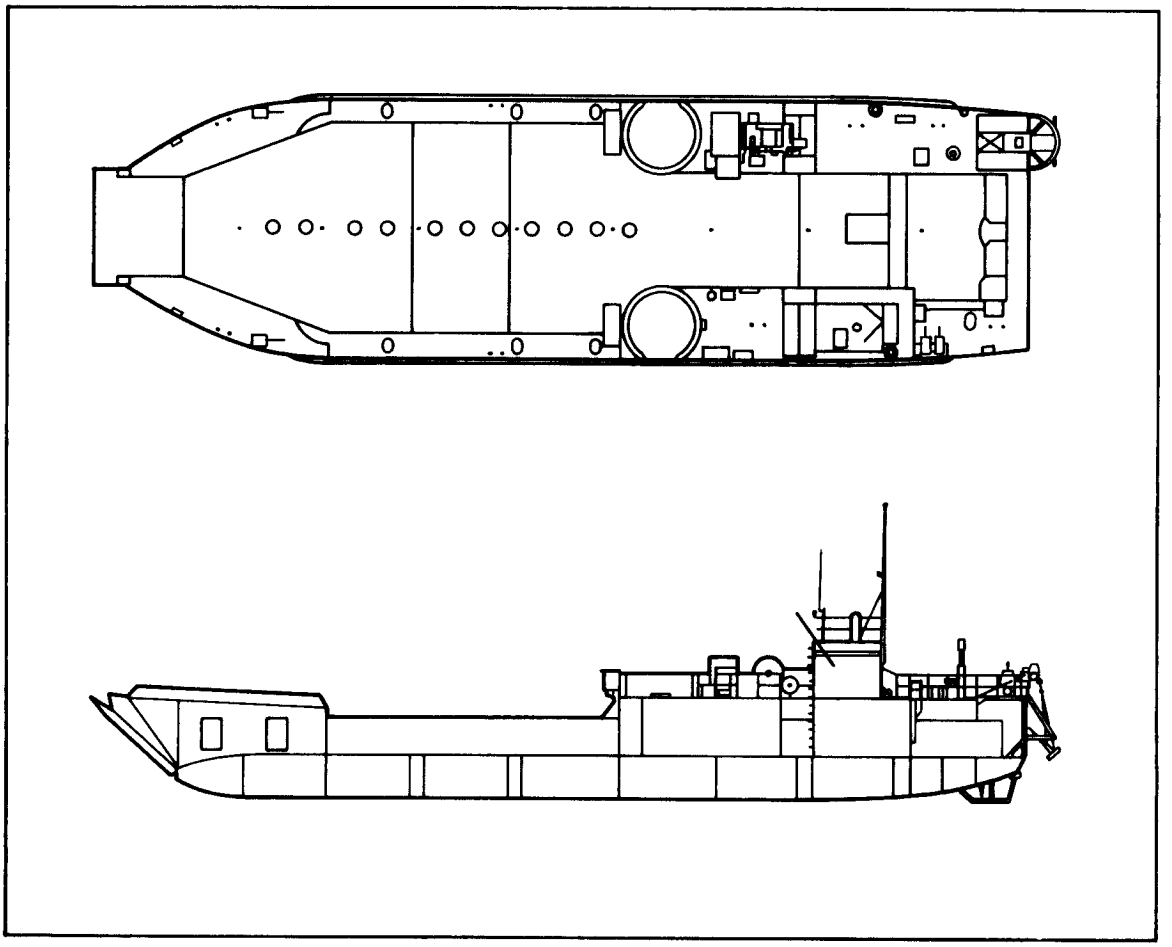
CONCLUSION

The MERRELL incident is a good example of providing salvage assistance to get a damaged vessel safely to port, together with rather severe localized problems of oil spill. Operations were handled well by all parties concerned, but severe complications produced by weather greatly expanded the effort and time involved to complete recovery effectively.

Typically, as with almost all marine emergencies it seems, early success was set back in midoperation. The element of time, as in battle, proved crucial. Success was finally achieved by unrelenting effort, ingenuity, and persistence.

SALVAGE OF YDT-9

FROM CHESAPEAKE BAY



YDT-9 SANK IN YORK SPIT CHANNEL, CHESAPEAKE BAY

YDT-9 was a diving tender converted from a World War II LCU/LCT Mk VI built in 1944. After years of use, it was being towed, stripped, from the Inactive Ship Facility.

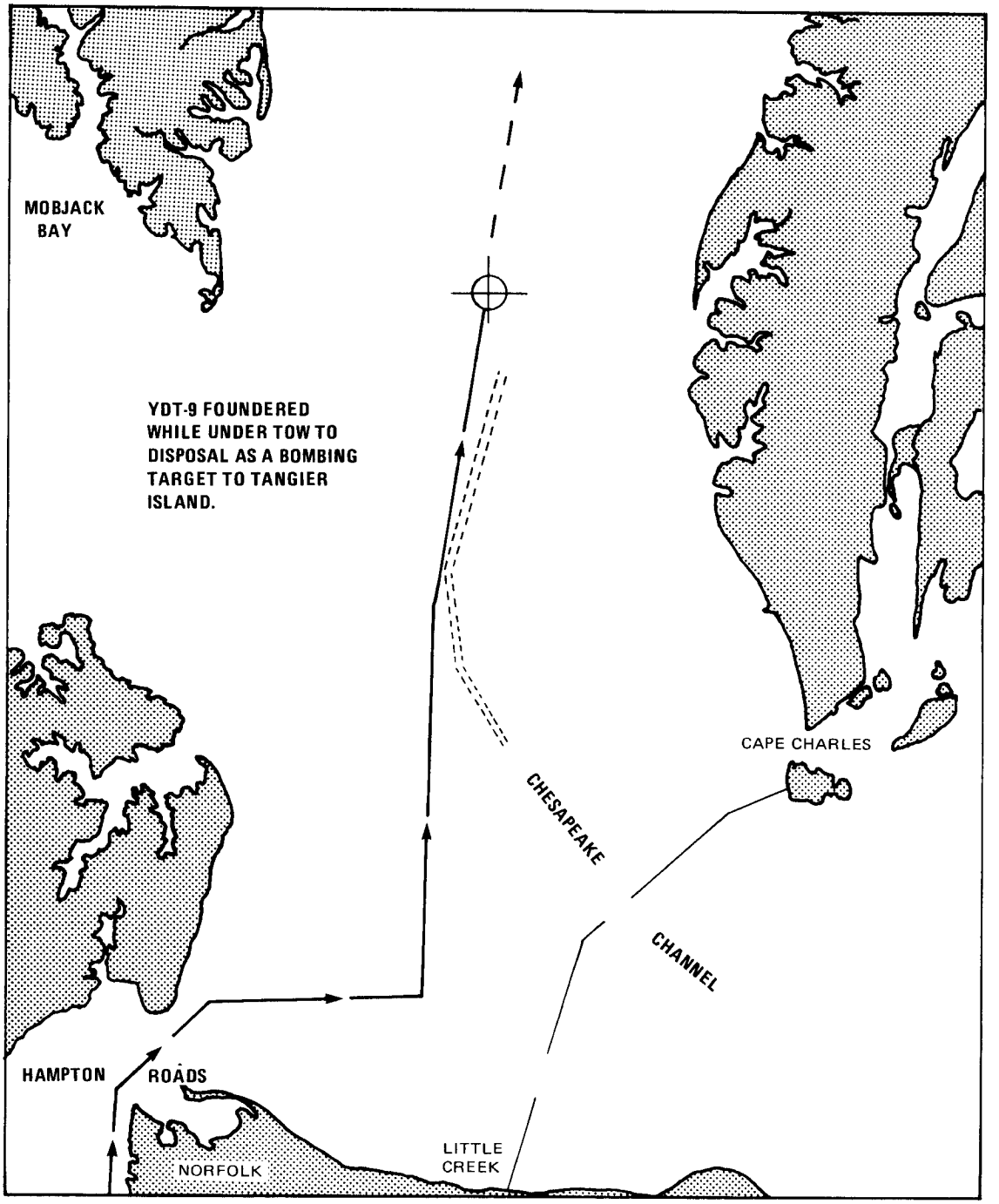
SALVAGE OF YDT-9 FROM CHESAPEAKE BAY

INTRODUCTION

While under tow by USS HOIST (ARS-40) on 4 April en route to disposal at the Tangier Island bombing range, the diving tender YDT-9 sank in 37 feet of water just north of York Spit Channel, Chesapeake Bay. She posed no pollution threat, but did constitute a navigational hazard in a busy channel. Salvage efforts commenced on 5 April with the arrival of USS OPPORTUNE (ARS-41) at the casualty site to join HOIST in an effort to lift the YDT. Adverse weather and current caused repeated problems with mooring and rigging of lifting bridles. After nearly two weeks of frustrating efforts, two unpowered lighters (YCs) were sent to lift the wrecked YDT and bring her to Tangier Island where she would be sunk and used as a bombing target as originally planned. Operations began on 8 May in worsening weather conditions. By 14 May, the lifting chains and all patches had been installed on the YDT. Weather conditions, however, then further deteriorated with 8-foot seas and winds up to 55 knots. When the weather cleared, divers reported that the YDT had broken in two from the strain on the chains and the movement of the YCs in the heavy seas. After still another unsuccessful lift attempt and more bad weather, the bow section was finally raised during the last two weeks of May. Cradled between two YCs, towed by USS ATAKAPA (ATF-149), she was taken to the Tangier Island range and sunk on 2 June. Two weeks later, amidst more foul weather, the stern section was raised (again using the YC lift) and towed by USS EDENTON (ATS-1) to the Tangier Island site. The stern section was sunk atop the bow on 17 June, ending the grueling 10-week-long salvage effort.

BACKGROUND

In April 1974, YDT-9, a converted LCU (originally an LCT Mk VI built in 1944) was removed from the Inactive Ship Facility at Norfolk, Virginia, for disposal as a bombing target at Tangier Island in the Chesapeake Bay. The years of heavy use had taken their toll of the craft's watertight integrity, and while under tow by USS HOIST (ARS-40), the YDT foundered and sank in York Spit Channel, about 23 miles north of Little Creek. The YDT had long ago been purged of petroleum or dangerous materials and constituted no pollution problem. However, with various portions of her hull and superstructure projecting to within 10 feet of the surface, she constituted a navigational hazard in line with and a few miles north of the entrance of York Spit Channel, the busy entrance to the northern reaches of Chesapeake Bay. The fact that the YDT's mast projected five feet above water permitted marking the hazard with a high intensity strobe flasher. It also indicated the proximity to the surface of this 110-foot, 160-ton obstacle, quite capable of damaging a variety of vessels using these waters.

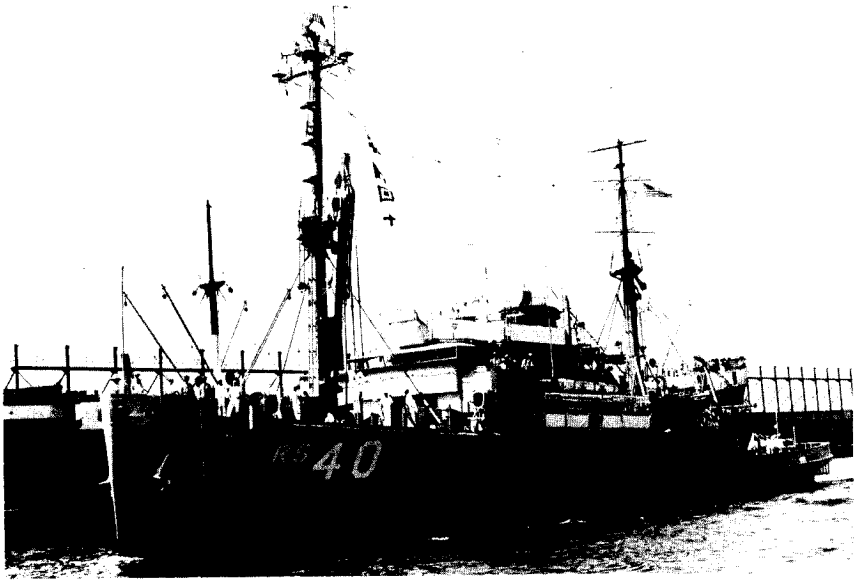


YDT-9 WAS LOST WHILE IN TOW TO DISPOSAL

The 30-year-old ex-LCU/LCT foundered just north of the busy York Spit Channel and constituted a hazard to navigation requiring removal.

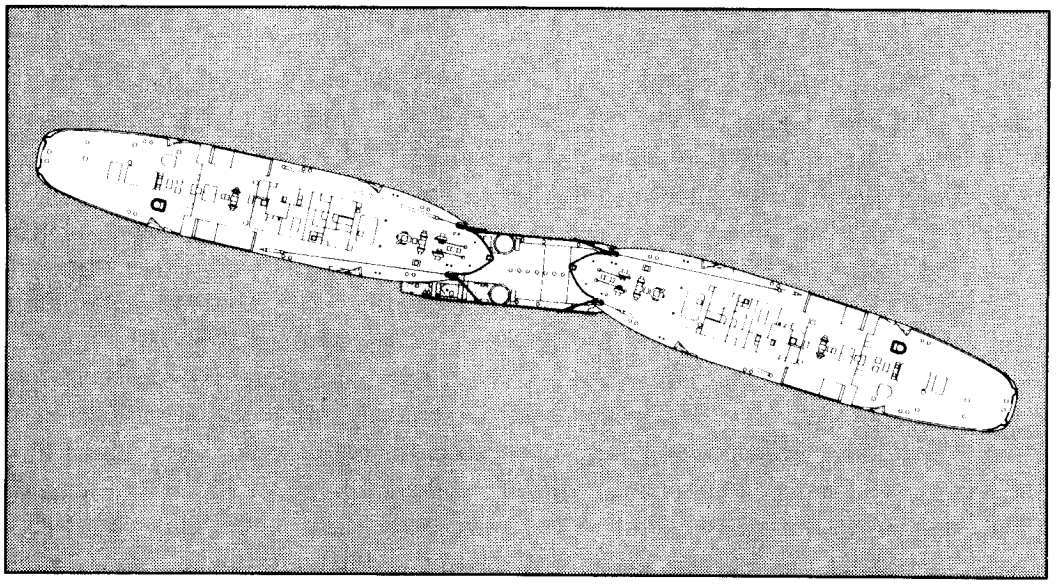
INITIAL SALVAGE EFFORTS

The HOIST promptly conducted a survey of the wreck, proceeded with salvage operations, and was joined by the USS OPPORTUNE (ARS-41). The wreck was on a northerly heading (010°) on hard mud at a mean depth of 42 feet. The forward third of the wreck projected clear of the bottom some two to three feet. This appeared to facilitate the passing of a chain bridle under the forward section which then could be lifted sufficiently, using the bow rollers of one of the ARS salvage ships, to permit the other ship to slip a second chain lifting bridle under the after section of the YDT. The YDT would then be raised in a dual bow-lift effort of both salvage ships, for removal from the channel. This concept was clearly sound, but circumstances of current and weather proceeded to conspire to defeat this approach. The natural elements continually made ship handling, mooring, diving, and work more difficult, when they weren't requiring complete cessation. The wreck was located in the primary tidal channel through which Chesapeake Bay floods and empties twice every 24 hours. All these elements not only made fixed moors a necessity, but also complicated their laying and use. After three weeks of frustrating effort with moors, messenger lines passed and parting, tidal current significantly shifting the wreck's orientation, chains positioned and then pulled away, and continual interruptions of work progress by bad weather, it was concluded that another approach was necessary.



HOIST DIVERS SURVEYED THE LOST YDT-9 AND STARTED LIFT PREPARATIONS

Divers from the USS HOIST (ARS-40) found the elderly (1944) ex-landing craft to be badly worn and corroded from years of hard use. This condition had led to YDT-9's sinking, and plagued HOIST's efforts to remove her.



A BOW LIFT OF YDT-9 BY THE TWO SALVAGE SHIPS WAS PLANNED

The position of YDT-9 on the bottom appeared to facilitate passing chain slings for lifting from the bottom using the bow-lift systems of the two salvage ships.

SECOND PHASE SALVAGE EFFORT

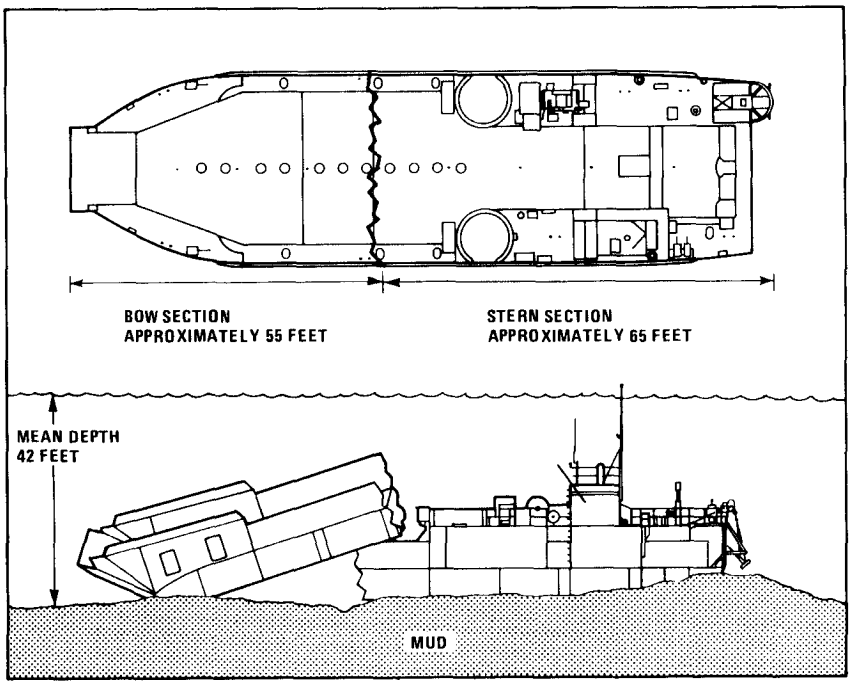
The next phase of work was based on the use of a pair of unpowered barges (YCs) equipped with beach gear to do the lifting, and thereafter to cradle the YDT to Tangier Island under tow. Again, in this phase, wretched weather complicated by tidal currents constantly hampered and interrupted operations. A more refined approach to lifting was employed as a precaution, since it had become evident that the type of problems incurred during the first phase could prove equally frustrating once the actual lift of the YDT began. This constituted providing for as much buoyant lift as possible within the compartments of the YDT. In addition, arrangements were made for very accurate positioning of the chain slings. Accordingly, the wreck was surveyed for dewatering, and a need for some 36 patches was determined, together with removing, regasketing, and reinstalling a number of hatches and manholes. It was also necessary to manufacture and install airflow and vent fittings so that each compartment would be made buoyant. Finally, all the preparatory work was completed and the lift chain slings were in position for raising the YDT, when particularly severe weather once again required a break in operations. The next day divers reported that the storm had caused the after lifting chain to cut into the wreck, which prevented moving it to the proper position for lifting. Another chain sling had to be put in position. The stern of the YDT was now too deep in the bottom mud to allow sweeping a messenger line underneath it. To facilitate this task, an after compartment was dewatered with compressed air to bring the stern clear of the bottom. At this point the YDT's 30 years of hard use

exacted their toll, and the YDT broke in half. On 14 May, after another frustrating two and one-half weeks, leaving the moors in place and carefully buoying off the wreck, the salvage unit suspended operations and returned to Little Creek to plan another attack on the problem.

FINAL AND SUCCESSFUL EFFORT

In the final phase, a straightforward approach to lifting was employed, much as in the earlier phases. With two sections of broken hull, however, a more extended effort was required involving two separate lifts.

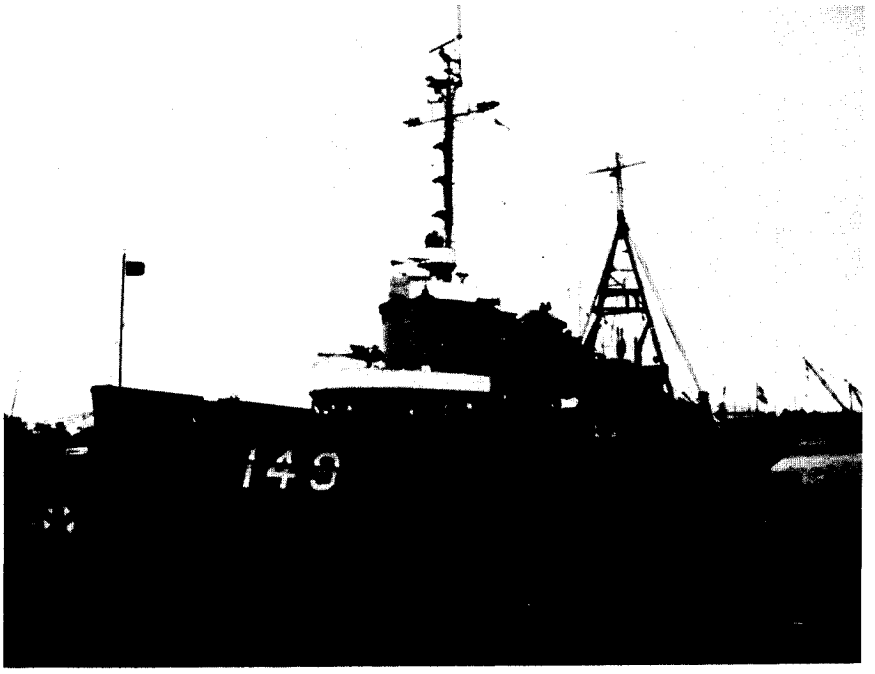
From Little Creek, Harbor Clearance Unit TWO sent a salvage unit to the wreck on 20 May, consisting of a seaplane crane YSD-53 and an LCM-6. Diver inspection of the wreck revealed that the 55-foot bow section lay with its broken after edge atop the forward edge of the stern section. Thus suspended at the rear (about ten feet off the bottom), the bow section sloped forward, downward at a 10°-15° angle, with a 15° port list. The stern section had a 5° list, with its port quarter about a foot above the mud line.



YDT-9'S RUSTED HULL BROKE IN HALF

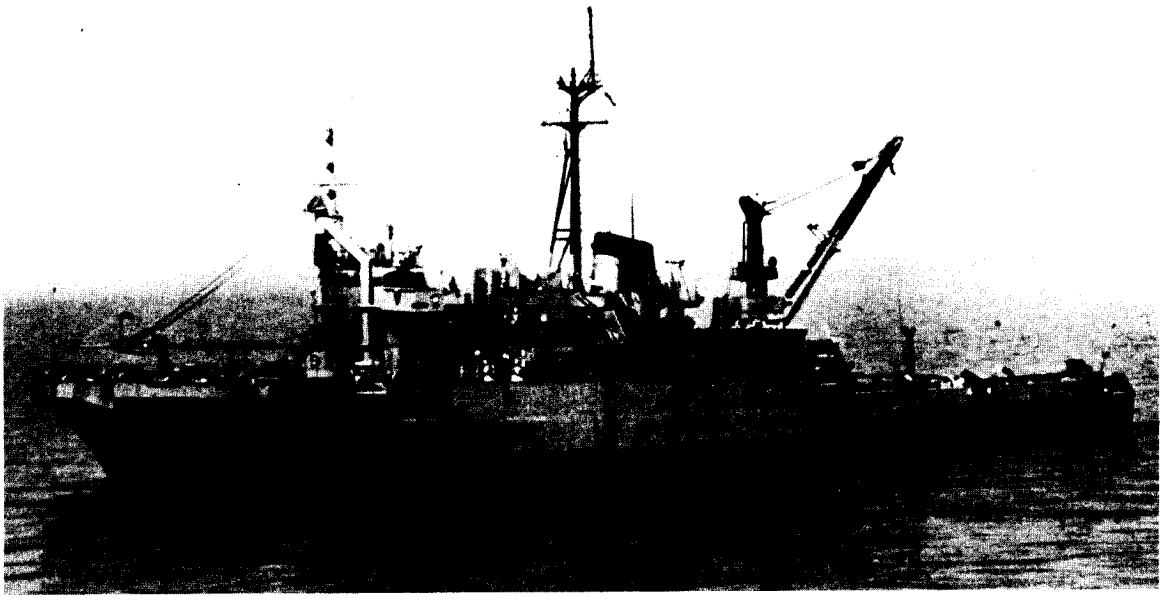
The salvage unit from Harbor Clearance Unit TWO, Little Creek, found the 55-foot bow section of YDT-9 resting on the after section, sloping 15° downward to port.

Bad weather once again caused frequent interruptions, and a week was needed to rig chain slings under the bow section of the YDT. Two YCs were again used for lifting, with the slings coupled to beach gear on the YCs. The first attempt at lifting was made on 29 May and failed. Despite being lashed in position, the chain slings slipped off the broken after end of the bow section and fouled between it and the stern section on which it lay. The chain slings were recovered and repositioned using wire fairleads, while adjusting the four-point moor of the YCs several times for best pulling angle. Again the chain slings were carefully lashed in position with about eight turns of 5/8-inch or 3/4-inch wire on each side. The forward sling was located about 12 feet abaft the bow, the after sling about 8 feet forward of the break. Pneumofathometers were placed forward and aft to guide the leveling of the wreck as the lift began, and thereafter until it was raised to the surface. On the next day, 1 June, a successful lift was achieved. Then, cradled beneath the two YCs, towed by the fleet ocean tug ATAKAPA (ATF-149), the bow section of the YDT was delivered to the Tangier Island bombing range the next morning. Here the YCs were maneuvered as required using two of HCU-2's LCM-6s and YSD-53, and the wreck was released to the proper bottom position on 2 June.



ATAKAPA TOWED THE BOW SECTION, SUSPENDED BENEATH TWO LIGHTERS, TO THE DISPOSAL RANGE

A team from Harbor Clearance Unit TWO first succeeded in raising the severed bow section, using chain slings.



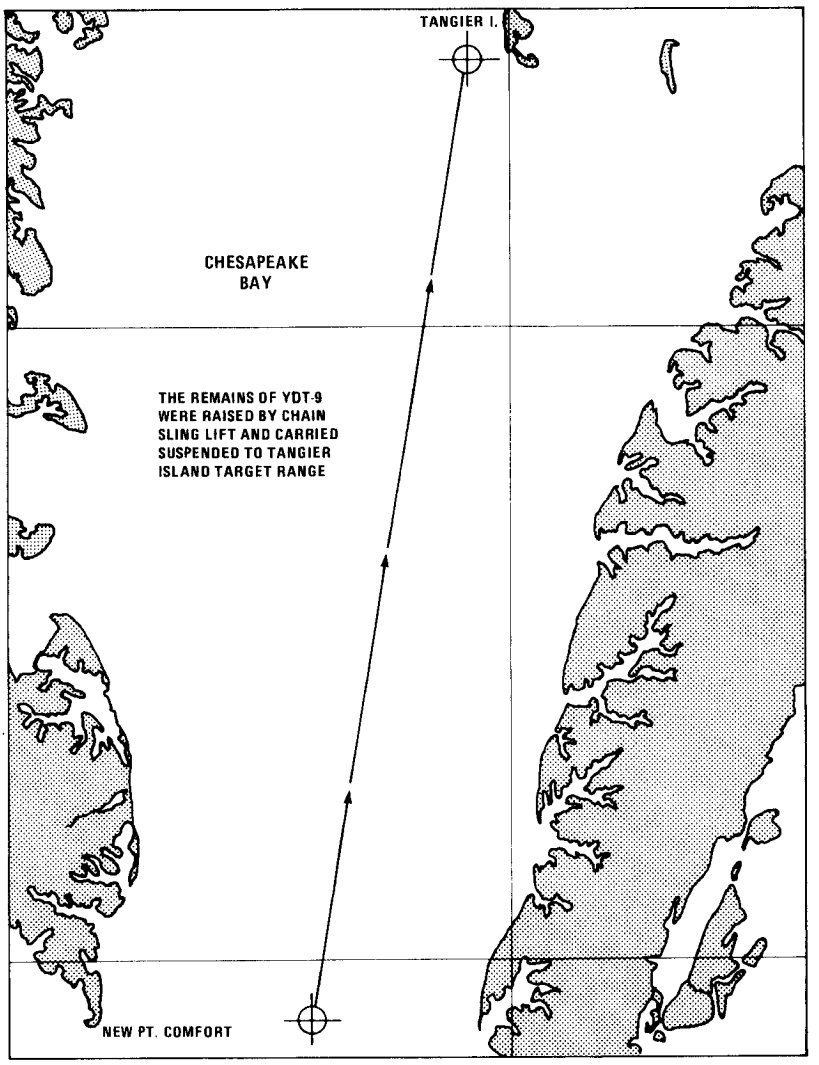
EDENTON WAS CALLED IN TO TOW THE STERN SECTION OF YDT-9 FOR DISPOSAL AT TANGIER ISLAND RANGE

The salvage team from Harbor Clearance Unit TWO continued to work on the stern section of YDT-9 and succeeded in raising it with lighters as with the bow section.

Ten days later, on 12 June, the salvage and rescue ship USS EDENTON (ATS-1) proceeded to the site where the stern section of the YDT remained on the bottom. Weather stopped operations the first day, and strong tidal currents prevented diving for six hours on the next. Operations then progressed rapidly, and chain slings were put under the wreck on the 14th. Recognizing the problems that had plagued earlier lifting, the 15th was spent in carefully adjusting, testing, and readjusting the position of the chain slings. Most of the 16th was spent waiting prudently for better weather; that night the stern section was raised and further secured with wire and chain. EDENTON then departed the area for Tangier Island towing the two YCs cradling the stern section of the YDT. On 17 June, the EDENTON arrived at the Tangier Island bombing range and deposited the after section on top of the bow section of the YDT, two and one-half months after initial salvage efforts began.

CONCLUSION

The first consideration to be drawn from these protracted and frustrating salvage operations is the dominating influence of weather and current regardless of the relatively protected location of the wreck, in only 35 to 45 feet of water inside Chesapeake Bay.



THE SEVERED HALVES OF YDT-9 WERE TOWED TO TANGIER ISLAND BOMBING RANGE FOR DISPOSAL AS A TARGET

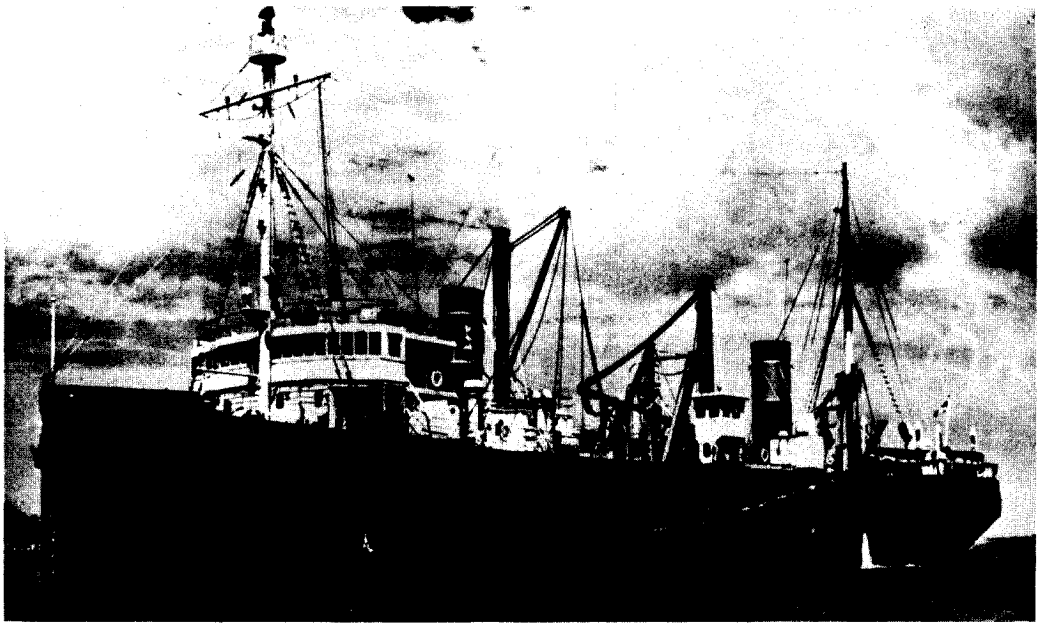
The second consideration is the importance, and difficulty, of positioning and securing chain slings under even as small a wreck as a YDT/LCU. Where only two slings can be rigged, the lift quickly goes dynamically unstable, with very little slipping, and is easily lost.

Finally, the inconvenient structural weakness of the 30-year-old hull of the YDT-9 can be expected in most hulks of World War II origin. Moreover, it seems likely that this structural weakness of old age is coupled with a deterioration of watertight integrity that will increasingly make such vessels the object of future salvage operations. This will as well render them easily broken and difficult to lift or move.

REMOVAL OF

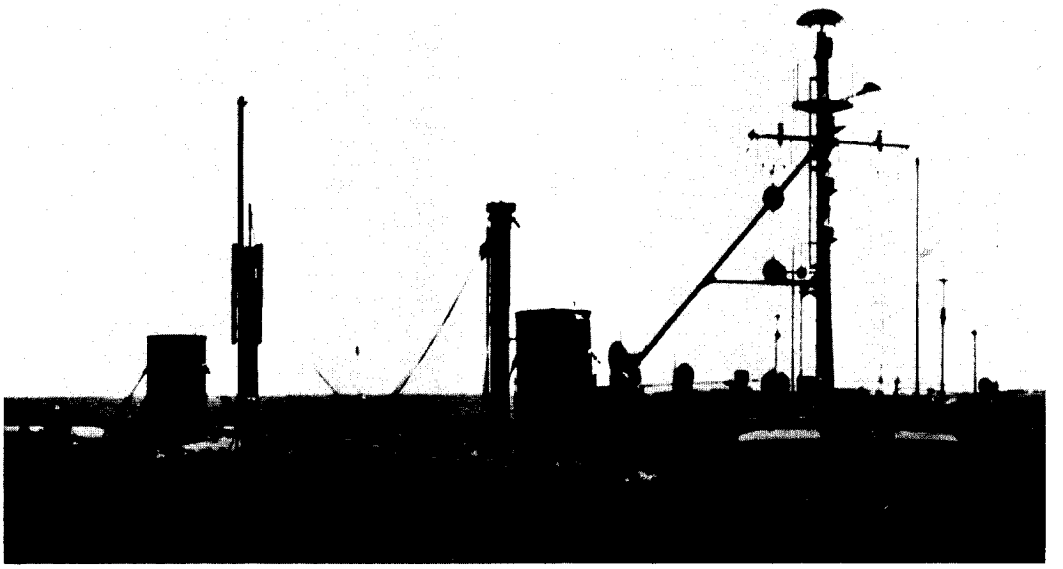
THE DREDGE MACKENZIE

FROM GALVESTON CHANNEL



MACKENZIE HAD A COLLISION WHILE DREDGING GALVESTON CHANNEL

A tanker collided with the U.S. Army Corps of Engineers dredge A. MACKENZIE while she was dredging Galveston Inner Bar Channel.



MACKENZIE SANK RAPIDLY, BLOCKING A BUSY CHANNEL

MACKENZIE sank within 15 to 20 minutes, swinging perpendicular to the channel, but with no loss of life. She is seen here resting on bottom in 42 feet of water before the soft bottom and scouring lowered her further.

REMOVAL OF THE DREDGE MACKENZIE FROM GALVESTON CHANNEL

INTRODUCTION

The U.S. Army Corps of Engineers (COE) dredge A. MACKENZIE sank in 42 feet of water in the busy Galveston entrance channel on 24 April 1974, after a three-vessel collision. On 7 May, following a request from the COE for assistance in removing the dredge from the navigation channel and in combating the oil pollution threat, SUPSALV mobilized a salvage team composed of resources from the Navy, COE, Murphy Pacific Marine Salvage Company, and several private subcontractors.

Much of MACKENZIE's diesel fuel oil escaped when the dredge sank. Full scale oil pollution abatement began on 10 May with the arrival of a Navy 17-ton oil skimmer from Boston, Massachusetts. Oil containment boom was deployed to funnel surface oil to the skimmer, making use of the swift tidal current. Subsequently, residual oil in MACKENZIE's fuel tanks was stripped to a fuel barge by water displacement pumping.

Commencing on 7 May, salvage crews and divers worked around the clock readying the hulk for lifting operations in parallel with oil pollution containment and recovery. After all superstructure was removed, the wreck was cut up into 13 sections by oxyarc equipment and explosives, and lifted by the large offshore barge derrick, MOVIBLE No. II. The bow section, salvaged first, was recovered on 24 June and the last section was recovered on 30 August. Salvage operations were successfully completed on 30 August, when divers conducted a thorough inspection and cleanup of the channel bottom. A more detailed accounting of these operations may be found in Supervisor of Salvage Report A. MACKENZIE Salvage Operation.

BACKGROUND

The Collision

On 24 April 1974 at about 1335, while dredging near the centerline of the Galveston Inner Bar Channel, the U.S. Army Corps of Engineers (COE) dredge A. MACKENZIE was struck to starboard of the after engine room by the Norwegian tanker BOW ELM. BOW ELM had just collided with M/V IDA GREEN, a research vessel owned by the University of Texas. BOW ELM, apparently to avoid a collision with the IDA GREEN, veered into MACKENZIE, which sank within 15 to 20 minutes. The 42-man crew of the MACKENZIE was taken aboard the IDA GREEN and returned to the COE pier at Galveston, with no loss of life. The collision closed the channel to traffic until the exact location of the sunken dredge could be determined.

Emergency Channel Measures

The channel, the only shipping access for Galveston, Houston, and Texas City, first required survey to determine the extent of blockage. Shortly thereafter, a task force was organized to remove the MACKENZIE. To provide temporarily for marine traffic, a bypass was established through the anchorage north of the channel in the vicinity of the MACKENZIE. The Jacksonville Engineer District loaned the hopper dredge GERIG to Galveston on 4 May to deepen the bypass channel.

OIL POLLUTION ABATEMENT

Basic Oil Pollutant Problem

At the time of sinking, MACKENZIE was estimated to have about 28,000 gallons of diesel fuel. A small oil slick indicated minor seepage of lube oil, and a lightweight floating oil containment boom was rigged around the MACKENZIE on 25 April by Corps of Engineers personnel. Divers secured seals over the fuel tank vents on 27 April.

Containment Boom Deployment

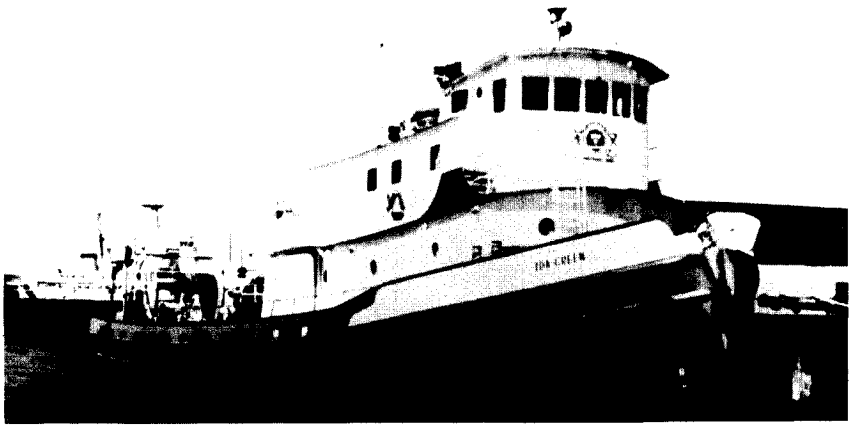
The primary oil trap was set up with floating oil boom and a new U.S. Navy oil skimmer craft to skim off the contaminated surface. Small craft patrolled the area and recovered flotsam. With the arrival of the U.S. Navy oil containment boom on 7 May, the pollution abatement phase went into full operation. The boom was provided under contracts with the Murphy Pacific Marine Salvage Company, and was deployed from Jacksonville, Florida, by truck. It was assembled at Fort Point, Galveston, by a work force of MACKENZIE crewmen supervised by Murphy Pacific, towed to the site in sections by Corps of Engineers tugs, and connected to mooring buoys. Two days were required to connect the boom array, with the Coast Guard assisting by laying termination buoys and ground legs. An aerial photo of the site shows the general nature of the deployed booms: two opposing V-booms were moored separately to catch oil and debris on the ebb and flood currents.

Boom Deterioration

Boom deployment started 14 May and remained unchanged, except for boom element replacements, until 24 June, when the western section was moved for the entry of the heavy lift barge. This involved about 800 operating hours, and the chains stretched, kinked, and

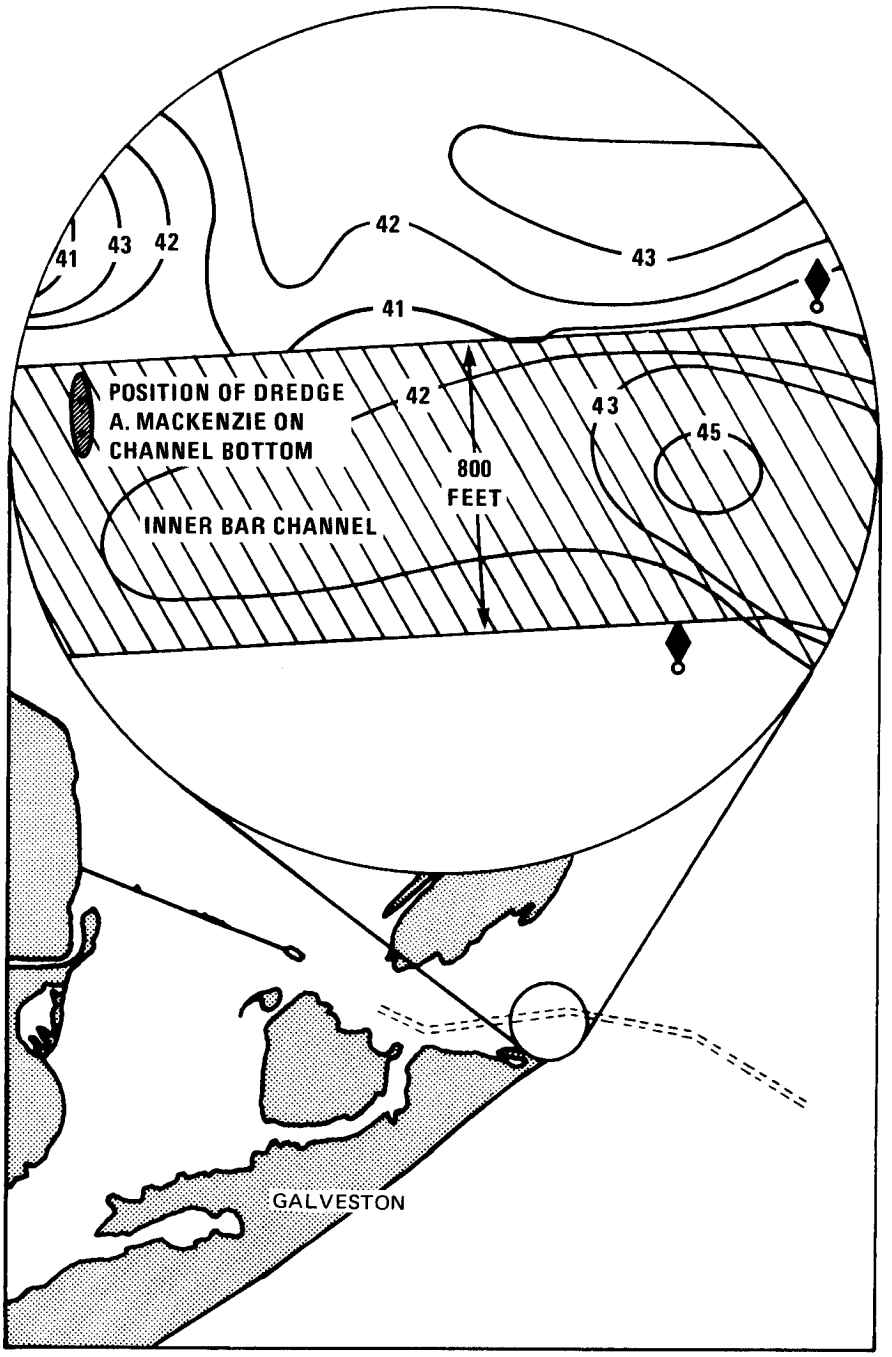
THE BOW ELM SANK THE DREDGE MACKENZIE

The Norwegian bulk carrier BOW ELM struck MACKENZIE's starboard side inflicting a gaping hole from which MACKENZIE quickly flooded and sank.

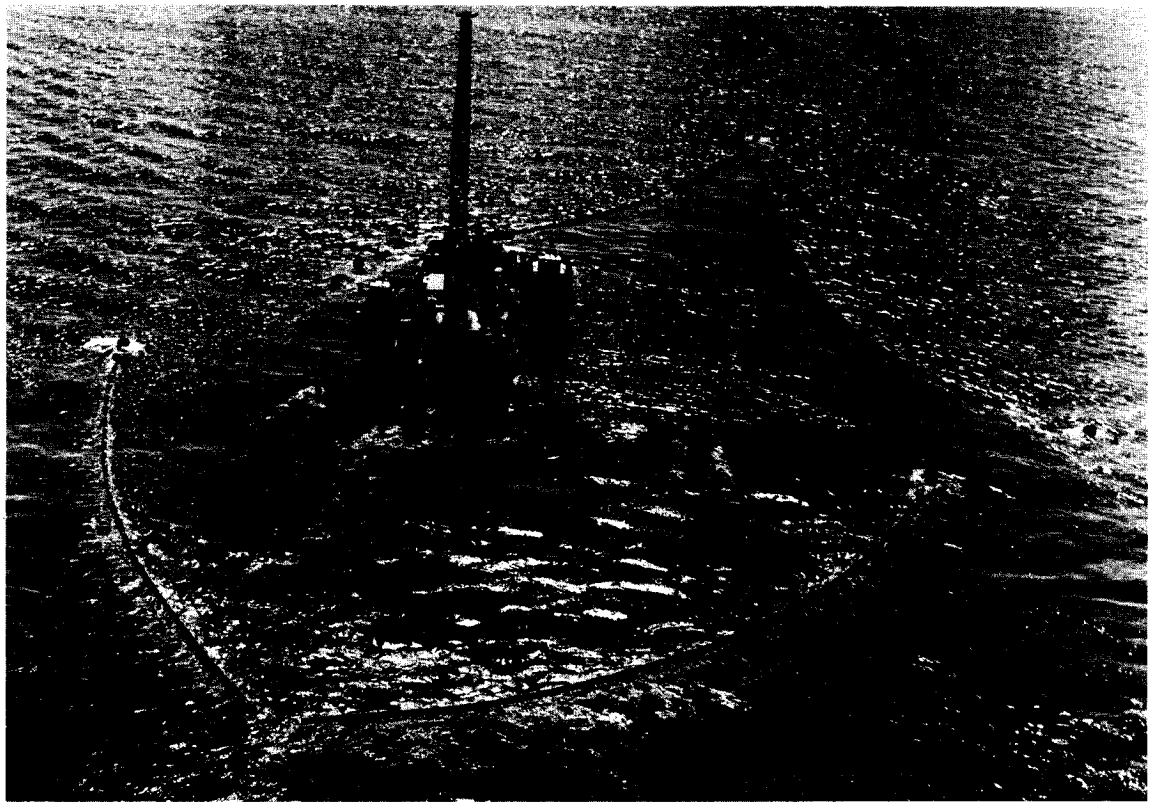


IDA GREEN ALSO WAS INVOLVED

In maneuvering to avoid this University of Texas research vessel, the M/V IDA GREEN, the BOW ELM ended up colliding fatally with the MACKENZIE.



DREDGE MACKENZIE WAS SUNK IN A COLLISION WHILE
DREDGING GALVESTON INNER BAR CHANNEL



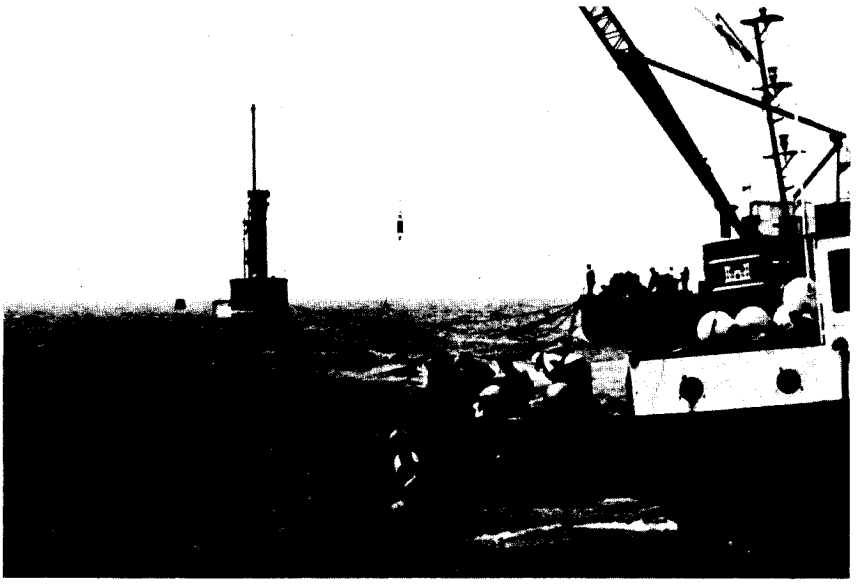
OIL CONTAINMENT BOOM WAS RIGGED

The V-traps were moored upstream and downstream of the sunken MACKENZIE. MACKENZIE's position, perpendicular to Inner Bar Channel, can be determined from her stacks protruding above the surface.

tore out many of the web-connector tabs. Varying tidal currents up to three knots generated forces that stretched the connecting chains supporting the inflatable sausage elements. By 20 June, over 30 sausage units had to be pulled and replaced before 500 hours of operation. About two-thirds required extensive patching. Prior to the Phase II lifts, the entire boom array was removed for repairs and was not redeployed.

Fuel Removal

Offloading of fuel from the wreck was accomplished without major spill problems although light, volatile diesel oil was involved. A COE barge from Galveston made up to the LIMA 400 work barge, and a water pump was placed aboard which was connected to MACKENZIE's oil tank fill pipe. Next, one of the oil tank's vents was connected to the fuel



OIL CONTAINMENT BOOM DEPLOYMENT

A Corps of Engineers tug assists in the deployment of the boom around MACKENZIE.

NAVY OIL REMOVAL SKIMMER

This JBF DIP 3003 skimmer was used to recover oil within and without the booms used to contain diesel fuel escaping from the sunken MACKENZIE.

barge alongside the work barge. Water was pumped into the wreck's oil tank, displacing the fuel into the fuel barge. The test being favorable, operations got under way early the next day, 18 May, and before noon about 9,000 gallons of diesel fuel were removed. The rest of the day was spent checking the remainder of the tanks, and by 1640, all fuel had been transferred to the fuel barge with no spills.

Skimming and Debris Removal

A prototype of the Navy JBF DIP 3003 skimmer removed floating oil. The craft responded satisfactorily at currents below 1-1/2 knots on the surface, but maneuverability and speed were marginal in maximum currents. Meanwhile, explosive cutting efforts continued to dislodge wooden decking and other debris, which were picked up by small craft patrols after each shot. This phase of the pollution control effort was straightforward and successful.

Pollution Removal Roll-Up

Roll-up of the oil pollution boom was completed prior to the end of the Phase II lifts, when it and the skimmer were removed for general maintenance and repairs. All material was returned to East Coast warehouses in early August.

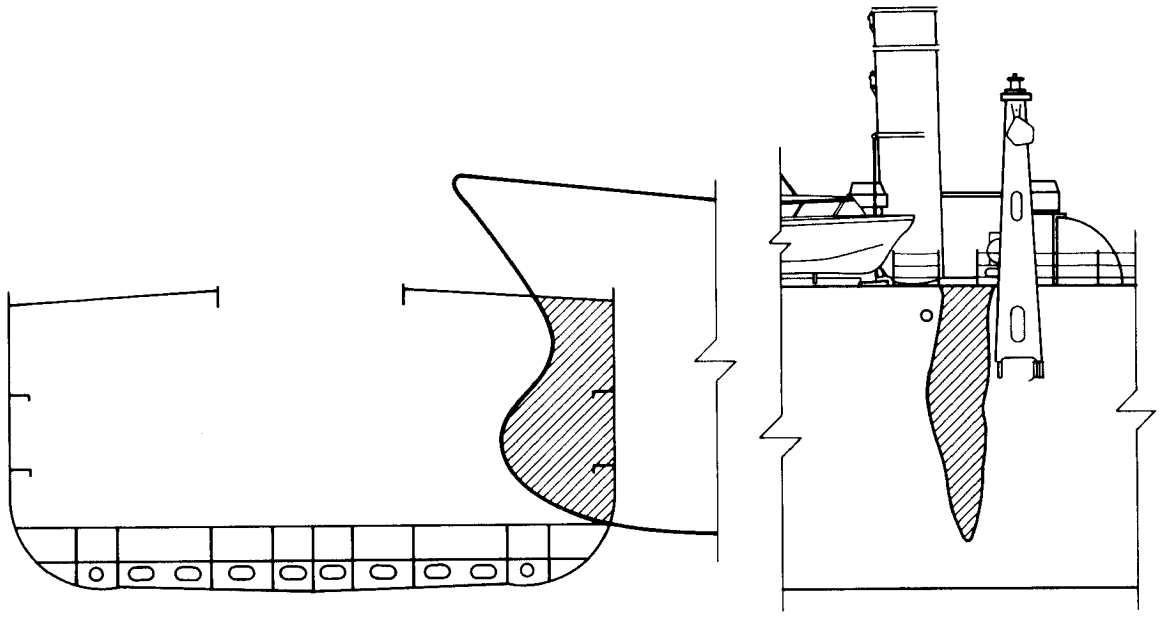
SALVAGE SURVEY, OPTIONS, AND PLANNING

MACKENZIE's Characteristics

A. MACKENZIE was built in 1924 and was one of the Corps of Engineers' oldest hopper dredges. She was a single-bottom steel ship transversely framed, of riveted construction, hoppers amidships, main propulsion aft, and main pump machinery forward. She was a twin-screw ship with twin rudders, two main diesels aft, and two forward. The thickest portions of the bottom shell were 25-pound mild steel plate.

Principal dimensions were as follows:

Length	268'5"
Beam	46'0"
Main Deck Depth	22'6"
Boat Deck Depth	30' approx
Service Displacement	3434 tn
Hopper Capacity	1656 cu yd



MACKENZIE'S STARBOARD SIDE WAS DEEPLY PENETRATED

The bow of the Norwegian bulk carrier penetrated the starboard side of MACKENZIE at frame 40, for a distance of over 15 feet, about 8 feet wide, resulting in massive flooding.

The hoppers had been extensively reworked in 1949 to eliminate the centerline drag and modernize to a port and starboard twin-drag arrangement. The hopper spaces were midway between two machinery spaces. The forward machinery space contained two main diesel generator units powering the main pump motor. The after machinery space also contained two main diesel generator units powering the motors for a twin-shaft drive. The boat deck consisted of 4x6 fir planks over steel beams. The main deck was the only steel deck that had continuity over the length of the vessel. The only major structure above the weather deck was the pilot house supporting the navigation bridge forward.

Initial Surveys

On 25 April, J and J Marine Diving Corporation of Pasadena, Texas, surveyed damage to the sunken dredge. They found the MACKENZIE upright, almost perpendicular to the channel. The top of the pilot house was above water, indicating about 18 to 20 feet over the main deck. Divers reported a large, jagged hole from the collision in the after engine room to starboard, at about frame 40, extending down from the boat deck to about two feet above the bilge keel. In this area, the wooden boat deck was badly splintered and the steel main deck jagged and pierced inward for about 5 to 6 feet.

Sounding the hoppers indicated that they contained about 550 cubic yards (nearly 700 tons) of material. No significant settling was noted during these investigations. The MACKENZIE lay athwart the channel, broadside to the current which at times exceeds 5 knots. This gave cause for concern over scouring away of the bottom adjacent to MACKENZIE's hull, into which the dredge could roll over or break in two.

Determination of Salvage Options

On 25 April, representatives of the Corps of Engineers and professional salvage consultants inspected the MACKENZIE for salvage. The findings indicated six technical alternatives for salving the dredge:

- Cut and wreck in place
- Raise with deck-edge cofferdam
- Raise by external lift
- Raise by internal buoyancy
- Sheet-pile cofferdam
- Burial in place

In the opinion of the consultants, the cost differences between the options were insignificant compared to the overall costs of salvage. On 30 April, the Galveston District Engineer recommended that the dredge A. MACKENZIE be considered a total loss, and that disposal be made as expeditiously as possible since the dredge posed a serious threat to navigation.

On 4 May, the Chief of Engineers granted authority to the Galveston District to remove the MACKENZIE from the Inner Bar Channel, and deemed it infeasible to raise the vessel for further use. Since the Galveston District lacked salvage expertise, the Supervisor of Salvage, U.S. Navy, was to provide consultant services and act as prime contractor for salvage.

Organization and Initial Operations

After agreement between the District Engineer and the Supervisor of Salvage was reached regarding the operation to be performed, SUPSALV directed Murphy Pacific Marine Salvage Company, under existing salvage contracts, to undertake the removal of A. MACKENZIE and to support the necessary pollution abatement salvage operations. Alex Rynecki, a marine architectural firm of Sausalito, California, was selected to perform engineering functions for developing a salvage plan, and Ocean Systems, Inc. of Morgan City, Louisiana, subcontracted for diving services. The divers began removing material and

MACKENZIE'S STACKS PROVED USEFUL IN DIVING

MACKENZIE's stacks extended well above the surface and were used as platforms and as caissons to shield divers against the channel current, as they descended to work in MACKENZIE's hull.

structures above the boat deck (necessary for any of the salvage plans), and within two days after the arrival of the first contractor representative, salvage operations were under way. The two engine room stacks were then partially cut away and platforms installed for diver access into the interior of the vessel. The remaining portions of the stacks were then ingeniously used as cofferdams to protect the divers from wave action and currents while entering the wreck. This use of existing stacks saved considerable time and expense by eliminating the necessity for fabricating a cofferdam.

The District Engineer established a separate task force under the Chief, Construction-Operations Division. The resulting task force drew personnel from the Corps of Engineers, U.S. Navy, Murphy Pacific Marine Salvage Company, and various subcontractors. Mobile office trailers were rented and set up at Fort Point Boatyard as the project office. Four temporary commercial telephone lines were installed with an extension to the hopper dredge dock. A radio network was established using portable sets obtained from the COE, Fort Point Boatyard, and four handi-talkie sets were assigned to key personnel so that continuous communication with salvage operations was available.

On 22 May 1974, following the approval of a definite salvage plan, divers started the transverse cut on MACKENZIE at frame 104. Murphy Pacific awarded a diving subcontract to Buck Steber, Inc. of Belle Chase, Louisiana, for another diving crew; and a subcontract to Technical Explosives, Inc. of Harvey, Louisiana, for technicians and explosives to assist in the cutting operations. On 10 June, operations commenced on a 24-hour basis.

Salvage Option Analysis

Of the six technical options available, four were eliminated immediately. Burial in place was unacceptable since it was almost certain that eventually the channel would be deepened and burial would only postpone the removal. The sheet-pile cofferdam was unacceptable because of depth and sea exposure. Unavailability of lift equipment and high risk ruled out external lift. Use of a deck-edge cofferdam depended heavily upon MACKENZIE staying upright and stable, which could not be assured, in a position broadside to the current.

Two options that remained for further engineering feasibility studies were:

- Foam buoyancy/cut in place combined
- Cut in place

The foam buoyancy approach entailed injecting buoyant foam into the stern sections, cutting the vessel at frames 48 and 78, removing the hopper section, towing the two buoyant sections to sea, and sinking them. Thereafter, the open hopper section would have to be cut up in place. Analysis indicated, however, that the bow and stern sections would float with boat deck awash. Since deep disposal areas were about 100 miles from Galveston, the two sections could not be towed that far with such limited freeboard. The total time and cost for this operation was estimated at 100 days to clear the channel with a total cost of $3,136,627.

Alternative Chosen: Cut in Place

The major engineering problems were to define cut lines and hull section lift weights accurately. Seven major transverse sections were chosen, with weight calculated after top hamper removal. The total time was estimated at 130 days to clear the channel and a total cost of $2,536,139. Accordingly, on 21 May, the District Engineer decided on this slower but less risky and costly option to cut in place. Although it would take about 30 days longer than the foam buoyancy method, the risk of failure was minimized. The plan required removal of all materials and structures above the boat deck, making transverse cuts at frames 20, 32, 48, 62, 78, 92, and 104, and using a large floating crane to lift the sections.

THE SALVAGE ENVIRONMENT

Channel Current

The most immediate effect of the environment was felt in the currents from area channel drainage and ebb tide of 3 knots (and occasionally, even faster) across the wreck site. Wind and chop also affected the mooring array at the site.

Storm Potential

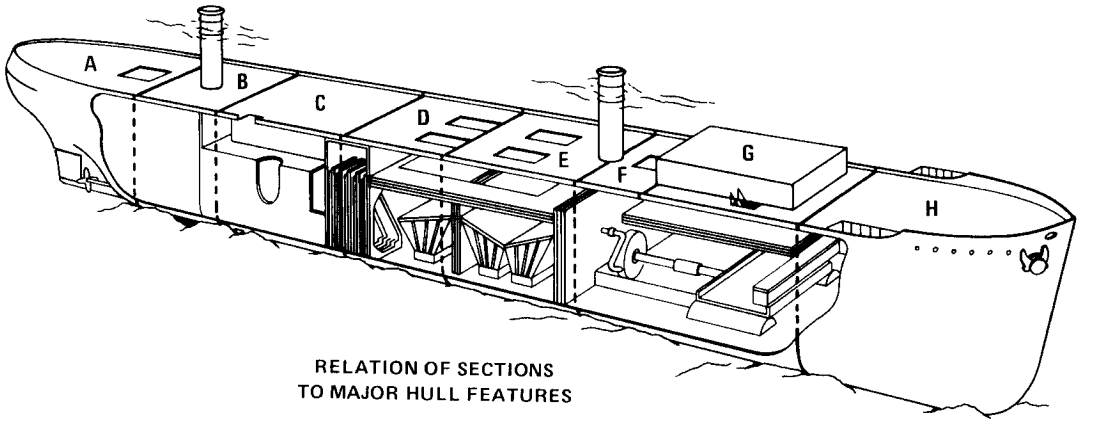
Long range weather was concerned with hurricanes that might disrupt the salvage operations. About five to seven days of advance warning was expected for such tropical storms in the Gulf, and the cut-in-place and remove method chosen required only a 24-hour advance notice to clear the site. The work barge, oil boom, and even the big lift barges could be slipped out of the moors and be under way within four to six hours. Fortunately this contingency did not have to be executed, although a tropical storm off the Yucatan Peninsula and two hurricanes along the Venezuelan coast were plotted and observed.

Silting

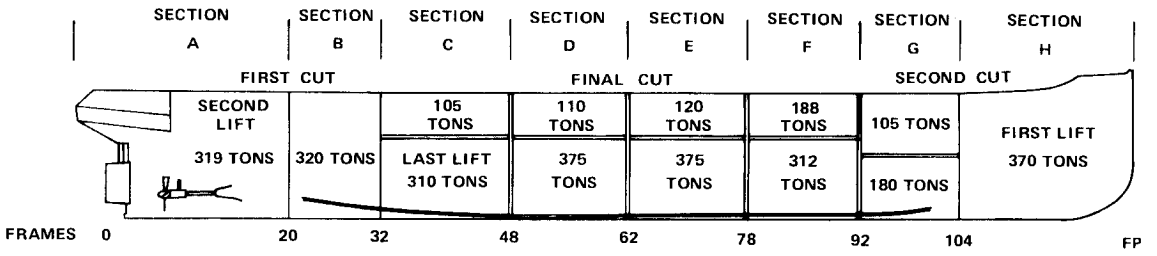
Silt deposition of up to one inch per week was observed on the main decks and up to three inches per week in machinery bilges. This led to various weight accumulations of 60 to 240 pounds per square foot in dead load lift. Dredging operations during Phase II markedly increased silt deposits as well as water turbidity in the wreck area. Despite jet washing, silt accumulation on the Phase III sections also was significant. Although silt deposit was troublesome from a weight standpoint, bottom suction effects were minor. Currents which allowed the deposition of silt were too swift to allow compacting of clay sufficient to hold sections being lifted.

CUTTING AND LIFTING PLANS

The initial decision was to cut the ship into eight major transverse sections. The schematic drawing shows the hulk after the preliminary removal of top hamper for lightening and diver access. Two major methods of hull section cutting were used: oxyarc burning and explosives. The A section (the stern to frame 20) and H section (the bow to frame 104) were the first cuts removed, and use of a 500-ton derrick barge crane was planned.



RELATION OF SECTIONS
TO MAJOR HULL FEATURES



CUTS, SECTIONS, AND WEIGHTS

SALVORS OPTED TO CUT MACKENZIE FOR REMOVAL

Based on estimates of sectional weights, it was decided, initially, to cut MACKENZIE into eight sections for removal from the channel by crane lift.

Phase I Lifts

The initial estimates of the weights of MACKENZIE's sections were determined from weight data sheets provided by the Corps of Engineers, Philadelphia District. Some factors were uncertain: the weight of silt trapped in the wreck and the cumulative weight of sodden dunnage and stores. Both A and H sections were considerably heavier than anticipated, and initial rigging was too light; this was largely due to silting, with 100 to 140 tons of silt trapped in each section. Breakout pull needed was carefully noted during lifts, to observe suction effects, but none was observed. See the Weight Factors table on page 84.

Phase II Lifts

Based on Phase I experience, all Phase II lifts were rigged to use the full 500-ton capacity of the lift crane. Weight estimates were adjusted for removal of machinery and fittings, and for refined silt deposit estimates. Heavy sections were to be severed into upper and lower sections, estimated at less than 400 tons, to provide adequate safety margin.

WEIGHT FACTORS

SECTION	ESTIMATED	CORRECTED EST. 7/15 (All weights in short tons)	ACTUAL
PHASE I			
A	227	–	319
H	194	–	370
PHASE II			
B	249	–	320
Upper C	244	–	105
Upper G	169	–	105
Lower G	293	–	180
PHASE III			
Upper F	227	115	188
Lower F	321	358	312
Upper E	336	176	120
Lower E	228	388	375
Upper D	274	164	110
Lower D	204	332	375
Lower C	238	258	310

Phase III Lifts

For Phase III, planning from analyses based on the previous lift results better predicted the weight elements and demonstrated a learning curve in understanding the factors involved.

TENDING DIVERS FROM THE WORK BARGE

Divers' lines were carefully tended at all times.

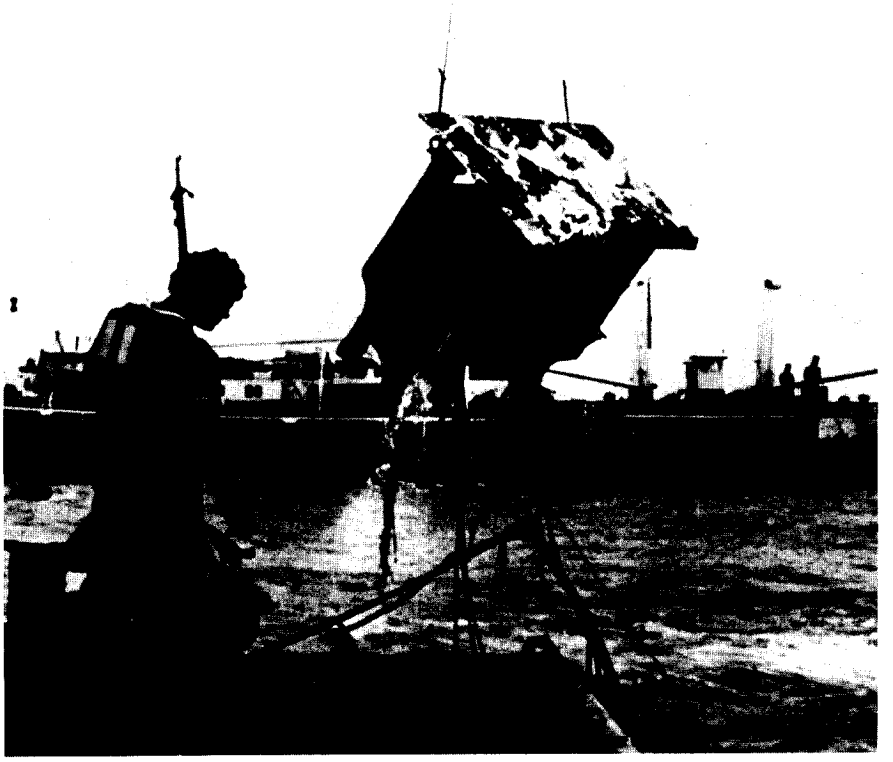
DIVING

General

Specific parts of the wreck were assigned to each diving contractor. The Ocean Systems, Inc. divers were assigned the forward portion of the wreck, and the Buck Steber, Inc. divers were assigned the after end. Each crew worked under diving supervisors who made working and inspection dives, with Ocean Systems divers on the noon-to-midnight shift and Buck Steber divers on the midnight-to-noon shift.

Procedure

Both diving contractors provided their own compressors, umbilicals, diving dress, communications, and switch gear. Buck Steber, Inc. provided a double-lock chamber that made deck decompression possible for working dives over 35 feet although its use was never required during the salvops.



REMOVING PART OF MACKENZIE'S PILOT HOUSE

Preliminary diving work involved removal of considerable top hamper from MACKENZIE, to clear the way for later work, as well as to reduce weight for the major lifting.

The two stacks of the MACKENZIE protruded conveniently above water, modified with platforms on their top portions, and gangways from the LIMA 400 work barge. The divers were thus provided access to the wreck, protected against the heavy tidal currents. It is estimated that over 60 percent of total diver time was spent inside the wreck. The major outside tasks were clearance of top hamper and rigging for heavy lifts. Underwater times per 12-hour shift amounted to about three 1-1/2-hour work turns per diver. Actual time in water per four-man team was about 18 diver hours per 12-hour team shift.

Diving Safety

There was no lost time due to diving accidents. Minor ailments included ear infection, and some infection of burn wounds.

Equipment was carefully operated and maintained. Continual efforts were made to patch and mend the diving gear. Ocean Systems, Inc. renewed umbilicals during the midpoint of the operation. The double-lock chamber of Buck Steber, Inc. was available for decompression when bottom time required it and no incidents of bends occurred. The divers generally observed paired procedure, and experienced no serious loss of communications between divers and supervisors.

OXYARC CUTTING

General

Removal of MACKENZIE's top hamper started on 9 May and had been cleared by 5 June. Ocean Systems divers started the transverse cuts at frame 104, and by 10 June, both the Ocean Systems and Buck Steber diving teams were at full strength and cutting around the clock.

The high silt content of Galveston Channel required that the divers' work be accomplished in almost zero visibility. Since the channel was subjected to ebb currents of up to 5 feet per second, most of the work was accomplished inside the wreck, where the divers were sheltered while cutting. The wreck interior was cluttered with a welter of debris, and since knowledge of working spaces was acquired by touch, each diver was assigned specific task locations. Additionally, exploratory and observation dives were made by the diver supervisors and the Salvage Master to assure that proper cuts were being made.

Equipment

Two 400-ampere welding generators were provided. The Ocean Systems team, assigned to the forward end of the wreck, used a leased Lincoln generator. The Buck Steber team at the after end used a Libby generator from a Navy Emergency Ship Salvage Pool. The early cutting with a 300-amp oxyarc system encountered some difficulty with the initial batches of ARCO arc-aire blue coated electrode. This was solved by using 400-amp machines and covering the electrodes with three wraps of 3M masking tape and epoxy varnish. Later, pink coated Crest Weld electrodes wrapped with a single cover of 3M electrical tape were used satisfactorily.

Workload

The overall amount of cutting for the MACKENZIE operation was estimated at 4,000 lineal feet. Almost 80 percent of the cutting was accomplished by oxyarc. About 6,800

pounds of rod were consumed on the job, which included about 6,500 pounds of Crest Weld rod. A general cutting rate of a little under 1-1/2 feet per dive hour, during 12-hour dive shifts, was achieved so that eight divers cut about 131 feet per day and used about 257 pounds of rod. As the salvors gained experience, the primary cutting technique was clearly demonstrated to be oxyarc in lieu of explosive cutting. Reasons cited were to assure schedules, to increase local visibility, and to reduce diving hazards inside the wreck. A properly sequenced procedure, employing both oxyarc and explosive cutting techniques, eventually proved to be the most positive means to initially cut the steel and to assure complete severance of sections, for efficient removal during the lift operation.

USE OF EXPLOSIVE CUTTING CHARGES

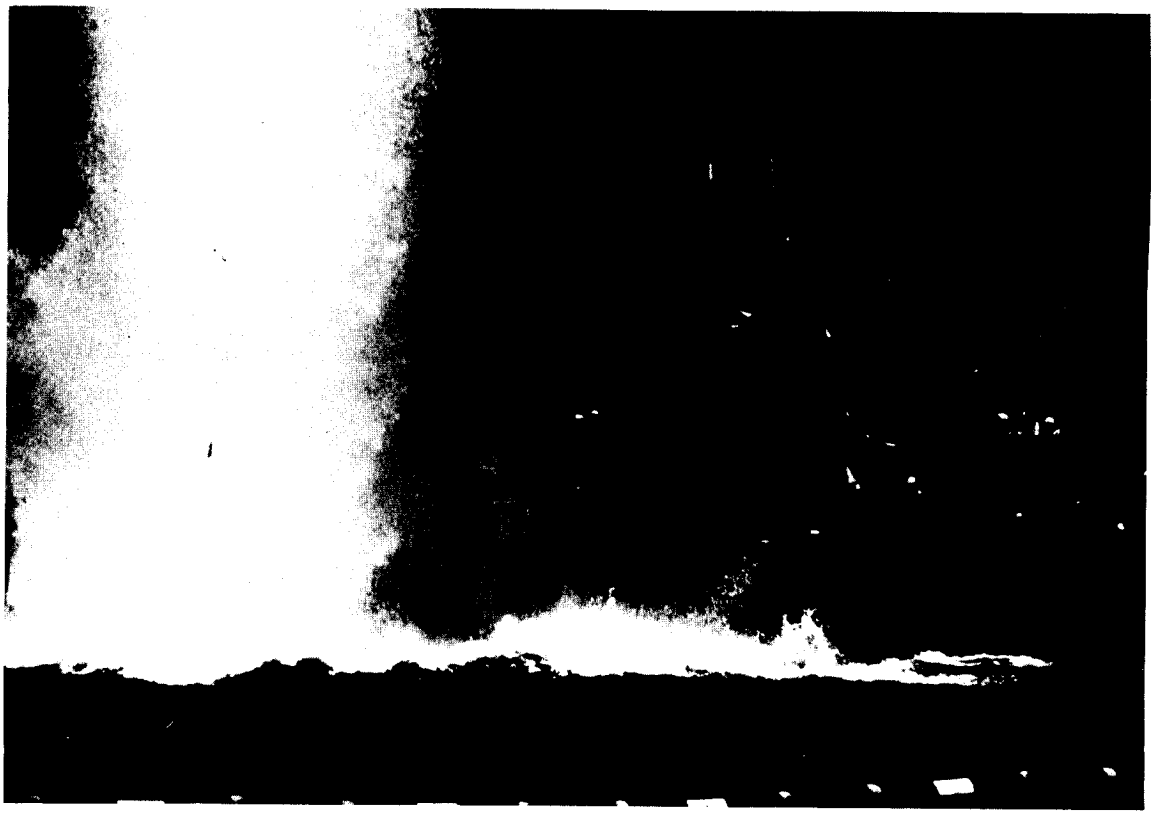
Cutting Plans

Technical Explosives, Inc. was contracted to provide explosive services for cutting. The primary cutting device to be used was a shaped charge made up of 26-gauge galvanized steel containers packed with C-4 explosive. Storage of the C-4 required a continuously guarded magazine at Fort Point. Handling procedures were in accordance with U.S. Army Corps of Engineers safety regulations. Permission was granted to move explosives by motor launch, in 50-pound batches, from the magazine to the salvage site, and to keep 150 pounds in a ready-service locker aboard the work barge LIMA 400. Two insulated chests were provided for storage and transfer of explosives.

Shaped-Charge Design

The project engineer and explosive technician designed two different cross-sectional configurations for shaped-charge containers – one with 2.2 pounds of C-4 per foot and the other, 0.8 pound per foot, fabricated in lengths of 18 inches and 48 inches. Use of the 2.2-pound-per-foot charges started in Phase I. The first shot, employing almost 10 pounds of C-4 in a 48-inch shaped charge, was used on the main deck to cut along a transverse line at frame 104-1/2. It succeeded in cutting and ripping a hole about 18 inches wide and 6 feet long. The 0.8-pound-per-foot C-4 units were not successful.

Charges made by packing C-4 explosives into long 2-inch angle iron were initially used to make horizontal cuts; however, they proved awkward to set up close enough to cut effectively and were abandoned. Hose charges of 1-1/2-inch and 2-1/2-inch fire hose packed with C-4 were used to cut longitudinals, stanchions, and pipes, with marginal success. The hose was wrapped around the object and the ends stretched and tied off with line to hold the hose tight to its target. The 2.2 lb/ft C-4 shaped charges bent in a 4-inch ring were useful



EXTENSIVE USE WAS MADE OF EXPLOSIVE CUTTING

Although major reliance for precision cutting was placed on oxyarc equipment, assurance of final severance of sections, longitudinally and transversely, was achieved by use of C-4 explosive charges.

for cutting through 1/2-inch-thick deck plate. "Blue Boy" conical shaped charges were used to punch drain holes through the main deck, but the aftereffects associated with explosive-bubble oscillation tended to plug the holes with debris.

Analysis of Explosive Cutting Phenomena

The physical mechanism of explosive cutting involves both the initial shock wave and the resonating gas bubble induced by the explosive to make the cut. Shock pressure at the water to explosive interface is approximately 10,000 atmospheres, but falls off rapidly as the shock wave passes through water. About half the energy of the explosion remains in the explosive-gas bubble after the shock wave passes on. It continues to expand and collapse at millisecond intervals to produce water hammer effects that can be devastating to ship

structures and can produce unwanted results. With greater lengths of 2.2-pound-per-foot C-4 charges, which used about 100 pounds of high explosive, large volumes of gas were generated. In the confines of MACKENZIE's interior, this produced large-scale disarray in addition to the cuts desired.

As a result of these undesirable effects from using long cutting charges inside MACKENZIE, as well as the difficulties in planting them, a compromise for explosive use was followed. Major reliance for precision cutting was placed on oxyarc equipment. To assure final severance, as mentioned earlier, arrays of the 2.2 lb/ft C-4 shaped charges in 18-inch and 48-inch linear configurations were used. Good results were achieved in assuring the complete separation of sections, longitudinally and transversely.

Environmental Effect

The Coast Guard was concerned that damage to marine life might result from explosive cutting. A meeting was held with representatives of the U.S. Environmental Protection Agency, U.S. National Marine Fisheries Service, and the Texas Parks and Wildlife Department to discuss the effects on the environment. All questions were answered to the satisfaction of the agencies. The representatives were given a tour of the wreck site and invited to visit the salvage operation at any time.

Both shaped-charge configurations were tested to study hull plate cutting effects and fish kill. Marine biologists from the Texas Parks and Wildlife Department observed the shots with representatives of the Coast Guard and the District Engineers. The shots demonstrated that the plate could be cut with the 2.2 lb/ft charge and revealed some minor, acceptable effect on marine life (a few dozen small catfish were recovered along with debris). Accordingly, permission was granted to proceed with explosive cutting, with no further environmental concern.

Cutting Operations

The major concern in explosive cutting was emplantment of charges. The best method of attaching the shaped charges proved to be that of using 1/2-inch bungee elastic cord fastened to brazing rod hooks that were poked through small holes made in the plate to be cut. This method, developed in Phase III, greatly speeded up the placement of charge arrays. Small ceramic magnets used to support 100 and 400 grains per foot primacord charges were not completely successful.

Placed properly, the 2.2 lb/ft C-4 shaped charges were capable of cutting any of the plates encountered. The 18-inch charges were effective in the cluttered structural areas, and

were widely used for horizontal cutting between upper and lower sections. They fit between frames and longitudinals, and could be placed above the shell plates, throughout the bilges, and along the longitudinals. The 48-inch charges were restricted by their length of cutting deck and shell elements. At first the 48-inch charges were almost impossible to rig vertically or externally, and were restricted to use where they could be laid flat, on the main deck and boat deck clearing operations. Later, their use was expanded by employing bungee cord lashing.

RIGGING AND LIFTING

Preliminary

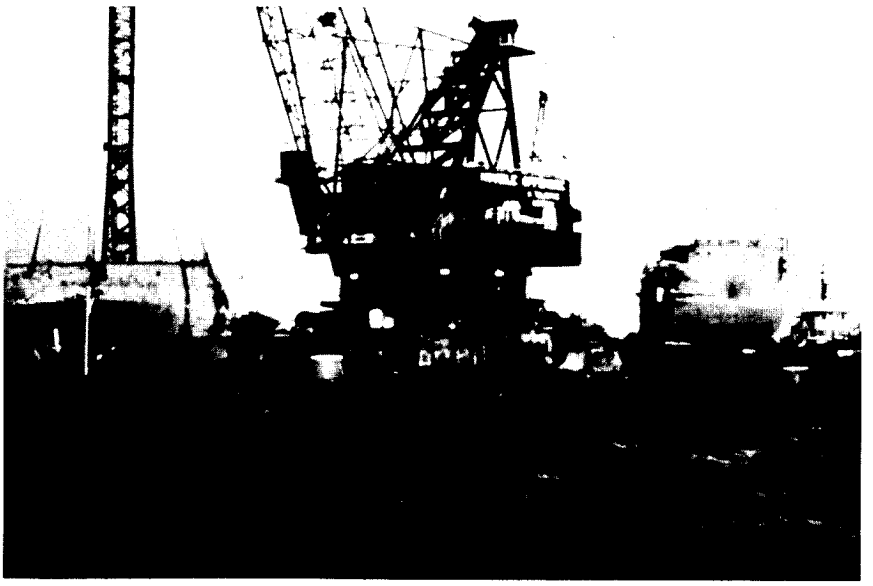
Operations commenced with the arrival on 24 June 1974 of MOVIBLE NO. II Teledyne heavy lift crane. The salvage master and the master of MOVIBLE determined a mooring plan, and at a meeting with the Houston Pilots Association and the U.S. Coast Guard officials, coordinated the necessary ship channel restrictions.

The U.S. Navy Supervisor of Salvage provided most of the rigging from Emergency Ship Salvage Material stores. This consisted, primarily, of 2-1/4-inch Di-Lok chain with backup shots of 2-1/4-inch stud-link chain. An additional purchase was made of sixteen 2-1/4-inch pear end-links to make up to 3-inch wire pendants from the lift barge.

Phase I Lifts

On 25 June the bow section was picked up, forward end first, to use leverage to break it away from the main hull. The attempt was unsuccessful because of an uncut 6-inch pipe in the forward engine room. After this pipe was cut, separation was easy and the bow was brought to the surface. The bow proved to be much heavier than anticipated initially, exceeding 370 short tons. Once clear of the water and allowed to drain, the weight dropped to 322 short tons, and within an hour the bow section was placed on the cargo barge.

To raise the stern section of MACKENZIE, the 2-1/2-inch slings were replaced by four 3-inch units. There were several days of difficulty extracting the stern section from its position, including hang-ups and rigging failure, but on the third lift attempt it cleared the water. The recorded weight was 390 short tons, which the crane master deemed too heavy for the existing rigging. Removal of loose debris and wood deck planking failed to produce an acceptable lift. The Salvage Master then boarded the section and found a foot of mud throughout the main and second deck. Drainage holes were cut in the hull and the mud was



PHASE I LIFT CONSISTED OF RAISING MACKENZIE'S BOW AND STERN SECTIONS

These two sections proved to weigh considerably more than estimated and required much draining and washing-out of mud, as well as removal of loose debris, before they could be lifted clear of the water and placed on barges for removal.

washed out with fire hoses. Lathe and heavy machine shop equipment were also removed. The stern section (weighing 362 short tons) was then picked clear of the water, loaded on the cargo barge, and moved away.

Phase II Cutting and Lifting

Refinement of the lift estimates following removal of the bow and stern sections determined that B section, the after half of the engine room, could proceed as originally planned, but the remaining sections had to be cut into upper and lower components. All lifts, henceforth, were rigged with 8 lift points using 3-inch wire pendants, and assumed that each piece would be under the 400-ton limit at 8x50 tons per sling for the big crane. This was done to reduce the time that the crane had to wait on site for rigging.

After completing Phase I lifting, the LIMA 400 work barge was back on site after a day's delay by adverse tide. Cutting was resumed on 29 June on frames 32, 47-1/2, and 94. The Ocean Systems divers worked in G section forward, removing the main diesel and pump motor units as well as doing the structural cutting. The wooden deck was stripped of the upper portions with explosives. By the end of the first week of July, over 70 tons of scrap had been removed, most of it coming from the forward machinery room. Meanwhile,

inspections revealed mud buildup in the MACKENZIE's bilge areas. Accordingly, demudding, with a small 3-inch jet line and air lift, was undertaken in the forward areas around the frame 94 cut line as well as at frames 32 and 47.

On 9 July, the dredge MACFARLAND arrived in Galveston and started working the north and south channels. Unfortunately, this channel work increased the rate of silting in the wreck and reduced diver's visibility to zero.

Oxyarc cutting at frame 32 was completed on 11 July, but the cut at frame 94 was held up by 100-pound steel ballast bars found to be lock-welded across the cut line. They were burned free and removed from the bilge area, one by one, to clear the bottom plating. The B section cut was then completed on 12 July, with shaped charges. The same day lower G section was separated at frame 94 by explosives. Concurrently, divers continued on upper G and continued the cuts to separate the upper and lower sections. They also started on C section and continued the transverse girthing cut at frame 47. Each section was rigged with chains as the longitudinal cuts were completed over the next four days.

On 22 July, the MOVIBLE NO. II arrived again at the wreck site, and at about 1440, rigging was complete. Upper G section was hoisted to the scrap barge, followed by lower G section at about 1830 and upper C at 2350.

Phase III Cutting and Lifting

Cutting proceeded with the caisson improvised from MACKENZIE's stack repositioned over the hopper area D section. Hopper area cutting was complicated; thick bituminous covering on the hopper sides prevented striking an oxyarc. Attempts to scale the coating from cut lines, with primacord blasting, proved ineffective. Pneumatic air hammers had to be rented to scale the cut lines with chipping tools. Further complications arose from MACKENZIE's 1949 welded hopper structure which was laid over the old riveted structure. In some areas there were 1-1/2 inches of triple-plate to sever. These regions, in the upper boundaries of the hopper wells, were difficult to cut with oxyarc. Some hoppers were almost full with dredge spoil that had to be removed by air lift before cutting. Lift rigging started on lower C on 2 August, and the hopper area bilge cut line at frame 78 as well as the transverse bulkhead there was completed with shaped charges the same day.

On 14 August, longitudinal separations of upper and lower E and F sections were completed. Lifting chains were rigged in F, D, and E sections, and two days later all chains were ready for Phase III lifts. Divers then inspected all the cut lines, remaining dredge spoils were air lifted, and a final 25 pounds of shaped charge was fired at possible tight spots on 17 August.

By about 1000 on 19 August, the mooring of MOVIBLE NO. II was complete and divers commenced rigging for lifts of the upper portion of section E. At 1255, it was placed on a scrap barge. The remaining six sections followed in rapid succession. By 1700 on 20 August, the MOVIBLE NO. II had finished, retrieved her anchors, and cleared the wreck site. This completed the removal of MACKENZIE from Galveston Channel 13 days ahead of schedule.

FINAL BOTTOM CLEANUP

Final bottom cleanup of the channel required removal of all fragments that might interfere with future dredging. This meant a careful diver search of the area, which was conducted from 30 August until 4 September. Spherical floats were laid over the former keel line of the wreck at 50-foot intervals. These markers formed the grid reference stations for a 1-foot by 1-foot grid, which the divers used to make slow careful walking sweeps of the bottom. Debris was hoisted to the surface in a large expandable metal basket lowered to the center of the wreck area. Finally, a rake drag was pulled over the area to pick up any pieces the divers missed.

CONCLUSION

Considerations

Although MACKENZIE was an effective and productive dredge at the time of her loss, she was 50 years old. To salve and restore her to service was technically feasible but uneconomical. The best economic solution was to minimize clearance costs and to maximize scrap returns. There was also the requirement to coordinate with parallel operations in Galveston Channel to dredge a bypass.

Operational Successes and Difficulties

In general, the planned operations and their technical accomplishments were successful in all phases. There were some technical difficulties, time consuming in their solution, but these are the essence of all salvage operations and were dealt with effectively.

One of these problems had to do with the use of explosives for cutting. Difficulty was encountered in achieving efficient hollow charge geometry. As explosive weight was increased to compensate for losses from shaped-charge standoff, peripheral underwater phenomena began to produce negative effects. The heavier charges induced secondary

explosive-bubble pulsations that tore the wreck structure in the area of the cuts, complicating access for diving operations. This was solved, in later explosive cutting operations, by using shorter length (smaller) line charges, and by devising a fastening system with hooks and bungee cords that permitted more accurate positioning.

Experience with lost time during Phase I lifts, from rerigging after the heavy lift crane was on station, led to efficient prerigging in Phases II and III. Relatively less expensive diver time, beforehand, was traded for crane time, for considerable saving in cost.

Oil pollution never became a serious problem because initial precautions to cap MACKENZIE's fuel vents and overflows were successful. The offloading accomplished in mid-May, however, provided the ultimate solution to the problem. The deployment of the boom oil containment and the occasional use of the skimmer proved more a demonstration of prudent readiness than a case of actual need.

Safety

There was no time lost to accidents during the entire operation. Safety standards were clearly defined, safety inspections were made periodically, and safety requirements were carefully enforced.

Weather

The weather had a remarkably small negative effect on the conduct of operations. About 60 hours of downtime for weather out of the 2,172 was experienced. The fact that weather did not interfere with a greater percentage of available time was fortuitous. This may readily be appreciated from knowing that originally a 10 percent contingency factor for weather had been allowed – typical for this part of the Gulf area.

Diver Performance

Underwater oxyarc burning is a job that demands one-man-one-cut assignments. Under conditions of low underwater visibility, each diver had to learn his working area by the touch and feel of spatial and form features. Diver tasks had to be laid out so that divers became familiar with their routes. Approximately one-third of total diver time was spent in oxyarc cutting, at an overall rate approaching 4 feet per hour when burning was under way, averaging about 1.36 feet per diver shift hour. The assignment of one contractor's divers to the forward area of the wreck and the other to the after end kept the assignments of

contracted tasks well defined. It also placed the teams in a competitive situation and challenged each diver to fulfill all specified objectives. Individual productivity is judged to have been generally high as a result.

At least one diver and usually two were in the water when diving operations were scheduled. This gave each diver about 4 to 5 working hours per 12-hour shift. It is estimated that about 18 man-hours of actual underwater work were accomplished per shift.

Supplies and Support

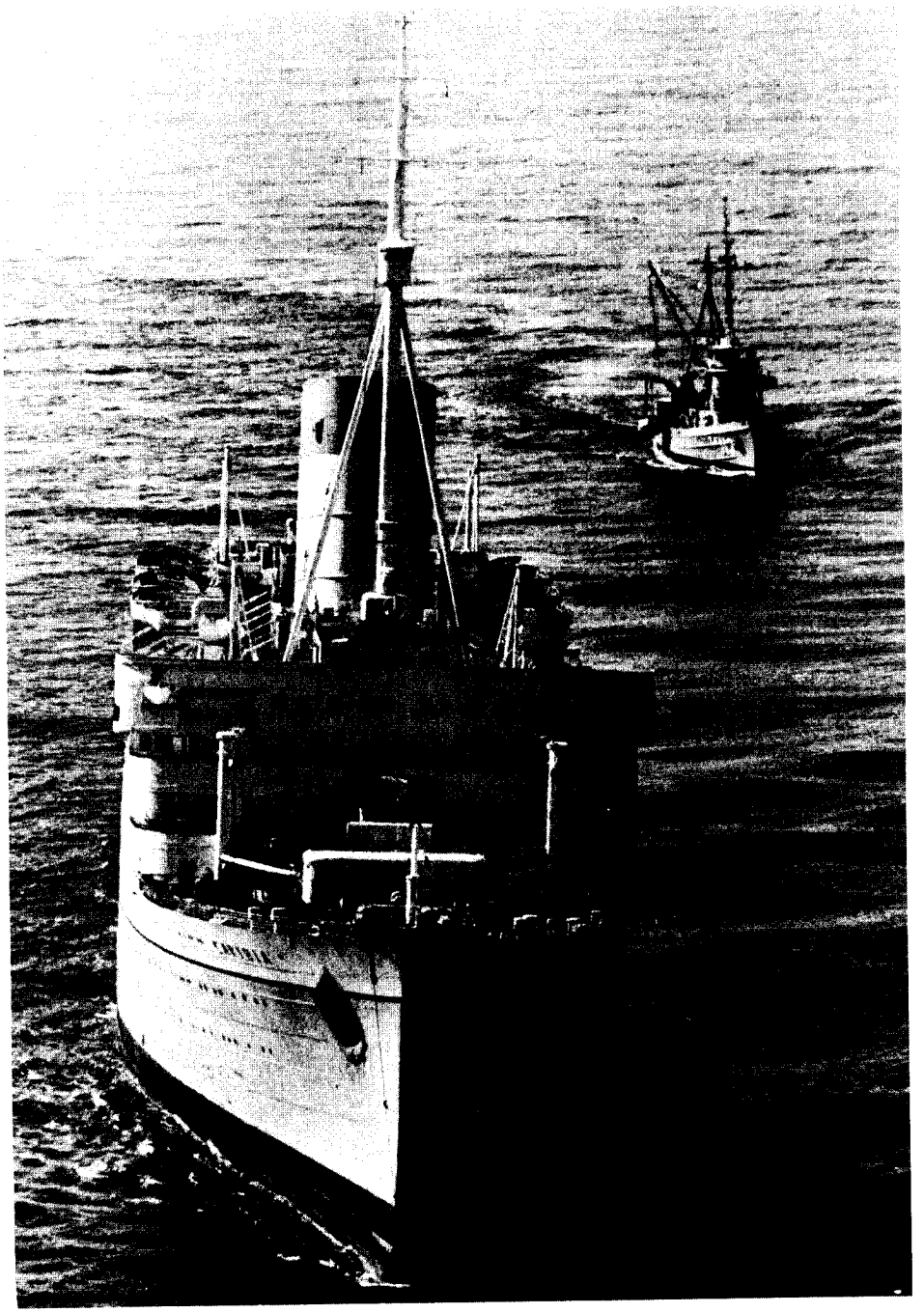
There were no significant delays for lack of men, material, or tools on site. The only critical supply item was oxyarc cutting rod, and supplies were given special attention by SUPSALVREP to guarantee a steady supply. Since the operation was conducted in an area with a wide range of commercial support for the local shipbuilding, offshore oil, and petrochemical industries, procurement of equipment was convenient. Several local Galveston marine machine shops and contractors were used to support the operation's industrial needs.

Daily purchasing and provisioning chores were handled by the Murphy Pacific office manager with the assistance of the COE District Resident Engineer's office. Radio contact was maintained between the office trailers and the work site, and launch availability was provided on 15-minute call by the Resident Engineer on a 24-hour-a-day basis.

CARIBIA EN ROUTE

TO SCRAPYARD:

AID IN HAWAII, LOSS AT GUAM



NEARING HAWAII, CARIBIA REQUIRED NAVY HELP

CARIBIA was being towed from New York to Taiwan and developed flooding aft. A team of Navy salvage specialists was sent to her aid aboard the fleet ocean tug USS TAKELMA (ATF-113), seen here astern.

CARIBIA EN ROUTE TO SCRAPYARD: AID IN HAWAII, LOSS AT GUAM

INTRODUCTION

In late June 1974, the former Cunard liner CARIBIA, under tow by the tug HAMBURG to a breaker's yard in Taiwan, began taking on water from unknown causes in calm seas, 100 miles east of Hawaii, and the owner's Honolulu agents appealed to the Navy for help. The Pacific Fleet Salvage Officer dispatched a team of Navy salvage specialists and a fleet ocean tug to lend assistance. The flooding was found to be caused by leaks and open valves in the liner's shaft alley and proved beyond the capacity of the pair of portable eductors carried by the salvage team. A 30-kilowatt generator and two submersible pumps had to be lifted to the ship by helicopter. The salvage team was then able to pump the ship dry, close valves, patch pipes, and departed from the CARIBIA off Honolulu on 9 July.

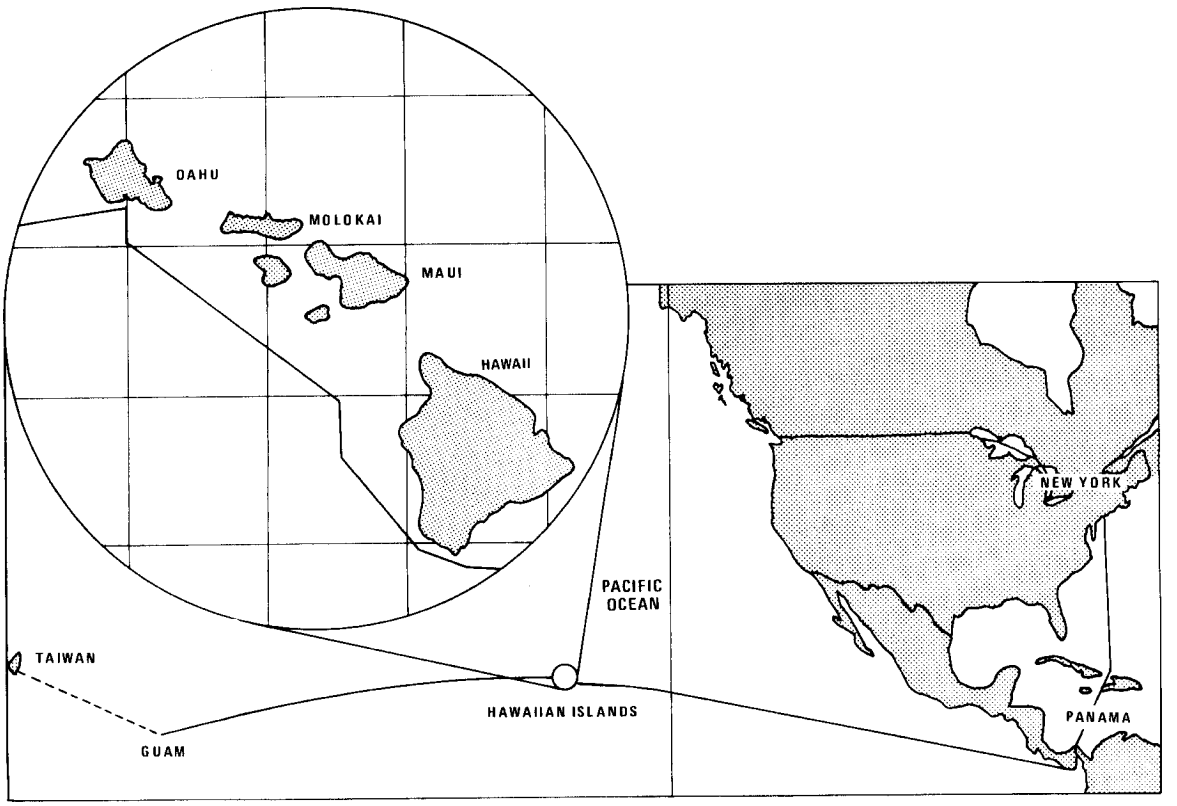
The tug HAMBURG continued the tow of CARIBIA across the Pacific. On 12 August, approaching Guam in heavy weather, the tug experienced engine troubles and, in danger of being pulled onto a lee shore, was forced to slip her tow. The storm grounded CARIBIA on the Apra Harbor breakwater and she began breaking up in the heavy surf. The bow remained on the breakwater but most of the hull slid down into Apra's entrance channel. SUPSALV was asked to supply side-scan sonar with precision navigation equipment and determine whether sections of the broken vessel constituted a threat to safe navigation in the Apra entrance channel. Thorough precision sonar search, diver investigation, and accurate survey of positions of the wreckage established that the channel remained safely passable, and that an immediate clearance operation would not be necessary for the Navy to keep Apra Harbor operational.

BACKGROUND

CARIBIA Experiences Flooding

CARIBIA was a 715-foot passenger liner of 25,000 gross displacement tons, launched in 1948 for Cunard Lines. By 1974, she had passed through the rigors of years of operation under a flag of convenience, and subsequent lay-up in New York. She was then sold for scrapping to ship-breakers, Taikien Industries of Kaohsuing, Taiwan. The material condition of CARIBIA that might be expected under the circumstances appears to have contributed to problems encountered. CARIBIA was under tow across the Pacific to Taiwan, by the West German tug HAMBURG in late June 1974, when trouble occurred southeast of the island of

Hawaii. Commencing approximately 23 June, the three-man "riding crew" aboard CARIBIA reported progressive flooding of her shaft tunnels and some adjacent spaces – causes unknown.



CARIBIA WAS IN TOW FROM LAY-UP IN NEW YORK TO SHIP-BREAKERS ON TAIWAN

Flooding, near Hawaii, required Navy help. Again requiring help off Guam, CARIBIA was lost before Navy help could come to bear.

Dispatch of U.S. Navy Assistance

Upon being advised of the difficulty of HAMBURG's tow, the Honolulu agents for CARIBIA sought U.S. Navy help, reporting flooding of up to 200 tons per hour. In response to the request, the Pacific Fleet Salvage Officer made arrangements that resulted in the standby salvage ship on Oahu, the fleet ocean tug USS TAKELMA (ATF-113), being dispatched on the evening of 5 July to assist CARIBIA. Special salvage personnel from Harbor Clearance Unit ONE (HCU-1) at Pearl Harbor were embarked on TAKELMA for duty as the boarding team for the CARIBIA.

TAKELMA rendezvoused with the tug HAMBURG and her tow the next day, about 30 miles southeast of the island of Hawaii. CARIBIA had a port list of 7-1/2 degrees and was down by the stern some five feet; but the tug master reported the flooding rate to be only 200 tons per *day*. Several hours were spent transferring the seven-man boarding party, provisions, two P-250 portable gasoline engine pumps, eductors, and other gear, by means of TAKELMA's whaleboat because CARIBIA lacked attachment points for high line transfer. Boarding took place midafternoon of 6 July, through a port side access hatch on CARIBIA's Bravo Deck.* Despite this being approximately a waterline level deck, the 8- to 10-foot seas and the general unsuitability of a whaleboat for this work essentially limited the transfer to pumps of the P-250 type. (The need for pumps of greater capacity was anticipated.)

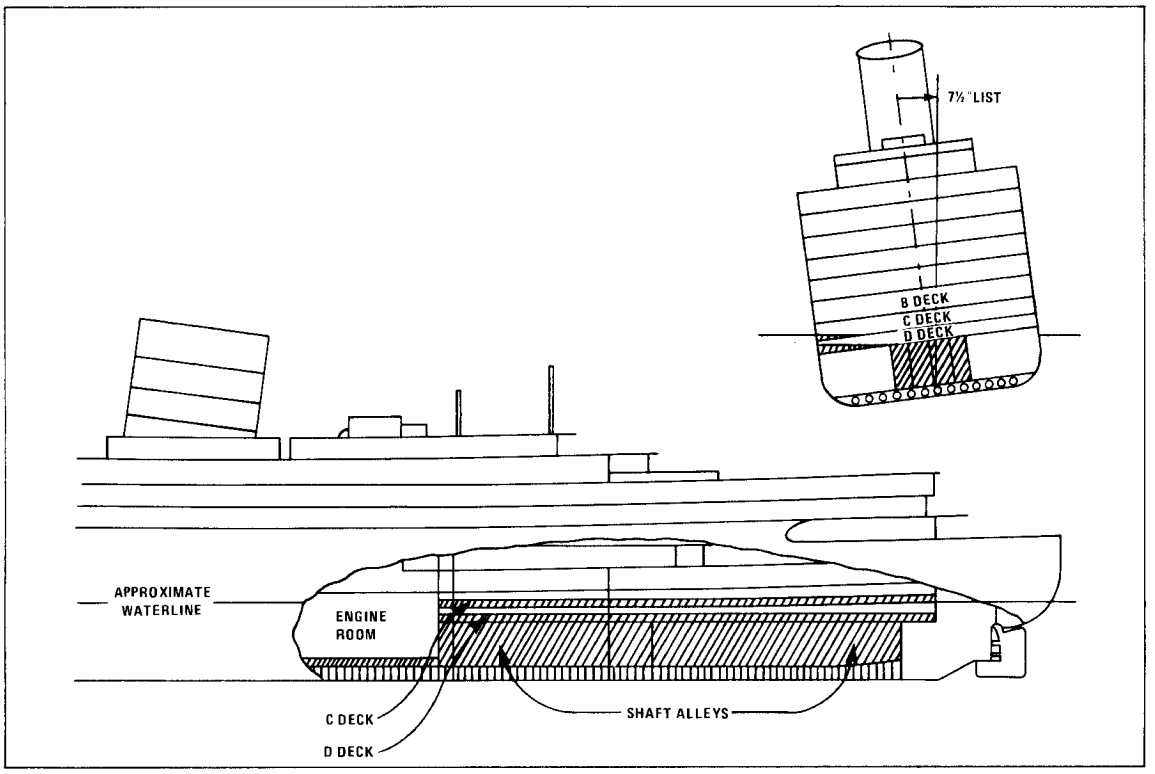
Initial Flooding Control Effort

After boarding, the HCU-1 salvage team was briefed by the CARIBIA's three-man riding crew on her flooding condition. It was learned that the flooding had originated in the shaft tunnels about 12 days earlier, and had progressively worsened. The cause of flooding was unknown.

The lowest and closest location for pumping that provided adequate ventilation for gasoline engines was from an athwartship passage above the flooded tunnels on Bravo deck, at approximately frames 80-85.† This location required a suction lift of 30 feet from the shaft tunnels, as well as a discharge head of over 100 feet. This capacity was beyond that of the P-250s combined with eductors. A trial effort was nevertheless undertaken about 1900. While this test was in progress, members of the boarding party surveyed the flooded areas of CARIBIA to make an accurate determination. They determined that, in addition to the shaft tunnels on Delta deck, the tank-top deck was flooded from the engine room after watertight bulkhead (frame 83) aft to frame 0. There were also wedges of water, port side, on both Bravo and Romeo decks – a consequence of water communicated upward through drains and other lines. There was minor flooding in the engine room, entering around the shafts at a rate of about 10 gallons a minute. This was quickly reduced to a trickle by tightening the shaft packing glands.

*CARIBIA's decks, proceeding downward from the main deck, were labeled A, *R*, B, C, D, & E.

†CARIBIA's frames were numbered from astern, numbers increasing proceeeding forward.



CARIBIA'S FLOODING

CARIBIA suffered flooding of her shaft alleys, as well as wedges on deck D, deck C, and in her engine room from progressive leaking.

Second Dewatering Effort

After about five hours of pumping, it was concluded that the P-250 pumps were ineffective; there was no appreciable change in the level of flooding. Then because of the emergency involved, a somewhat hazardous expedient was undertaken. One of the P-250 pumps was moved to Delta deck and a two-step lift of water was attempted in order to reduce the height of the head with which each pump had to deal. Because Delta deck lacked ventilation, precautions had to be taken to deal with the concentration of carbon monoxide produced by the P-250 gasoline engines. All personnel were evacuated from the space while the pump was operated for up to an hour and a half; then 45 minutes were allowed to ventilate the space. After about 24 hours of this somewhat dangerous and ineffective jury-rig operation, it became apparent that the dewatering job would require the capacity of

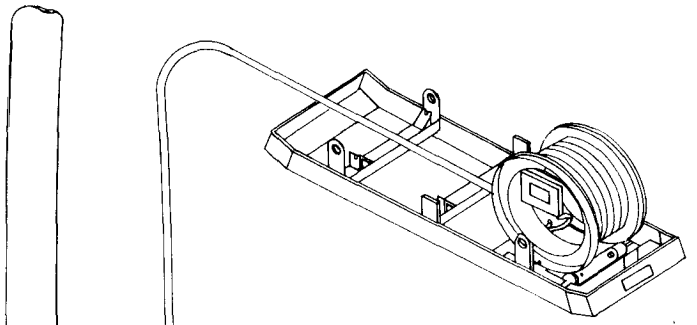
at least 4-inch submersible electric pumps. When this was reported to the Fleet Salvage Officer, he arranged for an air lift of two such pumps and a 30-kilowatt generator, using a CH-53 helicopter from Kaneohe Marine Corps Air Station on Oahu. It was also intended to transfer three more such pumps, a 75-kilowatt generator, and associated gear from TAKELMA. Helicopter rotor clearance on TAKELMA's fantail, however, proved too hazardous and the second transfer was canceled.

Since flooding was believed to have originated in the shaft tunnels, it was decided to place a submersible pump as low as possible in each of the shaft tunnels. Water on the decks above would drain back as the level in the shaft tunnels receded. The boarding party was informed by the riding crew that the watertight hatch between the tunnels was ajar and there was free communication between the two spaces. Accordingly, and because the 30-kilowatt generator could power but one 4-inch submersible pump at a time, it was decided to dewater the after shaft tunnel, since high water would flow to this space.

At 1800 on 7 July, the draft of CARIBIA was 37 feet aft – an increase of one foot since the previous day. It was computed that CARIBIA had at that time approximately 3,744 tons of water in the compartments cited above. At 1847, placement of a 4-inch pump was completed and pumping of the after shaft tunnel began. At 2400, the after shaft tunnel was pumped down approximately one-third and it appeared that the submersible pump could keep ahead of flooding. The water level in the forward tunnel and higher spaces had only dropped a very little; moreover, the port list had increased to 10 degrees. Accordingly, the second submersible pump was installed in the forward shaft tunnel. Rigging took approximately an hour and a half, and pumping was started immediately to relieve the water pressure on the after engine room bulkhead. It was pumped down as much as possible before shifting pumping operations back to the after shaft tunnel. Throughout the night, all hands were required for rigging and shifting the submersibles to lower pockets as water receded.

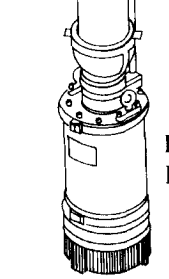
Early on 8 July, TAKELMA requested that COMSERVGRU FIVE provide two 1-1/2-horsepower submersible pumps for pumping the gymnasium and reefer sections of Delta and Charlie decks. TAKELMA returned to Pearl Harbor for these units and was back to CARIBIA by early evening.

On CARIBIA, pumping of the shaft tunnels continued and after water in the forward shaft tunnel was pumped below the deck plates, a hole was discovered in a 3-inch salt water cooling line to the starboard shaft. Salt water was being discharged from this hole at a rate of approximately 50 to 75 gallons per minute. Bleed-off valves were found open at three of

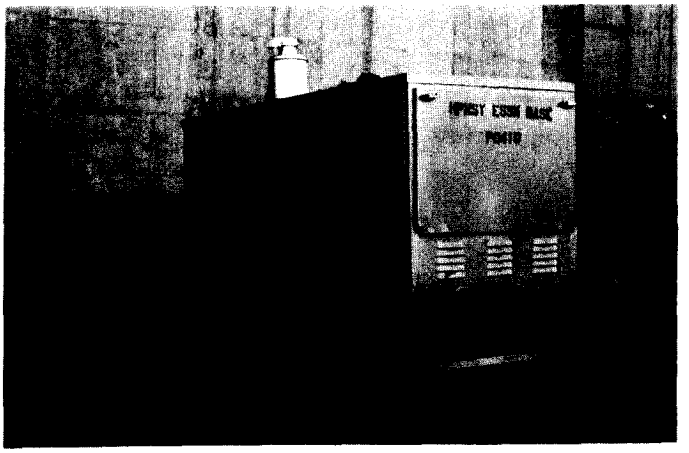


PUMP DEPLOYED FROM SKID, WITH HOSE AND POWER CABLE CONNECTED

PUMP, HOSE, AND CABLE REMOVED FROM SHIPPING CASE



PUMP PROPER



30-KILOWATT PORTABLE GENERATOR

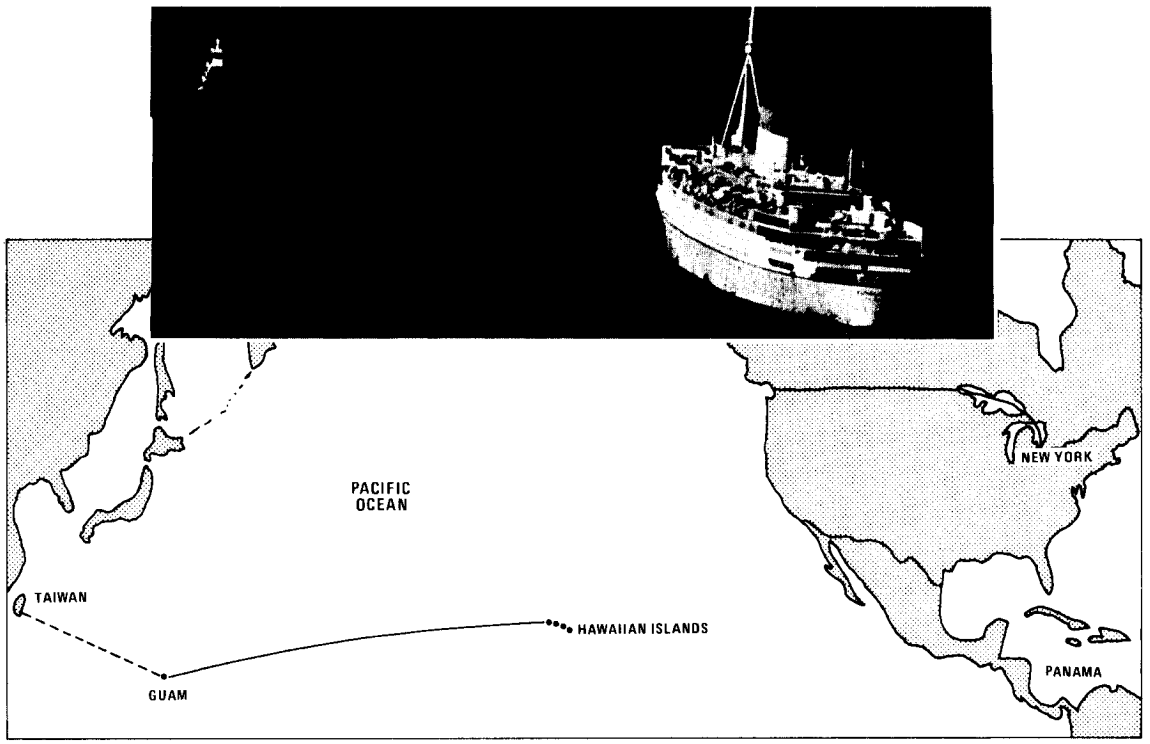
SUBMERSIBLE PUMP SYSTEM COMPONENTS

The fuel pumps and one generator were helo-lifted to the CARIBIA to strip water from flooded shaft alleys and adjacent spaces.

the shaft bearings, discharging a steady flow of seawater. The valves and piping in this area and the engine room were in a high state of deterioration. The valves were closed, the 1-inch hole soft patched, and the 3-inch cooling line was isolated at the main cutoff valve.

At approximately 1530, TAKELMA transferred the two 1-1/2-horsepower submersible pumps with associated extension cords to CARIBIA by light line. Due to noncompatible connectors, resplicing the jury rigging of the leads for these pumps was required. By 0130 on 9 July, CARIBIA's port list had been reduced to approximately 7-1/2 degrees.

At 0340, a supplementary crew from TAKELMA boarded the CARIBIA and began unrigging and transferring the 4-inch submersible pump from the after shaft tunnel to the gymnasium area. At approximately 0615, pumping commenced, and by 0730, the gymnasium area was pumped as low as possible with the 4-inch submersible pump and the 1-1/2-horsepower submersible was used to strip the remaining water. During this stripping process, the 4-inch submersible pump was unrigged and transferred forward to the reefer deck spaces. These remaining spaces were pumped and stripped by 1045, 9 July, and unrigging of equipment for offloading commenced.



CARIBIA'S TOW CONTINUES

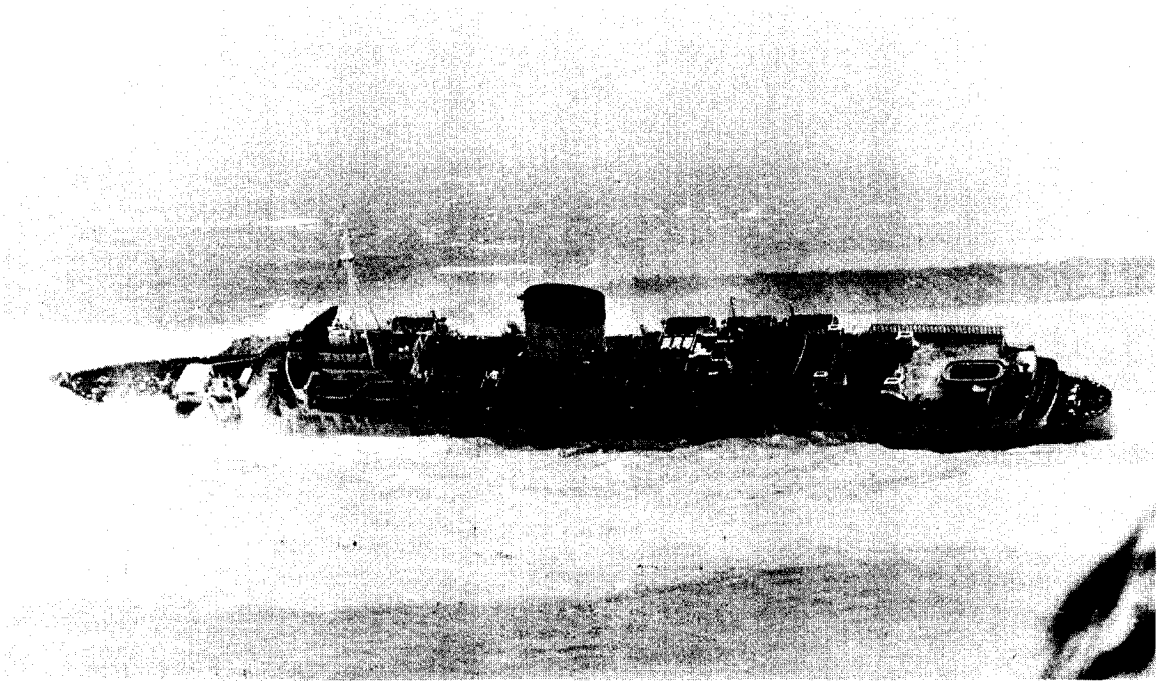
With the Navy's emergency salvage assistance successfully completed, CARIBIA departed Hawaii still under tow by the German turbine tug HAMBURG.

The only spaces not dewatered by the boarding party were the elevator lift, centerline at frame 43 by the gymnasium, and the steering gear room which was contaminated with diesel fuel. Leaving these spaces flooded was found acceptable by the CARIBIA's company agent and other concerned boarding officials. At approximately noon, the CARIBIA's agents and insurance and port officials boarded her for inspection. After their inspection was completed, the company's agent requested that the 30-kilowatt generator, a 4-inch submersible pump, and associated equipment be left aboard for emergency pumping as necessary to make CARIBIA seaworthy for continuing her voyage. COMSERVPAC Salvage Officer granted the request. Final offloading of personnel and equipment was effected by approximately 1330 on 9 July.

On 10 July, equipped with emergency pumping equipment from the U.S. Navy, HAMBURG with CARIBIA in tow stood out from Honolulu for Kaohsuing. It would turn out that this was not the last that the Navy would have to deal with CARIBIA.

CARIBIA IN TROUBLE AGAIN

Over a month later, early morning on 12 August, the Search and Rescue Coordinator for Commander, Naval Forces Marianna Islands, Guam received an emergency message that the tug HAMBURG with SS CARIBIA in tow was in difficulty about four miles outside Apra Harbor. Southwesterly winds 30 to 40 knots had been blowing for several days, with gusts to 60 knots. HAMBURG, as a result of an earlier failure of one of its main turbines, was experiencing power problems – a very uncomfortable situation with Guam's rocky coast in the storm's lee, with or without a tow. Moreover, the 5-knot towing speed logged throughout HAMBURG's voyage with CARIBIA made this small power margin dangerous, to say the least, even had her power plant been functioning properly. A rescue helicopter was sent to lift the three-man riding crew on CARIBIA to safety. At 0730, a call was made to have the only salvage vessel available locally, USS GRASP (ARS-24), go to the rescue. GRASP, however, was in the midst of a minor overhaul (restricted availability) at the Ship Repair Facility, Guam. GRASP's engines had to be put back into running condition, and various scaffolding, a temporary fire fighting hookup, and other yard equipment had to be cleared. Before this was completed, HAMBURG found it necessary to cast off CARIBIA, and she was blown onto the northern side of Apra Harbor's entrance, the Glass Breakwater. GRASP then set about preparing for a retraction and commenced rigging two sets of beach gear. The opportunity to attempt salvage did not materialize because the winds and sharp rocks of the breakwater quickly took their toll of CARIBIA. By 1100, she took a 70-degree list to port, putting her stern under water, and exposing holes already torn in her bottom from the bow to 250 feet aft.

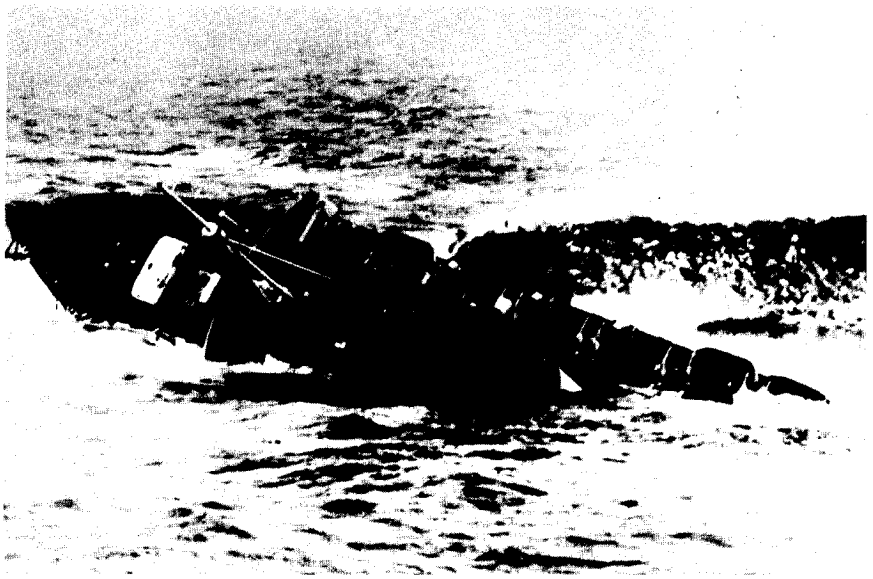


CARIBIA IS DRIVEN AGAINST THE END OF GLASS BREAKWATER, GUAM

The tug HAMBURG, its power failing in a lee shore storm, was forced to jettison her tow, CARIBIA, which was then blown on the Spanish Rocks end of the Apra Harbor breakwater. This view is looking northwest from Adotgan Point, across the harbor entrance.

CARIBIA BREAKS UP INTO A NAVIGATION HAZARD

CARIBIA continued to increase her list under the wind and the 15- to 18-foot surf pounding against Glass Breakwater. The next day, 13 August, CARIBIA's bow broke off on Spanish Rocks, the northerly entrance pillar of Apra Harbor. The remainder of the hull then slid, under water, down the steep slope of Spanish Rocks in the direction of the channel. But, how far down the slope? How far across the channel did she lay? How far upward did she project from the channel bottom? These questions posed a serious problem for Navy port authorities at Guam. Apra Harbor is a major naval operating base in the western Pacific and the channel had to be closed to all ship traffic until the degree of hazard was determined. The Fleet Salvage Officer, meanwhile, requested that SUPSALV contract with supporting civilian technicians for precision sonar services.

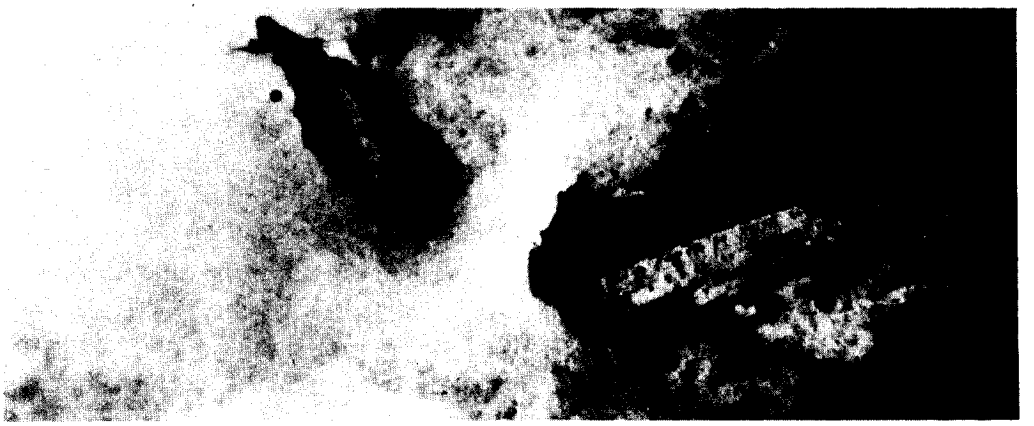


CARIBIA LISTS TO PORT

Punctured by the coral rock of Glass Breakwater, CARIBIA takes a 70° list to port and her stern goes under water.

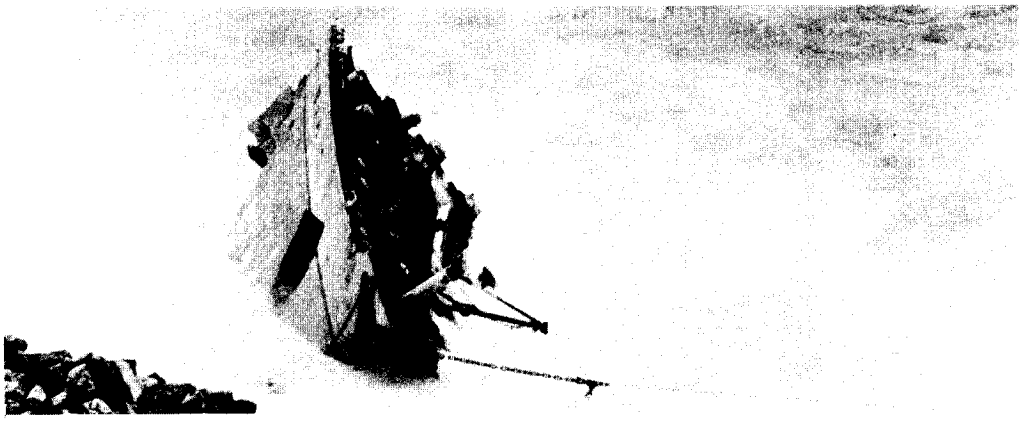
CARIBIA STARTS TO BREAK UP

With her stern under water, CARIBIA starts to buckle along a hull frame under her bridge.



Going –

Going –

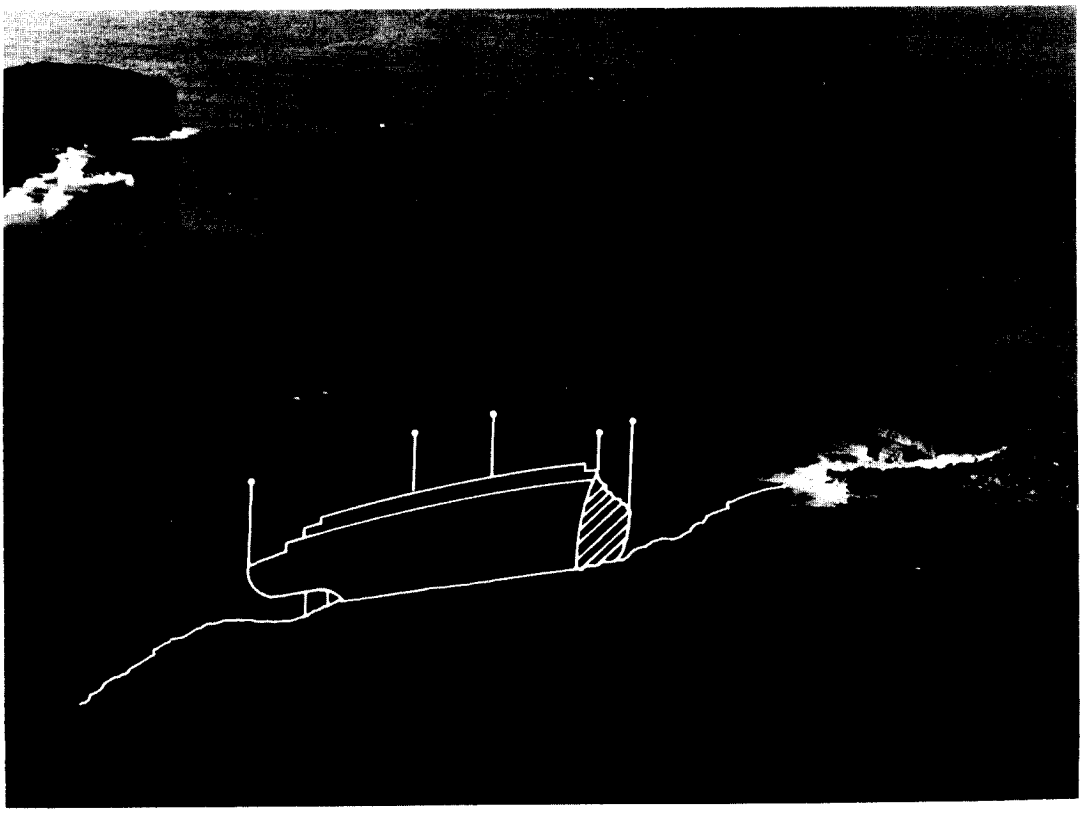


CARIBIA BREAKING UP

Gone. CARIBIA's hull sliding down into the channel, with her bow remaining on Spanish Rocks.

SURVEYING THE CHANNEL OBSTRUCTION

On 14 August with seas still too rough for safe diving operations, USS GRASP (ARS-24) was again ordered under way to make an initial survey of the harbor entrance. Fathometer reading runs were made of the extreme southern side of the channel, closest to Orote Peninsula. No depth anomalies inconsistent with charted depths were found. This was confirmed by similar soundings by the Coast Guard cutter BASSWOOD on 15 August, and the fleet ocean tug USS MOLALA (ATF-106) on 16 August, while still waiting for safe water conditions for diving. This same date Commander, Service Group THREE arrived on the scene and assumed command of operations. Meanwhile, side-scan sonar and Autotape precision navigation equipment arrived at Guam, and on 17 August, both sonar survey and diving operations got under way in moderating seas. Divers from GRASP approached and buoyed the deep-water end of CARIBIA's hull with salvage floats. The following day, GRASP divers swam out the entire hull of CARIBIA and buoyed it with crown buoys.

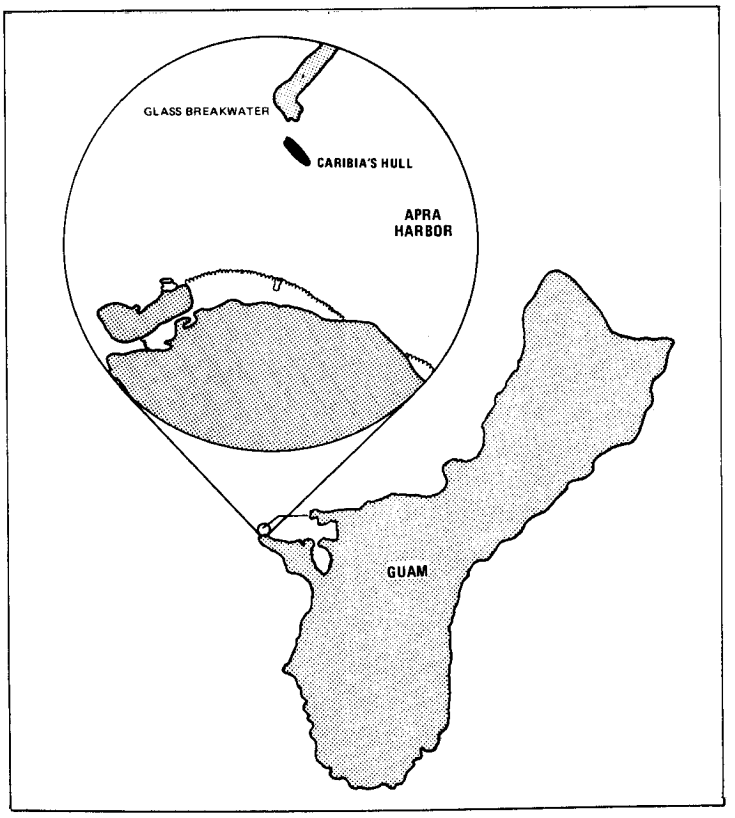


CARIBIA'S FINAL POSITION

A sketch shows CARIBIA's hull positioned under the buoys set to mark location of the obstacle on the edge of Apra Harbor entrance channel.

During this time the salvage ship USS BOLSTER (ARS-38) had been dispatched from Subic Bay. BOLSTER arrived on 18 August and her commanding officer assumed command of the CARIBIA survey and clearance task unit, relieving the commanding officer of GRASP. With the side-scan sonar precision navigation equipment contracted for by SUPSALV, it was now possible to determine quickly and precisely the exact position of CARIBIA's hull, other wreckage, and details of the surrounding channel bottom area. The CARIBIA did constitute a major obstruction across the northern half of the channel with soundings of as little as 30 feet recorded across CARIBIA's hull. It was concluded that the southern half of the channel was clear, with soundings as charted. Accordingly, the Coast Guard placed an illuminated obstruction buoy just inboard of CARIBIA, and Apra Harbor was considered to be open for Navy operation.

At a subsequent meeting of parties interested in shipping at Apra, at the Ship Repair Facility, Guam conference room, COMSERVGRU THREE presented the findings of operations in a briefing. He also pointed out the status of the channel for civil shipping: the



CARIBIA'S BROKEN HULL ENDED UP IN APRA HARBOR'S ENTRANCE CHANNEL

After breaking up on the end of Glass Breakwater, the CARIBIA, minus its bow, slid down the Spanish Rocks into the channel edge.

Navy had merely surveyed the wreck for the U.S. Corps of Engineers (COE). The matter of the navigability of the channel for civil marine traffic was the purview of the COE port authority, and the matter of port opening resided with the Coast Guard Captain of the Port.

This concluded the concern with CARIBIA for Navy salvors. The Inland Water status of CARIBIA's position as a channel obstacle remained for subsequent resolution by the COE.

CONCLUSION

The CARIBIA affair points up a number of salvage-related issues – several beyond activities of the actual work the Navy was called upon to perform, in relation to CARIBIA.

In the first phase of the operation, it is apparent that fear for the safety of the tow, the requirement for hazardous commitment of Navy personnel, and deployment of Navy salvage resources probably could have been avoided had a proper "cold-iron" tow procedure been observed. Realistically, many flag-of-convenience marine enterprises can be expected to be conducted to maximize profits with disregard of safety at sea. The absence of a properly qualified riding crew, trained and supervised in making scheduled watertight integrity inspections, is hardly surprising.

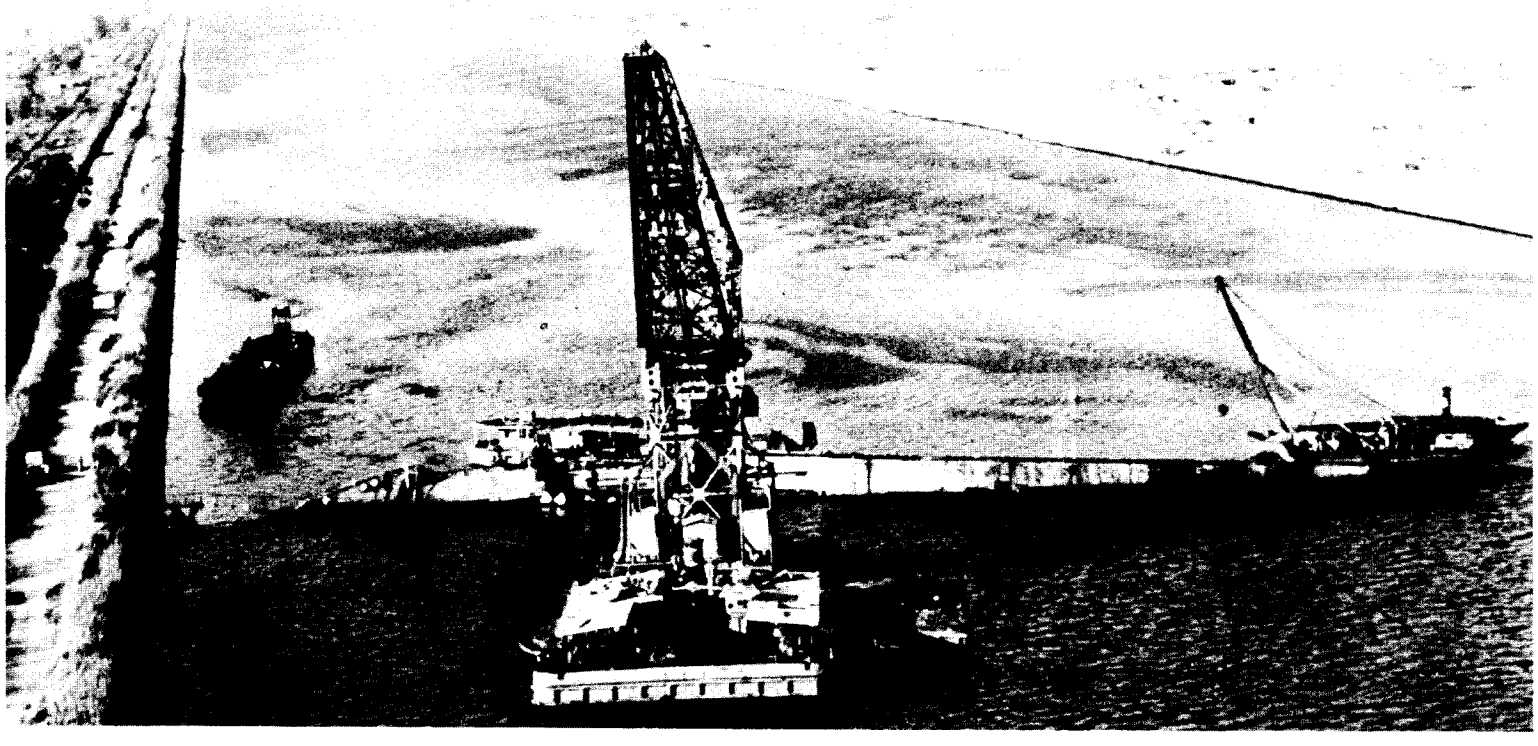
The second lesson that critical analysis of the CARIBIA leads us to, is the hazard of fetching up on a lee shore with inadequate or even marginal towing power. The storm at Guam, into which HAMBURG towed CARIBIA to its end, had been blowing for several days. This was really long enough for a prudent mariner to be able to assess the potential danger and stand off safely to leeward of Guam, where thousands of miles of unobstructed sea room were available.

Within the operations conducted by Navy personnel, the lessons were not learned through errors. Response was prompt, timely, and effective. When an apparent emergency justified cutting corners by operation of a gasoline engine pump in a confined space, the hazard was understood, accepted, and properly dealt with. CARIBIA's flooding was efficiently stripped and its cause removed. Later, after CARIBIA had foundered on the Apra breakwater and sunk into the entrance channel, effective expedients were used to survey the problem as quickly as sea conditions would safely permit.

The efficiency and effectiveness of a helicopter lift of emergency salvage gear, as well as rescue, can be expected to increasingly figure in situations where conventional transportation is not possible. Indeed, it can be expected to lead to successful salvage and rescue that would have been impossible in the past.

CLEARING

THE SUEZ CANAL



SCUTTLED WRECK BLOCKS THE SUEZ

At the end of the Yom Kippur War in 1973, ten such wrecks blocked all Suez Canal traffic. The successful U.S. Navy operations to clear this vital Egyptian waterway contributed directly to improved Middle East relations.

CLEARING THE SUEZ CANAL

INTRODUCTION

As a consequence of the mediation efforts of the United States to end the Yom Kippur War between Israel and the Arab states in 1973, the United States was committed to a major role in the clearance of the Suez Canal.

The major aspect of the clearance involved the removal of 10 vessels from the navigational channel. In addition, however, minesweeping operations were necessary before salvage personnel, ships, and equipment could safely enter the canal. A large amount of explosive ordnance material in the canal, its approaches, and along its banks also required preliminary removal.

The minesweeping was conducted by the U.S. Navy using carrier based helicopter sweeps. Removal of explosive ordnance was conducted by U.S., U.K., French, and Egyptian forces, with an additional U.S. contribution by training Egyptian personnel and providing them with equipment.

Once the canal was safely cleared of explosives, salvage clearance of ships and craft began. The Supervisor of Salvage (SUPSALV) acted as the Navy's agent in directing the clearance of the 10 vessels blocking the canal. This was done under the arrangements with SUPSALV's principal contractor, the Murphy Pacific Marine Salvage Company. The task was efficiently and rapidly carried out between 29 May and 20 December 1974, ahead of schedule.

BACKGROUND

The United States and the Republic of Egypt entered into an agreement early in 1974 as a result of U.S. negotiation in the cessation of the Yom Kippur hostilities between Israel and the Arab states. The United States was to assist in clearing mines and unexploded ordnance from the canal. In April, a bilateral agreement was entered into for the removal of the 10 wrecks blocking the canal, with the U.S. Navy designated principal salvage agent. The Supervisor of Salvage (SUPSALV) was tasked with direction of the clearance, using the resources of the Murphy Pacific Marine Salvage Company, SUPSALV's primary salvage contractor.

The Suez Canal waterway consists of 101 miles; 41 miles of land-cut canals connect 60 miles of dredged lake and marsh channels. The width of the channel is 360 feet and the

depth is approximately 40 feet. Because of the small seasonal difference in the level of the Mediterranean Sea at the Port Said end, the current in this sea-level waterway is negligible.

The 10 wrecks, which had made the canal impassable for nearly eight years since the 1967 Six Day War, were of various sizes and types, and were extensively damaged or deteriorated. Only one craft, a dredge, was deemed salvageable. The wrecks dotted the entire 101-mile length of the canal, but were concentrated in three general zones:

- *Northern Zone.* The entrance to the canal at Port Said on the Mediterranean Sea was blocked by the 438-foot passenger ship MECCA, and the 230-foot cargo ship ISMAILIA.

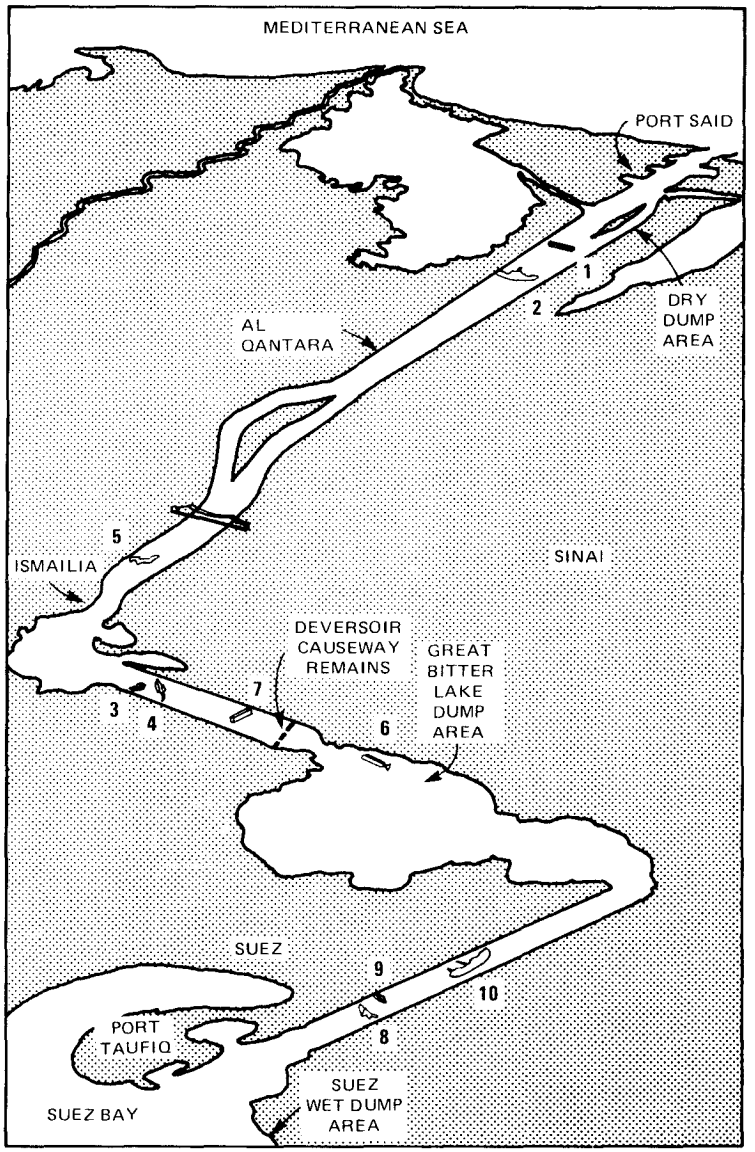
- *Southern Zone.* Access to the canal at Suez City on the Red Sea was blocked by a 174-foot dredge, a 165-foot tug, and the 358-foot tanker MAGD.

- *Central Zone.* The midportion of the canal, near Great Bitter Lake and Lake Timsah, was littered with a 3,800-ton concrete caisson, 3 dredges, and a 165-foot tug.

The salvage environment varied throughout the canal as a consequence of differing water conditions. In the Northern Zone from Port Said to Al Qantara, silt from the eastern branches of the Nile causes poor underwater visibility and produced heavy silting in wrecks. Water currents were weak and produced little problem.

In the Central Zone of the canal from Al Qantara to the southern end of Little Bitter Lake, the bottom changes to hard packed coarse and fine sand. Currents are negligible. Underwater visibility is good, except in the Lake Timsah region, where it was obscured by mud conditions caused by agricultural drainage and waste disposal. The high salinity of Great Bitter Lake had no impact on salvage, but a uniquely dense and opaque 9-foot oil-polluted saline layer about 40 feet below the surface prevented sonar operation and hampered diving. This caused a shift to the use of dragging for ordnance removal.

In the Southern Zone from Little Bitter Lake to Suez City, the canal bottom is relatively hard -- a mixture of silt and stone outcroppings. Although underwater visibility was better than in the other areas of the canal, here strong tidal currents hindered diving and caused heavy silting of wrecks.



NORTHERN ZONE

1. **CARGO SHIP ISMAILIA**
2. **PASSENGER SHIP MECCA**

CENTRAL ZONE

3. **TUG MONGUED**
4. **DREDGE KASSER**
5. **DREDGE 23**
6. **DREDGE 15 SEPTEMBER**
7. **CONCRETE CAISSON**

SOUTHERN ZONE

8. **DREDGE 22**
9. **TUG BARREH**
10. **TANKER MAGD**

THE SUEZ CANAL

Clearance of the Suez Canal involved removal operations for ten separate wrecks tabulated above. Locations are indicated by the numeral positions along the canal.

ORGANIZATION

Upon conclusion of the agreement with Egypt for the United States to effect the removal of wrecks from the Suez Canal, it was agreed within the U.S. government that the Department of State would provide policy guidance and funding to the Department of Defense to execute the task. The U.S. Navy was designated the executive agent to perform the task, with the Supervisor of Salvage (SUPSALV) employing an existing commercial salvage contract for actual work.

Commander, SIXTH Fleet, the Mediterranean area naval commander, established Task Force 65 to execute the many aspects of the canal clearance, assigning task group designations to the various elements involved. During the minesweeping phase of operations (Operation NIMBUS MOON), Commander, Mine Warfare Force served as the Commander of Task Force 65 (CTF 65). Upon completion of NIMBUS MOON on 21 June, Commander, Naval Inshore Warfare, Atlantic, became CTF 65. SUPSALV was designated the responsibility to direct the clearance of wrecks from the canal and was designated as the Commander of Task Group (CTG) 65.7. Other task group assignments were as follows:

TG 65.0 – the four successive flagships:
USS IWO JIMA (LPH-2)
USS INCHON (LPH-12)
USS BARNSTABLE COUNTY (LST-1197)
USS BOULDER (LST-1190)

TG 65.1 – the minesweeping group

TG 65.2 – Royal Navy minehunting craft and clearance divers

TG 65.3 – logistic helicopters

TG 65.4 – local logistic elements

TG 65.5 – U.S. Navy explosive ordance demolition (EOD) units

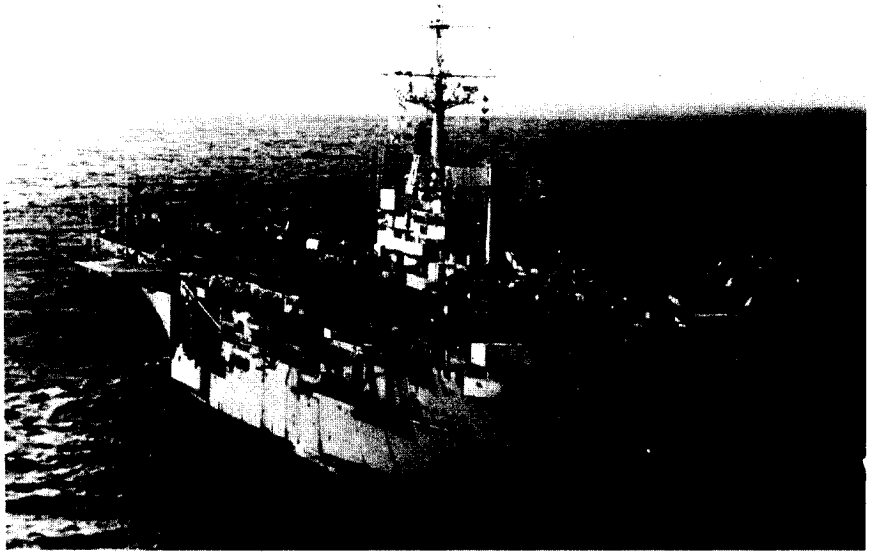
TG 65.6 – U.S. Army EOD units

TG 65.8 – French Navy minesweepers and demining divers

The Supervisor of Salvage accompanied by a small 9-man staff coordinated operations, first from the Suez Canal Authority (SCA) building at Port Said, later transferring to an SCA building in Ismailia as the operation progressed southward.

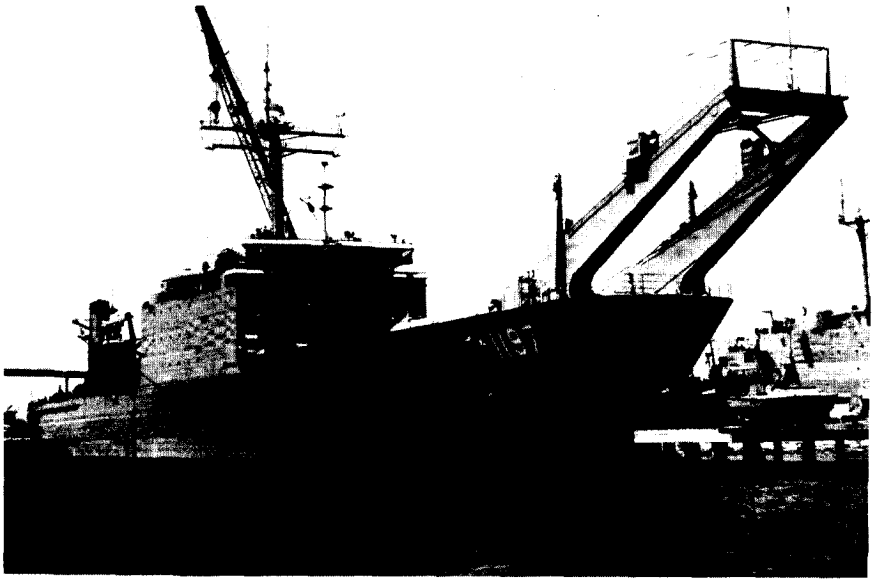
IWO JIMA WAS THE FIRST FLAGSHIP OF TASK FORCE 65

During the helicopter minesweeping phase of the Suez clearance, Operation NIMBUS STAR, amphibious assault ships served as flagships to provide optimum support for the minesweeping and logistic helicopters. USS IWO JIMA (LPH-2) had the duty first.



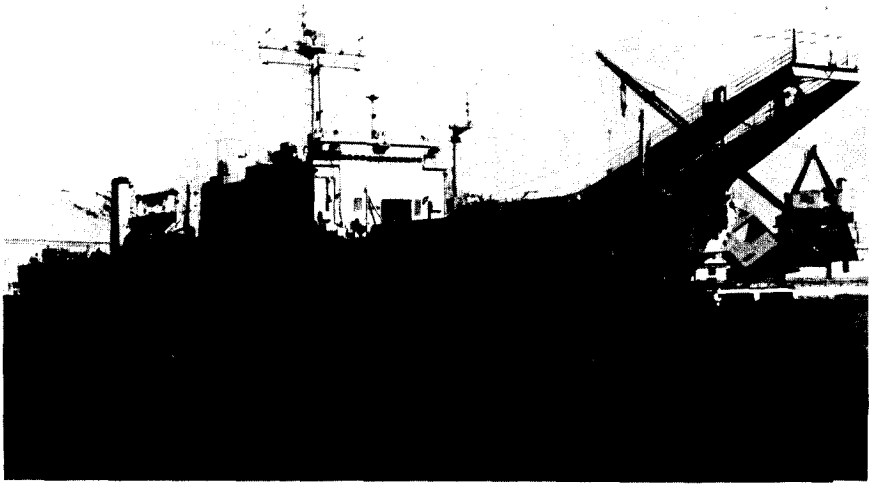
INCHON WAS THE SECOND FLAGSHIP

USS INCHON (LPH-12) completed the work of providing support afloat for minesweeping and logistic helicopters.



BARNSTABLE COUNTY WAS THE THIRD FLAGSHIP OF TASK FORCE 65

With the completion of minesweeping, a new commander for Task Force 65 moved to the USS BARNSTABLE COUNTY (LST-1197) and the flagship moved southward into the Suez Canal from Port Said to Ismailia.



BOULDER WAS THE FOURTH FLAGSHIP

USS BOULDER (LST-1190) relieved BARNSTABLE COUNTY and served until completion of the clearance of the canal.

Murphy Pacific and its subcontractor operations were directed by their project manager, assisted by several senior salvage masters. Task Force 65 operational planning established authority for all in-country operations from the standpoint of logistic support. Medical, Supply, Cargo Handling, Communications, and Aircraft Support were provided by a combination of U.S. Army, Marine Corps, Navy, and Air Force assets from many different commands both in Europe and CONUS. The Suez Canal Authority provided messing, berthing, and vehicular transportation for all Task Force 65 personnel ashore. These facilities had to be developed as quickly as possible in an area which had extensive war damage and had been abandoned by the civilian population for over seven years. Requirements for messing, berthing, and office space existed in Port Said, Ismailia, and Port Taufiq. Billeting for transiting personnel arriving and departing by commercial air was required in Cairo. Resources to achieve minimal levels, by western standards, of messing and berthing were extremely limited.

Medical Support, Public Health, and Preventive Medicine

The medical support of NIMBUS STAR/MOON and NIMROD SPAR was originally organized with the main consideration being surgical support in the event of trauma related to mine explosions, explosive ordnance demolition, or diving mishaps. Initially, this support consisted of a surgical team aboard the USS INCHON (LPH-12) anchored off Port Said equipped with operating suites and MEDEVAC helicopters. A medical dispensary for treatment of minor illness was established in Ismailia. Qualified independent-duty Corpsmen were attached to Army and Navy EOD teams. As operations proceeded, it became apparent that, overwhelmingly, the problem was not trauma but rather public health. Infectious disease, sanitation, and messing and berthing problems occupied the vast majority of the time of the Medical Officer and his staff. The largest single problem area confronted was a diarrheal syndrome, probably representative of cases of amoebic, shigella, other salmonellas, and "travelers" dysentery. Only a few were seriously ill, but almost all personnel assigned suffered some discomfort, often repeated, and significant work time was lost due to this. Malaria prophylaxis was instituted for all personnel, with eight weeks follow-up prescribed after return to home duty station.

PRELIMINARY OPERATIONS

Commander, SIXTH Fleet issued plans which established Task Force 65 and provided guidance for minesweeping (Operation NIMBUS STAR), the provision of training and advisory assistance for land and water explosive ordnance clearance (Operation NIMBUS MOON), and the removal and salvage of the 10 designated wrecks from the navigable channel of the canal (Operation NIMROD SPAR). The Task Force was composed of units drawn from all branches of the U.S. armed forces – Army, Navy, Air Force, and Marine Corps.

MINESWEEPING CAME FIRST

Before salvage operations to remove scuttled wrecks from the Suez Canal could begin, minesweeping was done by helicopter-towed magnetic minesweeping sleds.

Operation NIMBUS STAR

The operation to sweep the Suez Canal and its approaches of sea mines was called NIMBUS STAR. It was conducted under Task Group 65.1, directed by Commander, Mobile Mine Countermeasures Command. Operations got under way on 22 April when units of Helicopter Mine Countermeasures Squadron TWELVE arrived in Port Said aboard the Task Force 65 flagship, USS IWO JIMA (LPH-2). The aerial sweeping used RH-53D Sea Stallion

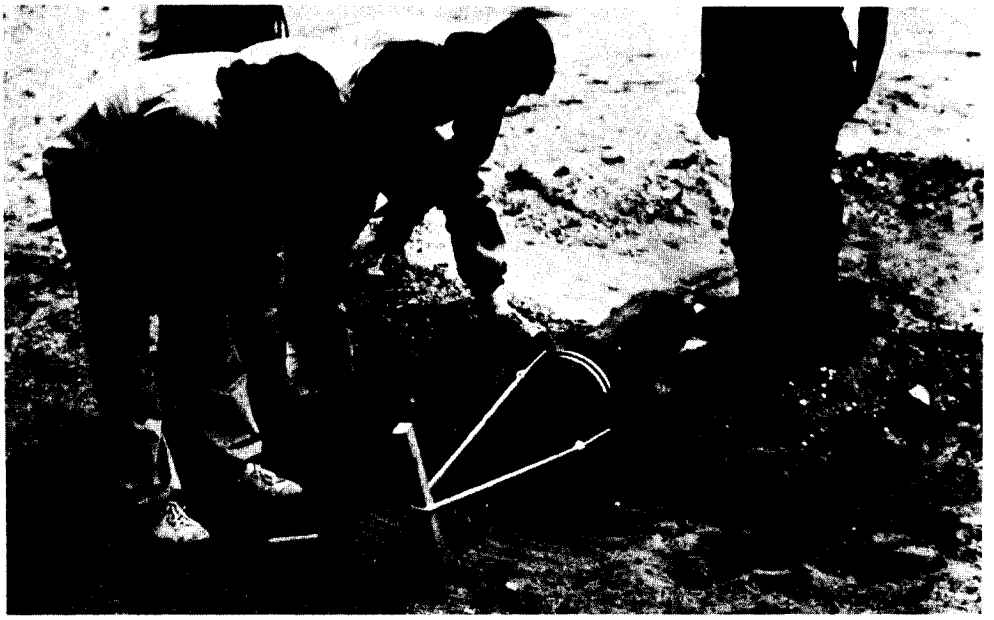
AERIAL MINESWEEPER AND SLED

Aerial sweeping used RH-53D Sea Stallion helicopters towing Mark 105 magnetic minesweeping hydrofoil sleds. Helicopters were continuously positioned using a Raydist-T precision electronic navigation system.

helicopters towing Mark 105 magnetic minesweeping hydrofoil sleds. Each helicopter was positioned continuously by a Raydist-T precision navigation system. By 29 April, airborne mine countermeasure operations were completed in the northern stretch of the canal from Port Said and its approaches to Ismailia. Lake Timsah south, including approaches and anchorages in Suez Bay, were swept by 30 May. During the course of Operation NIMBUS STAR, over 7,616 linear miles of sweep track were flown encompassing an area of over 120 square miles.

Operation NIMBUS MOON – Land

Operation NIMBUS MOON was the name given to removal of unexploded ordnance such as bombs, shells, land mines, or other explosive devices from the canal. It consisted of land and water phases. The U.S. Army explosive ordnance demolition (EOD) task group (65.6) was organized from 29 U.S. based commands to provide training and assistance to Arab Republic of Egypt (A.R.E) Army personnel who cleared all unexploded ordnance up to 250 meters on either side of the canal. Commencing on 29 April, over 1,500 A.R.E. Army personnel were trained in EOD techniques. U.S. personnel functioned as advisors only during actual clearance operations. Clearance of land mines from the canal banks was reported as 100 percent complete on 3 July 1974. The A.R.E. Army reported that, aided by British personnel and U.S. Army equipment, they cleared a total of 686,000 antitank and antipersonnel land mines in the operation in addition to recovering and destroying 13,567 hazardous unexploded ordnance items. The clearance operations encompassed over 30 square miles of land area. NIMBUS MOON – Land operations were complete and remaining U.S. Army EOD personnel returned to CONUS on 25 July 1974.



EGYPTIAN ARMY ORDNANCE MEN DEFUSE A DUD

U.S. personnel acted as advisors as the Egyptians conducted the actual clearance. Here a pyrotechnic "pinwheel" wrench was used to unscrew the fuse from an unexploded bomb, once personnel were safely clear.

Operation NIMBUS MOON – Water

The water phase of Operation NIMBUS MOON was conducted as a joint effort by the United States, United Kingdom, France, and Egypt. The participating units consisted of three Royal Navy minehunter ships, a French two-ship diving group, and Egyptian explosive ordnance disposal diving teams trained by the U.S. Navy.

Each area of the canal was searched at least twice mostly using Royal Navy minehunting sonar or U.S. Navy side-scanning sonar, supplemented by magnetometers and coordinated by Cubic DM-40 precision navigation equipment. This proved effective below the 8-meter depth and canal slopes above 8 meters were searched by divers. Visual inspection of suspected ordnance contacts, identification, and destruction of ordnance was carried out by Royal Navy and French Navy clearance diving teams, as well as by Egyptian Navy forces trained earlier by U.S. EOD specialists. U.S. Navy EOD divers acted primarily in an advisory capacity to the Egyptians.

The Klein side-scan towed sonar could detect an object as small as a 155-millimeter projectile at 50 meters away. The sonar search began in early May 1974 at the southern end of the canal at Suez City (km 162), and proceeded northward through heavy ordnance concentrations at former Israeli and Egyptian crossing points. Sonar operations were conducted up to the earthen causeway thrown up by the Israelis at Deversoir, just north of Great Bitter Lake, then north to the Port Said area, skipping over the British sonar effort which was proceeding south from Port Said.

Sonar search provided for multiple sonar sweeps across the canal to detect a contact several times. The multiple sweeps running both north and south also provided different aspects on the same object. The sonar detection system localized contacts for diver search, providing a 95-percent probability of targets in a 10-meter circle. It was successful in detecting 250-pound and 500-pound bombs, projectiles, rockets, aircraft, trucks, pontoon sections, and various war debris.

The magnetometer system was similar to those installed in the tail boom of P-3 ORION aircraft. Modification allowed it to fit into a towfish body and to be towed under water from the stern of any vessel. Later an array of four towfish (ganged sensors) was used to increase the effective area of coverage. This array allowed the operator to classify the relative size of the contact more precisely by comparing the four individual readouts of the system.

Magnetometer operations started in Suez Bay with some tests to determine the system's ability to detect and localize ferrous contacts for diver investigation. The results showed that total system performance was accurate enough to place divers within 5 meters of an object. Magnetometer detection was utilized in Suez Bay and in Great Bitter Lake

EARTH CAUSEWAY BLOCKING CANAL AT DEVERSOIR

During the Yom Kippur War, Israeli engineers extemporized a canal crossing just north of Great Bitter Lake to move around units into Egypt.

CAUSEWAY REMOVAL AT DEVERSOIR

The Israeli-built causeway across the canal was removed by both excavating equipment and dredging.

where background magnetic levels were low. The magnetometer proved to be the only effective detection system in the anchorage areas in Great Bitter Lake, since the sonar could not penetrate an abnormally high saline bottom layer. Ganged magnetometer search proved effective in locating all ferrous objects that had to be inspected by divers to determine which were unexploded ordnance. Scuba-diving, here, was made hazardous by the presence of hydrogen sulfide as well as a dense, polluted deep brine layer, which required divers to wear many extra weights. After unsuccessful experiments to disperse the layer mechanically, the SCA used a net drag sweep through the area to clear it for dredging.

A key to the mission's success was the precision electronic navigation system, which operated with an interrogator located on a search boat and two shore-based responder stations. The Cubic DM-40 system was able to provide fixes accurate to 1/2 meter over a distance of 40 kilometers.

Evaluation sampling searches were necessary to give the search commander the statistical effectiveness of search in specific areas and in the canal as a whole. This quality control identified areas that did not receive sufficient search effort and were identified for later investigation.

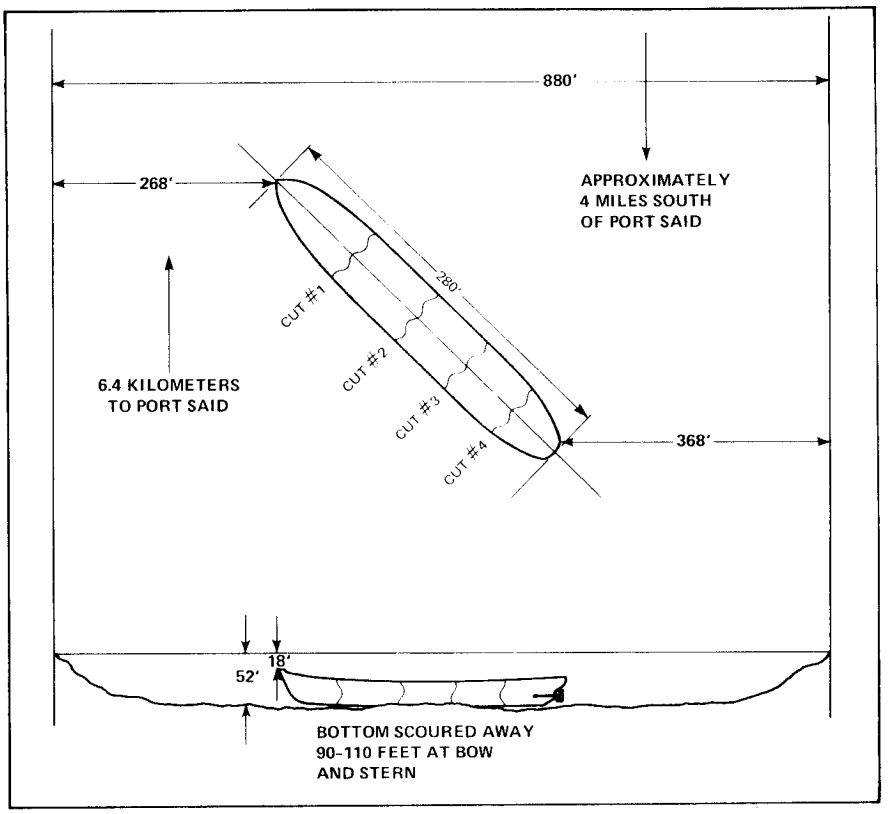
During the operations by the clearance forces from 11 April to 20 December, approximately 7,500 unexploded ordnance items were found in the Suez Canal proper. An additional 1,000 items were found in harbor basins and anchorages outside the canal. The search also located approximately 700 major nonordnance items, such as tanks, trucks, pontoon sections, boats, and barges, that were removed later by the Suez Canal Authority. Operational success can be attributed to the efficient use of diver assets, use of sophisticated sensor search systems, and statistical analysis.

Salvage Survey

For the preclearance wreck survey, the first step was a check of the wrecks for unexploded ordnance – seven by U.S. Navy explosive ordnance disposal divers and three by Royal Navy clearance divers. The wrecks were essentially clear, except for fishermen's gelignite charges around a tug and three pieces of ordnance near a dredge.

The salvage survey was then undertaken on eight of the 10 wrecks. Three of the wrecks were given particularly close survey to ascertain whether refloating was possible. This was done for the dredge 15 SEPTEMBER, in particular, because of Egyptian desire for its intact recovery for repair and reuse. For two other vessels, refloating was a possible option for efficient clearance.

The finds of the survey will be found tabulated for each wreck in conjunction with a graphic aid to illustrate the narrative for each clearance.



SITUATION OF THE CARGO SHIP ISMAILIA

ISMAILIA, the northernmost wreck, was scuttled in the canal about 4 miles south of Port Said. Her superstructure and propulsion machinery, except boilers, had been removed. She was supported amidships in the bottom mud, but current scouring had left about one-third of her bow and stern cantilevered. ISMAILIA was dismantled into sections for removal along the cut lines indicated.

CLEARANCE OPERATIONS

NORTHERN ZONE

Clearance of SS ISMAILIA

Clearance of the Suez Canal began with the removal of silt from the ISMAILIA wreck on 3 June 1974. The Suez Canal Authority (SCA) diving barge BAYOUMI was moored over the wreck, and silt removal operations were begun to gain cutting access to the double bottoms, and to lighten the wreck for lifting.

The diving teams worked one at a time using a 6-inch air lift. Each diver was limited to one non-decompression dive per day until delivery of a recompression chamber at the

beginning of the second week. As the extent of the silt removal became apparent, effort was expanded to two teams of divers using two 6-inch air lifts. Air lifting alone was successful for the top layers of mud, but lower layers were compacted and had to be loosened with a high pressure water jet at 300 pounds per square inch before air lifting.

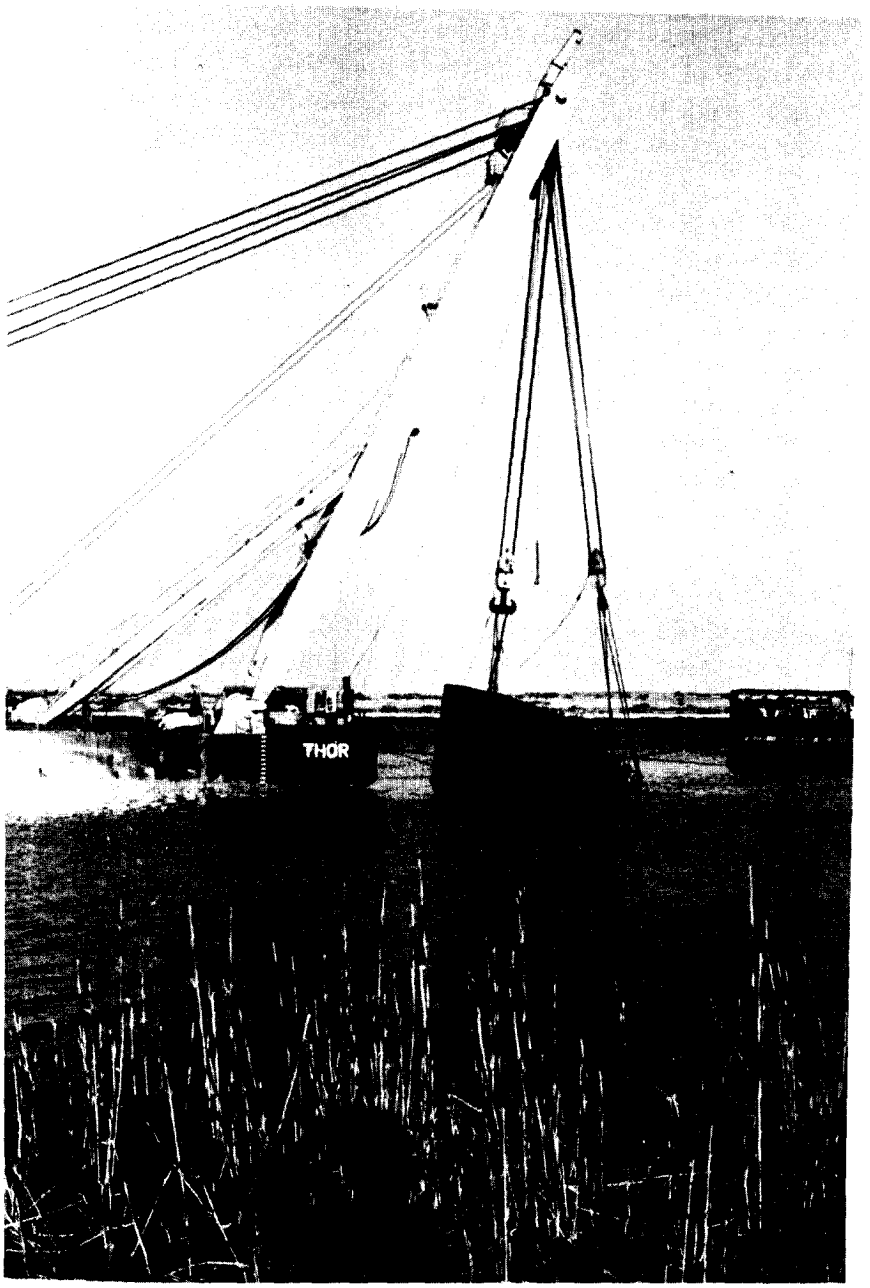
Cutting operations on the 1,500-ton ISMAILIA's hull commenced on 14 June. Prior to its sinking, ISMAILIA was being scrapped, and her machinery and much of her decking had been removed. Cutting could have gone faster by using more oxyarc burning, but the use of explosives was favored because ISMAILIA provided training for more difficult work in other wrecks to follow, where explosive cutting might be mandatory. After 14 days and the expenditure of 2,400 pounds of explosive, ISMAILIA had been cut into five sections and awaited the arrival of the heavy lift crane THOR, a sheerleg A-frame type derrick with two additional six-fold deck purchases. Salvage operations on ISMAILIA resumed on 13 August when THOR arrived from Bremerhaven, Germany.

Removal went slowly at first, with some delay due to incomplete cutting at the bow, the first section attempted. Also, the lifting slings ripped the skin of the ship, so that the crew had to rerig the after sling under the hull, requiring seven days in all. The second section to be lifted was the stern section. Based on the experience with the bow section, a sling was rigged under the hull and the second lift required only two days.

ROLAND, the sister crane to THOR, assisted with the remaining two sections of ISMAILIA.

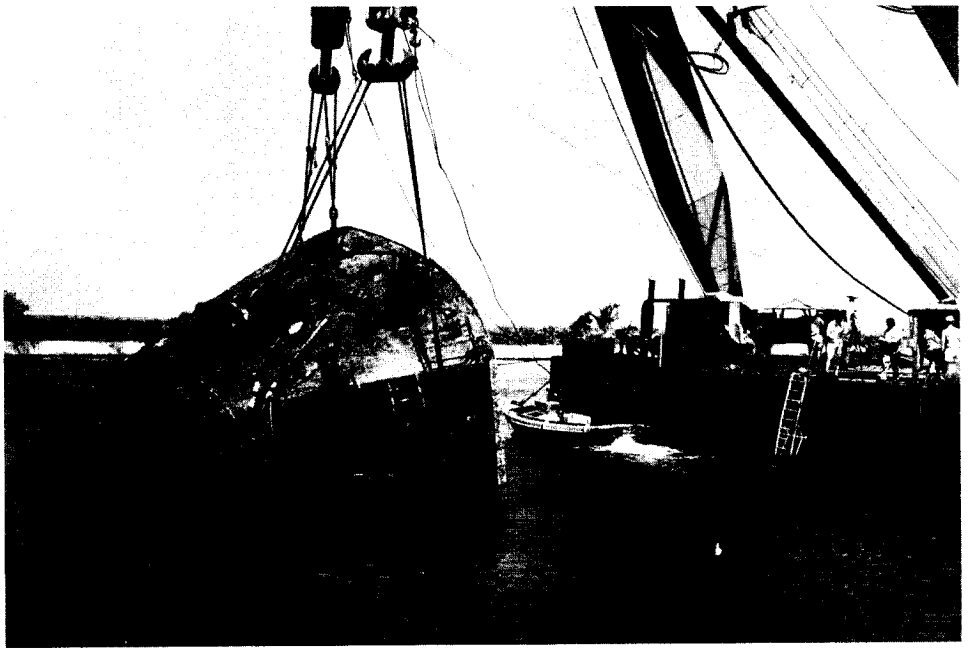
EXPLOSIVE CUTTING WAS USED EXTENSIVELY

Use of underwater explosive cutting was used in efficient combination with oxyarc cutting. Explosive cutting was particularly effective for shearing along scored lines made by oxyarc.



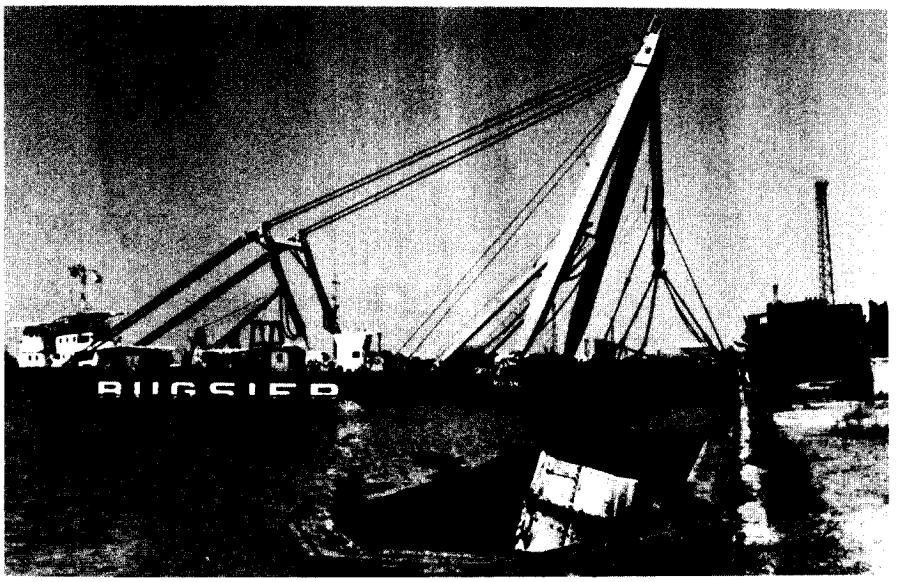
ISMAILIA'S BOW IS REMOVED BY HEAVY LIFT CRANE THOR

ISMAILIA's bow is being lifted by THOR's 500-ton-capacity shear-leg system, near a patch of the papyrus reeds associated with Egypt over the centuries.



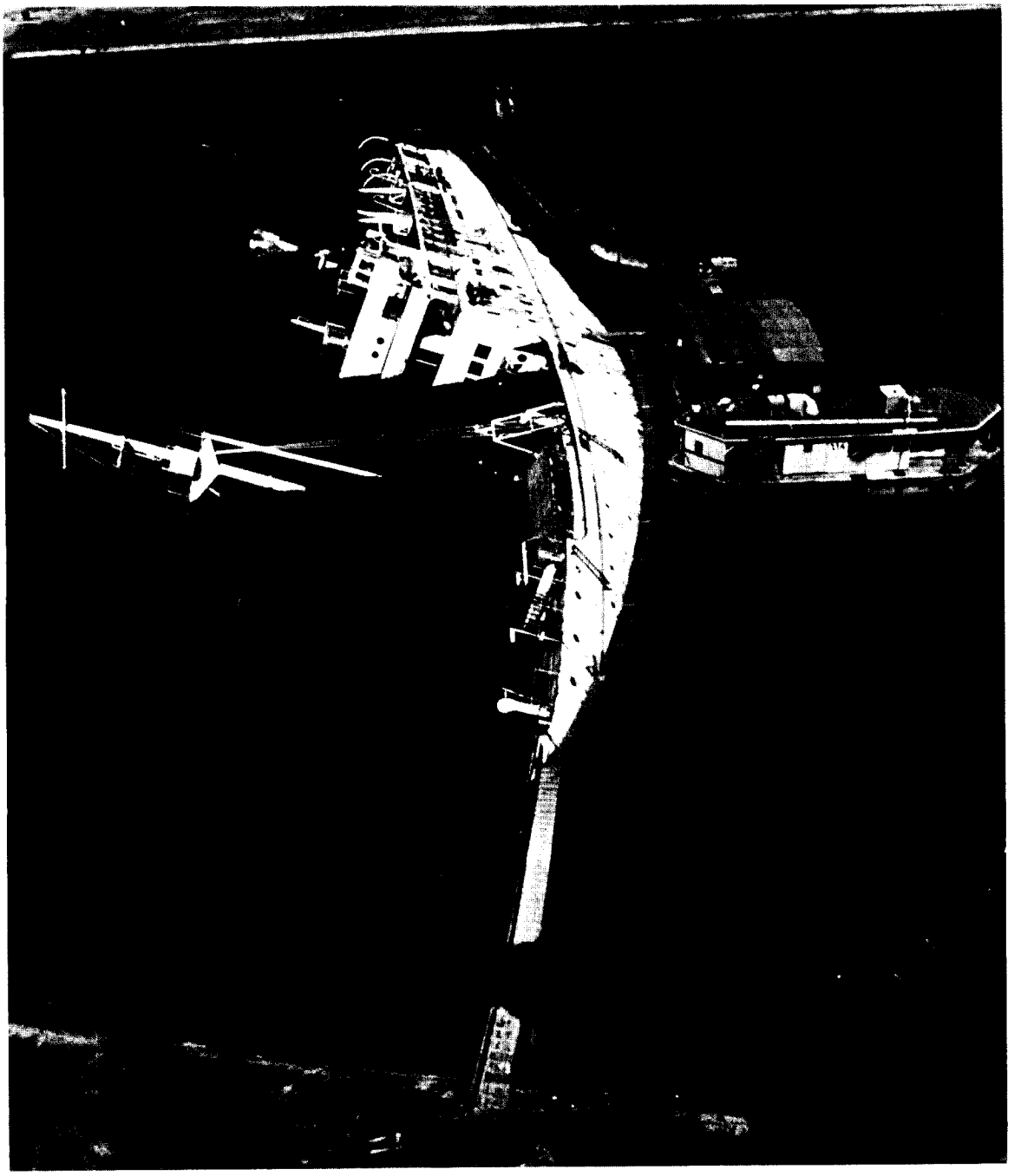
CLOSE-UP OF BOW LIFT OF ISMAILIA

Note the convenient and secure attachment of one chain sling through the hawsepipes.



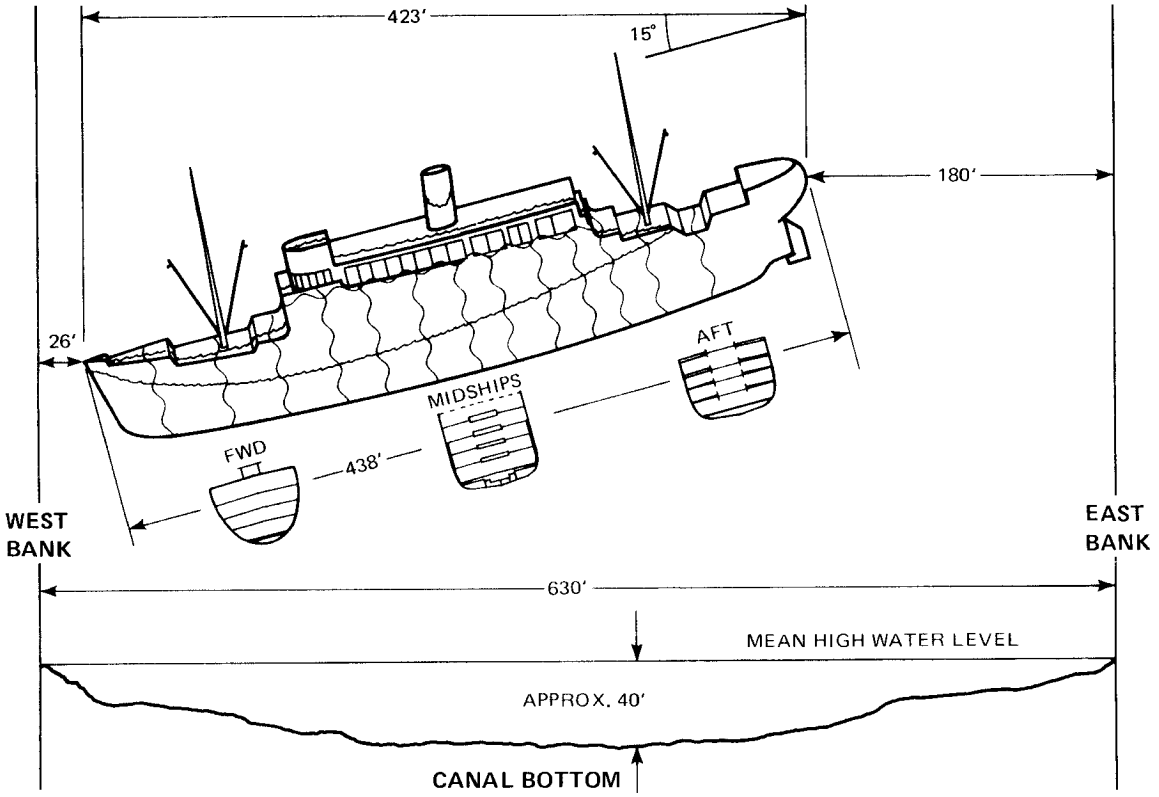
TYPICAL HEAVY LIFT RIG FOR ISMAILIA SECTIONS

The heavy lift crane ROLAND has moved the section still partially submerged in order to use the assistance of buoyancy in carrying the load. It is in the process of adding the section to others in the dry dump on the canal's edge.



SALVAGE COMMENCES ON MECCA

Suez Canal Authority barges were rigged as work platforms and sectioning of the superstructure with oxyarc cutting got under way.



POSITION OF STEAMER MECCA AT KILOMETER 7

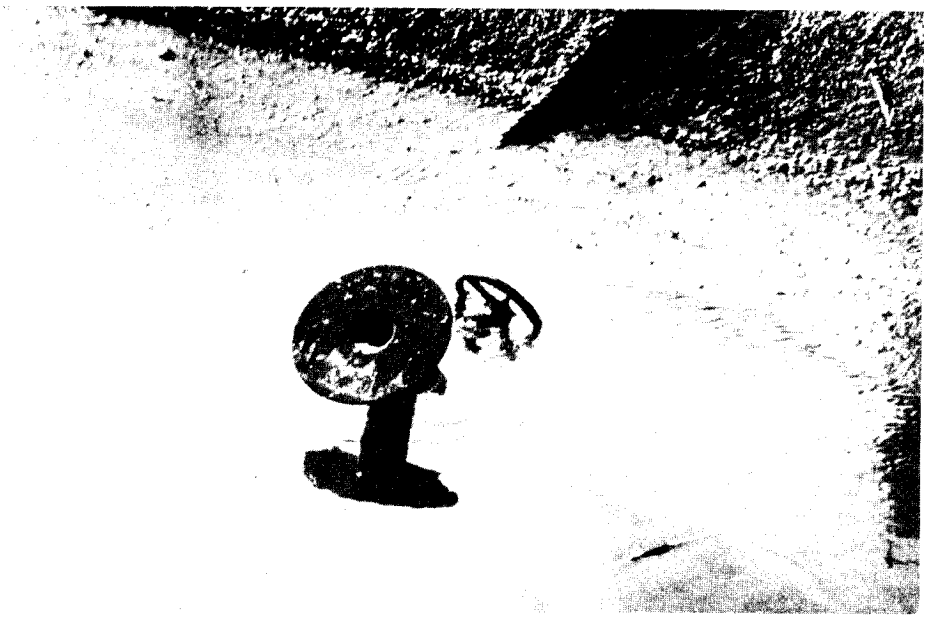
Diagram shows cuts used for sectioning as well as principal canal dimensions.

Explosive Cutting

Explosive cutting proved efficient, and cutting skill increased as the operation progressed. Careful placement of explosive charges adjacent to the frames of the wreck was essential to facilitate a shearing action. Charges placed away from the frames frequently distorted the wreckage rather than cutting it. Increased weight of explosives was not a substitute for careful charge placement. Increase of cutting charges distorted the wreck to such a degree that the diver's ability to place subsequent charges was seriously impaired. Angle-iron charges and hose charges were equally effective.

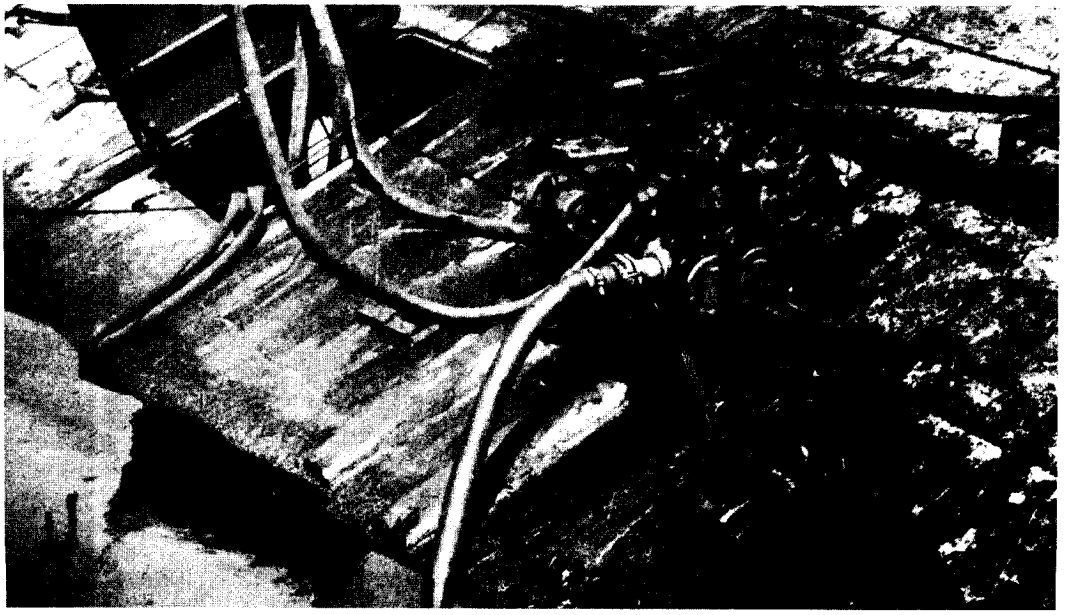
Clearance of the MECCA

Salvage operations on the 6,700-ton MECCA commenced in early June, as soon as SCA barges could be rigged as work platforms. First, a diving survey was conducted, followed by commencement of underwater oxyarc cutting. Second, oil removal operations got under way to remove surface oil and oil from MECCA's tanks. The oxyacetylene cutting was undertaken sectioning her above-water superstructure for lift by the SCA's 80-ton crane.



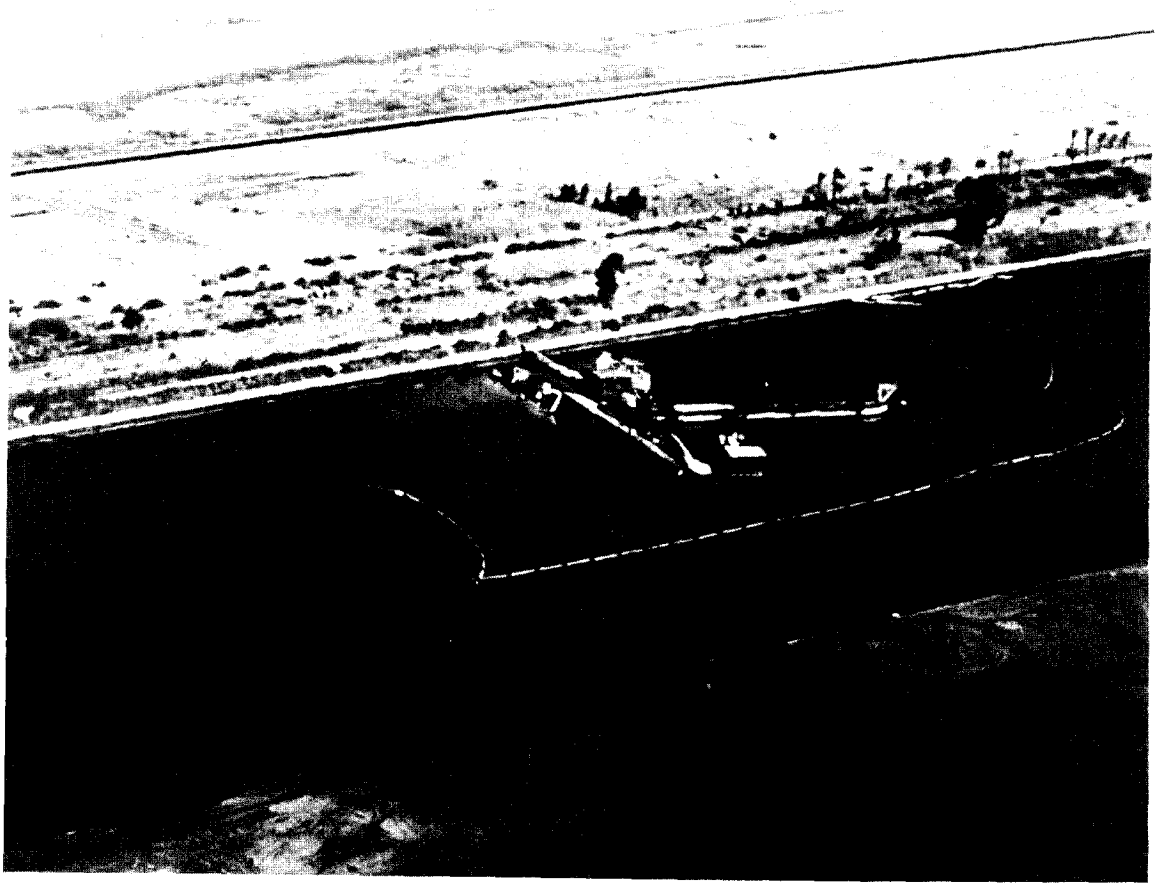
HOT-TAP SPOOL ON MECCA

To remove fuel oil from MECCA, two hot-tap flanges were installed on the amidships tanks.



PUMPING EQUIPMENT FOR HOT-TAP REMOVAL OF OIL

Pumping installation for fuel oil removal was on MECCA's port side for clearing amidships tanks.



CONTAINMENT BOOM FOR OIL SEEPAGE

During oil removal from MECCA, seeping oil was collected in bight shown at the right.

The surface oil essentially was removed without difficulty in a day, but seepage continued to reappear and required collection when significant amounts accumulated. Spray and air curtains were rigged to minimize interference with divers.

Cutting and removal of MECCA's superstructure began immediately after completion of the salvage survey on 29 May, and was completed within 30 days. SCA burners worked topside with oxyacetylene burning equipment, while divers worked under water with oxyarc equipment. Activities proceeded routinely, with increased reliance on explosive cutting rather than oxyarc. Oxyarc, however, predominated cutting of areas of light construction.

DIVER EMERGES FROM WORKING ON MECCA

Cutting of the hull proceeded under water as well as topside on the exposed portion.

TASK FORCE FLAGSHIP MOVES SOUTH PAST MECCA OPERATIONS

USS BARNSTABLE COUNTY (LST-1197) was able to deploy from Port Said to Ismailia with the increased channel clearance, once MECCA's stern had been removed.

The first part of MECCA's hull to be removed was a 16-foot section of the stern. This provided increased channel clearance for passage of the Suez Task Force Commander's new flagship USS BARNSTABLE COUNTY (LST-1197), en route to Ismailia. (BARNSTABLE COUNTY replaced USS INCHON when minesweeping operations were completed in June.)

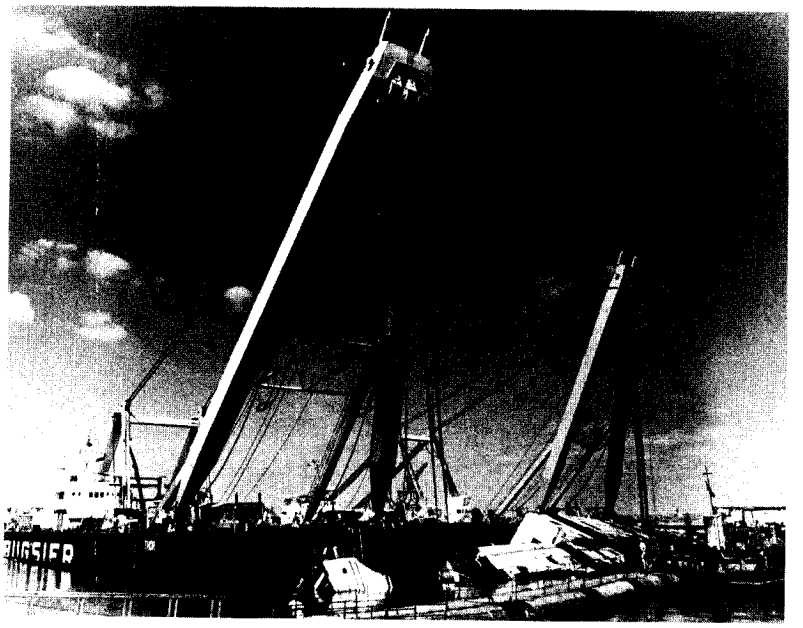
At cut 12, mud and debris inside blocked divers' access and required removal using air lifts. Subsequently the mud, debris, and wreckage were shifted by cutting charges, making it difficult for divers to gain access to the structure or to determine what had to be cut. Two major decisions affecting cutting were then made. The first was to order the second heavy lift crane mentioned earlier. Arriving at the Suez Canal on 15 September, this crane, the ROLAND, permitted pairs of sections on either side of planned cuts to be lifted as single 900-ton lifts using THOR and ROLAND together. Elimination of extra cuts saved considerable time in the overall operation. The second decision was to speed up work on MECCA by employing a second cutting team to start forward and work aft.

By this stage, good techniques for explosive cutting had been developed. It was found particularly effective, for instance, to "shoot" from outside the wreck. In addition to generally easier access, this presented other advantages. Larger charges could be used without disrupting other work, and shooting against the support of the frames again was found to improve the capability of the charge to shear the hull plating; there was less interference from mud, debris, and wreckage.

CLEARING AWAY MECCA'S SUPERSTRUCTURE

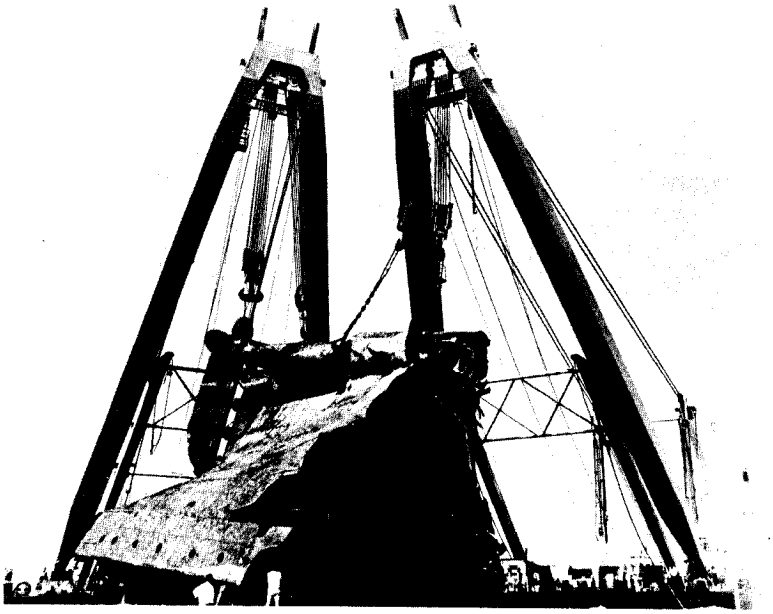
A Suez Canal Authority 80-ton crane was used to clear MECCA's sectioned superstructure before heavy lift of the hull sections began.

Lifting of MECCA's superstructure began with the arrival of an SCA 80-ton crane at the site on 10 June. The heavy lift phase of MECCA's removal began with the arrival of THOR at the MECCA site late in the third month of salvage operations. Later THOR joined ROLAND to commence working in tandem, as described earlier. Difficulty was encountered in lifting the last section of MECCA. THOR and ROLAND attempted this lift on 15 October, and as the section broke the surface, one of ROLAND's chain slings cut completely through it, transferring all weight to ROLAND's other sling. This sling then parted, causing hooks, slings, and chains to backlash violently. Fortunately, no personnel were injured or equipment was damaged. THOR was able to set its side of the section down without damage. All connections had to be redone on this section and a considerable amount of structure and machinery had to be cut away to lighten it for lifting. After accomplishing the lightening, THOR and ROLAND completed this final lift on 17 December, concluding the Northern Zone operations.



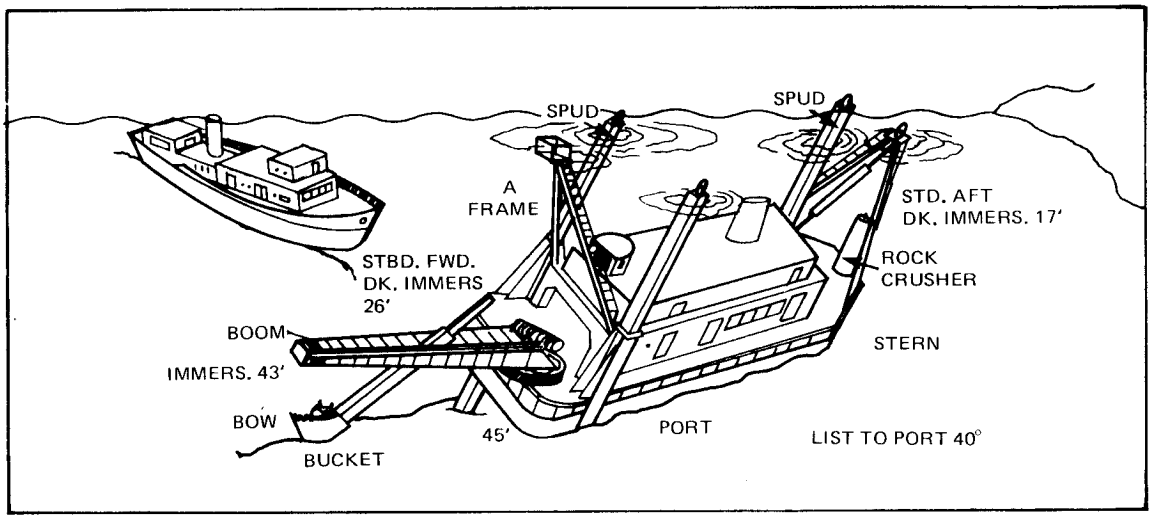
LIFTING MECCA'S HULL SECTIONS

The heavy lift cranes THOR and ROLAND were used to lift MECCA's hull as it was sectioned by oxyarc and explosive cutting.



MECCA'S STERN IS DEPOSITED IN DRY DUMP

MECCA's hull was put ashore in sections, near Port Said, for scrap removal.



MONGUED AND KASSER LAY ALMOST SUBMERGED IN CLOSE PROXIMITY

The tug MONGUED was on an even keel on the gently sloping bottom. The bucket dredge KASSER was tilted 45° to port by her starboard mooring spuds, which were jammed in an extended position when she sank.

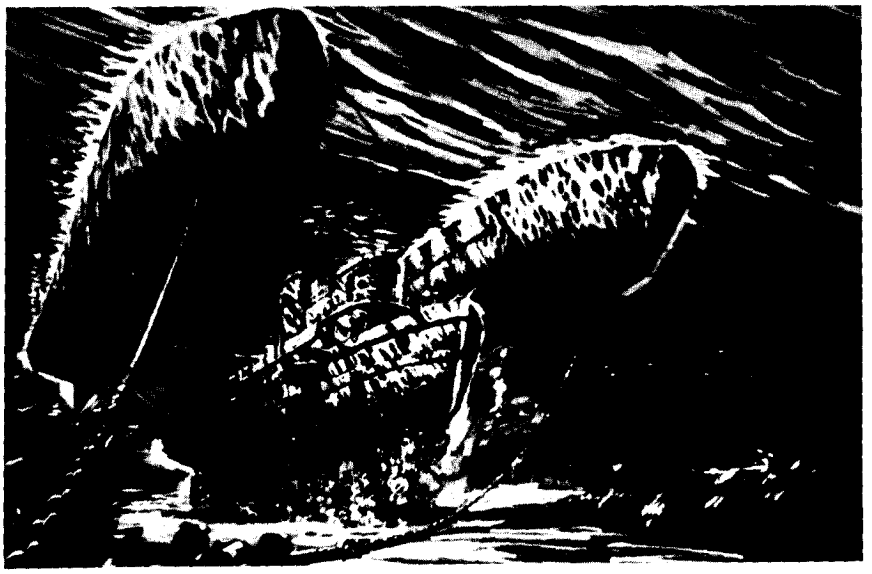
CLEARANCE OPERATIONS

CENTRAL ZONE

Trim and Rig Operations

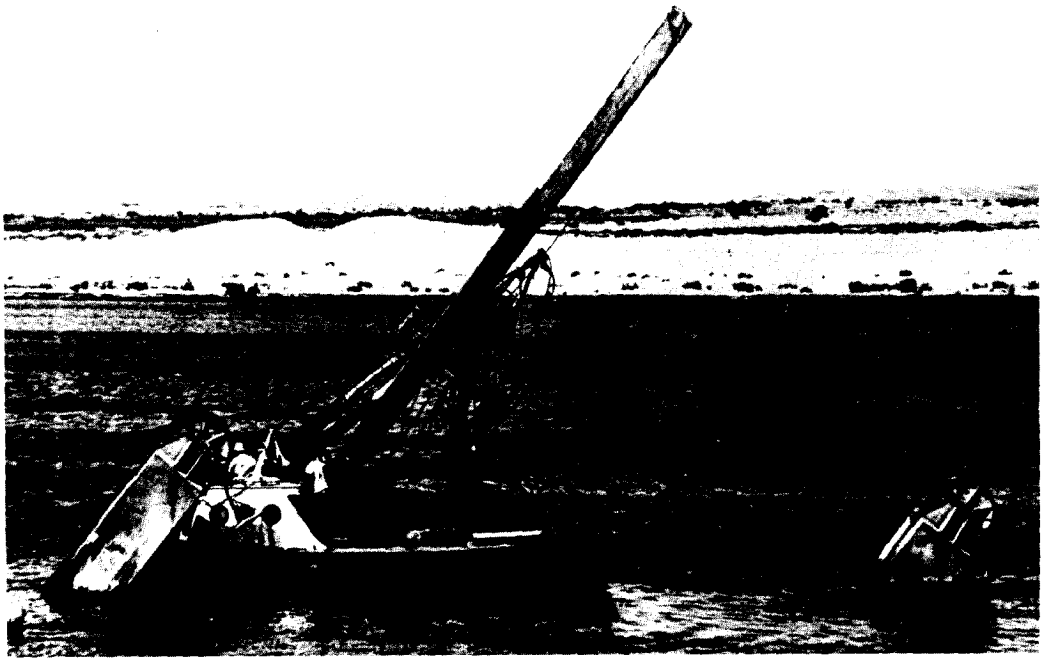
As a preliminary to removal of the 1,200-ton dredge KASSER, the 1,200-ton tug MONGUED, and the 1,600-ton DREDGE 23, trim and rig operations were carried out to prepare the wrecks for side-lift between the heavy buoyant-lift vessels CRANDALL (YHLC-2) and CRILLEY (YHLC-1). The trim work consisted of removal of any structure from the wrecks that would interfere with rigging or lifting. Rigging consisted of putting in messengers to expedite the passage of lift wire once CRANDALL and CRILLEY arrived on site.

Operations got under way on 2 August with a team working from the SCA 25-ton crane barge BAYOUMI. Work began first on KASSER; the upper gate of her extended starboard spud was opened with an explosive charge, and the dredge leveled herself from a 45° list. Other preparations included removal of the spuds, dipper bucket and arm, ladder, and turntable, for a total reduction of 100 tons.



MONGUED WAS RAISED WITH BUOYANT LIFT VESSELS

Lift wires are passed under the salvage object and secured to the lift vessels, which are flooded down to maximum draft. When the ballast water is pumped clear, the salvage object is lifted free, then towed to shallow water where it grounds. The procedure is repeated to relocate the object.



DREDGE KASSER WAS TILTED 45° BY AN EXTENDED MOORING SPUD

The extended spud was sheared with an explosive charge and KASSER leveled herself.

The trim and rig team moved next to MONGUED. By 12 August, all damaged metal that could foul lift wires had been cut away. After a tripod atop the pilot house had been burned off, the wreck allowed draft of 15 feet for maneuvering the YHLCs in the KASSER/MONGUED area.

From 6 to 10 September, the trim and rig team, operating from a diving barge and aided by a SCA 80-ton crane and two scrap barges, worked on DREDGE 23. Dredge buckets and the ladder were removed by scoring the connection plates with oxyarc and shearing with explosive charges. Trimming was completed with the removal of the kingpost, two deck winches, fenders, and fender brackets.

Silt removal operations were begun on KASSER and MONGUED on 21 August, with two diving teams on each wreck using 4- and 6-inch air lifts. Although mud depths up to 8 feet were found in the machinery spaces of KASSER, it averaged 1 foot or less. Silt removal was completed on MONGUED on 22 August and on KASSER on 24 August. Only the small amount of silt in the engine room was removed from DREDGE 23 because with the weight of the silt the lift was within the capacity of the YHLCs.

Clearance of the Tug MONGUED

It was decided to lift MONGUED first since she was narrower than KASSER and allowed more margin for passage around the sunken concrete caisson, in transit to the Great Bitter Lake dump area. On 30 August, the heavy lift craft moored over MONGUED – CRILLEY to the north and CRANDALL to the south, bows to the west bank.

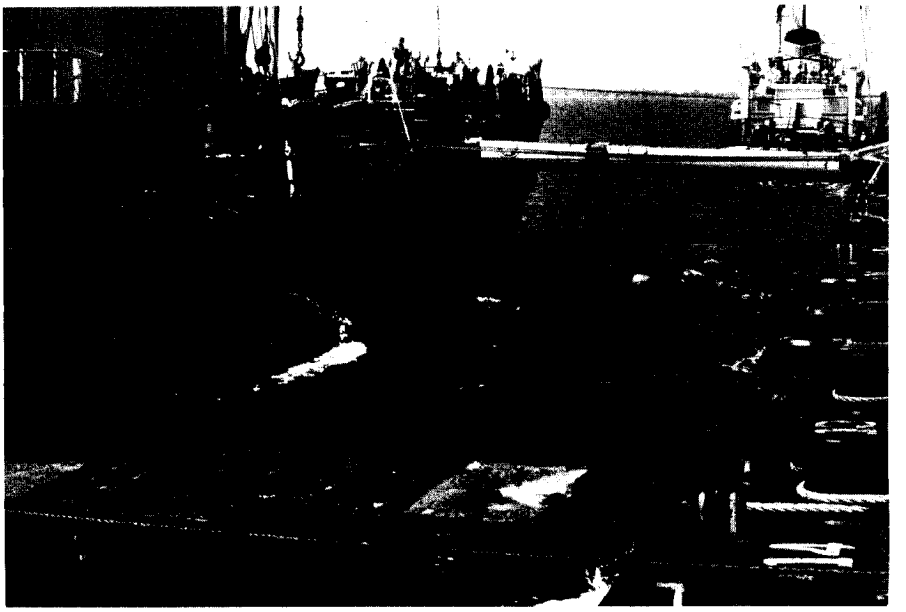
By 3 September, 17 wires had been passed, and MONGUED was ready for the first lift. It was to be done by lifting the wreck clear of the bottom and rigging three more wires, for a total of 10 pairs of lift wires for subsequent lifts. By day's end on 4 September, the lift craft had been ballasted down, lift wires had been tensioned and pinned, and the lift craft had been deballasted 50 percent to stretch the wires in preparation for the second lift. The following morning, an 18-inch lift was made.

The lift craft were deballasted early 5 September, raising them to a draft of 12-1/2 feet. This raised the wreck 5-1/2 feet, to a keel depth of 57 feet. Using four SCA tugs, the nest was then pivoted 45° around a shallow spot and moved a distance of 20 meters, where it grounded. Inspection by divers revealed that MONGUED had been lifted out of a 4-foot-deep hole.

The next day, the YHLCs again lifted the wreck and suspended it between them at a keel depth now decreased to 45 feet. After working clear of a shallow spot, the nest got under way for Lake Timsah to a new grounding area, two miles south of Ismailia, west of the main channel. The two lift craft were towed stern first by an SCA tug, with MONGUED

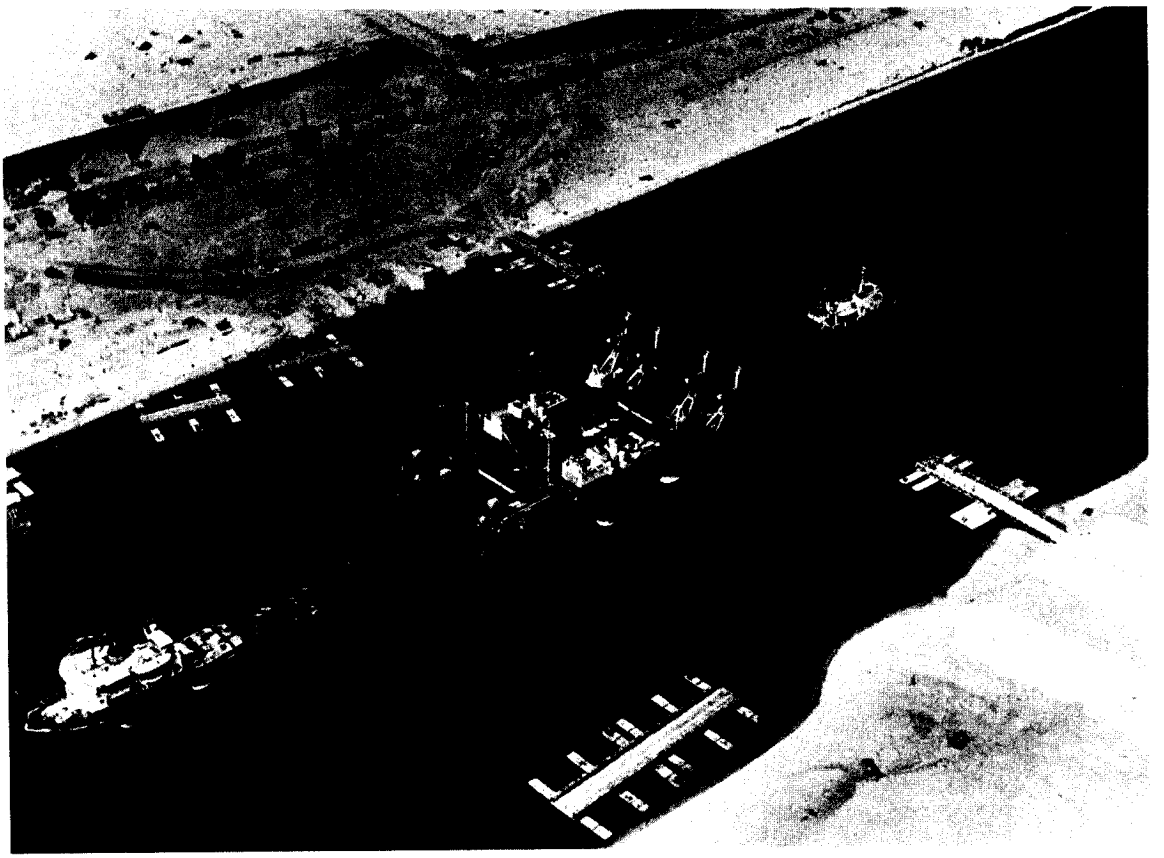
BUOYANT LIFT STARTS FOR TUG MONGUED

MONGUED can be seen dimly under water as YHLCs CRANDALL and CRILLEY commence lifting.



TUG MONGUED SURFACED

YHLCs CRANDALL and CRILLEY with MONGUED suspended, being readied for tow.

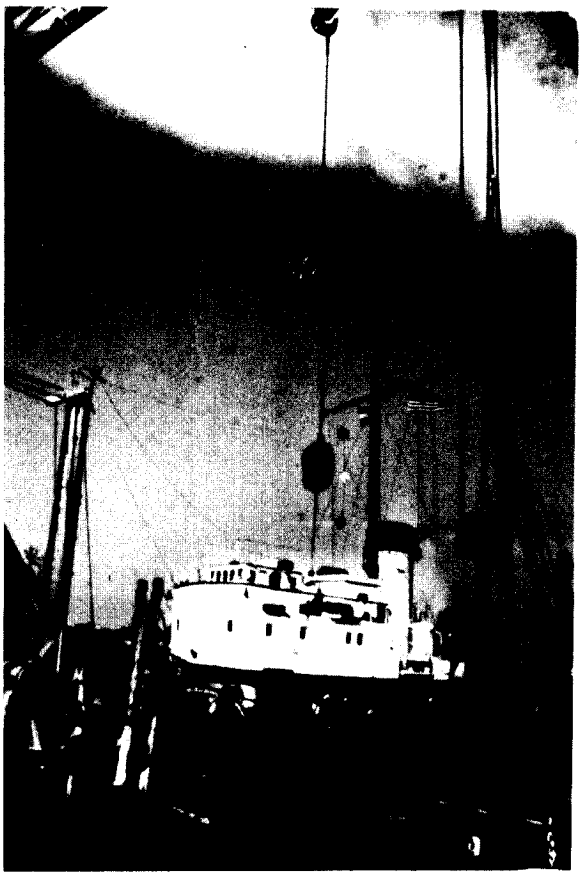


MONGUED IS CARRIED IN TOW TO DUMP

MONGUED is suspended beneath CRANDALL and CRILLEY as the nest is towed to the dump in Great Bitter Lake.

suspended bow first at a slight upward angle between the lift craft. Tow wires from MARINER were rigged to the bow of each lift craft to provide good position control of the nest. Another SCA tug was used alongside as directed. Later that morning, MONGUED grounded and was dragged to a designated temporary grounding area. It was decided to make another lift here, expecting that an additional 2-foot rise could be obtained despite some settling of MONGUED in the soft silt bottom. This rise would be enough to clear the residual uncleared spoil of the Deversoir causeway, en route to the dumping area in Great Bitter Lake.

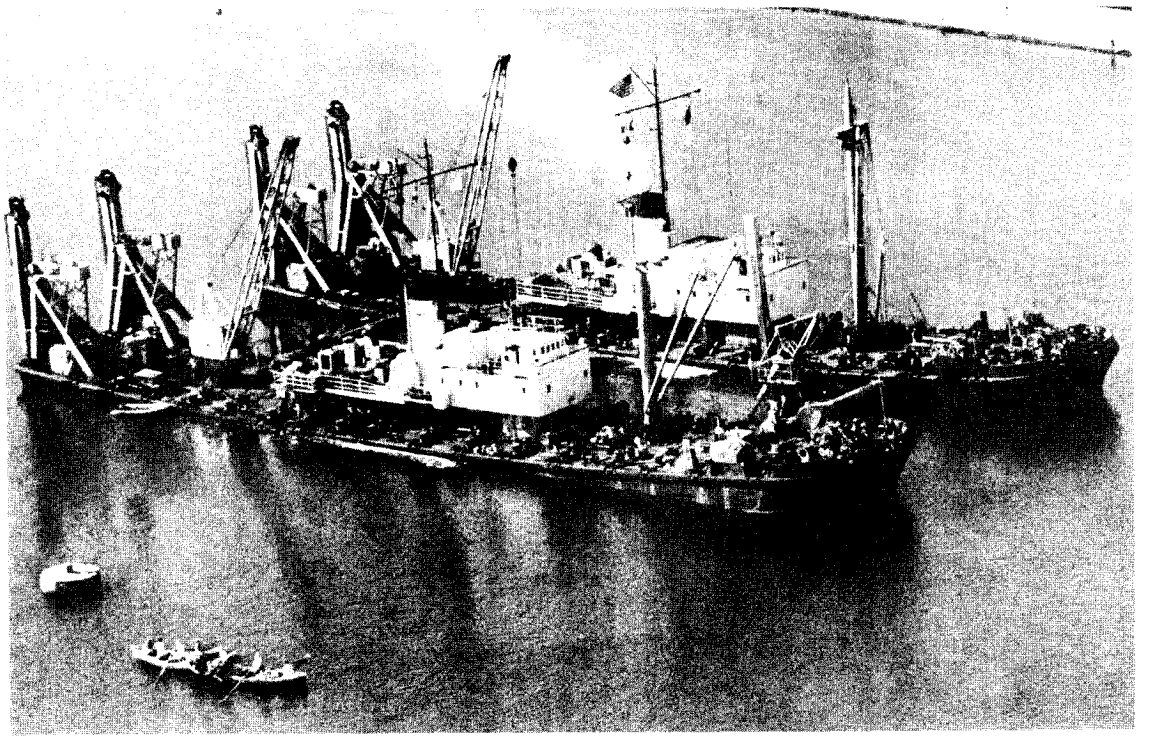
The lift raised the wreck more than 7 feet for a net gain of the needed 2 feet, then thought sufficient to clear the causeway shallows. On 8 September, the nest proceeded to the dumping area with MONGUED slung at a keel depth of 44 feet. With good tug control, the craft and the wreck negotiated the restricted channel between the sunken concrete



CLEARING RESIDUAL SPOIL FROM DEVERSOIR CAUSEWAY REMAINS

Causeway removal shown in earlier photos proved to be too shallow, and additional removal of rocks was necessary.

caisson and the west bank without difficulty. (There was approximately 165 feet of navigational clearance for the 122-foot-wide nest.) Early 8 September, a recheck of the depth over the causeway shallows found rocks at 43 feet instead of the expected clearance of 46 feet. Therefore, the nest was anchored north of the causeway while the SCA Dredging Division worked around the clock to clear the remaining obstructions. After successful passage, the nest then proceeded toward the disposal ground. The wreck grounded as the nest turned from the canal proper into the access channel to Great Bitter Lake, but another lift raised MONGUED sufficiently and she was pulled into the dump area. The operation completed, the lift craft were unrigged on 12 September to begin transit northward for lifting operations on the KASSER.



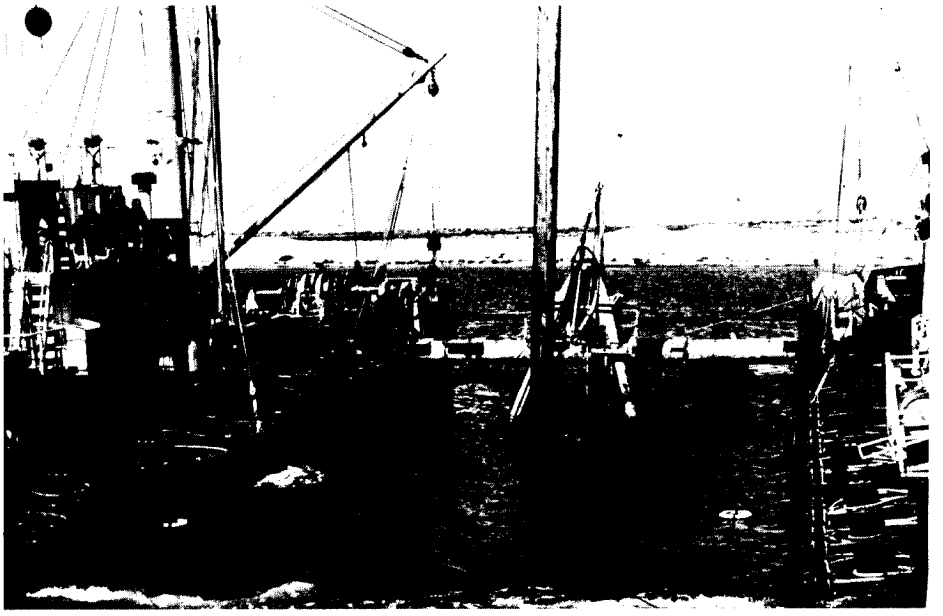
CRANDALL AND CRILLEY FLOOD DOWN TO LIFT KASSER

Note KASSER's upright position in comparison to the list shown before severing the extended mooring spud.

Clearance of the Dredge KASSER

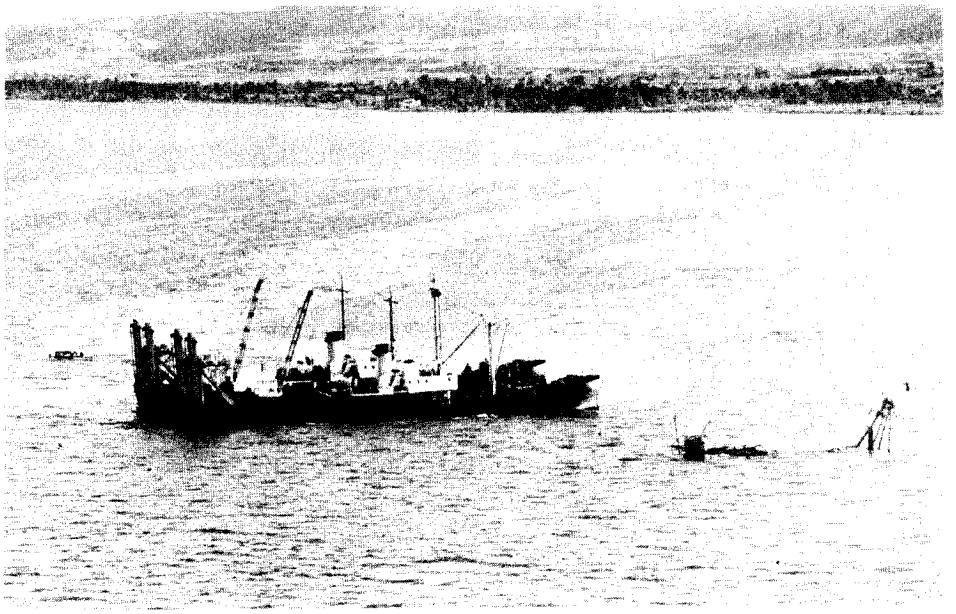
On 14 September, CRILLEY and CRANDALL were moored over KASSER's stern, and by 22 September, all 17 lift wires were in place. The lift craft were then ballasted down, wires were pinned, and the craft were deballasted for a lift of 7 feet. With an 8-inch line to CRILLEY and CRANDALL, an SCA tug managed to pull the nest approximately 50 yards northward to Lake Timsah before grounding. The grounding included the good fortune of trimming the KASSER, so that with the next lift, a draft reduction greater than the vertical lift capability of the lift craft was achieved. The net rise was 7 feet, but a hump on the bottom encountered in the grounding had caused the wreck to trim up 5 feet by the stern and down 5 feet by the bow, for a new maximum draft of 42 feet. This was sufficient for passage over the remains of the Deversoir causeway, and a planned third lift in Lake Timsah could be eliminated.

KASSER was then towed south to Great Bitter Lake where a third lift on 25 September made more trim improvement and evened her draft at 32 feet fore and aft. This gave access to the designated dump area, where the wreck was deposited.



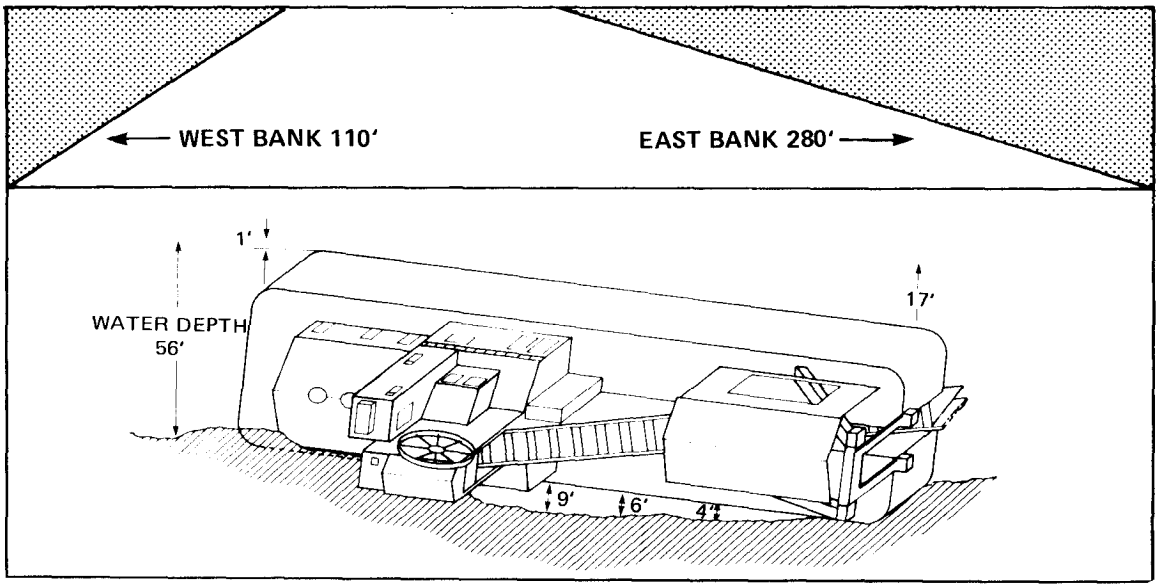
KASSER BETWEEN THE LIFT CRAFT

Lift wires have been passed beneath KASSER and are rove around the lifting bitts of CRANDALL and CRILLEY.



KASSER AND MONGUED DEPOSITED IN WET DUMP

Only the tops of stack and superstructure can be seen above water, on either side of the YHLCs.



POSITION OF DREDGE 23 AT KILOMETER 92

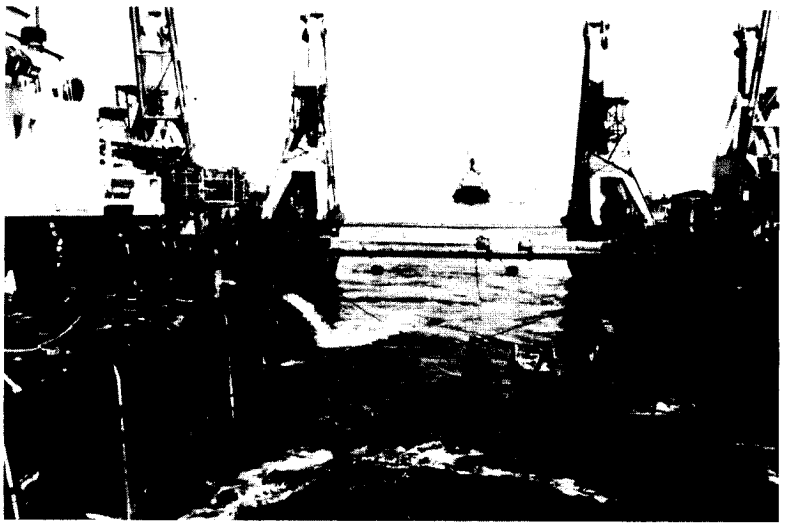
Just north of Ismailia, DREDGE 23 lay on its side blocking the western half of the canal.

Clearance of the DREDGE 23

THOR and ROLAND arrived at the wreck site on 23 September to begin removal of DREDGE 23. By 26 September, parbuckling anchors had been set, and the parbuckling wires were rigged under the hull and fastened to the anchors. The first two attempts, with THOR and ROLAND pulling in tandem, failed to parbuckle the dredge to the required attitude. ROLAND was then employed alone, using a lift on the dredge's gantry to generate a righting moment. On the first attempt ROLAND successfully pulled the dredge into an upright position. The YHLCs CRANDALL and CRILLEY were moved over the dredge, lift wires were rigged, and the first lift was made on 5 October. After the dredge was lifted, the nest proceeded southward toward Lake Timsah, one SCA tug towing, another restraining, and small SCA tugs assisting. After grounding lightly several times, the wreck grounded hard on an obstruction 1-1/2 miles south of its original position.

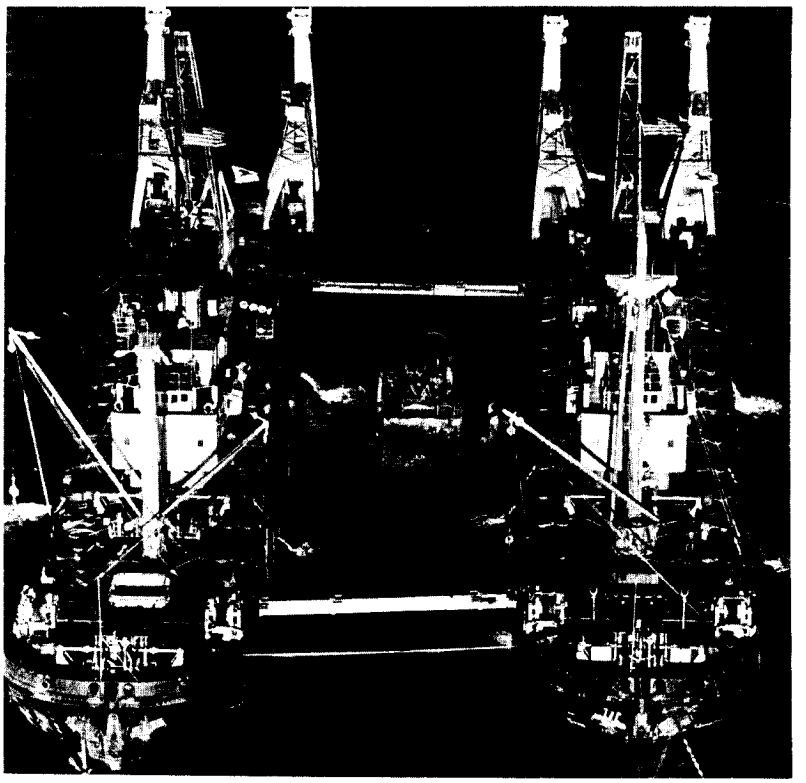
A second lift that reduced the maximum draft to 43 feet was made on 7 October. The wreck and the lift craft then continued southward, clearing the concrete caisson and Deversoir causeway shoal, and entered Great Bitter Lake the next day. On 9 October, the final lift was made and DREDGE 23's wreck was deposited in the designated dump area between MONGUED and KASSER.

With the dumping of DREDGE 23, the simpler heavy lift operations in the Central Zone were complete, and attention could be directed to the more complex problems presented by the dredge 15 SEPTEMBER and a concrete caisson.



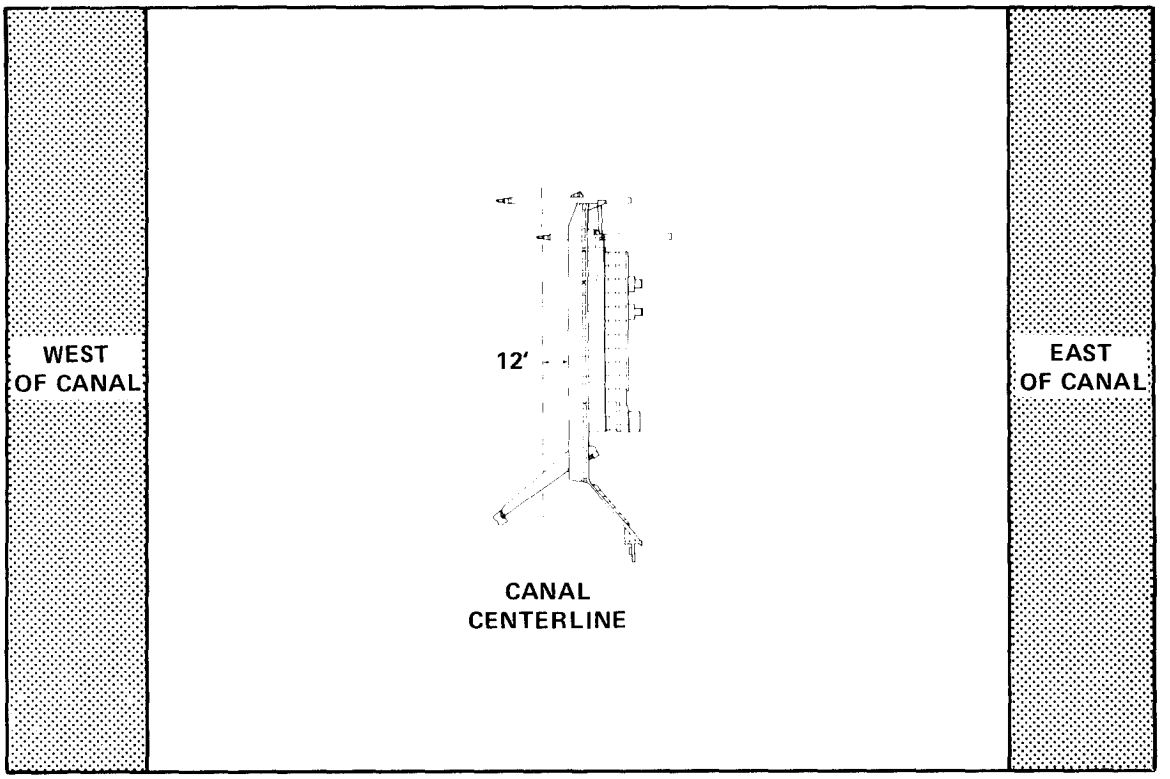
DREDGE 23 SURFACES

YHLC pumping ballast as bucket-chain gears of DREDGE 23 rise above the surface.



DREDGE 23 WELL CLEAR OF BOTTOM

Raised to minimum depth, the dredge is towed to the wet dump in Great Bitter Lake.



POSITION OF DREDGE 15 SEPTEMBER AT KILOMETER 98

This dredge was the one vessel scuttled in the canal deemed worth salvaging and rehabilitating. Her recovery involved desilting, patching, and parbuckling to an upright position before she could be pumped free of water, refloated, and delivered to the Suez Canal Authority yard at Ismailia.

Salvaging Dredge 15 SEPTEMBER

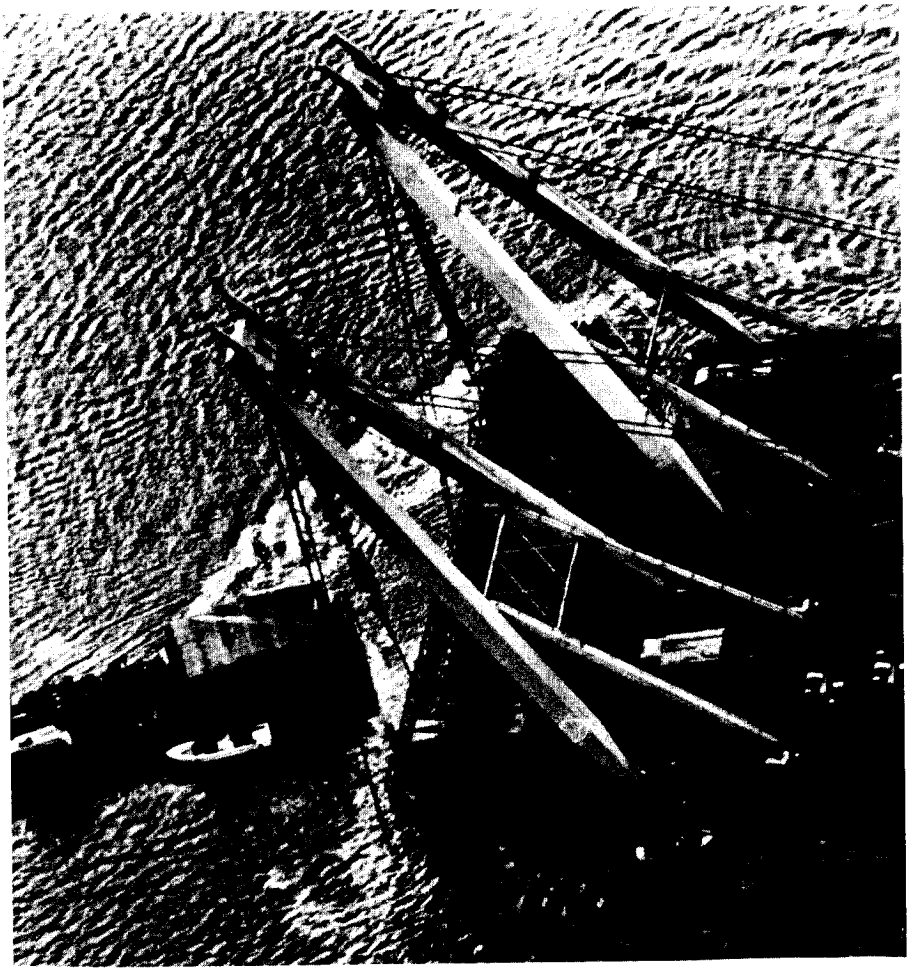
During the salvage survey, the refloating of the 2,000-ton 15 SEPTEMBER had been deemed feasible. THOR and ROLAND would parbuckle it upright, and lift it until the main deck was clear of the water. Then buoyancy could be established by dewatering the hull until the dredge was afloat.

On 25 September, accompanied by an SCA 80-ton crane and a diving barge, the trim and rig team arrived to commence preparations for parbuckling and lifting. Due to interruptions by other priorities, this work took two months. THOR and ROLAND arrived on 24 November and were moored perpendicular to the dredge to the west – THOR to the south and ROLAND to the north.

On 25 November, the trim and rig team, working with the crane crews, began recovering messenger wires that had been rigged previously, and running messengers for the remaining lift wires required. On 30 November, parbuckling required just 27 minutes but the parbuckling force of 950 tons had caused minor damage to the hull of the dredge. THOR's starboard wire cut 3 feet into the deck and port side gunwale. Four additional lift wires and chafing plates were rigged, and lifting operations commenced shortly after noon on 2 December. After application of 1,600 tons of lift, THOR's and ROLAND's main hooks and gin tackle lifted the dredge off the bottom. As the hull was raised above the surface, buoyant lift progressively was lost and the amount of lifting force had to be increased. Continuous lightening of the wreck became necessary for further lifting. Remaining silt and debris were washed out of each deck as it surfaced, and drain holes were burned when natural drainage did not exist. Then, with application of maximum load on THOR and 10-percent overload on ROLAND, 15 SEPTEMBER was raised until the main deck was 5 feet out of the water forward and 5 feet beneath the surface aft. It became evident that additional buoyancy would be required to surface the remainder of the main deck to pump out the hull.

STACKS OF DREDGE 15 SEPTEMBER APPEAR

Workers in small craft inspect, as the heavy lift cranes THOR and ROLAND raise the dredge.



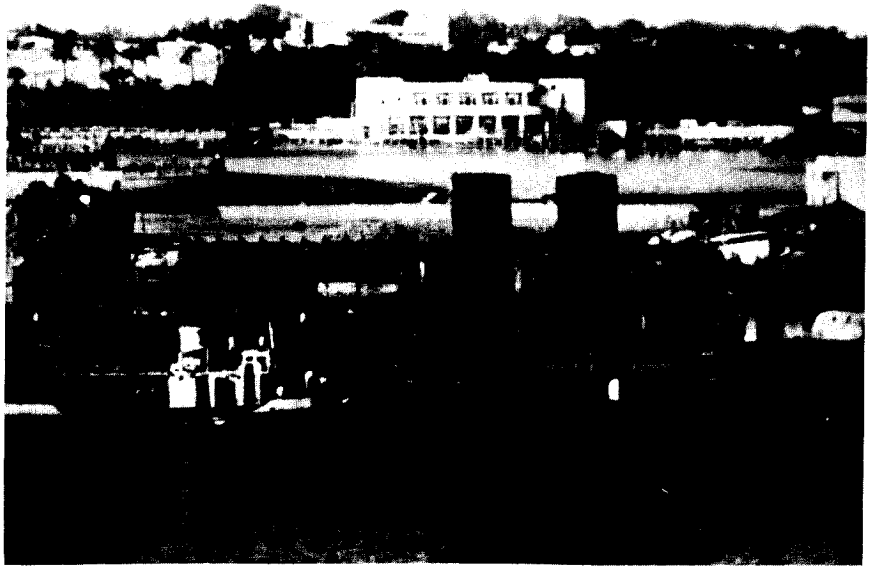
15 SEPTEMBER'S MAIN DECK HELD CLEAR OF SURFACE

With the dredge still suspended by the heavy lift cranes THOR and ROLAND, pumping is carried on continuously to maintain buoyancy.

The after ballast tanks were patched and blown for more buoyancy, but numerous leaks detracted from this measure. Pumping was undertaken, with the bulkheads of the main deckhouse as a cofferdam, using one 6-inch, nine 3-inch, and several small submersible pumps. Care was taken during the dewatering to prevent shifting the center of gravity of the suspended wreck toward the already overloaded ROLAND, and pumping was concentrated aft to trim the wreck and lighten the load on ROLAND. With the dredge still suspended by THOR and ROLAND, pumping continued until the 15 SEPTEMBER was afloat. The following day, 15 SEPTEMBER was taken under tow by the German tug BUGSIER 26, with THOR trailing astern holding the 200-ton ladder off the bottom. After an uneventful 22-kilometer tow up the canal, 15 SEPTEMBER was delivered to the SCA yard in Ismailia at dusk on 6 December.

DREDGE 15 SEPTEMBER IS TOWED TO REPAIR YARD

The dredge was towed, partially supported by the crane THOR, to Ismailia for repairs.

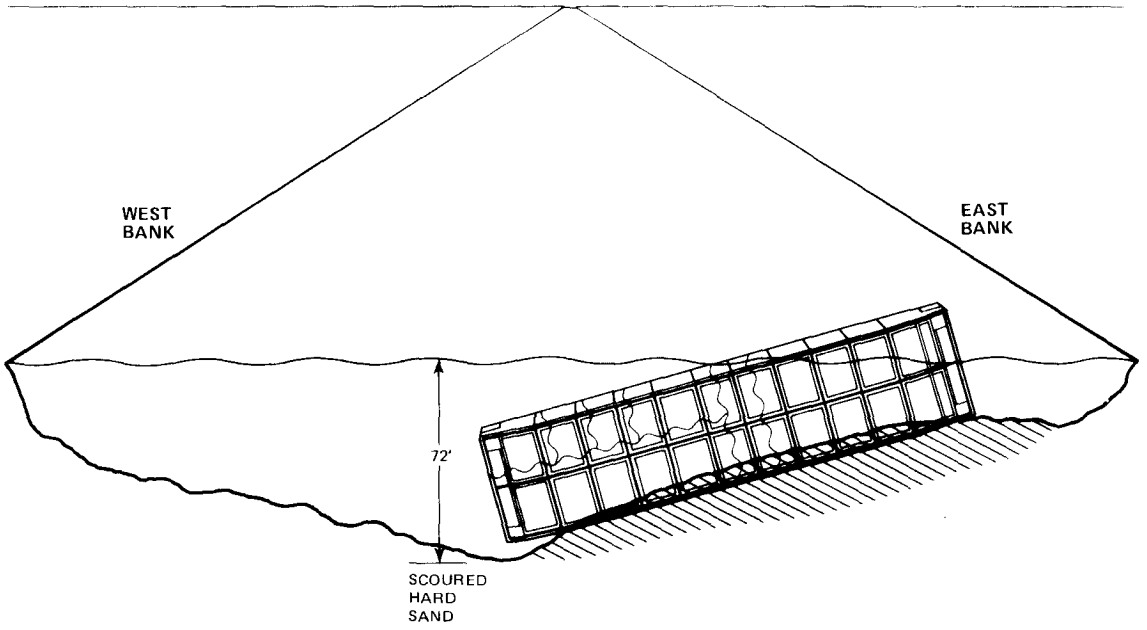


DREDGE 15 SEPTEMBER ARRIVES AT REPAIR YARD

The dredge was delivered to the Suez Canal Authority yard at Ismailia for repairs.

Clearance of the Concrete Caisson

Operations on the 3,800-ton caisson commenced on 30 August when the trim and rig team, aided by the crane barge BAYOUMI, arrived and began a second survey. This revealed that there was more additional damage than identified earlier. A crack originally 2 inches wide had opened up to 8 inches. In addition, it appeared that explosive charges, probably for fish killing by fishermen, had been detonated alongside since the survey 48 days earlier. These explosives had created a 12-foot-diameter hole in one end and a 5-foot-diameter hole in the other, and coupled with stresses on the cantilevered western end, had opened the crack amidships. The additional damage did not preclude the original salvage plan of sectioning and lifting.



POSITION OF CONCRETE CAISSON AT KILOMETER 87

This 3,800-ton craft was removed after sectioning by the heavy lift craft CRANDALL and CRILLEY. The concrete was severed by explosive charges, and the reinforcement bar by oxyarc cutting.

The caisson was cut by shattering the concrete with explosive charges, and finishing by oxyarc cutting of reinforcing bars (rebar). Four linear-shaped charges, packed with C-4 explosive at 3 pounds per foot, effectively cut the lower side. Silt removal in the western end of the caisson, using a 10-inch air lift, was completed on 10 October. Silt in the eastern end was removed several weeks later just prior to lift of that section.

On 11 October, the YHLCs CRANDALL and CRILLEY moved into position alongside the western end of the caisson – CRANDALL to the north and CRILLEY to the south, bows westward. Previously rigged messenger wires were taken aboard, pulling of the heavy lift wires commenced, and by 16 October, the 20 3-inch heavy lift wires had been pulled under the wreck with some difficulty. The following morning, 45-foot spreaders were rigged between the YHLCs and they were ballasted down, both to check the vertical clearance over the wreck and to commence pinning down the lift wires. Meanwhile the condition of the caisson changed dramatically for the worst overnight when the western end dropped 7 feet into a depression in the canal's bottom. The increase of the maximum draft to 72 feet now seemed to preclude the lift planned, and on 19 October, CRANDALL and CRILLEY unrigged, leaving the messengers in place, to proceed to other operations while the western end of the caisson was lightened.

Lightening the western end required severing and removing the upper compartment. All explosive charge cutting was done from the outside so divers would not have to risk working inside a badly cracked concrete structure. The removal of five sections, totaling about 550 tons, required cutting 514 linear feet of reinforced concrete. This used 500 pounds of C-4 explosive; 258 pounds of burning rod, and 185 hours of diving time during an 18-day period.

The lower portion of the western end had been lightened to an estimated 900 tons and could be stern lifted by the two YHLCs operating together. On 12 November, CRANDALL and CRILLEY moored stern-to on the western section of the caisson, bows to the south. Using messengers rigged for the earlier side-lift attempt, four 3-inch wires were pulled under the caisson up over the gantry hook rollers. They were then pulled back under the caisson again, and up to the deck tackle. Rigging, proceeding slowly as each wire was fought under the wreck, was completed on 17 November. A side lift was used to preclude a potentially disastrous unintentional grounding en route to the dump area. With the first lift attempt on the morning of 21 November, the east end of the section would not come free. Divers cleared rubble and on the second attempt, the section was lifted from the depression and moved about 65 feet southward, then was lowered to the canal's bottom in 51 feet of water. When the section was lifted on the following morning, two strands of one wire parted and the section had to be returned to the bottom.

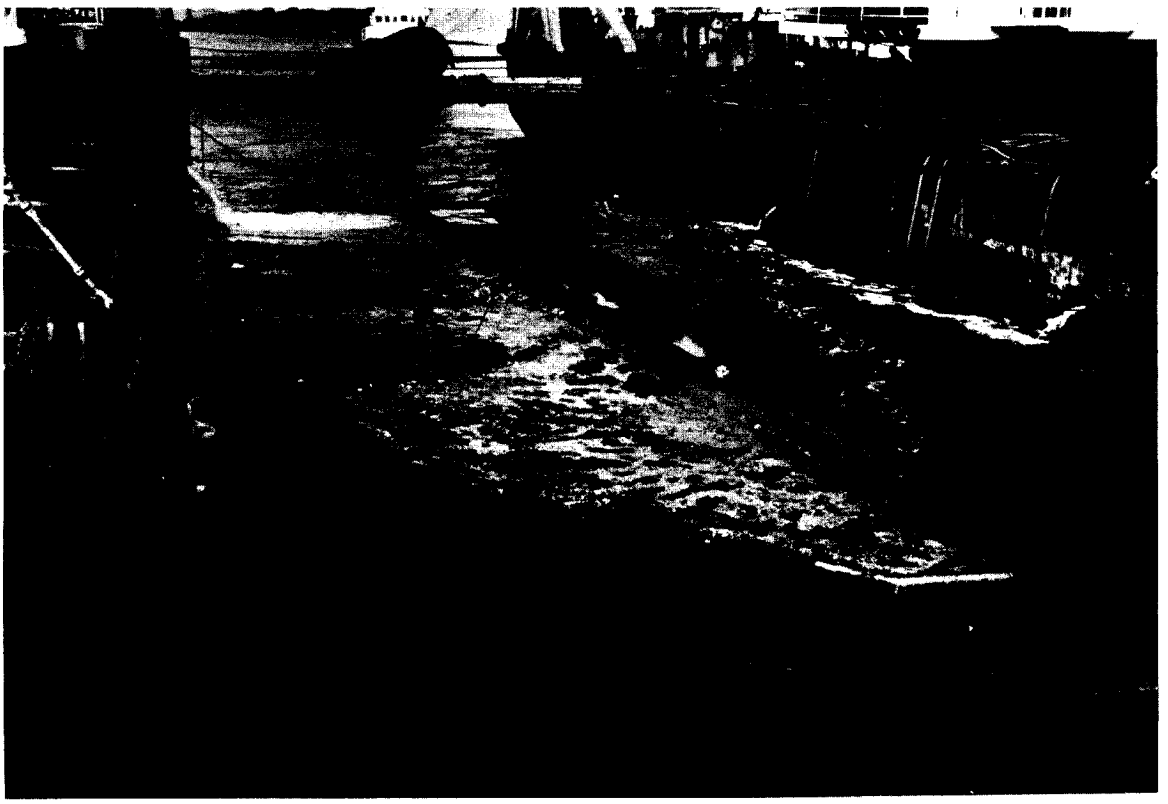
SIDE LIFT BRINGS CONCRETE CAISSON TO SURFACE

YHLC is pumping ballast to raise the lightened caisson.

CRANDALL and CRILLEY began rigging for side lift of the eastern section on 26 November. The first lift, made on 30 November, was successful although some wires appeared to be damaged by the sharp concrete corners. To be safe, the caisson was set down to remove approximately 150 tons of mud, to pass two additional pairs of wires, and to improve the position and lead of another pair. A second lift was made on 5 December, when the section was twisted and grounded to take advantage of a natural rise on the bottom. A third lift was made on the morning of 8 December, and the wreck, with a 48-foot draft, was grounded near the Deversoir causeway. Since this shoal area had been cleared for a 44-foot tow in September (MONGUED), careful examination of the bottom was again undertaken

to avoid any difficulty. Large rocks were removed by divers and a crane, and other high spots were lowered by divers to achieve a 47-foot clearance. Since the next lift reduced the draft to only 45 feet, on 10 December, the causeway remains were crossed without difficulty. The section then grounded a kilometer from the dumping ground in Great Bitter Lake, and had to be lifted one more time before being deposited in the dump area.

After an unsuccessful attempt to use the heavy lift crane THOR to raise the eastern section of the caisson, the YHLCs CRANDALL and CRILLEY returned to the western section on 14 December, and began passing six pairs of heavy lift wires. Rigging and first lift on 18 December proceeded without difficulty. A second lift was made to the top of the causeway spoil at Deversoir the morning of 19 December, and a third lift to just short of the dump area that afternoon. Final dumping of the western section of the caisson at 1730 local time on 19 December marked the completion of ship salvage and clearance operations in the Suez Canal, the removal of all wrecks from the Northern and Southern Zones having been completed earlier.



CLOSE-UP OF CONCRETE CAISSON

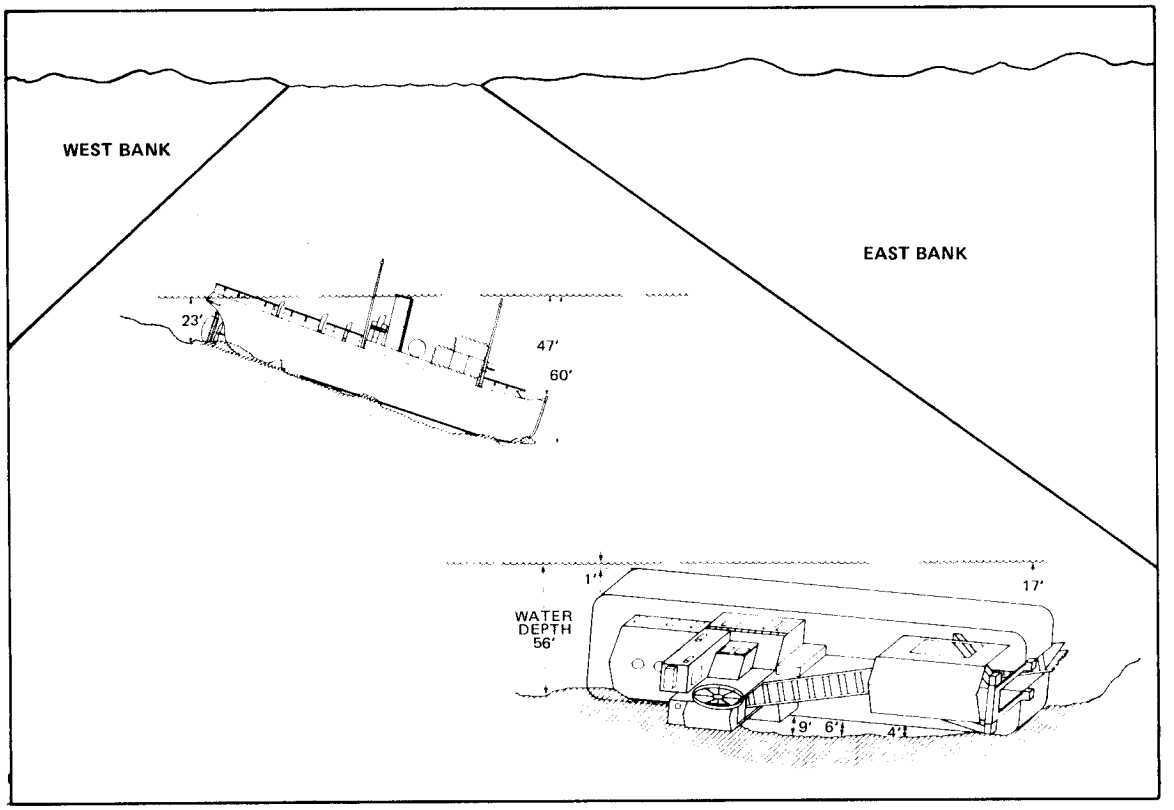
Caisson is held at surface by the YHLCs. Holes in caisson are readily visible.

CLEARANCE OPERATIONS

SOUTHERN ZONE

Clearance of the DREDGE 22

DREDGE 22, displacing 1,200 tons, lay bottomed on its starboard side, approximately 22° past horizontal. Its position was perpendicular to the canal centerline with the bow 144 feet from the east bank and the stern 150 feet from the west bank, in an average depth of 52 feet. The hull was in poor condition from rusting and possessed numerous holes in the turn of the bilges to both port and starboard. In addition, sections of the main deck had been blown open and were rusted through, and the shelter deck had been carried away, leaving only steel framing.

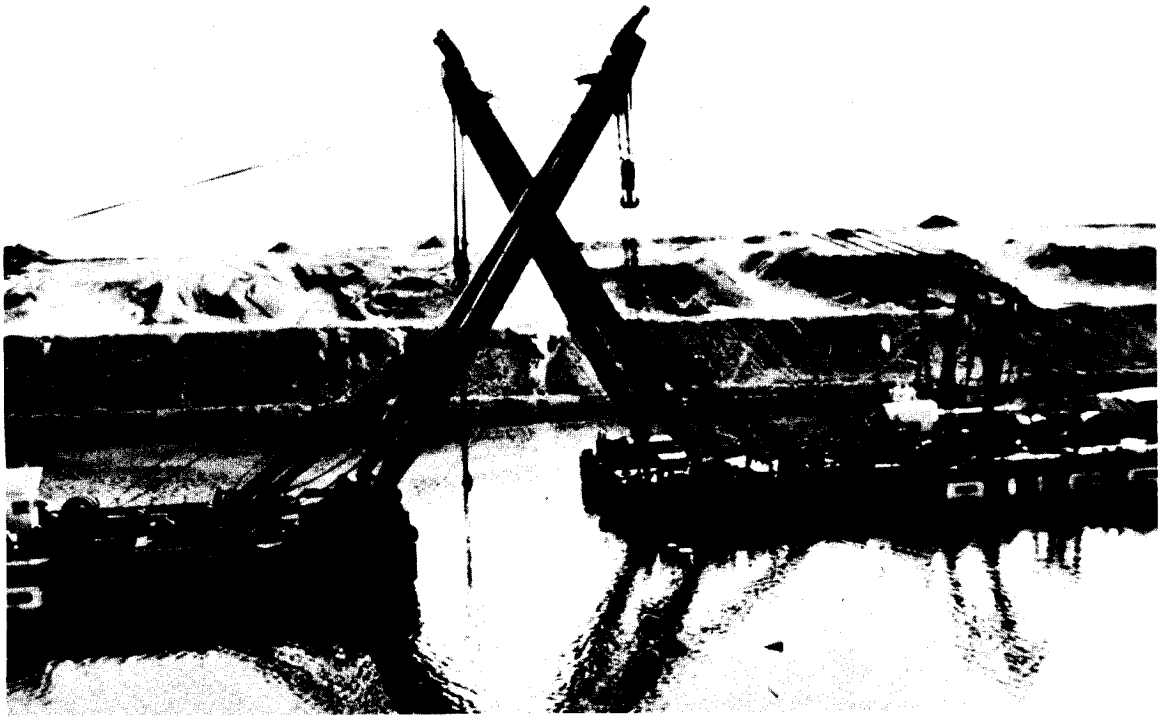


POSITIONS OF BARREH AND DREDGE 22 AT KILOMETER 158

Despite the problems of interference due to close proximity and strong tidal currents, BARREH and DREDGE 22 were removed by the heavy lift cranes THOR and ROLAND, after trimming away superstructure and parbuckling DREDGE 22 to an upright position.

Dredge buckets and ladder were removed during the period of 15 to 22 October, and was the most difficult and time-consuming part of the trimming operation. The removal of the dredge's fenders, primarily with oxyarc cutting as well as some blasting with shaped charges and primacord, also took place at this time. Silting of DREDGE 22 was not significant. After the trimming work, ROLAND and THOR moored over DREDGE 22 and on 23 October commenced passing parbuckling wires under her. In addition, bolsters were fitted to the turn of the bilges and to the deck edges to prevent crushing the hull. THOR and ROLAND then completed the parbuckling operation expeditiously and without incident on 27 October.

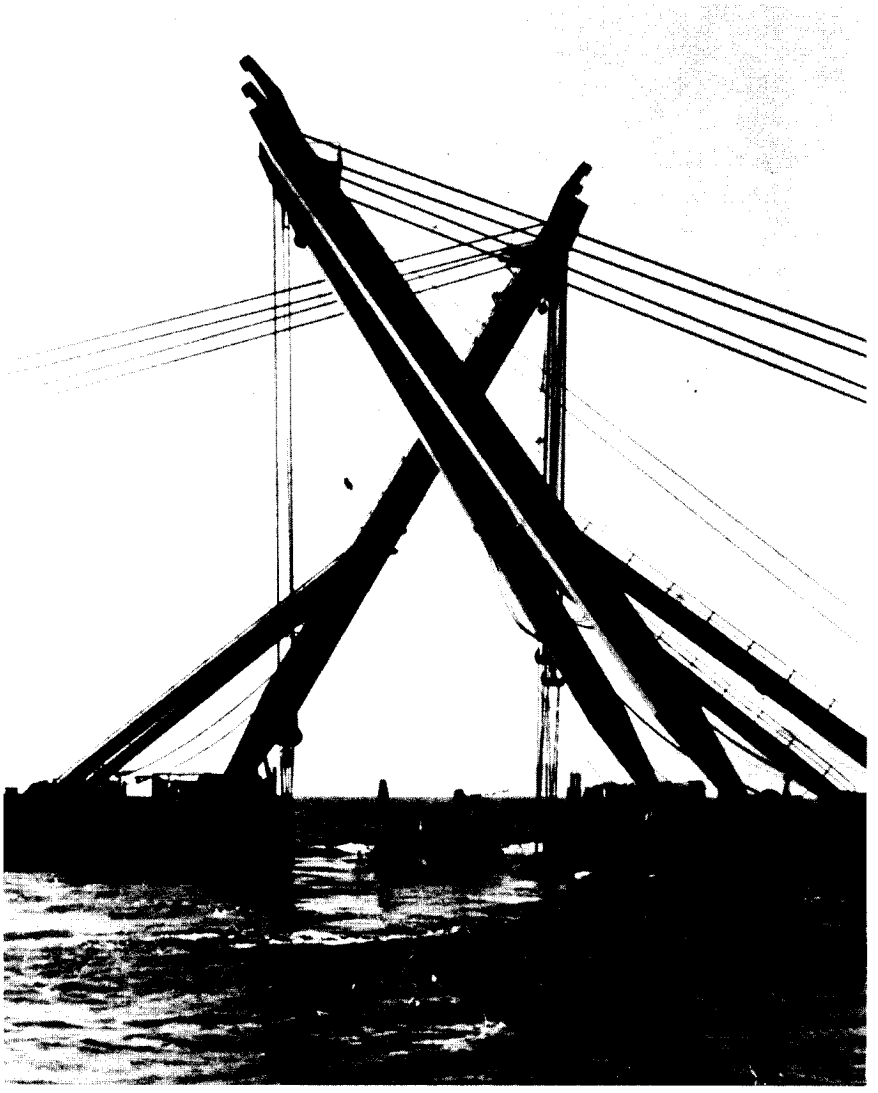
After parbuckling, it was discovered that a 3/8-inch-thick by 4-foot-long steel bolster at the turn of the bilge had been crushed into the hull approximately 4 feet. Precautions were taken to distribute the lifting loads over an even wider area by constructing larger bolsters of 3/8-inch plate stiffened with five sections of railroad rails welded to the plate. Two such bolsters 20 feet long were fitted on each side at the stern, and two similar 33-foot bolsters were fitted to the bow.



PARBUCKLING DREDGE 22

Parbuckling was readily accomplished by the heavy lift cranes THOR and ROLAND working in concert. It did, however, result in some crushing of DREDGE 22's rust-weakened hull.

THOR and ROLAND were then moored in position and heavy lift wires were rigged, using two SCA barges. Two of the parbuckling wires could be used as lift wires, but two more had to be repositioned, one of which required 4 days for divers to tunnel through sandstone under the hull. Positions were jetted out of the bottom on each side of the hull to be able to place four bolsters at the turn of the bilge for protection against lift wires. Using the main hook and gin tackle, ROLAND and THOR commenced lifting on the ebb tide on the morning of 4 November, lifted the dredge to the water's edge, and transported her to the wet dump area south of the southern entrance to the canal on Suez Bay.



DREDGE 22'S SUPERSTRUCTURE SURFACES

Still working in concert, THOR and ROLAND raise DREDGE 22 to the surface prior to towing the remains to the wet dump in Suez Bay.

Clearance of the Tug BARREH

The 1,200-ton tug BARREH, 165 feet long, lay diagonal to the canal centerline, with a 10° port list, its stern 100 feet from the west bank.

The hull was sound, although the stack and the superstructure above the 01 level had fallen to port, the wheelhouse lay detached on the canal bottom, and eight portholes were broken, open, or missing. The hull was silted to a depth of 4 feet in the engine room, and to 3 feet in the boatswain locker aft of the engine room.

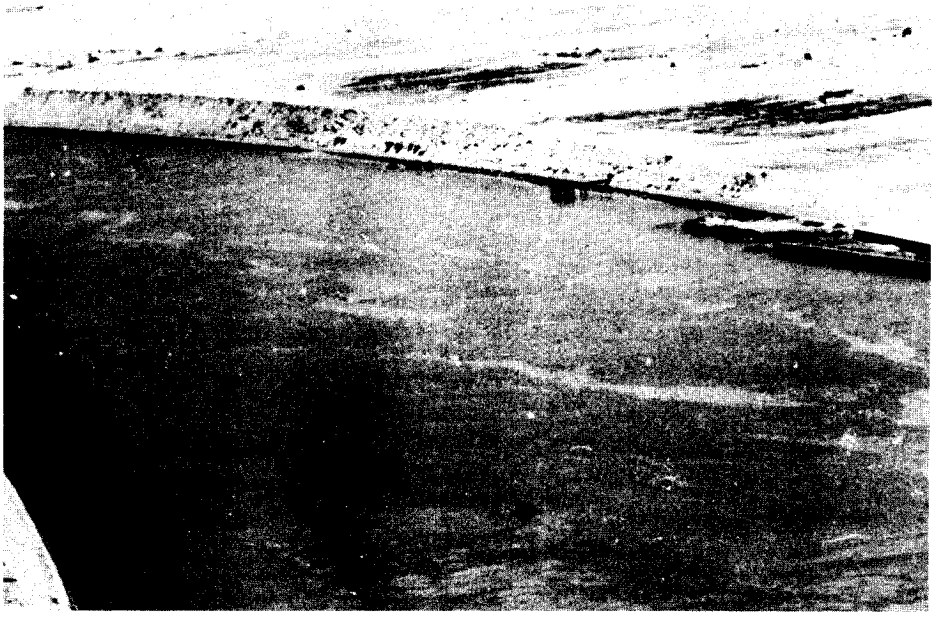
The SCA crane and diving barge were moored in a four-point moor over BARREH on 6 October, and trim and rig operations began. BARREH, on an inclined revetment, was moored to the Suez Canal's west bank to prevent her sliding deeper during the salvage operations. BARREH's stack was the first piece lifted to the surface. Loose wreckage on the tug's deck was cleared, anchor chains were cut and removed, and finally the upper bridge structure was lifted on 13 October. At the time of rigging the messenger wires on 8 October, it was considered desirable to be prepared to use either THOR and ROLAND or CRANDALL and CRILLEY to lift the BARREH. The use of the YHLCs required the greatest number of lift wire messengers; therefore, eight messengers for this purpose were passed under the wreck to provide for that alternative.

The silt removal was done between 8 and 13 October. Divers used a 4-inch air lift to clear the after berthing compartment, after which multiple air lift operations commenced. A 6-inch air lift was used in the forward berthing compartment, and a 4-inch air lift in the engine room, with frequent use of a high pressure water jet to break up packed silt. The after boiler room was not cleared because of the suspected presence of undetonated explosives.

On 5 November, THOR and ROLAND moved to the BARREH site and moored alongside each other, over the tug, to port. The wreck was lifted clear of the bottom on 7 November, moved to the center of the canal, and set down. The next morning at slack tide, BARREH was raised and transported to the wet dump area without incident. Both cranes were unrigged and returned to the MAGD salvage site the following morning.

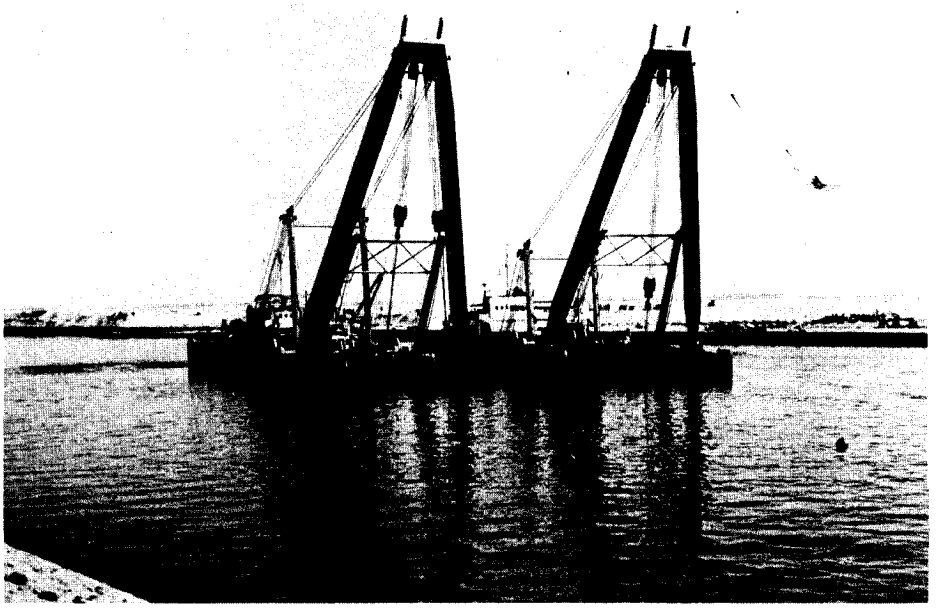
Clearance of the Tanker MAGD

The 2,400-ton tanker MAGD lay on her starboard side, 30° to the canal centerline, with her bow approximately 130 feet from the west bank. In 10 feet of mud on the canal bottom and 14 feet of water clear above it, the hull was in poor condition. Although the



TUG BARREH BOTTOMED

The stern and stack of BARREH are visible protruding above water in the foreground.



TUG BARREH RAISED FOR REMOVAL

The heavy lift cranes THOR and ROLAND moved BARREH to the Suez Bay wet dump.

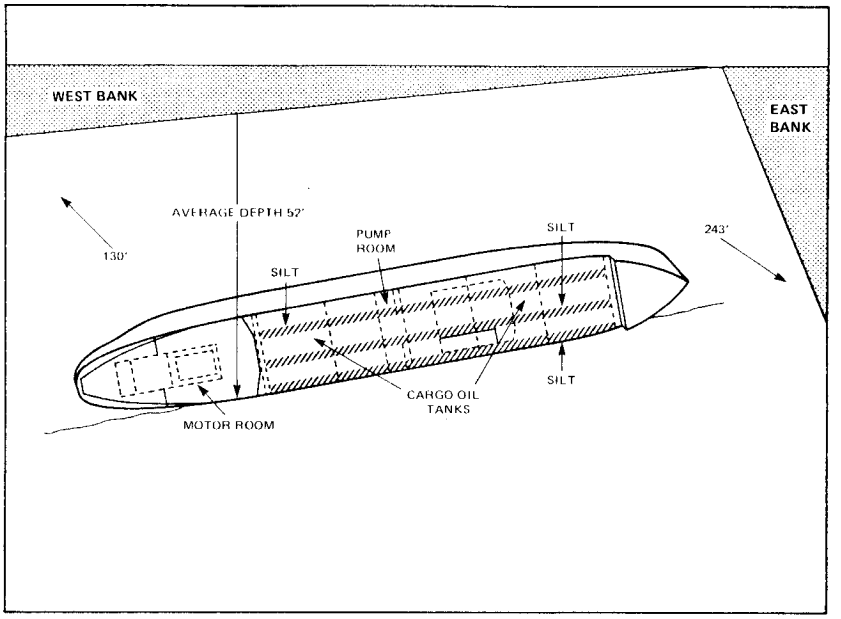
superstructure was intact, cargo tank tops were buckled, plating and rivets were missing, and damage in the tankage was widespread. MAGD was silted to a depth of 2 to 4 feet in the starboard and center tanks, and 4 to 6 feet in the port tanks. Mud was pocketed throughout the engine room in depths varying from 3 to 10 feet.

Salvage of the MAGD was made somewhat complex by the swift tidal currents, the requirement for extensive diving in sectioning the hull, and the need to remove much silt. A decision was made to use cofferdams to give divers protected access to the interior of the hull, where operations could be conducted out of the current. Placement of cofferdams was given top priority and nine cofferdam holes were cut along MAGD's hull.

The procedure for setting a cofferdam consisted of cutting an access opening for the cofferdam on the upward side of the wreck facing the surface (starboard). An additional opening was cut alongside for the air lift. Once the cofferdam was lowered into the starboard tank, the first task was to clear an internal area by air lift to enable the cofferdam to be further lowered into the centerline tank. After silt removal from the engine room, cofferdams were pulled out and moved forward to the next station along MAGD's hull. At each station, divers generally started removing silt in the starboard tank, and moved downward (athwartships) to the port tank. Silt removal operations were completed on 12 November.

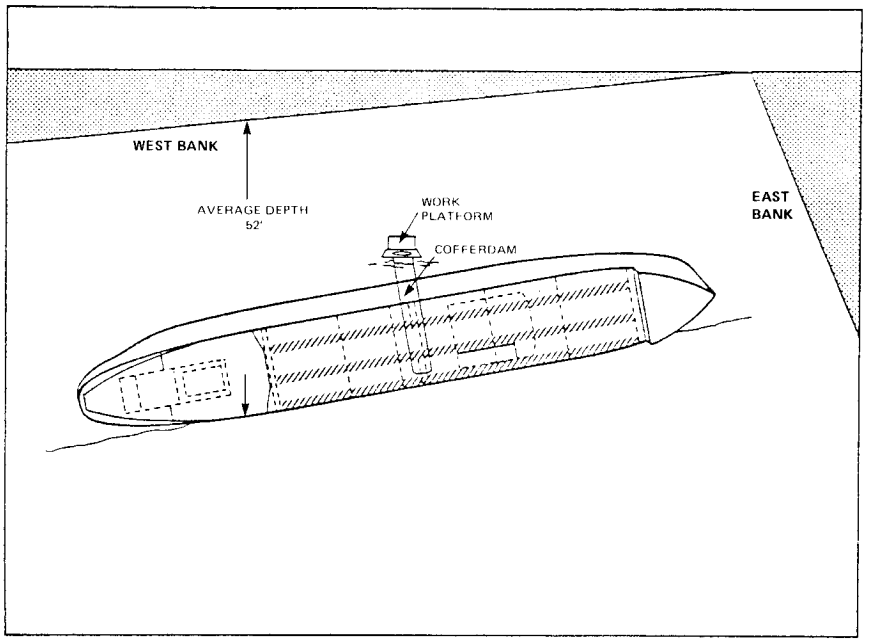
After the cofferdam had been placed and the silt removed for the single cut at frame 43, cutting operations commenced. Oxyarc was used exclusively, with the exception of heavy-duty primacord used to clear scale and marine growth from the cut line along the starboard (or upward) side.

Sectioning the hull actually commenced on 25 October. The main deck cut was completed on 31 October. The starboard side was kept intact until 7 November to permit placing the parbuckling and lifting wire messengers. When this side was finally cut through, the stern section slid approximately 15 feet southward away from the rest of the hull, rolled 12° toward the vertical, and its forward end lifted 6 feet off the bottom. On 9 November, THOR and ROLAND prepared to parbuckle the stern section with the port list now reduced to 78°. THOR rigged for deck tackle and maneuvered into position over the forward end, while ROLAND moored over the stern. From THOR, 3-inch straps were rigged over bow rollers down across the deck of MAGD, under the port side, around the keel, and up the sloping starboard side to parbuckling hooks rigged at the deck edge. From ROLAND, a parbuckling wire was brought from her port hook, and rigged to MAGD in the same manner as THOR. Parbuckling was carried out on 10 November after 27 minutes of pulling effort. Upon completion, the stern section was upright with approximately 15 feet of stack above water.



POSITION OF TANKER MAGD AT KILOMETER 157

MAGD lay on her starboard side just east of midchannel, pointed 30° west of midchannel. She had collected heavy deposits of silt on the starboard bulkheads of all her tanks as a result of lying on her side in the extremely muddy water.



COFFERDAM INSTALLATION

Cofferdams were installed on MAGD's upward-facing port side to facilitate diving operations inside her hull.

COFFERDAMS RIGGED ON MAGD'S HULL

Cofferdams have been positioned at two places on MAGD's port side and the work barge for diving is alongside.

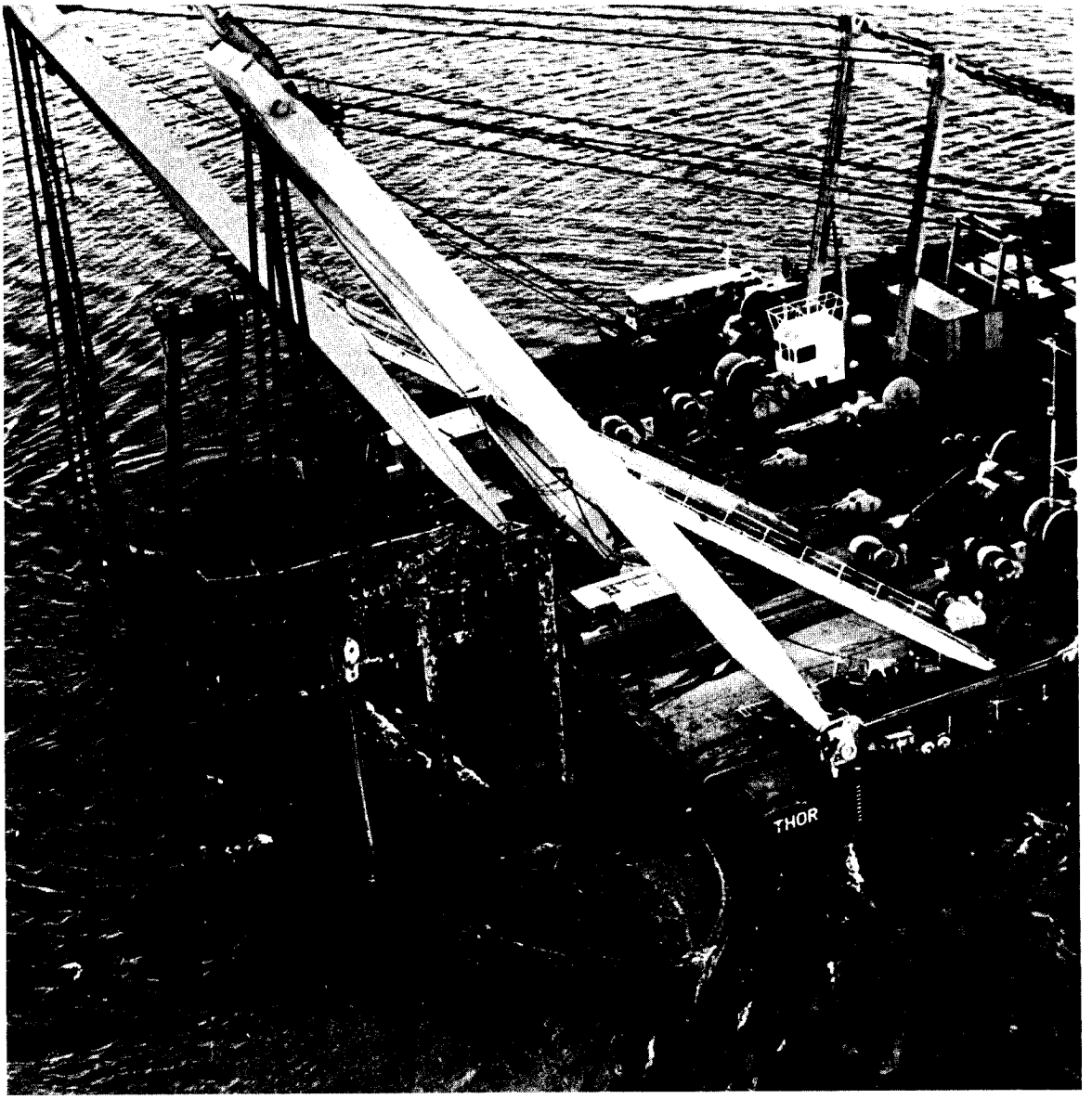
CLOSE-UP OF COFFERDAM

Workman on platform is tending lines going to diver inside MAGD's hull.

On 11 November, THOR and ROLAND rigged for lift of the stern. ROLAND took position over the after end of the stern, picking up a wire there. THOR, a little forward of ROLAND's port bow, picked up the forward edge of the stern. With each craft rigged to lift 1,000 tons, with main hooks and deck tackle working together, the stern section was lifted during the afternoon slack tide. While under tow to the dump site, the wreck grounded near Port Taufiq. The outboard starboard wire of ROLAND parted with the wire under the wreck. The second wire from ROLAND also parted but was pulled from under the wreck as ROLAND lurched forward. THOR remained attached to the wreck. Both purchase wires on ROLAND's deck gear were crushed when the lift wire parted. A day was spent in rerigging after the damage, rerunning an additional heavy lift wire using a spare messenger still rigged to the stern of MAGD. The section was relifted on 14 November and again put under tow. When THOR and ROLAND set the wreck down for the night, it had rolled slightly toward ROLAND, and on lifting it the next morning, the deck tended to pinch the lift wire on ROLAND. A second lift attempt brought the section up satisfactorily, and it was then towed to the wet dump site south of DREDGE 22.

After depositing the MAGD stern, ROLAND and THOR returned to commence parbuckling MAGD's bow on 16 November. The cranes positioned themselves at the ends of the bow section, THOR to the north and ROLAND to the south, and early on 18 November parbuckling commenced. ROLAND, exerting a force of 500 tons, appeared to be lifting, but THOR, exerting a force of 80 to 120 tons, appeared to be pulling the wire through the hull. After rotating the bow 20°, the parbuckling effort was suspended temporarily. Divers reported that the forward parbuckling wire from THOR was bearing against the forecastle deck, had cut through that deck completely, and through all but 10 feet of the main deck. It was decided to add an additional parbuckling wire and hook forward, and also retain the existing hook, but to move the wire forward of the cut. On 20 November, the parbuckling effort began once more and the bow section was righted properly.

Lifting preparations were interrupted to permit the passage of four pilgrim ships with Mecca-bound passengers, the first ships to transit the canal since 1967. Then on 21 November, THOR and ROLAND positioned themselves for lift of the MAGD bow section. The following morning, after the remaining lift wires were passed, THOR applied 600 tons and ROLAND applied 550 tons to lift the section. The two cranes got under way, towed stern first by BUGSIER 26 and MARINER. The wreck was placed back on the bottom in the late afternoon to await a daylight transit to the dump area. Depositing MAGD's bow section in the Suez wet dump area early on 23 November concluded the Southern Zone salvage operations.

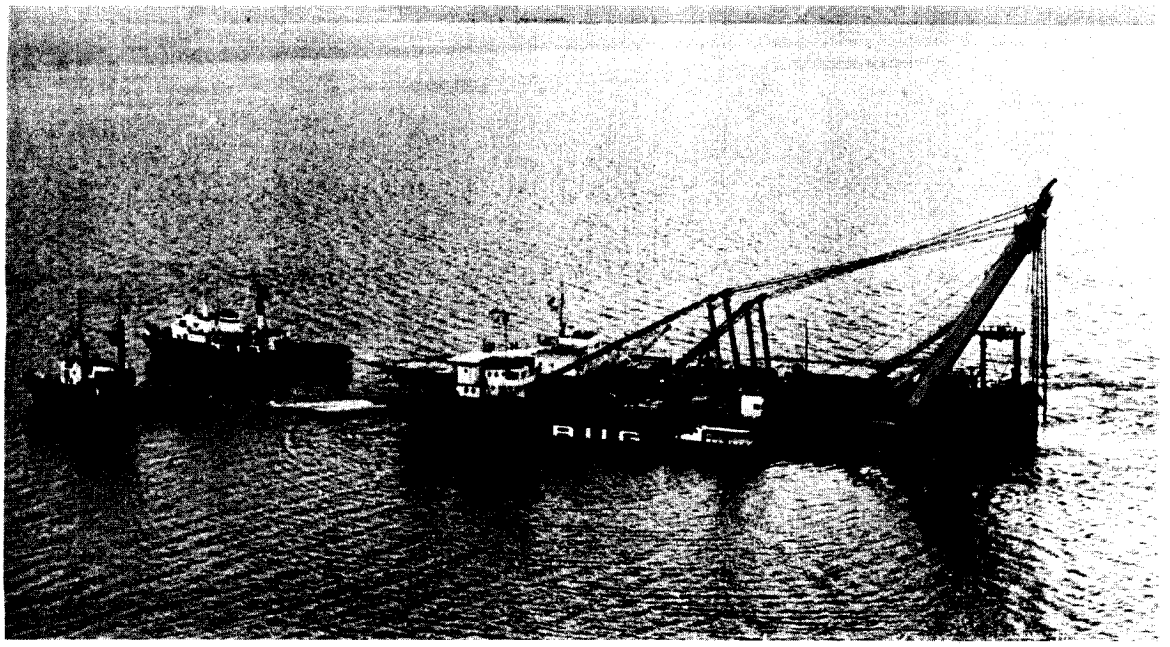


MAGD'S BOW SECTION IS SURFACED

After parbuckling MAGD's bow from its starboard side on bottom to a vertical position, THOR and ROLAND raised it to the surface for towing clear of the channel.

SALVAGE OPERATIONS ENHANCE U.S. RELATIONS

On November 20, pilgrim ships with Mecca-bound passengers were the first to transit the canal. Lifting of the final wreck, the tanker MAGD, was interrupted to permit passage of these travelers, so important to the Moslem world.



TOWING MAGD'S BOW CLEAR

Heavy lift cranes THOR and ROLAND held MAGD's bow suspended while it was being towed by Suez Canal Authority tugs to the Suez Bay wet dump.

NAVY FRIENDS AT THE WORKING LEVEL

Salvage operations in the Suez Canal had an influence at not only the foreign policy level. The traditional friendliness of U.S. personnel actually engaged in salvage work helped undo years of hostile propaganda.

CONCLUSION

The 1974 Suez Canal clearance operation was a complex and arduous undertaking. It was carried out efficiently and rapidly as a consequence of the good planning, skill, and hard work of the agencies engaged. U.S. naval units completed the minesweeping required of the canal's 101 miles in less than a month. U.S. Navy and Army personnel cooperated with Egyptian, British, and French naval and military personnel to remove some 690,000 items of unexploded ordnance from the canal and its shores. Finally, SUPSALV coordinated the efforts of the Murphy Pacific Marine Salvage Company to clear 10 major ship wrecks from the canal's main channel. This task was complicated by extensive scuttling damage and deterioration from long immersion. The work was completed ahead of schedule, in six months time.

Urgency of clearance did not preclude proper attention to safety. No fatalities and only a few serious casualties occurred during all of this dangerous work. Preventive medical measures also were carefully observed by the salvage organization, particularly because of the severe water-associated health problems of the region; such as schistosomiasis (bilharzia), other gastrointestinal parasites, and dysentery. Only minor infection or ill health was observed; however, a notation regarding exposure was put in all health records for diagnostic guidance in the event of subsequent delayed illness.

Perhaps the most important lesson from these operations was the importance of early, accurate, and thorough information. The need to get salvage work under way quickly necessitated some initial dependence on wreck and depth data that unfortunately proved inaccurate. While this is nothing new in salvage, it usefully reemphasizes a basic dependence on effective survey and reporting for efficient planning and conducting of such work.

Finally, it is perhaps not too much to conclude that the effective coordination of salvage is another important role in which the Navy can contribute to U.S. foreign policy. The continuous improvement in U.S. relations with the Middle East, commencing with clearance operations at Suez, can be viewed with both pride and satisfaction by the Navy and the salvage community that coordinated so effectively on this job.

SUMMARY OF

DOWNED AIRCRAFT

SEARCH AND RECOVERY OPERATIONS

IN 1974

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SUMMARY OF

DOWNED AIRCRAFT

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IN 1974

SUMMARY OF DOWNED AIRCRAFT SEARCH AND RECOVERY OPERATIONS IN 1974

INTRODUCTION

Substantial difficulty is involved in the location and recovery of aircraft that have crashed at sea or in large bodies of water. There is frequently a need to determine the cause of the accident quickly. It may involve failure of a structural or mechanical component in a production series, which must be remedied, or in other cases it may indicate problems of overhaul or maintenance that must be corrected. In any event, prompt, efficient recovery without further damage to critical debris is frequently urgent.

For these reasons, the Supervisor of Salvage is charged with providing the necessary direction and support for undertaking such operations for recovery of U.S. military aircraft, and in special cases, for recovery of civil aircraft. The support may consist of complete deployment of all naval and commercial resources to locate and recover the aircraft. In other cases, more limited support, such as a few elements of either location or recovery resources, may suffice. In most cases, the accumulated knowledge and experience of the Office of Supervisor of Salvage, Navy salvage forces, and special commercial expertise are combined as a team for prompt achievement of aircraft recovery.

OPERATION	DATE OF CRASH
Search and Recovery of U.S. Navy RA-5C Aircraft off Key West, Florida	5 March
Search and Recovery of U.S. Marine Corps F-4J Aircraft from Subic Bay, Philippine Republic	4 June
Recovery of U.S. Air Force F-106 Aircraft from Lake Superior	13 June
Search and Recovery of U.S. Navy A-7E Aircraft off Naval Air Station, Mayport, Florida	14 July
Search and Recovery of U.S. Navy RA-5C Aircraft from Gulf of Mexico, off Naples, Florida	13 August
Recovery of U.S. Marine Corps F-4B Aircraft from Japanese Inland Sea	19 October

SEARCH AND RECOVERY OF U.S. NAVY RA-5C AIRCRAFT OFF KEY WEST, FLORIDA

Date: 5 March 1974
Location: 35 miles west, off Key West, Florida
Condition: Wreckage in 24 feet of water
Task: Search and Recovery

Background

During the morning of 5 March, an RA-5C attached to squadron VAH-3, NAS, Key West, Florida, experienced an engine and hydraulic power failure and crashed into the Gulf of Mexico about 35 miles west of Key West.

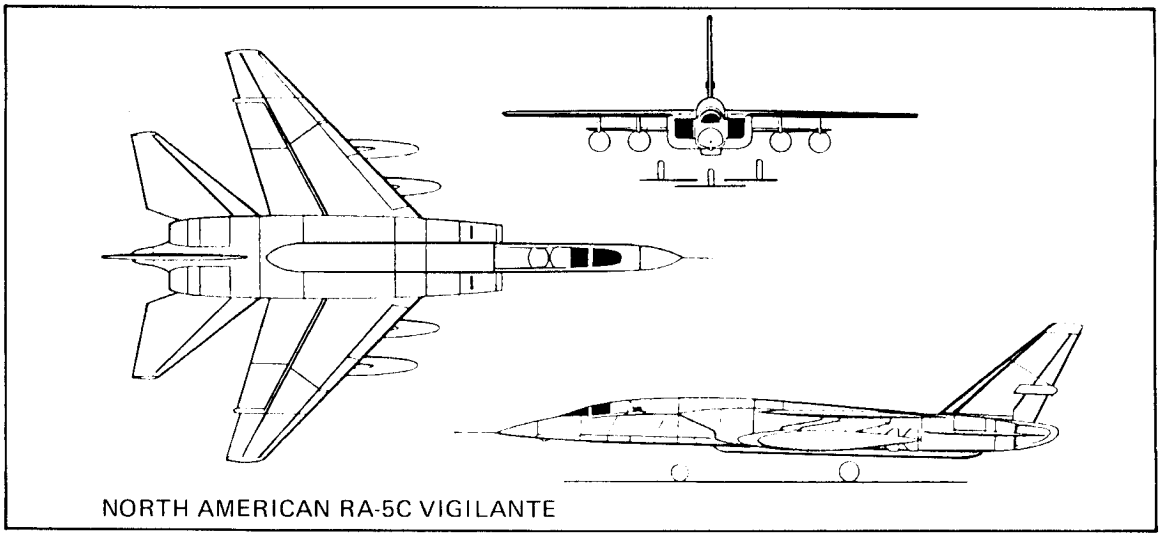
The pilot initiated the ejection of both crew members at an altitude of about 10,000 feet. Fishermen on shrimp boats anchored nearby saw two parachutes descend. However, only the rear seat crewman was recovered. Navy and Coast Guard Search and Recovery (SAR) aircraft and boats searched the area in an unsuccessful attempt to locate the pilot. Ten days later, the pilot's body was sighted floating in the area by a fishing vessel and was recovered during the search for the aircraft wreckage.

Several fishing vessels anchored in the vicinity of New Ground shoal saw the aircraft crash. A Navy SAR helicopter was dispatched at the time of the crash and arrived on scene about one-half hour later. Despite the shallow water, no wreckage was sighted.

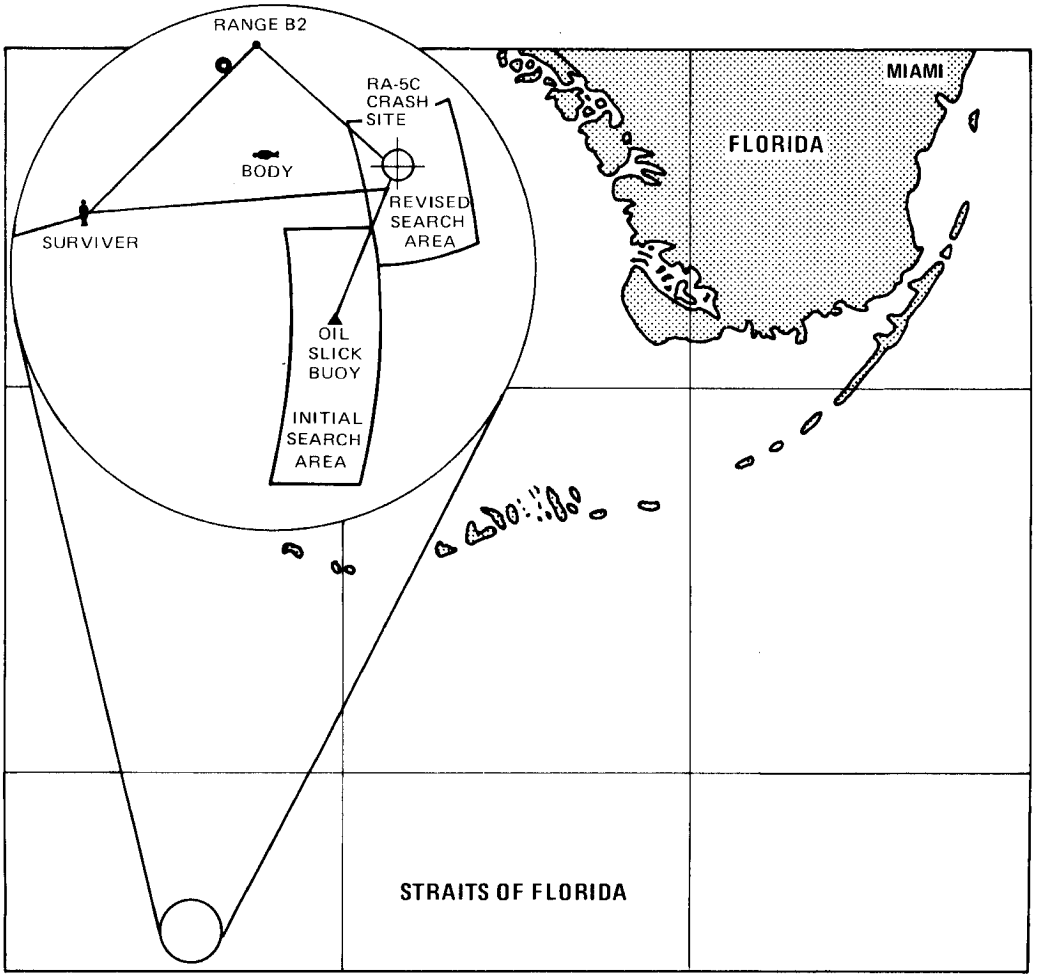
The Navy SAR helicopter placed a buoy in an oil slick in the vicinity of the crash site. It was initially reported that this buoy was set within one-half hour after the crash. Later it was learned that the buoy had not been deployed until two to three hours later – after the slick had drifted over two miles from the point of impact (see map).

Planning the Search

The Supervisor of Salvage (SUPSALV) was notified of the crash on the afternoon of 5 March, and was requested to provide assistance in the search and recovery of the aircraft.



NORTH AMERICAN RA-5C VIGILANTE



LOCATION OF NAVY RA-5C AIRCRAFT LOST OFF KEY WEST

ALCOA Marine Corporation, a SUPSALV prime contractor for search and recovery matters, and its subcontractor Seaward, Inc. were tasked with the job that evening. Mobilization of search equipment and personnel was completed in Key West by 1700 on 7 March.

Precision navigation reference stations were set up on Rebecca Shoal Light, nine miles west of the buoy, and on a boat anchored adjacent to the New Ground shoal navigation buoy. The search was conducted from a 40-foot aviation rescue boat (AVR) belonging to NAS, Key West. A high speed, turbine powered reconnaissance swimmer landing craft (LCSR) belonging to the Naval Air Development Center (NADC) field unit at Key West was used for the 40-mile transit to the search area. Later in the search, a private party fishing boat was chartered and anchored near the search area to provide both hotel services and a platform for the precision navigation station, eliminating the time-consuming transit. A helicopter was used to ferry the navigation system operator and batteries to Rebecca Shoal Light each day.

Conducting the Search

Navy explosive ordnance demolition (EOD) divers from Key West searched the area around the oil slick marker buoy on 6 March without success. On 7 March, a side-scan sonar search was made in the vicinity of this buoy, again with negative results. Since the marker buoy was believed to have been set in the source of the oil slick, a square search area centered on this buoy was selected.

After a week of searching, it was established that both the position of the oil slick marker buoy and the position of the Coast Guard aid-to-navigation buoy marking New Ground shoal were in doubt. This information, when combined with newly acquired observations from shrimpers who witnessed the crash, led to the selection of a new search area to the northeast and operations were shifted on 14 March. The aircraft wreckage was located by the high resolution, side-looking sonar, and was positively identified on 16 March in 24 feet of water, at longitude 24°37.02'N, latitude 82°23.36'W. The search team was demobilized and returned to their respective bases of operation on 17 March.

Planning the Recovery

Plans were then put into effect to load an NAS mobile crane and 1,000 gallons of fresh water into a LCM-8, borrowed from the NADC field unit, to retrieve and wash down the pieces of wreckage. At a late evening briefing, it was determined that the fleet ocean tug USS ATAKAPA (ATF-149) was remaining overnight in the Key West area. This vessel was

far better suited for the recovery operation than the LCM, and its services were obtained. ATAKAPA proceeded to the site and in less than 3 days had recovered 85 to 90 percent of the wreckage.

Conducting the Recovery

For the actual recovery work, the NADC turbine boat first transported the EOD divers to the site of the wreckage buoy to determine the disposition of wreckage. Cargo nets were used by the divers and smaller pieces of the aircraft were picked up, netted, and secured to the larger wreckage pieces for pickup by crane. This work involved six divers who conducted 24 dives totaling 24 hours bottom time.

On 20 March, the NADC LCM-8 was dispatched to the recovery site for transfer of the wreckage from the fantail of the ATAKAPA to the LCM-8. The LCM returned to the NADC pier with the wreckage that evening. The next day, the LCM transferred the wreckage to the pier for offloading by the NAS riggers.

Conclusion

This accident and search illustrate the need for careful collection and analysis of all data relating to a crash location. Nearly a week of search effort was wasted because of the following factors:

- The New Ground lighted buoy was located 1.25 miles from charted position. Eyewitnesses stated their positions relative to this buoy.
- The failure of the Accident Board to get full and complete statements from all the fishermen who witnessed the crash.
- The failure of the helicopter crew to buoy the oil slick when first sighted, and their failure to log the time when the buoy finally was placed in the oil slick.

The search effort required to locate the aircraft wreckage probably would have been greatly reduced had the plane been equipped with a salt water activated sonar marker beacon. Such beacons are commercially available and their cost for installation on Navy training and experimental aircraft should be considered against the cost and importance of search and recovery.

SEARCH AND RECOVERY OF U.S. MARINE CORPS F-4J AIRCRAFT FROM SUBIC BAY, PHILIPPINE REPUBLIC

Date: 4 June 1974
Location: Subic Bay, Philippine Republic
Condition: Wreckage in 132 feet of water
Task: Search and Recovery

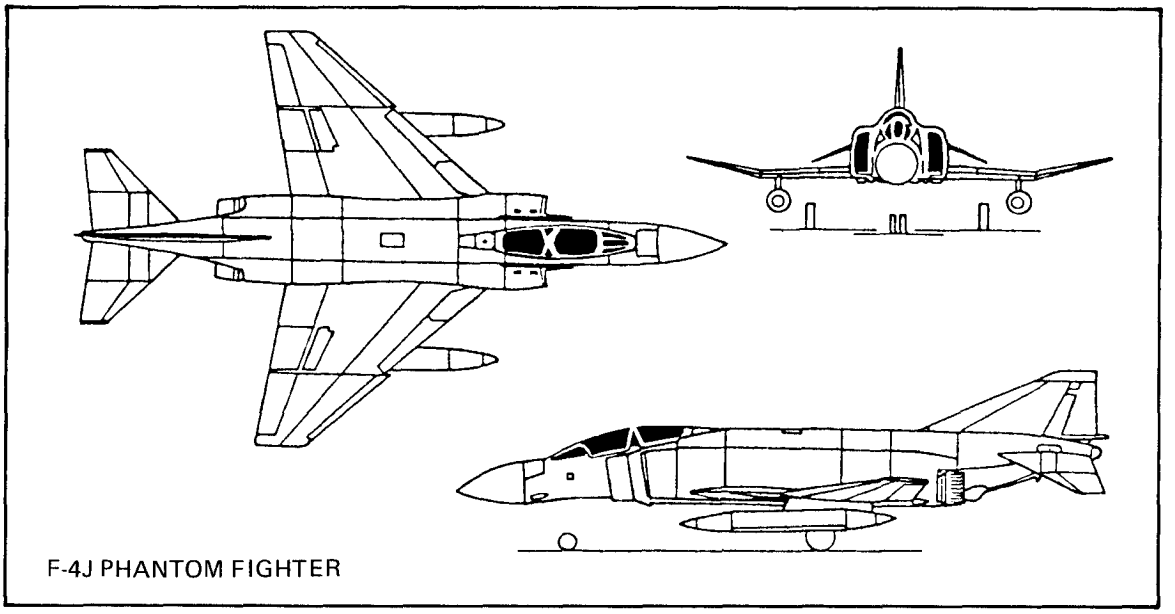
Background

On 4 June, a U.S. Marine Corps F-4J fighter aircraft crashed into the waters of Subic Bay. Both the pilot and the radar observer ejected safely and were picked up shortly thereafter.

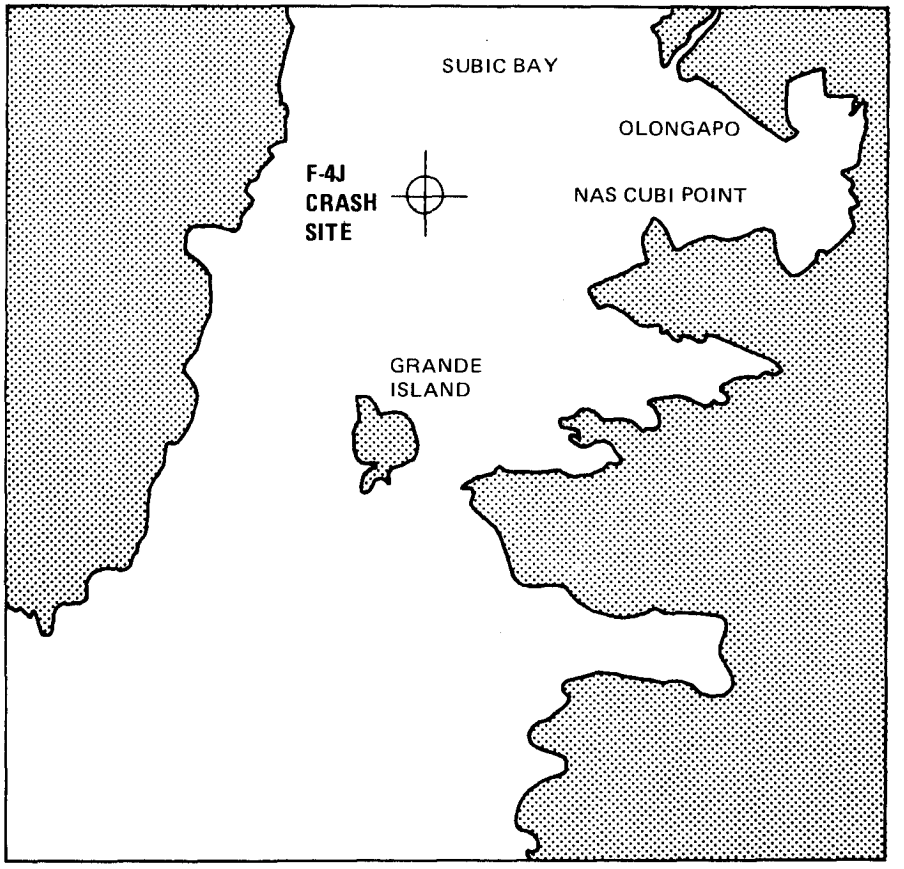
Eyewitnesses to the crash placed the impact point within the fleet anchorages on the west side of Subic Bay (see map). Oil slicks were sighted on the surface, and location efforts were initiated on 6 June, using U.S. Naval Base, Subic assets plus the submarine rescue ship USS COUCAL (ASR-8) and salvage ship USS GRASP (ARS-24).

Planning the Search

The aircraft was originally reported floating intact for a "few minutes," then sinking in fleet anchorage C-9. The craft master who recovered the pilot and RCO said he marked the wreckage using a life jacket as a buoy, but this was never found. A reported position was received from two airmen who took visual sight lines on the crash from opposite ends of the runway at NAS, Cubi Point. Upon being notified that GRASP was being considered for a search and recovery operation, GRASP divers proceeded to buoy the two ends and center of an elongated oil slick in the Charlie anchorage area. Since none of the reported crash site positions coincided, it was decided the entire Charlie anchorage (approximately a one by one and a half mile area) would have to be searched. The charted water depth was 22 fathoms. In view of the relatively large area to be searched, a drag was implemented to cover the area more quickly than possible with divers alone.



F-4J PHANTOM FIGHTER



LOCATION OF MARINE CORPS F-4J AIRCRAFT LOST IN SUBIC BAY ANCHORAGE AREA

On the morning of 8 June, GRASP anchored in the vicinity of the reported crash site and commenced dragging. Two workboats were rigged with a drag spring-wire between them. USS COUCAL (ASR-8) was in port at Subic for salvage and diver training. Although not officially assigned to the operation, she assisted by dragging with two of her boats and providing divers to check drag snags while GRASP divers were diving with Kirby-Morgan Bandmask (KMB-9) equipment.

Two helicopters from Helicopter Squadron FOUR searched briefly with dipping sonar. Both workboats were rigged to buoy and release their drag line, and to proceed to buoy any positions marked by helo smoke flares. This effort was short lived when the helos were required for another commitment.

These first search efforts, consisting of bottom-dragging and helo-towed sonar, were conducted from 6 to 8 June, during which time the tail section of the F-4J was snagged and recovered. Diver searching and dragging continued through 15 June when it was interrupted for 3 days by tropical storm Dinah. GRASP located what appeared to be an area of debris concentration, and moored close aboard for diver recovery.

ALCOA Marine Corporation and its subcontractor Seaward, Inc. had been tasked on 11 June to undertake sonar search for the aircraft. The search team and all equipment arrived at Manila on 15 June. After arrival, some problems in locating customs and freight personnel delayed release of the equipment for half a day. All search gear and personnel were then transported by helicopter to Subic Bay that afternoon. The GRASP was contacted and reported that she felt she was in a fruitful area of wreckage, so it was decided to install the equipment aboard. GRASP indicated that if the debris area proved to be poor, she would be available for use as a search platform thereafter.

On the next day, 16 June, stations for a Del Norte precision navigation system were positioned ashore. Two responder stations were set up, one on Grande Island and one at NAS Cubi Point. The search area and station locations are shown on the map. While the navigation system was being installed, arrangements were made to use a workboat from GRASP as the sonar search platform and a search was conducted parallel to GRASP.

The main aircraft debris area was acquired by the sonar and shown to be approximately 75 to 100 feet on the starboard quarter diving station of GRASP, at a depth of 132 feet. A towed dual side-scan sonar, manufactured by the EG&G Company, was then used for bottom search. The wreckage seemed to be in a circular area about 150 feet in diameter. Long sonar tows approximately one-half mile around GRASP revealed no further scattering of the missing aircraft. Another contact was acquired, however, about two-tenths of a mile north of GRASP in the very center of anchorage C-16.

On 17 June, additional sonar localization runs were made to further define the aircraft debris pattern and the unidentified contact. A buoy was placed on the northern contact and divers from GRASP investigated. From their description, it was rejected as a missing 105mm howitzer lost the year before when it was being helo-lifted across the bay. A buoy was placed on the aircraft wreckage for GRASP to use to reposition its moorings and as a visual aid for the divers. The search technicians and their equipment were then removed from the ship and transported to shore and the navigational station on Grande Island was taken down.

Conducting the Recovery

On 16 June, a 9- by 4-foot section of the aircraft's jet intake bellmouth was recovered and transferred to Subic Bay Ship Repair Facility's YSD floating crane. Because the aircraft was badly broken up, wire rope straps at times severed pieces of the aircraft wreckage making rerigging necessary. The next day, an engine, a large section of fuselage with the tailhook, two small sections of fuselage, and a wing stub were recovered. The third day, the second engine, part of the cockpit section, and two more sections of the fuselage were retrieved. The fourth and last day of operation, 19 June, more cockpit, including electronic parts, and right wing section were recovered. The Marine Corps investigator then reported he was satisfied that enough wreckage had been recovered to evaluate cause of the crash and terminated the F-4J salvage operations.

Conclusion

Repeatedly, underwater search operations for lost aircraft become protracted by erroneous position information. In this instance, even the relatively restricted confines of Subic Bay absorbed the better part of a week's search because of a target area expanded by conflicting position reports. Realistically, such information must be expected to originate from many nonexpert witnesses, who frequently are quite inaccurate in their observations. A need for optimizing the effectiveness of Navy accident reporting by operating forces may be implied. Efficient search procedures have been evolved in the salvage community. In a number of ways, however, search remains time-dependent on the reliability of the information on which the initial datum point is based.

RECOVERY OF U.S. AIR FORCE F-106 AIRCRAFT FROM LAKE SUPERIOR

Date: 13 June 1974
Location: Lake Superior, off Marquette, Michigan
Condition: Wreckage in 30 feet of water
Task: Recovery

Background

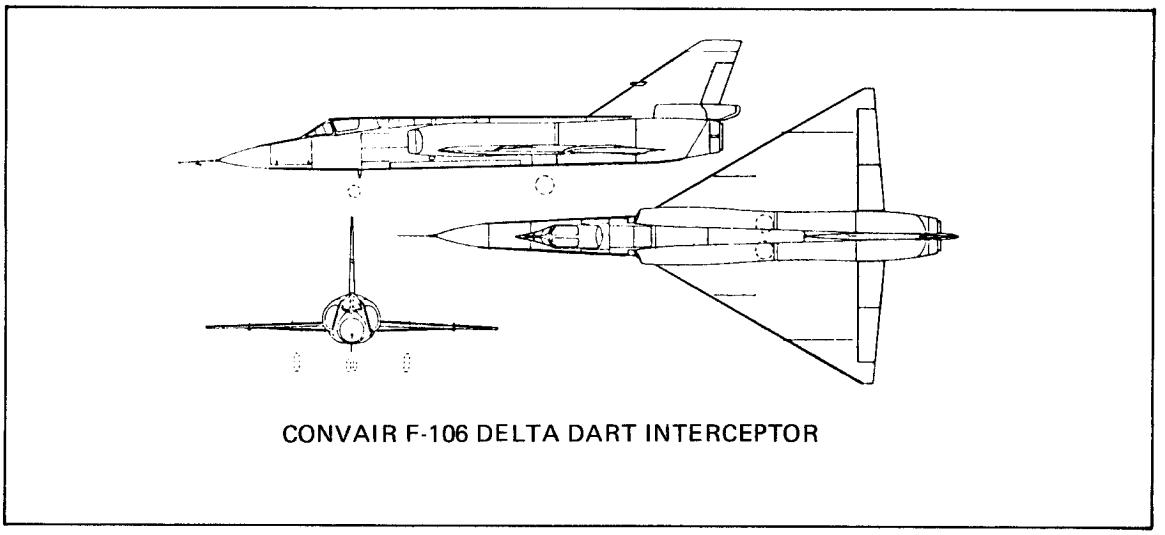
On 13 June, a U.S. Air Force F-106 interceptor fighter aircraft, from Sawyer Air Force Base, Michigan, suffered a power failure a minute and a half after takeoff. This necessitated the pilot's ejection, which was accomplished safely. The aircraft then crashed in Lake Superior, 11 miles north of Sawyer AFB and approximately 400 yards offshore, at Marquette, Michigan. The assistance of the Supervisor of Salvage in recovering the wreckage of the aircraft was requested by Sawyer AFB. Marquette City Police divers located the wreckage in 30 feet of water and marked the engine location with buoys.

Planning the Recovery

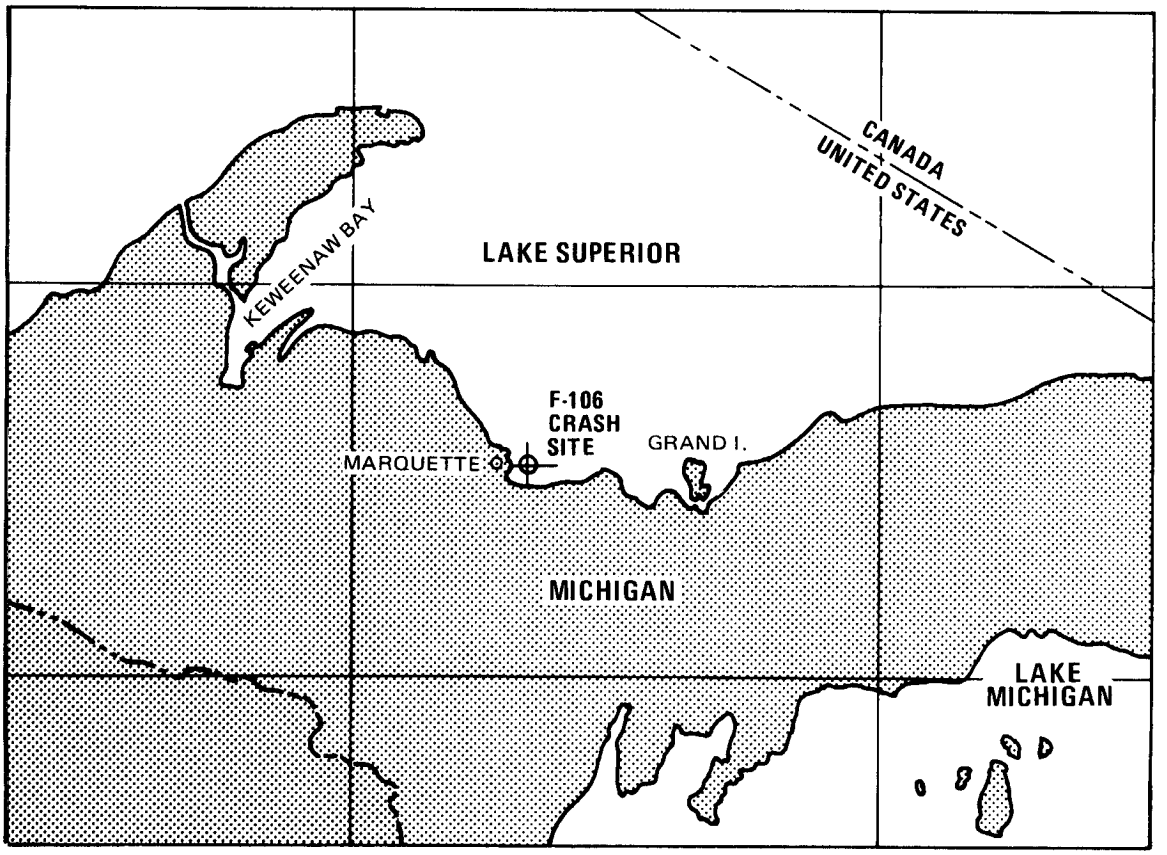
Since the aircraft had already been located close offshore at a depth of 30 feet and marked by local divers, no search effort had to be planned. A U.S. Army Corps of Engineers 32-ton capacity, barge-mounted derrick was available in Marquette. Arrangements were made to move it to the aircraft wreckage site to raise sections of wreckage and debris. It was expected that diving operations would be facilitated by the clear water conditions reported.

Recovery Operations

On 14 June, a recovery party from Harbor Clearance Unit TWO (HCU-2) departed Little Creek, Virginia, for Marquette, Michigan, traveling via U.S. Air Force transportation. The team arrived at midday, 15 June, and commenced operations immediately. Due to the



CONVAIR F-106 DELTA DART INTERCEPTOR



LOCATION OF AIR FORCE CRASH OFF MARQUETTE, MICHIGAN

violence of the crash, the aircraft was completely broken up and spread over an area of approximately 150 yards. During the first afternoon's operations, divers located and recovered two sections of engine compressors, one section of afterburner, and several small engine parts. The following day, severe weather conditions prevented all diving operations. On the morning of 17 June, diving and recovery operations were resumed. Divers recovered airframe components, engine accessories, and electronic equipment of the aircraft. No large pieces were recovered except the engine. Divers searched for cockpit instrument gauges but found only three. Diving continued on the following day with recovery of some engine accessories and cockpit components. Diving operations were suspended on 19 June while awaiting guidance from the Air Force accident investigation board. Operations were then resumed on 20 June and continued through 22 June to recover fuel accessory components, engine instrument panels, compressor parts, and a generator. Approximately 90 percent of the engine and accessories and 70 percent of the fuel system components were recovered, which fulfilled the requirements of the Board of Investigation.

Conclusion

No problems were encountered during the diving operation and recovery of the F-106 aircraft wreckage. Contributing factors were the previously marked location in shallow water, the clear water conditions, and good weather. The HCU-2 diving and recovery team proceeded quickly and efficiently. Good arrangements for travel to the accident site, for operating support, and for recovery requirement coordination, provided by the Air Force, contributed to the efficient execution of the mission.

SEARCH AND RECOVERY OF U.S. NAVY A-7E AIRCRAFT OFF NAVAL AIR STATION, MAYPORT, FLORIDA

Date: 14 July 1974
Location: 3 miles northeast of Mayport, Florida
Condition: Wreckage in 35 feet of water
Task: Search and Recovery

Background

At dusk on 14 July, a U.S. Navy A-7E aircraft in its landing approach turn into NAS, Mayport, suffered complete loss of oil pressure. The pilot immediately straightened out the turn to parallel the shore, and ejected safely. He was recovered safely by SAR helicopter about one-half hour later.

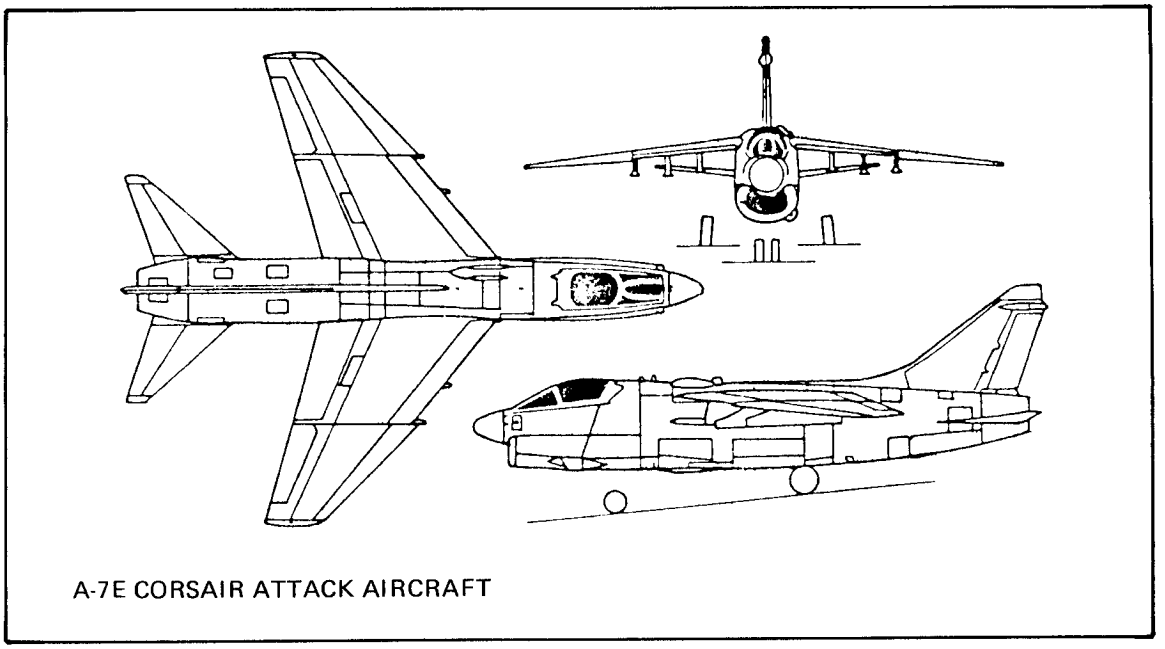
Based on the wingman's estimate, doppler navigation fix of the crash point, and a reported oil slick, the impact area of the aircraft was believed to be approximately three miles northeast of the air station and about two miles from the nearest shore. An eyewitness standing on the St. Johns River entrance channel jetty also furnished a line of bearing.

Divers from the USS ESCAPE (ARS-6) attempted to locate the wreckage with hand-held sonar from 15-18 July. On 18 July, the minesweeper USS LEADER (MSO-490) searched the crash impact area with its minehunting sonar without success.

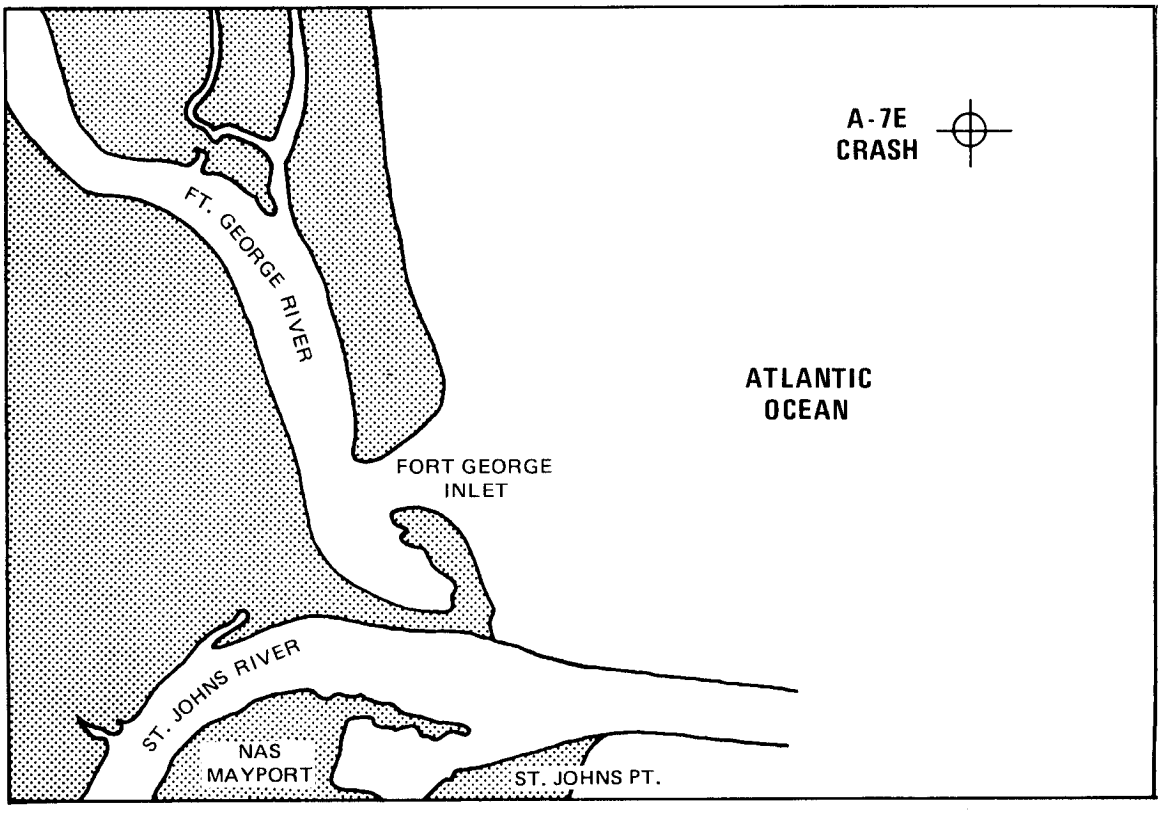
Planning the Search

On 18 July, the Supervisor of Salvage (SUPSALV) was requested to provide assistance in locating the aircraft wreckage. SUPSALV in turn tasked its contractors for search and recovery, ALCOA Marine Corporation and Seaward, Inc., to perform a sonar search for the aircraft.

Seaward search personnel arrived in Mayport late in the night of the 18th. Mobilization of the search team was completed during the next morning. At this time, the Seaward Project Manager met with the Naval Safety Center Representative, and the Commanding Officers of USS ESCAPE and USS LEADER. All background crash data was reviewed. Since the pilot had not yet been debriefed, it was arranged to meet with him. Then, based on his



A-7E CORSAIR ATTACK AIRCRAFT



LOCATION OF NAVY CRASH OFF NAS MAYPORT, FLORIDA

information, corroboration from a police helicopter that had been on the scene, and the jetty eyewitness's bearing line, the most probable search area was redetermined to be well north of the initial search area. A three-square-mile search area was set up, therefore, which encompassed the new estimated position, that of the reported oil slick, and the eyewitness bearing line.

Conducting the Search

A 45-foot diving boat from USS GRAND CANYON (AD-28) was outfitted as a search platform for the side-scan sonar during the afternoon of the 19th. Shore stations for the precision navigation system were established on a fishing pier and on an unused lighthouse. The sonar search commenced in the late afternoon and continued only until 1830, when a fault developed in the sonar recorder. Since USS LEADER was just coming on scene for its search throughout the night, it was decided to return ashore for repairs and test of the sonar, and be ready for the following day's operation. (The sonar fault was a missing fuse holder cap which had apparently been knocked off during shipment.) At approximately 2200, LEADER acquired a good sonar contact at latitude 30°28.2'N, longitude 81°22.4'W in 35 feet of water.

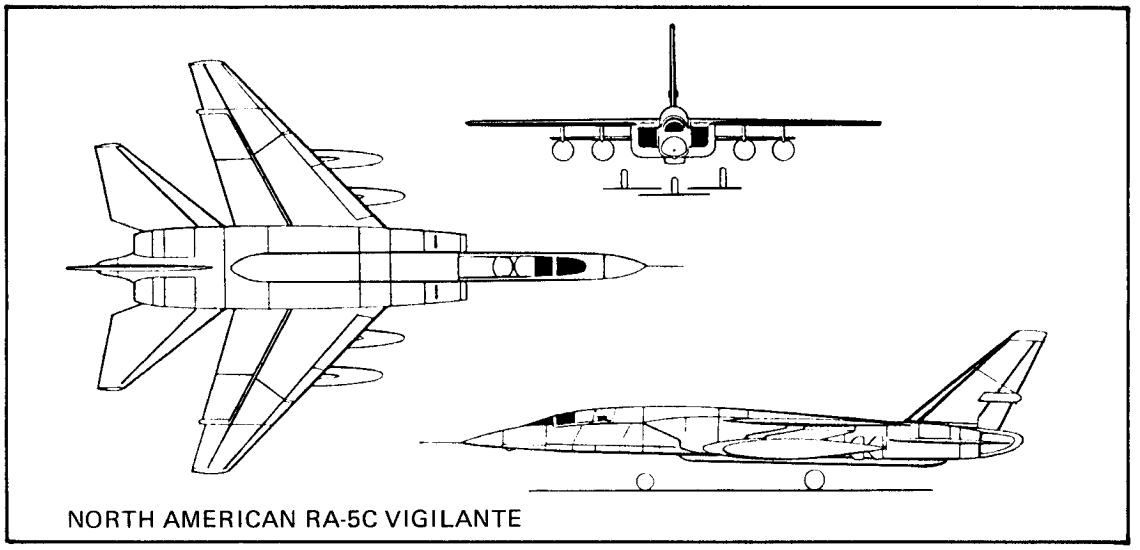
Conducting the Recovery

Early the next morning, 20 July, ESCAPE moored over the position and divers were able to verify the contact as the A-7E aircraft. ESCAPE then was able to recover those portions of the wreckage, including the engine, that were required for accident investigation purposes.

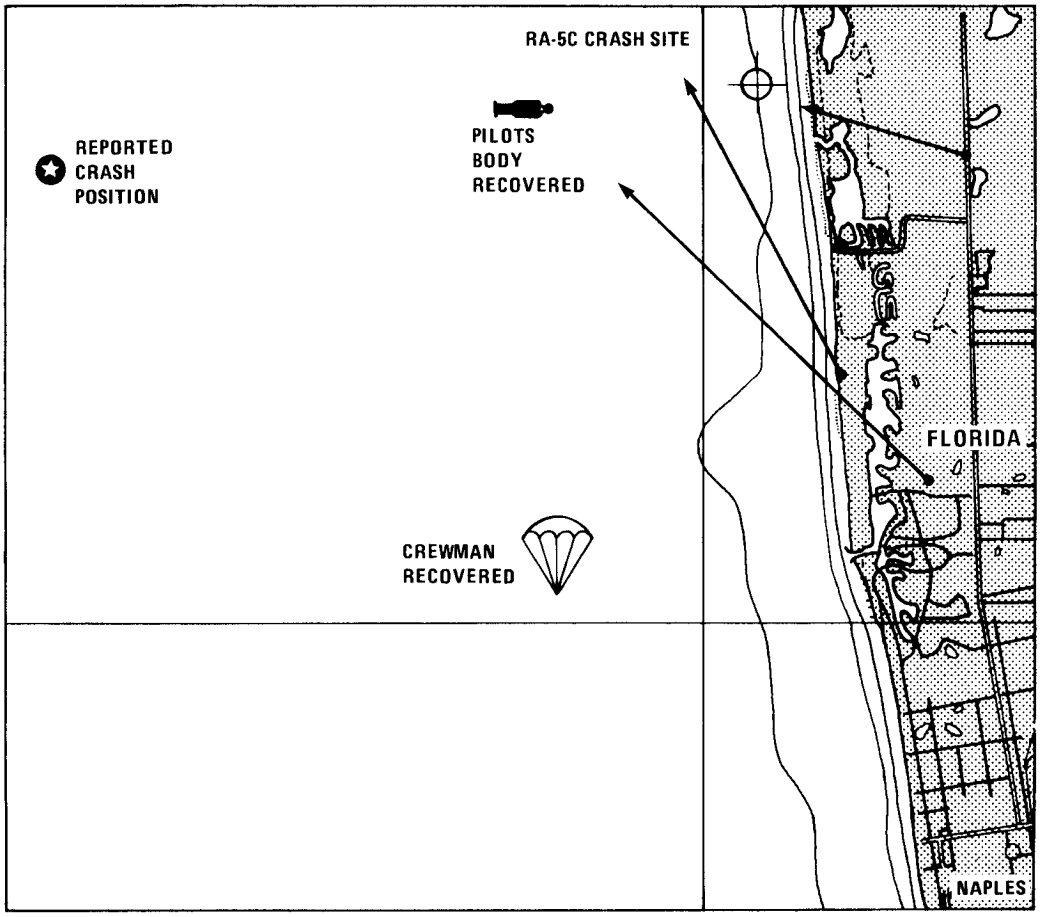
Conclusion

Although this recovery was essentially routine, two aspects are useful for future guidance. The loss of four days of search effort on an incorrectly determined impact point shows yet another instance of the need of a means for reconciling all location information before laying on substantial search efforts.

The subsequently successful use of mine-location sonar to find the aircraft wreckage points up a useful resource sometimes available for recovery search work. It should be kept in mind for search requirements when commercial service is inconvenient or delayed. Under routine circumstances, however, the cost of commitment of a fleet unit will probably weigh against frequent employment unless it is desirable for sonar training.



NORTH AMERICAN RA-5C VIGILANTE



LOCATION OF NAVY RA-5C CRASH OFF NAPLES, FLORIDA

three-man team of Explosive Ordnance Disposal (EOD) divers from Key West was called in to search the area. This diver search, with hand-held sonar, proved fruitless as did several other diver searches conducted 3 to 5 miles from the buoy based on oil slicks and other information.

Planning the Subsequent Search

The Supervisor of Salvage was notified of the crash on 14 August, but since debris had been located, he presumed that services would not be required. A formal request for assistance, however, was made the next day. ALCOA Marine Corporation, and its subcontractor Seaward, Inc., were tasked with the job and their personnel arrived in Tampa that evening. An initial survey was conducted the next morning, 16 August, and search and navigation equipment was set up at Fort Myers Beach that evening.

Meanwhile, several more eyewitnesses were interviewed. The lines of bearing they provided triangulated quite well with the fisherman's estimated position. Precision navigation reference stations were then set up on the south end of Vanderbilt Beach and 1,400 yards south of Clam Pass.

Conducting the Successful Search

The search team got under way at 0900 17 August, using the 42-foot Coast Guard crash boat. In proceeding to the scene, the boat came upon the pilot's body floating on the surface, which was taken to Fort Myers Beach Coast Guard Station. That afternoon, the sonar search finally got under way, and the aircraft debris was detected almost immediately. Several confirmation runs were made, and by 1530 hours, diver verification was completed. A sizable marker buoy was then put into position to mark the wreck.

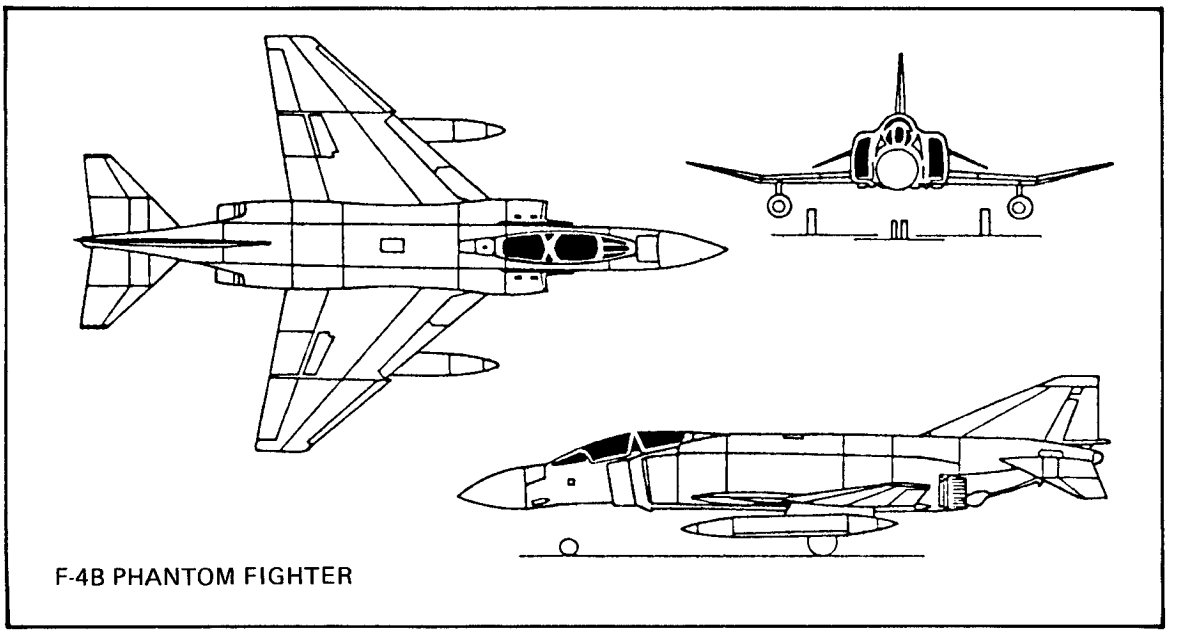
Conducting the Recovery

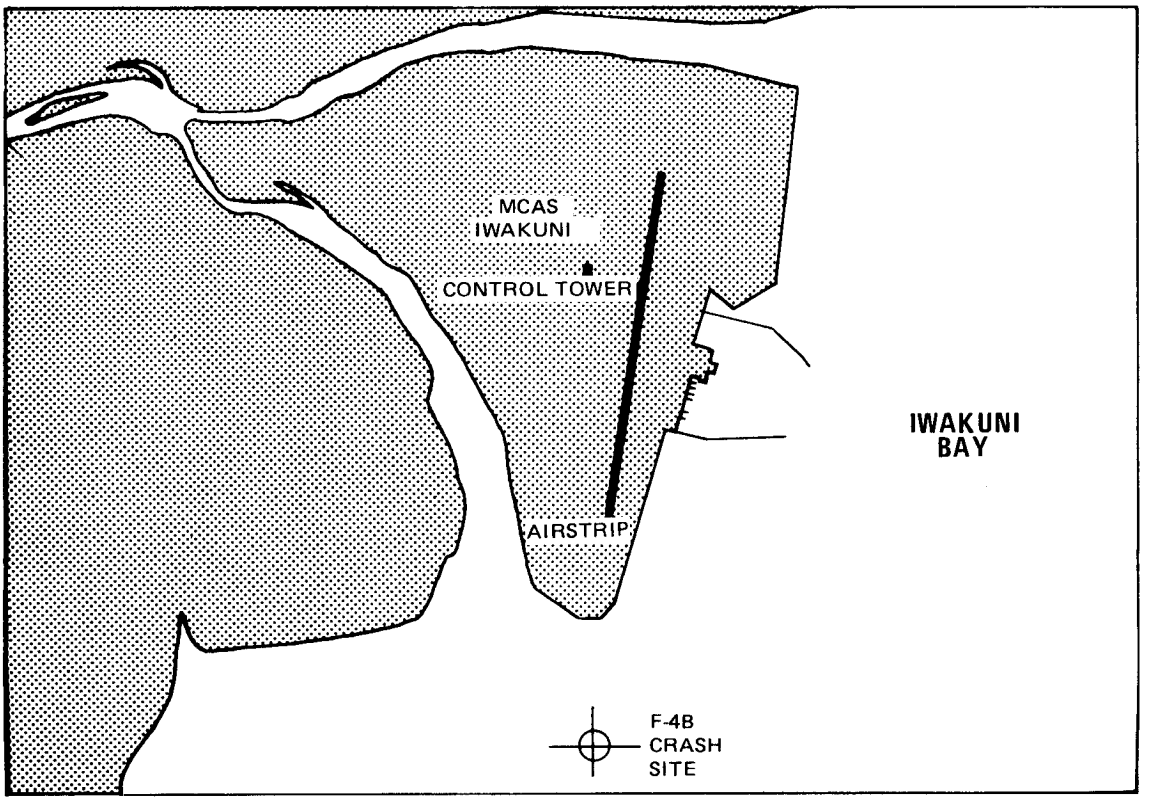
On Sunday, 18 August, arrangements were made to use the Coast Guard buoy tender, JUNIPER, based in St. Petersburg, to conduct the recovery. The JUNIPER arrived on the scene Monday, 19 August at 0800, and commenced recovery using the EOD divers from Key West. By midday, six divers from Harbor Clearance Unit TWO at Little Creek, Virginia, arrived on scene and took over the diving task. The JUNIPER delivered the major portion of the wreckage to Key West, Florida.

During eight hours of diving and recovery, the engines, substantial portions of the fuselage and the landing gear, and much small debris were recovered, for a total of 95 percent of the aircraft.

Conclusion

This operation constituted another important recovery required in the interests of aviation safety, since two other such aircraft had been lost recently from unknown causes. The wreckage of this aircraft was essential for analysis to prevent future such losses. Once again there was the problem of reconciling conflicting location reports.





LOCATION OF MARINE CORPS F-4B LOST IN JAPANESE INLAND SEA OFF MCAS IWAKUNI

unsuccessfully through the arrival of SAFEGUARD on 25 October. SAFEGUARD's first effort was to plant crown buoys to define the area already covered by dragging. The following morning, local fishermen reported fouling a net between two of the buoys, and bringing up aircraft wreckage. Dragging was focused in this area and part of an inflight fueling probe was recovered. This location was then buoyed for the next day's search.

Recovery Operations

The next day, 27 October, SAFEGUARD went into a two-point moor over the previous day's recovery site. Although hampered by rising winds, diving operations proceeded, and the outer section of the port wing of the lost aircraft, the nose wheel strut, and a heat exchanger were recovered. During the next seven days, over 90 percent of the wrecked F-4B was recovered. Larger sections were lifted by means of wire or nylon straps. Smaller sections of the aircraft, such as engine parts, hydraulic components, and electronic gear, were recovered using a metal basket lowered to the bottom. Recovery operations were extended, in particular, to recover the forward and after fuel pump gearboxes. When these were recovered on 3 November, engine manufacturer technical representatives stated that they had conclusive evidence of the cause of the crash, and recovery operations were concluded.

Conclusion

Although this recovery of aircraft wreckage from the sea was not marked by any unusual incidents, it is worth noting the protracted effort required to recover crucial engine components from a low visibility bottom. Where the recovery of such relatively small objects from the debris of a violent crash is mandatory for accident analysis recovery, operations can be expected to be protracted.

A problem that recurred during this operation was that of two divers severely cutting their knees on jagged edges of torn metal. Occurrence of such injury is difficult to avoid when diving work must be conducted by SCUBA swimmers in the vicinity of violently torn duraluminum and titanium wreckage.

INDEX ALPHA
SALVAGE OPERATIONS CUMULATIVE INDEX

1. PURPOSE

This is a consolidated index of salvage operations reviewed in the published series of annual SALVOPS reports:

SALVOPS 69 – NAVSHIPS 0994-012-6010
SALVOPS 70 – NAVSHIPS 0994-012-6020
SALVOPS 71 – NAVSEA 0994-012-6030
SALVOPS 72 – NAVSEA 0994-LP-012-6040
SALVOPS 73 – NAVSEA 0994-LP-012-6050
SALVOPS 74 – NAVSEA 0994-LP-012-6060

2. INDEX CATEGORIES

Index listings are presented in the following major categories:

I – Ships/Vessels Requiring Assistance
II – Aircraft Search/Recoveries
III – Miscellaneous Assistance Tasks
IV – Salvage Vessels/Craft/Units
V – Specialized Equipment
VI – Type of Task

3. REPORT PAGE REFERENCES

Index entries are keyed to the individual SALVOPS report and page number within the report. For example: SALVOPS 72, page 69 is listed as 72-69.

4. RELATED INDEX

See also Index BRAVO for a companion listing and precis of each article contained in the published SALVOPS reports.

I. SHIPS/VESSELS REQURING ASSISTANCE

II. AIRCRAFT SEARCH/RECOVERIES

II. AIRCRAFT SEARCH/RECOVERIES (cont.)

III. MISCELLANEOUS ASSISTANCE TASKS

VI. TYPE OF TASK (cont.)

INDEX BRAVO

ARTICLES IN THE SALVOPS REPORT SERIES

1. PURPOSE

This index lists the articles contained in the published series of annual SALVOPS reports and provides an abstract of each article. Articles are presented in the following sequence:

SALVOPS 69	–	NAVSHIPS 0994-012-6010
SALVOPS 70	–	NAVSHIPS 0994-012-6020
SALVOPS 71	–	NAVSEA 0994-012-6030
SALVOPS 72	–	NAVSEA 0994-LP-012-6040
SALVOPS 73	–	NAVSEA 0994-LP-012-6050
SALVOPS 74	–	NAVSEA 0994-LP-012-6060

2. RELATED INDEX

See also Index ALPHA for a detailed page index of the types of salvage operations covered thus far in the SALVOPS report series.

LISTING OF SALVOPS ARTICLES

SALVOPS 69

- Recovery of Deep Research Vehicle ALVIN
- Recovery of Implanted Acoustical Beacon Snap-7E
- Recovery of ex-USS HAKE in SUBSALVEX-69
- Salvage of the Nuclear Submarine USS GUITARRO (SSN-665)
- Efforts to Recover the Dredge SANDPUMPER
- Recovery of the Dredge NEW JERSEY
- Salvage Operations - Guyana - Efforts to Raise M/V POWIS
- Salvage of Grounded Vessel SS ALAMO VICTORY
- Salvage and Towing of USS FRANK E. EVANS (DD-754)
- Salvage of Grounded Vessel SS NORWICH VICTORY
- Aircraft Search and Recovery Activities

SALVOPS 70

- The Recovery of Bunker "C" Fuel Oil from the Sunken Tanker, SS ARROW
- Blowout of Chevron Oil Well Platform Along the Gulf Coast
- Salvage of the ex-USS REUBEN JAMES (DE-153) at Dahlgren, Virginia
- Salvage of the Sunken Harbor Tug, YTM-538 at Mayport, Florida
- Search and Recovery of Solar Eclipse Instrumentation Package off the Virginia Capes
- SQUAW - Submerged Mooring of a Model Submarine Hull
- Implantment of Hydrophone Array Tower off Block Island, Rhode Island
- Salvage Operations of Harbor Clearance Unit One - Vietnam
- Underwater Search and Recovery of Aircraft - Lake Mead, Nevada
- Summary of Downed Aircraft Search and Recovery Operations - 1970

SALVOPS 71

- Salvage Efforts and Disposal of USS REGULUS (AF-57) off Hong Kong
- Participation of U.S. Navy Forces in Azores Fixed Acoustical Range (AFAR) 1971 Operations
- Recovery of the Ketch, ATOM, From Assateague Island, Virginia
- Recovery of ex-USS HAKE in SUBSALVEX-71
- Search and Recovery of U.S. Air Force B-52 Aircraft in Lake Michigan
- Use of Pressurized Sphere Injector (PSI) in Lifting the Barge, BOOTH, from the Gulf of Mexico
- Search and Recovery of U.S. Air Force B-57 Aircraft in Great Salt Lake, Utah
- Salvage Operations of Harbor Clearance Unit One in Vietnam
- Summary of Downed Aircraft Search and Recovery Operations in 1971

SALVOPS 72

- Recovery and Disposal of SS SIDNEY E. SMITH from the St. Clair River, Port Huron, Michigan
- M/V ORIENTAL WARRIOR - Oil Pollution Control and Debunkering Operations
- M/V ORIENTAL WARRIOR - Salvage and Disposal Operations
- Recovery of Oil from M/V SOLAR TRADER at West Fayu Island, Pacific Islands Trust Territory
- Search and Recovery of U.S. Coast Guard Air Cushion Vehicle from the Straits of Mackinac, Lake Huron
- Debunkering and Salvage of Dredge ATLANTIC at Elizabeth River, Norfolk, Virginia
- Search and Recovery of USS GEORGE BANCROFT (SSBN-643) Anchor and Chain off Portsmouth, N.H.
- Recovery of USS TUCUMCARI (PGH-2) from Caballo Blanco Reef off Puerto Rico
- Search and Recovery of U.S. Air Force F-4E Aircraft off Coast of Turkey
- Summary of Downed Aircraft Search and Recovery Operations in 1972

SALVOPS 73

- Rescue of the Deep Submersible PISCES III and Crew from 1,600 Feet
- Prompt, Economical Underwater Repairs to USS F.D. ROOSEVELT (CVA-42)
- Salvage Efforts and Stripping of USNS JACK J. PENDLETON (T-AK-276)
- Foam Sink-Proofing of LST for Test of Haiphong Minesweeping
- Clearance of Tug Wreck from Coney Island Channel
- Removal of Fouled Ground Tackle from Deepwater Petroleum Systems, Estero Bay, California
- 1973 Support Operations of the Azores Fixed Acoustical Range (AFAR)
- Support Operations for the Joint Casualty Resolution Center, Southeast Asia
- Recovery for Crash Analysis of P-3B Aircraft Wreckage off Brunswick, Maine
- Summary of Downed Aircraft Search and Recovery Operations in 1973

SALVOPS 74

- Retraction and Recovery of USNS Tug LIPAN
- Buoyant Foam Sink-Proofing in Southeast Asia
- Locating and Photographing the Wreck of the MONITOR
- Tow, Repair, and Oil Spill Recovery for USNS PVT. MERRELL
- Salvage of YDT-9 from Chesapeake Bay
- Removal of Dredge MACKENZIE from Galveston Channel
- CARIBIA En Route to Scrapyard: Aid in Hawaii, Loss at Guam
- Clearing the Suez Canal
- Summary of Downed Aircraft Search and Recovery Operations in 1974

ABSTRACTS OF SALVOPS 1969 ARTICLES

Recovery of Deep Research Vehicle ALVIN

ALVIN, a manned submersible, was lost in 5,050 feet of water in October 1968 off Cape Cod, Massachusetts. Initial efforts to recover the submersible in the fall of 1968 were unsuccessful. ALVIN was located again the following year, and salvage efforts were conducted in August. ALUMINAUT, another manned submersible, dived to the bottom, homed in on the wreck with sonar and attached lift lines with its manipulators. ALVIN was then raised, towed to shallow water and recovered.

Recovery of Implanted Acoustical Beacon SNAP-7E

SNAP-7E, an experimental beacon moored in 16,000 feet of water off Bermuda, mysteriously ceased operation in October 1968. The recovery plan called for snagging one of the mooring legs using grapnels. Recovery operations began on 23 November 1969, and after 4 days and several unsuccessful passes, the elusive mooring leg was hooked, and the buoy recovered.

Recovery of ex-USS HAKE in SUBSALVEX-69

In May 1969 the ex-USS HAKE, a submarine hulk, was sunk in Chesapeake Bay at a depth of over 100 feet. This action was taken to provide a practical training exercise and a reevaluation of the concept of raising submarines with large, rigid pontoons. Preparations continued throughout May, culminating in a final lift on May 22. All deadlines were met, much salvage expertise developed, and the validity of the pontoon concept again established.

Salvage of the Nuclear Submarine USS GUITARRO (SSN-665)

The USS GUITARRO, in final stages of construction at the San Francisco Naval Shipyard, sank alongside the pier in 30 feet of water on 15 May 1969. The salvage plan included the use of cofferdams fitted over the sub's hatches to make the hull watertight, the blowing of strategic tanks for buoyancy, and a floating crane to provide lift. All preparations were completed, and the submarine successfully refloated on 18 May.

Efforts to Recover the Dredge SANDPUMPER

On 22 September 1969, while operating in the My Tho River near Dong Tam, South Vietnam, the dredge SANDPUMPER suffered an explosion in her suction pump and sank in 35 feet of water. Two heavy lift craft partially raised the dredge and moved it to shallow water for dewatering. However, widespread mudding and flooding prevented final recovery and operations were terminated in mid-December.

Recovery of the Dredge NEW JERSEY

On 22 November 1969 the dredge NEW JERSEY, while conducting operations in the My Tho River near Dong Tam, South Vietnam, struck a mine and sank in 20 feet of water. Harbor Clearance Unit One was tasked with the salvage effort. Using standard patching and pumping techniques, the damaged areas were made watertight and the dredge refloated.

Efforts to Raise Motor Vessel POWIS off Coast of Guyana

The M/V POWIS, on 22 February 1969, struck a submerged barge, flooded and settled atop the barge. After difficulty was experienced by local salvage forces, the assistance of the Supervisor of Salvage was requested. The SUPSALV Representative developed a salvage plan, supervised the preliminary stages, and set the groundwork for the successful completion of the task.

Salvage of Grounded Vessel SS ALAMO VICTORY

ALAMO VICTORY, an MSTS cargo ship, was driven hard aground at Gulfport, Mississippi during Hurricane Camille in August 1969. A SUPSALV contractor was tasked with the retraction. Six sets of beach gear were used to refloat the vessel by pivoting into an 18-foot channel dredged from the grounding site into deep water. Retraction was completed on 18 September.

Salvage and Towing of USS FRANK E. EVANS (DD-754)

On 2 June 1969, while maneuvering in the South China Sea, the destroyer EVANS was rammed and cut in half by the Australian Aircraft Carrier HMAS MELBOURNE. The bow section sank immediately; however, the stern remained afloat. Quick, effective damage control efforts by LARSON (DD-830) and TAWASA (ATF-92) brought flooding under control and prevented the stern from sinking. The stern was then towed 825 miles to Subic Bay, Philippines.

Salvage of Grounded Vessel SS NORWICH VICTORY

The SS NORWICH VICTORY, en route to Vietnam with a cargo of ammunitions and fuel oil, ran hard aground on 25 September 1969 off Triton Island. CONSERVER (ARS-39), GRAPPLE (ARS-7), GRASP (ARS-24) and CHOWANOC (ATF-100) participated in the ensuing retraction. Seven legs of beach gear were layed and 1,875 tons of cargo offloaded. After several unsuccessful attempts, the NORWICH VICTORY was pulled free on 8 October, and proceeded to Danang, South Vietnam.

Aircraft Search and Recovery Activities

This article summarizes operations undertaken to locate and recover five downed aircraft in 1969. Portions of three aircraft, a USAF T-33 jet trainer, a USAF HH-53C helicopter and a Scandanavian DC-8 airliner, were recovered. Two jet fighters, a USN A-4F and a USAF F-106 could not be recovered.

ABSTRACTS OF SALVOPS 1970 ARTICLES

Recovery of Bunker "C" Fuel Oil from the Sunken Tanker SS ARROW

In February 1970 the tanker SS ARROW ran aground, broke in two and sank in 90 feet of water, resulting in a major oil spill in Chedabucto Bay, Nova Scotia. To prevent further spillage, the oil remaining in the sunken tanker was removed using a steam supported pumping system and the hot tap method of hull penetration. Despite near freezing temperatures, over 37,000 barrels of oil were recovered from the wreck by the time operations were secured on 11 April.

Blowout of Chevron Oil Well Platform Along the Gulf Coast

A Chevron multi-well oil platform exploded and burned in the Gulf of Mexico off the Louisiana coast on 10 February 1970. During the period between extinguishing the fire and capping the wells, a significant oil spill was expected. To contain this spill and prevent damage to the nearby oyster and shrimp industries, an oil boom and skimmer were employed. Damage to the local beaches and industry was avoided despite occasional breaks in the boom.

Salvage of the ex-USS REUBEN JAMES (DE-153) at Dahlgren, Virginia

The hulk of the destroyer escort ex-REUBEN JAMES, rolled onto her starboard side and sank in 10 feet of water off Dahlgren, Virginia on 14 March 1970. Harbor Clearance Unit Two, tasked with righting and refloating the ship, devised a 6-phase salvage plan. By 9 April, using beach gear and dewatering, the original 87 degree list had been reduced to 7 degrees. The hull was then made watertight and stability tests run in preparation for refloating, which was accomplished on 16 April.

Salvage of the Sunken Harbor Tug YTM-538 at Mayport, Florida

YTM-538 was struck below the waterline by a propeller of the USS PAWCATUK (AO-108) while assisting the oiler into Mayport, Florida on 17 July 1970. The tug sank on an even keel in 41 feet of water on the south side of the channel to the Naval Station basin. Using floating cranes and beach gear, Harbor Clearance Unit Two lifted the tug from the channel in just over one month. The YTM was refloated and moved onto a marine railway on 1 August.

Search and Recovery of Solar Eclipse Instrumentation Package off Virginia Capes

A rocket pod carrying vital photographic coverage of a solar eclipse sank in 5,850 feet of water, 75 miles east of Norfolk, Virginia on 7 March 1970. Operating from the USS OPPORTUNE (ARS-41), the unmanned submersible CURV III was used for search and recovery. On 22 March, eight hours into the second dive, the missing package was located and the submersible's claw attached to it for lifting. CURV then brought the package to the surface where it was hoisted aboard the OPPORTUNE, undamaged.

SQUAW – Submerged Mooring of a Model Submarine Hull

SQUAW, a sonar training target moored at a depth of 300 feet off San Diego, California, unexpectedly broke its moor and surfaced in early 1970. The Supervisor of Salvage was tasked to undertake the re-mooring operations. Three ships, the USS CHOWANOC (ATF-100), the USS MOLALA (ATF-106)

and the USS KALMIA (ATA-187) completed the task within seven days, using a drop system for implanting the moor. The moor, consisting of four legs, was designed to hold the SQUAW in position 300 feet below the surface, in 3,492 feet of water for 5-10 years.

Implantment of Hydrophone Array Tower off Block Island, Rhode Island

The barge YC-1429, with a 100-foot hydrophone array tower installed, was intentionally sunk in 104 feet of water in November 1970 for experimental use. Careful preparations and planning led to a successful controlled flooding, sinking and positioning of the tower and barge. Once bottomed, the barge was rotated to the position where the hydrophone array would be most effective.

Salvage Operations of Harbor Clearance Unit One in Vietnam

Using highly mobile salvage craft and teams, Harbor Clearance Unit One conducted a variety of salvage operations in South Vietnam in 1970, frequently under hostile fire. These operations included groundings, collisions, breakdown and enemy action. By the end of 1970, the U.S. reduction in force had begun, HCU-1's in-country manning level reduced, and a number of her salvage craft turned over to the South Vietnamese Navy.

Underwater Search and Recovery of Aircraft in Lake Mead, Nevada

On 25 November 1970 a Cessna U-206 aircraft crashed into Lake Mead, Nevada, sinking in 400 feet of water. Because of the great depth, the ADS-IV deep diving system was used for search and diving operations. Despite the onset of winter, near zero bottom visibility and a heavy layer of silt, the aircraft was quickly located. Divers then attached a specially constructed sling to the aircraft, and it was recovered on 7 December.

Summary of Downed Aircraft Search and Recovery Operations in 1970

Of the aircraft search and recovery operations conducted in 1970, six were considered significant and were included in this article. Search and salvage operations were conducted on two Navy F-4J Phantoms, two Navy A-6A Intruders, as well as one Air Force F-4D Phantom. An intensive search was also conducted for an F-102 Interceptor in the Gulf of Mexico, with negative results.

ABSTRACTS OF SALVOPS 1971 ARTICLES

Salvage Efforts and Disposal of USS REGULUS (AF-57) off Hong Kong

The USS REGULUS was driven aground by Typhoon Rose on 17 August 1971. Salvage efforts, limited to offloading of stores, oil and other salvageable materials, were conducted by the USS SAFEGUARD (ARS-25), USS GRASP (ARS-24) and the USS ABNAKI (ATF-96). During these operations an extensive survey was performed, and it was decided that the REGULUS was beyond economical repair and should be stricken and sold, with the stipulation that the hulk be quickly removed. Topside weight was removed, the hull cut into two sections, and each section removed.

Participation of U.S. Forces in Azores Fixed Acoustical Range (AFAR) 1971 Operations

The installation of AFAR in 1970 had not resulted in a useable facility. Repairs were required to the transmitting tower, two receiving stations and an oceanographic buoy. The USS KIOWA (ATF-72) and the USS NAUBUC (YRST-4) worked together to implant the buoy. CURV III, an unmanned submersible operating from the NAUBUC, attached special fittings to the transmitting tower and connected them to a recovery vessel. CURV also located the cables to the receiving stations and prepared them for retrieval.

Recovery of the Ketch ATOM from Assateague Island, Virginia

On 25 October 1971, the ketch ATOM went aground on Assateague Island. Civilian volunteers immediately went to the assistance of the 69 year old French owner, but were unable to refloat the stranded craft. The U.S. Navy provided a team of salvage experts which succeeded in refloating the ATOM on 6 November.

Recovery of ex-USS HAKE IN SUBSALVEX-71

The ex-USS HAKE, a submarine hulk, was intentionally sunk in Chesapeake Bay on 9 August in 100 feet of water for use in SUBSALVEX-71. The exercise had three purposes: to provide experience and training for personnel; to evaluate the effectiveness of submarine salvage techniques; and to test actual submarine salvage equipment. USS OPPORTUNE (ARS-41) and USS PRESERVER (ARS-8), supported by Harbor Clearance Unit Two, rigged all pontoons and prepared the submarine for the lift. The ex-HAKE was surfaced and towed back to port on 13 September.

Search and Recovery of U.S. Air Force B-52 Aircraft in Lake Michigan

On 7 January 1971 a B-52 aircraft crashed into Lake Michigan in 240 feet of water. A detailed search, using side-scan sonar, located the wreckage. Recovery efforts were postponed until spring. The salvage forces assembled again in May, this time with the ADS-IV deep diving system. Despite the depth, cold water and near zero visibility, the required pieces of wreckage were recovered. SALVOPS were terminated on 13 June.

Use of Pressurized Sphere Injector (PSI) in Lifting the Barge BOOTH from the Gulf of Mexico

The pipelaying barge BOOTH was sunk in 50 feet of water by a storm in 1969. To raise the barge, a unique method of overcoming negative buoyancy was utilized. Using Pressurized Sphere Injector (PSI)

machinery, thousands of 11-inch plastic spheres were injected into the barge, displacing the water. This method successfully raised the 2400-ton barge on 23 August.

Search and Recovery of U.S. Air Force B-57 Aircraft in Great Salt Lake, Utah

An Air Force B-57 aircraft crashed into 22 feet of water in the Great Salt Lake on 13 April 1971. Utilizing a precision navigation system and side-scan sonar, the wreckage was quickly located. Divers from HCU-2 and other facilities assisted in recovering the wreckage. By 9 June, all required wreckage had been recovered, and operations were terminated.

Salvage Operations of Harbor Clearance Unit One in Vietnam

HCU-1 performed river clearance tasks in the Mekong Delta in early 1971, using LCM-8s rigged with A-frames as salvage lift craft. The unit also patched the mine-damaged SS ROBIN HOOD. The unit's work in training and equipping Vietnamese salvage forces is highlighted. HCU-1's active salvage role in Vietnam ended in June 1971.

Summary of Downed Aircraft Search and Recovery Operations in 1971

During the year 1971 the Supervisor of Salvage provided assistance for the search and recovery of four lost aircraft. Two of the aircraft were Navy F-4J Phantoms, one of which was successfully located and recovered. A Marine Corps helicopter was also successfully recovered from Chesapeake Bay. In addition, ninety percent of an Air Force F-4 Phantom was retrieved from near Tampa, Florida.

ABSTRACTS OF SALVOPS 1972 ARTICLES

Recovery and Disposal of SS SIDNEY E. SMITH JR. from the St. Clair River, Port Huron, Michigan

The sunken coal freighter, SIDNEY SMITH, broken in two sections, partially blocked the shipping channel opposite Port Huron and presented a grave navigational hazard. Each wreck section was first lightened by installing polyurethane foam for buoyancy and then removed from the channel with hydraulic pullers. The recovered sections were then prepared for final disposal. Salvage operations began 22 June and concluded 18 November.

M/V ORIENTAL WARRIOR Oil Pollution Control and Debunkering Operations

Following a fire at sea, the ORIENTAL WARRIOR was towed into Jacksonville, Florida where the vessel sank alongside a pier. Initial efforts managed to contain a 90,000-gallon oil spill. An oil recovery team debunkered the WARRIOR, recovering 290,000 gallons of oil. Recovery methods included vacuum pumping, skimming, blowing and hot tapping. Throughout the operation oil containment measures prevented a major oil spill.

M/V ORIENTAL WARRIOR Salvage and Disposal Operations

Debunkering completed, the salvors undertook the task of refloating the flooded and fire-damaged WARRIOR. Although essentially a patch and pump operation, the task was far from routine as the hull was severely weakened amidships. A controlled combination of dewatering, ballasting and parbuckling was required to refloat it without breaking the hull. The task was accomplished on schedule and the hull disposed of at sea by sinking it with explosives on 1 October 1972.

Recovery of Oil from M/V SOLAR TRADER at West Fayu Island, Pacific Island Trust Territory

The M/V SOLAR TRADER ran aground in late December 1971. It had been slowly leaking oil for six months when SUPSALV received a request for oil pollution abatement assistance. An oil pollution specialist was dispatched to the scene and arrangements made to debunker the vessel. In a nine-day effort ending 23 July, 45,000 gallons of oil were removed from the wreck. Minor oil spills were contained and removed with booms and a skimmer.

Search and Recovery of U.S. Coast Guard Air Cushion Vehicle from the Straits of Mackinac, Lake Huron

The air cushion vehicle, ACV-3, sank in 110 feet of water on 23 November 1971. It was left in place over the winter when initial recovery attempts failed. Operations resumed in June 1972 with the USCG SUNDEW as the lift platform. The vehicle was first lifted to a depth of 40 feet where divers attached a specially designed sling for hoisting it aboard the SUNDEW. Recovery was accomplished on 12 June.

Debunkering and Salvage of Dredge ATLANTIC at Elizabeth River, Norfolk, Virginia

SUPSALV assistance was requested in August 1972 to halt the spread of oil pollution from the sunken dredge ATLANTIC, and to remove the dredge and two smaller craft sunk adjacent to it. Oil containment and removal equipment was immediately employed and the dredge stripped of accessible

remaining oil. The two smaller craft were pulled clear and salvage operations begun on the dredge. Salvage operations included the use of beach gear, patching, pumping and a large plastic sheath around the hull.

Search and Recovery of USS GEORGE BANCROFT (SSBN-643) Anchor and Chain off Portsmouth, N.H.

On 5 July 1972, the nuclear submarine GEORGE BANCROFT lost her anchor and 135 fathoms of chain in 400 feet of water. On 11 June, in just seven minutes of active searching with side-scan sonar, the anchor and chain were located. The USS NIPMUC (ATF-157), using an anchor hawk, snagged the chain that evening on the fourth attempt. The anchor and chain were recovered the next day.

Recovery of USS TUCUMCARI (PGH-2) from Caballo Blanco Reef off Puerto Rico

The hydrofoil gunboat TUCUMCARI struck a submerged reef at high speed on 16 November 1972. On impact, the forward strut collapsed, while the two main struts embedded themselves deeply in the coral. Preparations to refloat the craft using beach gear were begun by the M/V RESCUE. Several retraction attempts were made, but the embedded struts held the craft firmly to the reef. On 21 November, with two tugs assisting the RESCUE and a helicopter providing lift to the stern, TUCUMCARI was pulled from the reef.

Search and Recovery of U.S. Air Force F-4E Aircraft off Coast of Turkey

On 8 September 1972 an Air Force F-4E aircraft crashed in 130 feet of water. Using the USS PRESERVER as a surface support platform, an intensive search for the wreckage was conducted with side-scan sonar. After 13 days, the aircraft was finally located well outside the prime search area. During the four days of salvage efforts that followed, the PRESERVER recovered enough of the wreckage so that an accurate determination of the cause of the accident could be made.

Summary of Downed Aircraft Search and Recovery Operations in 1972

This article reviews five aircraft search and recovery operations conducted by the Navy in 1972. Two were for fighter aircraft, a Navy F-14 and an Air Force F-4E; both were successful. A Navy TA-4J was successfully located but recovery efforts were foiled by adverse weather. In addition, a Navy HH-2C helicopter was located and recovered, as well as two Air Force RA-4C aircraft which had been in a mid-air collision.

ABSTRACTS OF SALVOPS 1973 ARTICLES

Rescue of the Deep Submersible PISCES III and Crew from 1,600 Feet

The mini deep submersible PISCES III was flooded during recovery by its mother ship VICKERS VOYAGER, during transatlantic telephone cable-burying operations off the Irish Coast. It plummeted to the bottom where it was trapped with its 2-man crew. Seventy-two hours later, CURV III, flown in from San Diego, California, succeeded in attaching a line with which PISCES and its crew were hauled to the surface and saved.

Prompt, Economical Underwater Repairs to USS F.D. ROOSEVELT (CVA-42)

Twice in 1973, emergency repairs were provided for the ROOSEVELT by means of rapid, effective, underwater work techniques. A badly damaged port rudder was repaired and the packing of the stern tube gland of #3 propeller shaft was replaced. In both cases, time-consuming and expensive diversion to a drydock was avoided.

Salvage Efforts and Stripping of USNS JACK J. PENDLETON (T-AK-276)

The PENDLETON was severely grounded at 17.5 knots at high tide on Triton Island in the South China Sea. A deck load of 100 tons (two generators) over #2 hold – too heavy for equipment on-scene – precluded unloading a crucial 280 tons in #2 hold, which was located over the point of grounding. In the short time available, retraction proved impossible. Four typhoons then pounded the area, broaching PENDLETON to, 70 yards further onto the reef. It was declared a loss and salvage was limited to stripping cargo, valuables, and fuel.

Foam "Sink-Proofing" of LST for Test of Haiphong Minesweeping

Successful completion of Project ENDSWEEP, the minesweeping of Haiphong Channel, had to be demonstrated by means of safe channel transit by a ship. An LST was chosen for the task and had to be made "sink-proof" by filling buoyant spaces with polyurethane foam. This was accomplished in record time and the channel transited safely and successfully.

Clearance of Tug Wreck from Coney Island Channel

In 1973 the U.S. Army Corps of Engineers' dredging program for New York Harbor was impeded by a tug hull in the Coney Island Channel. USS OPORTUNE and her divers succeeded in passing chain slings under the wreck. The slings were then used to raise the wreck from the channel-bottom, by means of the bow lift system of the OPPORTUNE, which then deposited the wreck in deep water.

Removal of Fouled Ground Tackle From Deepwater Petroleum Offloading System, Estero Bay, California

In attempting to enter a moor to offload jet fuel at Estero Bay, the USS SUAMICO fouled its anchor in the hose line bottom connection. SUAMICO dropped its anchor, which a salvage team was able to retrieve without damage to the hose. The operation was safeguarded against pollution by first enclosing the site with oil containment booms. Fortunately this necessary precaution was not tested by any spillage of the jet fuel involved.

1973 Operations in Support of the Azores Fixed Acoustical Range (AFAR)

In July 1973, the Director of Ocean Engineering conducted a sequence of operations during the good summer weather, designed to bring AFAR to full operating capability. The tasks included: properly reorienting one of the three 120-foot-high acoustic towers mounted on the sea bottom at 1,000 feet; retrieving, refurbishing, and replacing a 5,000-pound underwater environmental monitoring buoy moored 200 feet below the surface; adding a NOMAD weather buoy to the system; and calibrating the AFAR system and components.

Support Operations for the Joint Casualty Resolution Center (JCRC) Southeast Asia

During an 82-day period, 77 square miles of coastal ocean bottom were searched for aircraft wreckage with personnel remains, to resolve the status of men listed as missing in action (MIA). Using the highly discriminating side-looking sonar, 36 positive contacts were obtained, 14 of which were aircraft related.

Recovery for Crash Analysis of P-3B Aircraft off Brunswick, Maine

In March 1973, a Navy P-3B crashed in the Atlantic shortly after takeoff on a local test and training flight. Proceeding from fixes hastily determined after the crash, the ALCOA SEAPROBE was used to conduct a successful search for the wreckage, which was deemed critical for accident analysis and prevention. Subsequently, ALCOA SEAPROBE was able to use its unique oil-well drill-pipe mounted system to recover the necessary wreckage. Assisted by the USS EDENTON (ATS-1), the wreckage was delivered to NAS Brunswick, for analysis.

Summary of Downed Aircraft Search and Recovery Operations in 1973

During the year 1973, the Supervisor of Salvage provided assistance for the search and recovery of five aircraft, in addition to the above P-3B. This included the following Navy types: an F-4B fighter, an HH-2D helicopter, an A-7E attack aircraft, and a TA-4J trainer, as well as a USAF RF-4C photo recon type.

ABSTRACTS OF SALVOPS 1974 ARTICLES

Retraction and Recovery of USNS Tug LIPAN

The fleet ocean tug USNS LIPAN (T-ATF-58), holed in a collision in the Strait of Juan de Fuca on 3 August 1974, was grounded to prevent sinking. A sister tug USS MOCTOBI (ATF-105) was sent to assist. LIPAN was patched, dewatered, and floated. Tow to a repair yard got under way, but proved unmanageable. LIPAN, then able to proceed under her own power, was escorted to Seattle, Washington, for repairs.

Buoyant Foam Sink-Proofing in Southeast Asia

Liquid-injected polyurethane foam was used to protect combat craft and shield barges in Vietnam and Cambodia against insurgent attacks. The quick-hardening foam was used in integral voids and add-on sponsons to effectively protect these craft against loss of buoyancy when pierced by hostile ambushes. The technique was particularly successful against shaped-charge munitions.

Locating and Photographing the Wreck of the MONITOR

In 1974, the Navy provided support to archeological efforts to verify the location, off Cape Hatteras, of the USS MONITOR lost in 1862. The support consisted of funding, personnel, and coordinating the availability of ALCOA SEAPROBE, under its contract with SUPSALV. Operations during April were successful in locating MONITOR, providing extensive photo coverage, and the preparation of a photomosaic by Navy photointerpreters, to document MONITOR's remains.

Tow, Repair, and Oil Spill Recovery for USNS PVT. MERRELL

USNS PVT JOSEPH F. MERRELL (T-AK-275) was severely damaged in a collision, on 29 December 1973, with a tanker off Cape San Martin, California. MERRELL was towed to a temporary haven at San Luis Obispo Bay. Oil containment measures were successful in minimizing pollution from MERRELL's ruptured fuel tanks, until a local storm tore up containment booms and interrupted temporary repairs. Once the storm subsided, a major pollution recovery effort was mounted to clean up the polluted shore. Temporary repairs were successfully undertaken on MERRELL and she was towed to Port Hueneme for disposal.

Salvage of YDT-9 from Chesapeake Bay

Under tow to disposal as a bombing target, the worn-out YDT-9 sank in York Spit Channel, Chesapeake Bay, on 4 April, in 40 feet of water, where it constituted a hazard to navigation. Its small size (160 tons, 110 feet) allowed for removal by bow lift with salvage ships, but bad weather, severe tidal currents, and technical difficulties disrupted operations. Finally, after two months, the YDT's two halves were successfully deposited at the designated target range.

Removal of the Dredge MACKENZIE from Galveston Channel

On 24 April, MACKENZIE was sunk in the busy Galveston Channel, in a three-ship collision. For removal, the decision was made to sever the hull into eight sections that could be lifted onto barges by

crane. As a necessary preliminary, diesel oil remaining in MACKENZIE's fuel tanks had to be carefully displaced into a fuel barge while the channel environment was shielded by oil containment booms tended by the latest type Navy oil skimmer. MACKENZIE was then laboriously cut up by oxyarc and explosive charges, and the sections and debris cleared from the channel as required.

CARIBIA En Route to Scrapyard: Aid in Hawaii, Loss at Guam

The 25,000-ton steamer CARIBIA, under tow to ship-breakers on Taiwan in June 1974 after 26 years of service, began flooding in her shaft alleys, near Hawaii. Navy help was sought and a salvage team with portable pumps removed the water and repaired the leaks. A month later, the towing tug HAMBURG experienced engine trouble approaching Guam, in a lee shore storm, and was forced to slip her tow. CARIBIA was blown onto the Apra Harbor breakwater, broke up, and slid into the entrance channel. Precision sonar search was required to determine a clear channel.

Clearing the Suez Canal

SUPSALV was charged with directing the U.S. role in clearing the wrecks of ten vessels from the Suez Canal. First the channel was swept by Navy helicopter minesweepers, which was followed by an international effort to clear other explosive ordnance from the canal and its banks. Actual ship clearance work was executed under contract by 19 December 1974, and all ten wrecks (including a dredge which was salved for repair and future use) were removed in under seven months time, ahead of schedule.

Summary of Downed Aircraft Search and Recovery in 1974

These articles review six aircraft search and recovery operations conducted under SUPSALV auspices in 1974. This included two Navy RA-5Cs and an A-7E, two Marine Corps F-4Bs, and an Air Force F-106.

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