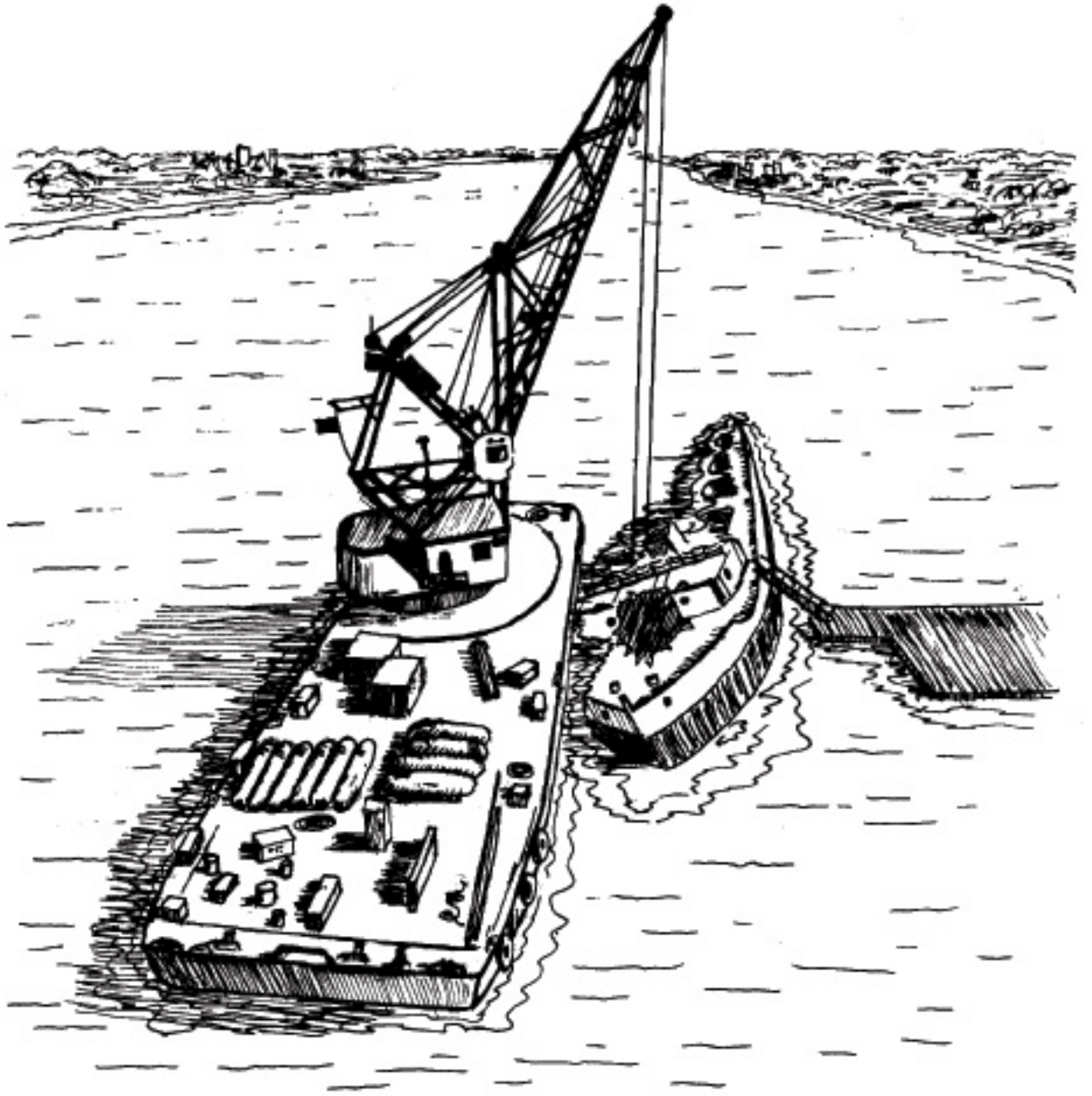
NAVSEA 0994-LP-012-6040

SALVOPS 72

A review of significant salvage operations conducted by U.S. Navy salvage forces and other salvage activities during 1972



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

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FOREWORD

These accounts of 1972 salvage operations are worthy of careful study by the Navy salvage community. However, all Navy personnel, whatever their specialty, will find much of interest in these pages. Salvage is a complex discipline with its own methods and equipment. But it is also basic seamanship, seamanship in perhaps its most demanding form. A salvor is above all a seaman. He works with ships in duress and what he does is of interest to all seamen.

Fortunately, U.S. Navy ships avoided serious accidents in 1972 despite their normal heavy operating schedules. However, Navy salvors were as busy as ever, applying their skills in a wide variety of salvage and oil pollution abatement tasks. The targets of their operations ranged from sunken commercial ships, endangering U.S. harbors and waterways, to a Navy hydrofoil gunboat stranded on a perilous reef. They recovered sunken objects, both familiar and exotic, including numerous downed aircraft and a Coast Guard air cushion vehicle. Indeed, the diversity of cases documented in this review illustrates once again that our Navy salvage forces must be equipped with both the training and the technology to meet any eventuality.

The search for new and improved techniques and equipment is a continuing and indispensable effort if our operating forces are to maintain a strong salvage capability. Navy salvors put some products of our developmental effort to effective use in these 1972 operations, including hydraulic pumps and hydraulic pullers; special equipment for combating oil pollution; and underwater foaming techniques. The report provides much useful information on these innovations and how they were applied in conjunction with conventional salvage methods.

Navy salvage operations grow more complex with each passing year. As they do, so does the importance of written records of previous operations. SALVOPS 72 is a useful addition to our library of professional knowledge, accumulated through the operational experience of Navy salvors. Note that we have included a consolidated index of previous editions with this issue!

J.H. BOYD, JR.
Captain, USN
Supervisor of Salvage, U.S. Navy

ABSTRACT

SALVOPS 72 is a review of significant salvage operations conducted by the Supervisor of Salvage, U.S. Navy, during 1972. The operations documented in this review are noteworthy for their great diversity, not only in the salvage techniques which were employed, but in the geographic locations of the operations and in the types of vessels which were salvaged. The massive and innovative salvage of the veteran Great Lakes coal freighter, SS SIDNEY E. SMITH, JR., is given extensive coverage. Operations on another commercial vessel, MV ORIENTAL WARRIOR, are documented in two articles: one for oil pollution abatement operations, and another for salvage operations. The successful removal of oil from MV SOLAR TRADER, which ran aground on a Western Pacific atoll, is also documented. Other articles describe oil pollution abatement and salvage operations on the sunken Dredge ATLANTIC at Norfolk, Virginia; search and recovery operations on a Coast Guard air cushion vehicle, or hovercraft, in the Straits of Mackinac; the freeing of a Navy hydrofoil gunboat, USS TUCUMCARI, from a reef off Puerto Rico; and the recovery of an anchor and chain lost from the nuclear submarine USS GEORGE BANCROFT. Operations to locate and recover a U.S. Air Force F-4E aircraft downed off Turkey are described in detail. The report also includes a summary of five other major downed aircraft search and recovery operations.

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RECOVERY AND DISPOSAL

OF

SS SIDNEY E. SMITH, JR.,

FROM THE ST. CLAIR RIVER,

PORT HURON, MICHIGAN

Overturned SMITH lies bottomed on starboard side, morning after night-time collision with PARKER EVANS (background). Hull, still intact, protrudes 250 feet into shipping channel. River current hammers at bow (upstream, right). SMITH broke up three days later.

CAPSIZED SIDNEY E. SMITH OBSTRUCTS RIVER CHANNEL

RECOVERY AND DISPOSAL OF SS SIDNEY E. SMITH, JR. FROM THE ST. CLAIR RIVER, PORT HURON, MICHIGAN

INTRODUCTION

The SS SIDNEY E. SMITH, JR. and the SS PARKER EVANS collided in mid-channel of the St. Clair River at Port Huron, Michigan, in June, 1972. The SMITH flooded almost immediately, overturned and sank, blocking the downbound lane of the busy river channel. Within 3 days, the swift current scoured the river bottom beneath the vessel, and the SMITH broke in half. Because the wreck posed a serious navigation hazard and was creating costly shipping delays, it was vital that it be removed from the channel as quickly as possible.

The difficulty and urgency of the SMITH operation gave rise to a bold, innovative salvage plan. Polyurethane foam was introduced into the wreck's submerged compartments to lighten each section of the vessel in mid-channel. To provide divers with safe access to underwater compartments for foaming and other salvage tasks, huge steel cofferdams and access tubes were fabricated and secured to the wreck. Finally, hydraulic pullers were positioned on shore to haul in the lightened bow and stern sections. The removal of the SMITH from mid-channel was accomplished in 3 months of intensive around-the-clock operations under conditions that continually challenged the skill, endurance and imagination of the entire salvage force.

LOSS OF THE SMITH

The SMITH and EVANS, both veteran Great Lakes freighters, collided at 0145, 5 June 1972. The nighttime collision occurred after the powerful 9-knot river current caught the bow of the upbound SMITH and carried the vessel across mid-channel into the path of the downbound EVANS.

Although the EVANS suffered only minor damage, and no crewmen on either ship were injured, the SMITH's starboard bow region was punctured. The 66-year-old ship had only minimal watertight integrity, and flooded immediately. Before any damage control measures could be taken, the vessel rolled on her starboard side and sank, straddling the downbound lane of one of the busiest and narrowest passages of the Great Lakes waterway.

Because of the swift current, the condition of the wreck steadily deteriorated. Turbulent water surrounded it, scouring away the river bottom, especially beneath the ship's forward area. Within a day the bow's support was eroded and the wreck began to break in half.

Anticipating the danger of a major oil spill, the Coast Guard acted swiftly to remove nearly 49,000 gallons of Bunker "C" fuel oil from the SMITH's tanks. By 8 June, the 489-foot wreck had apparently broken completely in half. The stern section, lying in about 40 feet of water, was only partially submerged. The bow section sank completely beneath the water's surface, settling into the scoured depression in the river bottom.

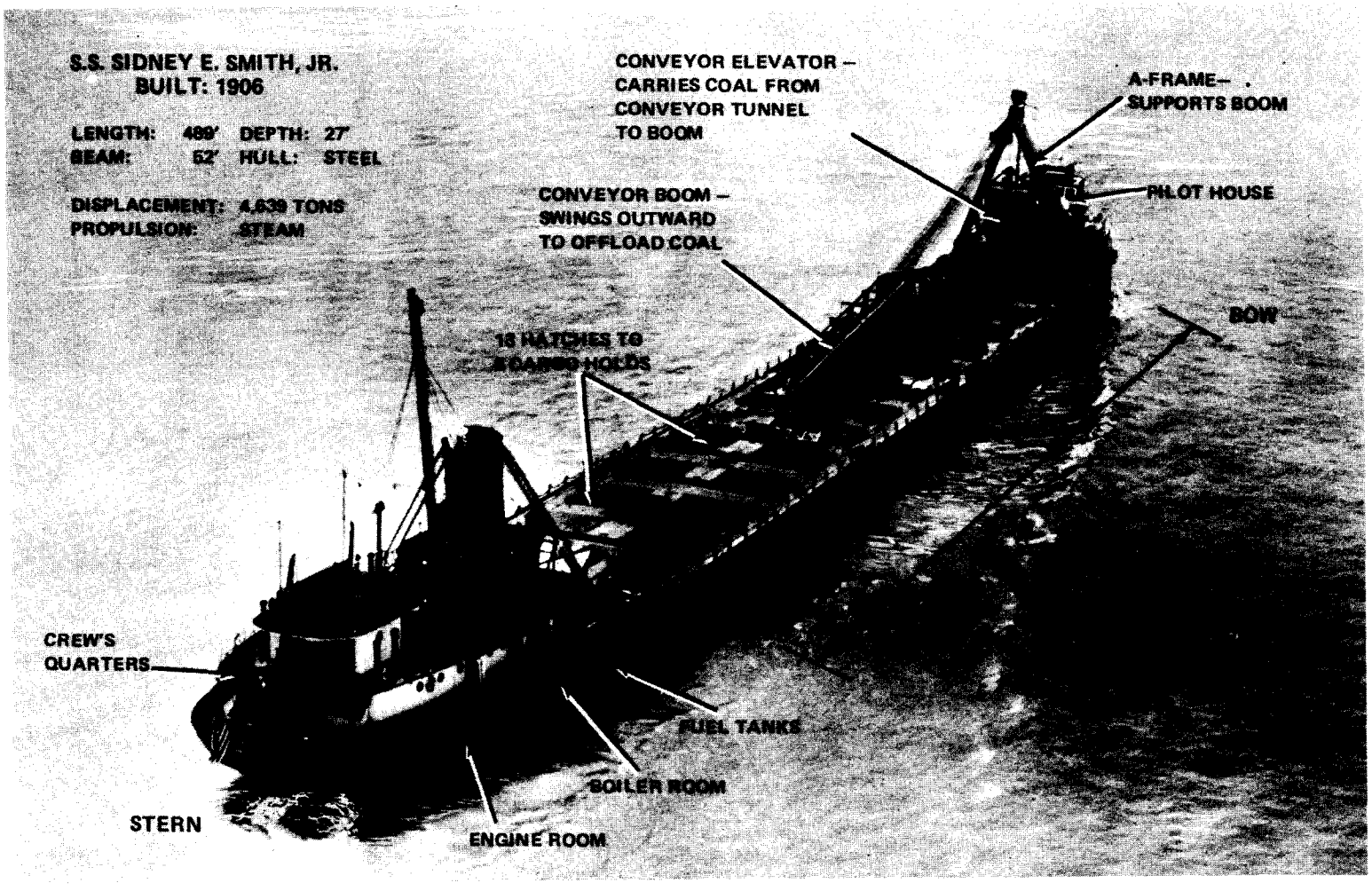
THE SALVAGE PROBLEM

The condition of the SMITH remained unstable even after the breakup. The scouring action of the river continued and both sections settled more deeply into the river bottom. The swift current hampered diving operations and close inspection of structural damage was nearly impossible. The passage of SMITH's sister ship, the SYLVANIA, on 1 July was fortunate as it afforded the salvage team an opportunity to examine the layout of the ship first-hand.

The salvors determined that the SMITH was carrying a substantial cargo of coal, but because the current had loosened the hatches and opened the cargo holds to the river, much of the coal had been washed away. In turn, tons of sediment had been washed into the wreck by the current.

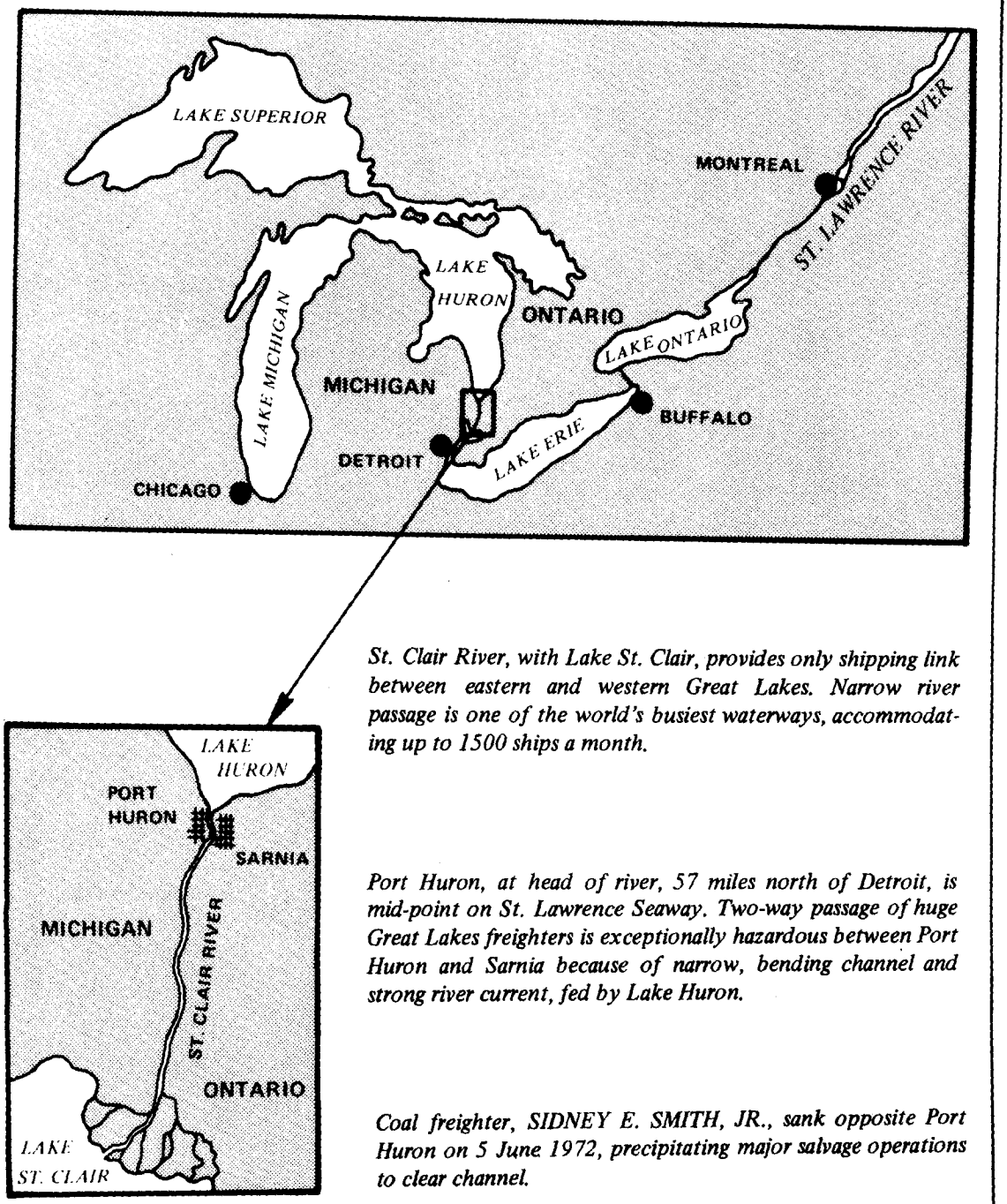
Flooding was also extensive. The SMITH was old and, as a self-unloading coal carrier, had spacious, open cargo holds and a conveyor tunnel that ran almost the entire length of the ship. Water first entered at the point of impact and then through the loosely fitting hatches after the heavy listing to starboard. Unchecked, it spread quickly throughout the vessel.

The wreck thus posed a formidable salvage problem, one which demanded not only a major, complex effort but also a rapid response. Although the Coast Guard had averted the danger of an oil spill and instituted emergency traffic controls in the channel, the SMITH still constituted a serious navigation hazard. With an already narrow and treacherous shipping lane cut in half, the danger of a second collision was very real.



Machinery for offloading coal dominates forward superstructure. Cargo holds, tanks and other interior spaces form vast underwater compartment with minimal watertight integrity. Freighter's design and construction make it exceptionally difficult to salvage.

SIDNEY E. SMITH – DESIGN AND CONSTRUCTION FEATURES

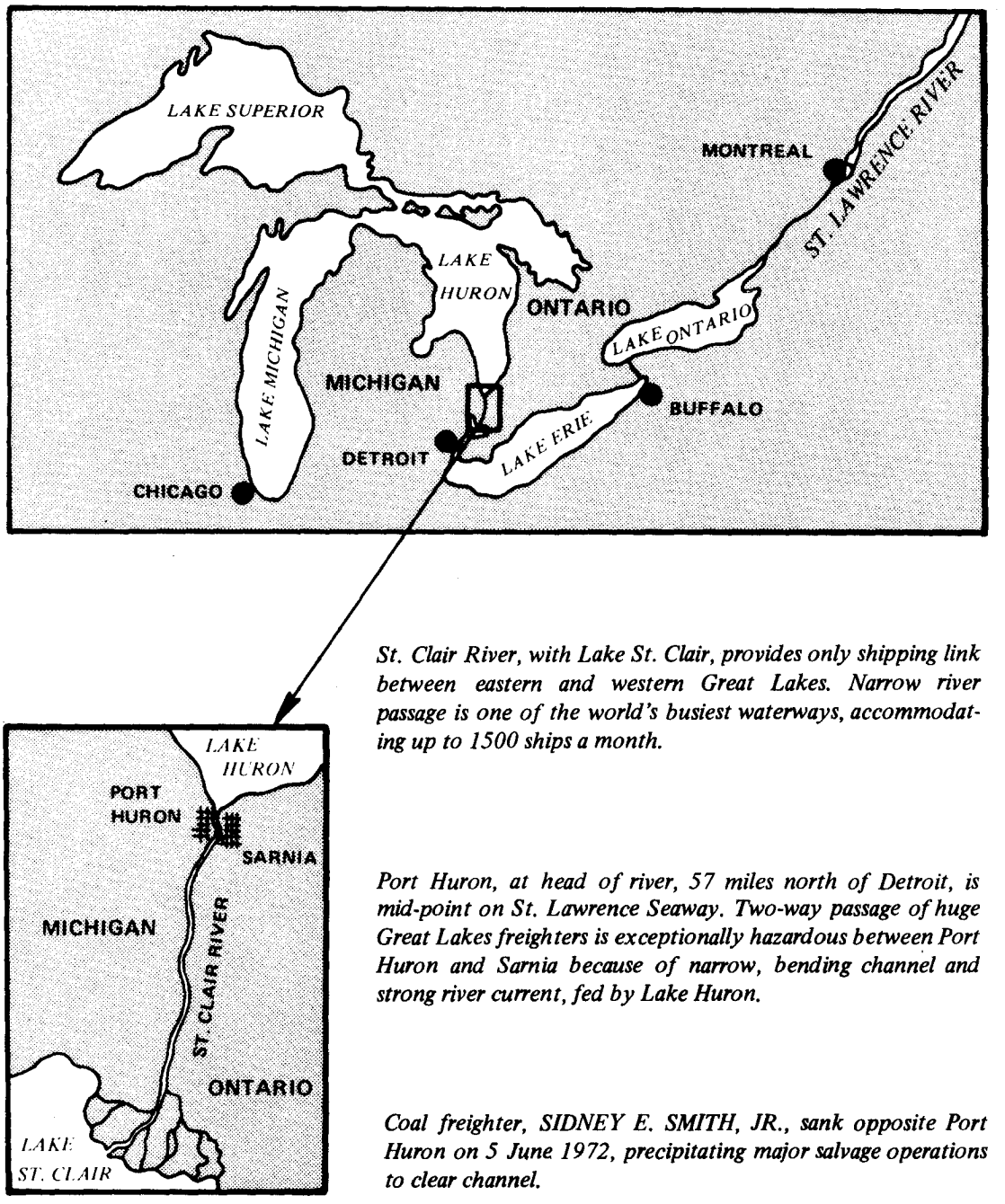


St. Clair River, with Lake St. Clair, provides only shipping link between eastern and western Great Lakes. Narrow river passage is one of the world's busiest waterways, accommodating up to 1500 ships a month.

Port Huron, at head of river, 57 miles north of Detroit, is mid-point on St. Lawrence Seaway. Two-way passage of huge Great Lakes freighters is exceptionally hazardous between Port Huron and Sarnia because of narrow, bending channel and strong river current, fed by Lake Huron.

Coal freighter, SIDNEY E. SMITH, JR., sank opposite Port Huron on 5 June 1972, precipitating major salvage operations to clear channel.

ST. CLAIR RIVER, VITAL GREAT LAKES SHIPPING ARTERY



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ST. CLAIR RIVER, VITAL GREAT LAKES SHIPPING ARTERY

PRINCIPAL PARTICIPANTS IN SMITH SALVAGE OPERATIONS

AGENCY	MAJOR ROLE
US Army Corps of Engineers (COE), Detroit District	Responsible for overall wreck removal and provided all floating assets and various accessory equipment and services.
US Navy Office of Supervisor of Salvage (SUPSALV)	Operational control of salvage operations to remove the sunken SMITH from the river channel and prepare the hulk for disposal at a remote site.
US Coast Guard (CG) Port Huron, Mich.	Responsible for pollution abatement, traffic control, buoy maintenance, and issuance of appropriate "Notices to Mariners."
Murphy Pacific Marine Salvage Company (MYPAC) New York City	Under a Supervisor of Salvage contract, provided salvage services and equipment as directed by the on-scene SUPSALV representatives.
Harter Underwater Construction Corporation (Harter), Annapolis, Md.	Under a Murphy Pacific contract, provided all diving services for the SMITH salvage operation.
Nicholson Anchorage Company Bridgeville, Pa.	Under a Corps of Engineers contract, installed anchors and platforms for on-shore hydraulic pulling system.
Lucker Manufacturing Company, Philadelphia, Pa.	Under a Murphy Pacific contract, manufactured 6 specially designed hydraulic pullers for on-shore pulling system.
Emergency Ship Salvage Material (ESSM) Bases	Strategically located supply bases operated by SUPSALV provided most standard items of rigging and salvage equipment.
Batelle Memorial Institute Columbus, Ohio	Consulted with Murphy Pacific on urethane foam quality problems.
James G. Ferguson & Son, Inc., Port Huron, Mich.	Under a Murphy Pacific contract, fabricated steel hatch covers, cofferdams, installation guides, flounder plates, and other special equipment and fittings.

ASSEMBLING THE SALVAGE FORCE

With each passing day, the SMITH's condition steadily worsened. It became clear that the ship's owners would be unable to undertake the required salvage effort. By 20 June, the U.S. Army Corps of Engineers (COE), which has ultimate responsibility for maintenance of federally controlled inland shipping lanes, assumed control. Because of the urgency and complexity of the SMITH situation, COE gave operational control of the removal effort to the Office of the Supervisor of Salvage (SUPSALV), U.S. Navy, whose representatives had already arrived on the scene to assist in formulating a salvage plan.

To supplement its own resources, SUPSALV mobilized its standing contractor, Murphy Pacific Marine Salvage Company. Murphy Pacific provided additional personnel and foaming equipment and, in turn, contracted with several other private firms for diving, construction of hydraulic pullers and other services. COE provided floating plant equipment, including the salvage work platform, a large derrick barge, and also contracted for the fabrication and installation of the anchoring system for the hydraulic pullers.

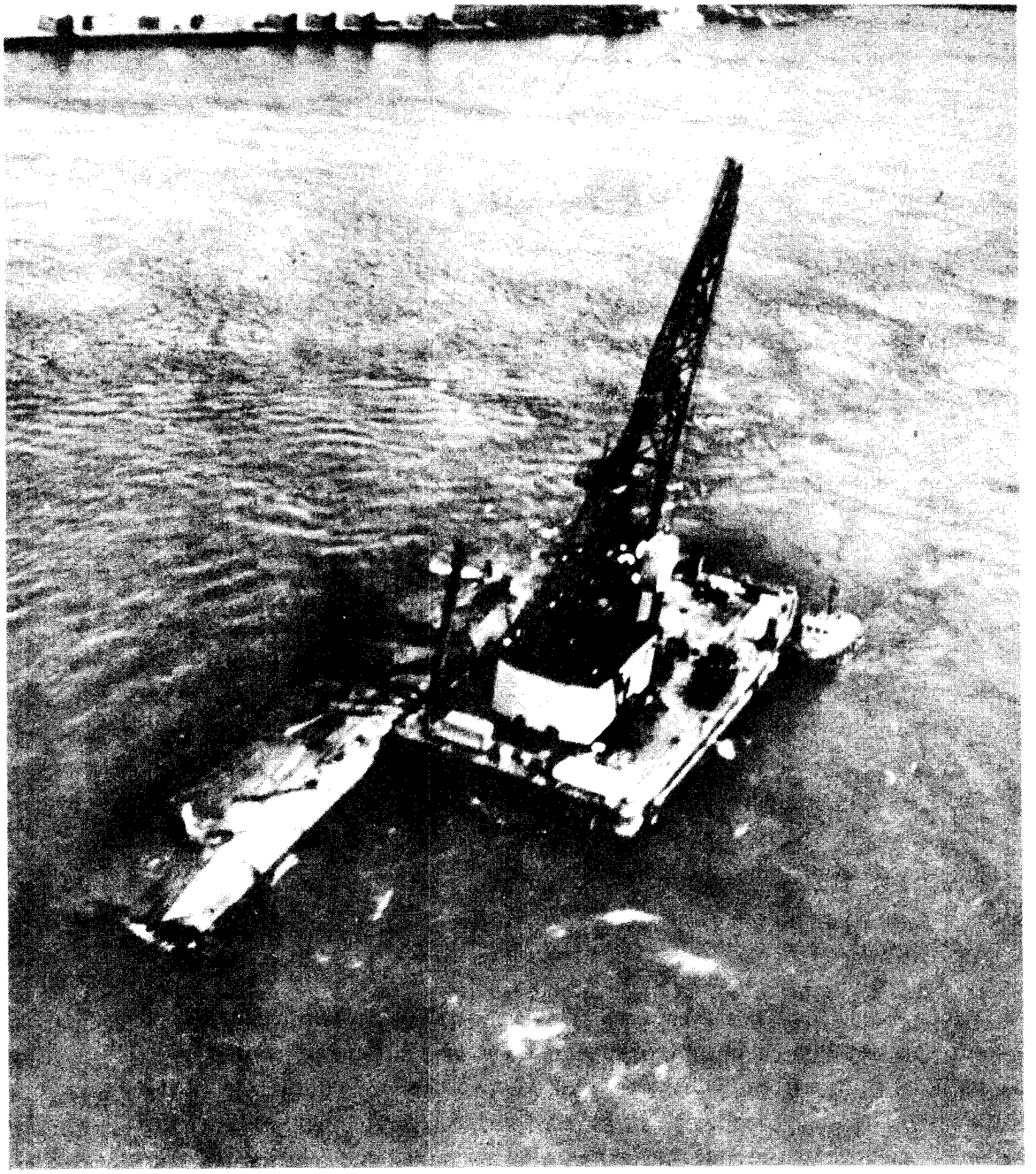
The removal of the SIDNEY SMITH was a joint effort coordinated by representatives from SUPSALV and COE. The Salvage Master was appointed from SUPSALV; Murphy Pacific provided the Assistant Salvage Master.

KEY FEATURES OF THE SALVAGE OPERATION

The salvage force was faced with several major problems, including a dangerous river current; limited working area and soft ground conditions ashore; the wreck's structural weakness; and time. As a result of the difficulty and urgency of the SMITH operation, several innovative salvage techniques emerged.

Due to the prevailing salvage circumstances, the salvors ruled out traditional dewatering methods to lighten the wreck. Instead, they decided to apply the relatively new "foam-in salvage" method which involved installing several thousand tons of polyurethane foam inside the wreck for buoyancy.

The salvage team's solution for installing much of the foam was also innovative. Large 12-foot x 40-foot steel hatch covers were fabricated to close off certain cargo holds to contain the foam. To provide divers access to and from the wreck during foaming operations, long steel access tubes and cofferdams were constructed and implanted.



Versatile barge provided large stable platform for salvops and heavy lift capability with huge, 60-ton crane. Barge, shown here moored to stern section, supported all phases of the operation. Salvors dubbed it the "Big D".

CORPS OF ENGINEERS' DERRICK BARGE, PRINCIPAL WORK PLATFORM FOR SALVOPS

On-shore preparations for pulling and anchoring were no less significant. Soft, loose soil and limited working space along the western riverbank, precluded the use of traditional beach gear and deadman systems. Accordingly, the salvors procured six hydraulic pullers and positioned them in pairs in an arc along the riverbank opposite the wreck. A specially designed anchoring system, consisting of concrete blocks with anchor legs implanted deep underground, was installed to hold the pullers in place.

The foam-in-salvage method, the use of hatch covers and cofferdams, and the innovative hydraulic pulling system proved to be the decisive features in the successful retrieval of the broken SMITH.

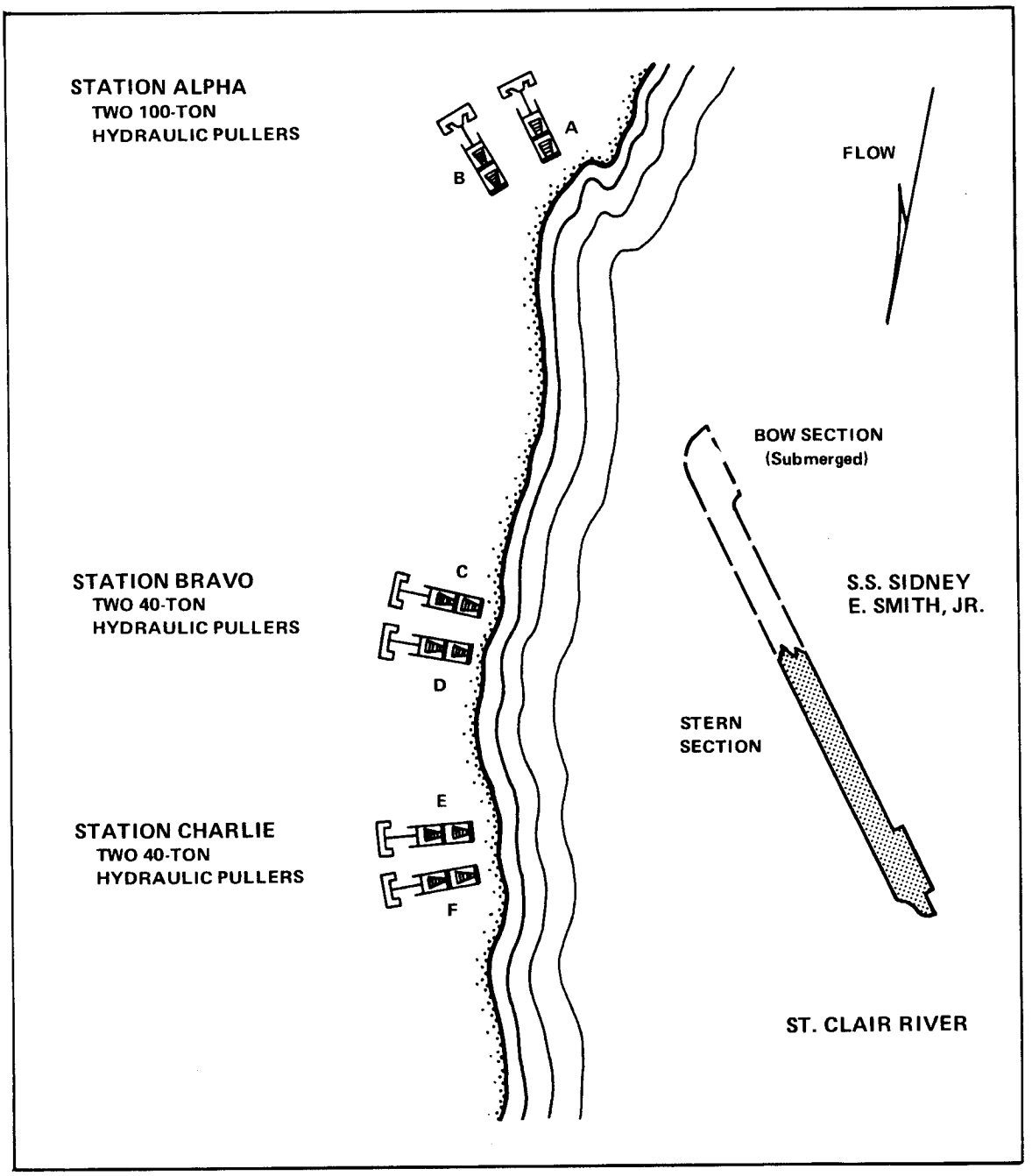
FOAM-IN-SALVAGE METHOD

Choice of Foam-in-Salvage Method

The SMITH operation marked only the second major operational application by the Navy of the foam-in-salvage method. It was first used on a large scale to salvage the grounded destroyer USS FRANK KNOX in 1965. Though still unperfected, it was a promising salvage technique. The SMITH salvage team chose to install foam to lighten the SMITH for several reasons. When introduced into the compartments of a submerged vessel, urethane foam expands to 30 times its original size and has a density as low as 2 lbs/ft^3. Although air is considerably more buoyant, foam better lent itself to the SMITH operation than dewatering with air since a foamed compartment need not be extensively patched or plugged. Foam has a self-sealing quality and hardens within seconds. As such, it enhances a vessel's structural strength as well as providing buoyancy.

Basic Foaming Process

Polyurethane foam is the product of a reaction between two chemicals, polyol and isocyanate. These liquid chemical components are stored in separate containers. A third chemical, liquified fluorocarbon, is blended with the two chemicals during the delivery process en route to the foam gun, or may be preblended in the separate chemical containers. Once the chemicals reach the foam gun, they are thoroughly mixed and released through the gun nozzle into the desired ship compartment. The pressure reduction upon release changes the liquified fluorocarbon to gas. Inside the waterfilled compartment, the polyol-isocyanate compound is rapidly expanded by the gaseous fluorocarbon. It hardens quickly, forming countless tiny cells with the fluorocarbon gas trapped inside. As the foam expands and hardens, it displaces an equal volume of water. The result is a rigid block of buoyant foam which fills the compartment and lightens the wreck.



Three pulling stations were established in an arc along riverbank opposite wreck. Pair of anchor blocks at each station anchored hydraulic pullers, which were interchangeable between stations. Arrangement above shows placement of the six hydraulic pullers at start of pulling operation on stern section.

LOCATION OF PULLING STATIONS

a subsurface anchoring system and engaged the Nicholson Anchorage Company of Bridgeville, Pa. to install it. Each puller would be held at the surface by a specially constructed anchor block of reinforced concrete with anchor legs implanted deep underground. Test borings revealed different geological conditions at the work site. At Pulling Station ALPHA, upstream, the anchor legs could be implanted in a formation of dense sand at depths of about 50 feet. However, at the two downstream stations a clay material, unsuitable for anchoring, was encountered to depths of 100 feet before reaching a shale bed-rock material. At these stations it would be necessary to implant the anchors some 20 feet into this underground rock formation.

The Nicholson Company used special, vehicle-mounted drill rigs to bore the shafts for the anchor legs. The legs were made up of wire rope bundles lowered into the shaft and grouted with cement. At the bottom portion, the strands of the bundle were unwound and separated so that the concrete grout could form a particularly strong clump as it hardened among the unlayed ends. The rock anchor legs also had a pair of conical under-reams at the bottom of the shaft, drilled by the rigs, which provided additional strength at the seating. Each block at the upstream station had three legs to provide extra stability for the loadings anticipated at this station. Two legs sufficed for each block at the downstream stations. The legs were angled 45 degrees from the horizontal and to each other to allow for varying angles of pull.

SALVAGE OPERATION IN THREE PHASES

The salvage plan was to lighten each section of the wreck in mid-channel with urethane foam, then haul it ashore. Once ashore, each section would be prepared for disposal. The three phases of the operation were as follows:

Phase I – Stern Removal Operations
Phase II – Bow Removal Operations
Phase III – Disposal of Wreck Sections

The salvors chose the stern section as their first target. It protruded further into the channel and posed a greater navigation hazard than the submerged bow section. It was also more accessible, its port side still several feet above water. Once the stern section could be retrieved, salvors would conduct bow removal operations in mid-channel concurrently with stern disposal operations ashore.

PHASE I – STERN REMOVAL OPERATIONS – 26 JUNE TO 6 AUGUST

While the pulling platforms and anchoring system were being constructed ashore, preparation of the stern section for foaming and rigging of pull points was under way in mid-channel.

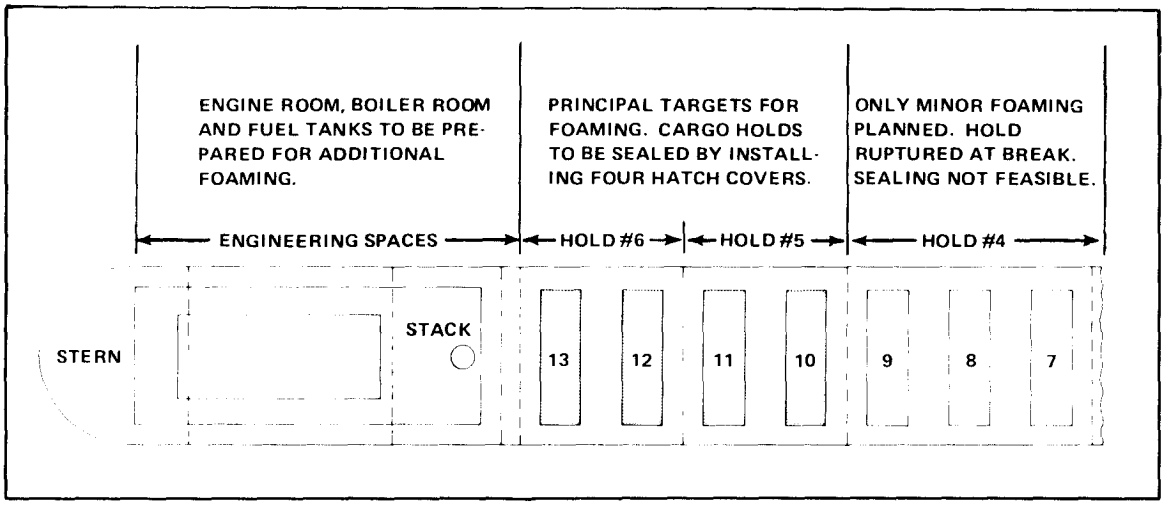
Moored directly to the stern section was the indispensable COE derrick barge. Foaming, diving and all other phases of the stern salvage operation were conducted from this large stable platform. The barge's deck was constantly crowded with salvage equipment, such as air compressors, diving and airlift equipment, foam tanks, and foam delivery equipment. The barge's 60-ton crane was capable of handling heavy and cumbersome objects, such as the foam tanks, and was vital to the installation of hatch covers and diver access tubes.

Hatch Cover Installation

Diver inspection of the stern section on 27 and 28 June bore out the salvors' expectations that the river current had dislodged the cargo hold hatches from their coamings. In order to contain foam inside the wreck, it was necessary to cover these large hatch openings with large 12-foot x 40-foot covers. The covers were fabricated by the Ferguson Steel Company, a Port Huron firm, according to specifications prepared by the salvage force.

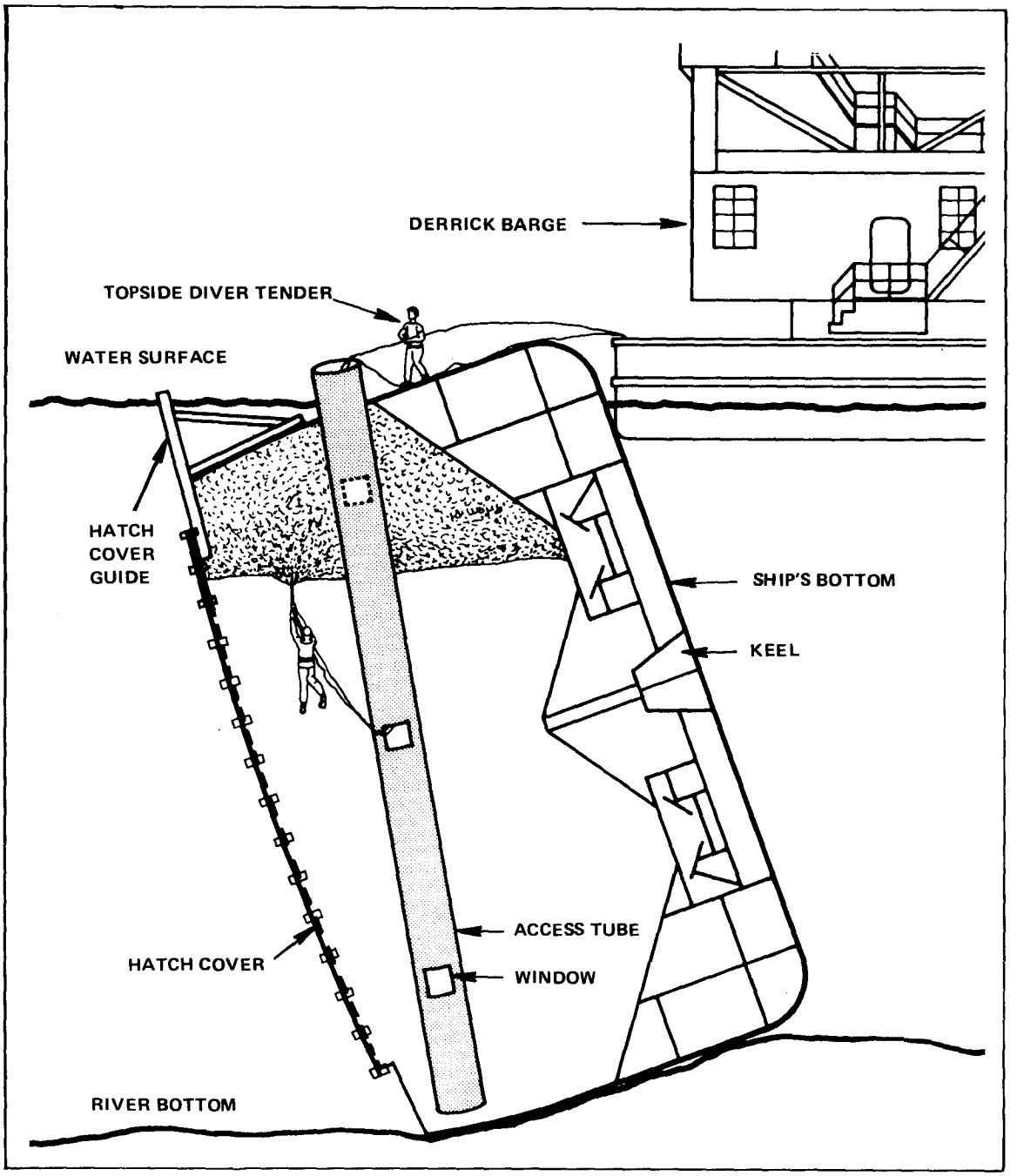
The salvage team began installing the first cover over hatch 13, cargo hold 6, on 1 July. The hatch cover edges were fitted with clips that were designed to slip under the hatch coaming and guide the cover as it was lowered into place. But as the barge crane began lowering the hatch cover into the water, the strong current interfered, preventing proper alignment. Although the edges of the SMITH's hatch coamings were above water when installation plans were formulated, the wreck had since settled, and they were now submerged. To facilitate installation, the salvors fabricated a hatch cover guide from 3-inch angle stock and secured it to the deck edge above the submerged coaming. Using this guide, which was essentially a pair of steel tracks, the salvors were able to lower the cumbersome cover and fit it properly into place.

The first cover was securely in place late on 2 July. During the next 2 days, the other three were placed over hatches 10, 11 and 12 with considerably less difficulty. Nevertheless, the river current, the unwieldy nature of the covers themselves, and occasional irregularities in the hatch coamings made hatch cover installation an arduous, time-consuming task.



Hatch covers were emplaced in succession over hatches 13, 12, 10 and 11, sealing cargo holds 5 and 6. Installation was accomplished in 3-day period despite difficulties in handling and securing the heavy, cumbersome steel covers.

HATCH COVERS SEAL CARGO HOLDS FOR FOAMING



Diver foams cargo hold from top down, using each window in succession as foaming progresses to lower levels. Here, diver is tended from topside. Second diver went down to tend foaming diver when working in restricted spaces.

FOAMING IN CARGO HOLD FROM DIVER ACCESS TUBE

Diver Access Tube Installation

To permit diver access to the cargo holds for foaming and exit from these spaces as they were progressively foamed, three steel tubes were constructed and placed vertically into the stern section's cargo holds 5 and 6 through the exposed port side. These diver access tubes measured approximately 60 feet long and 3 feet in diameter, and extended down to the bottom (starboard side) of the ship.

Each had three "windows" at different levels through which the diver could pass as he foamed a compartment. For example, after foaming the top portion of a compartment, the diver would re-enter the tube through the top window, seal it off with a soft patch, descend to the next lower window, re-enter the compartment and continue foaming. After foaming to the level of the bottom window, the diver would again enter the tube and return topside.

Removal of Debris

With the hatch covers and diver access tubes in place by 4 July, salvors began airlifting debris from the wreck. Several days earlier, a considerable quantity of coal was expelled from cargo hold 6 using a high pressure water jet. Pumping operations from 1 to 8 July, using 6-inch and 10-inch-diameter airlifts, succeeded in removing most of the coal and sediment from holds 4, 5 and 6. It was necessary for divers to rake much of the coal to the airlift intake.

After debris removal, divers prepared the wreck for the installation of foam. Holds and compartments were further inspected and cleaned; doors and hatches were secured; and major holes and cracks were plugged. Crawl holes were cut to permit divers an entrance to tanks and small spaces. For diver safety, obstructions and loose objects were removed, loose deck plating was secured, and "travelling lines" were rigged through the dark, machinery-cluttered spaces.

Foaming the Stern Section

Foaming began on 4 July, a month after the collision. During the period 4-15 July, an estimated 1,700 tons of foam buoyancy were installed using both the diver and probe methods. The SMITH'S cargo holds were the principal targets for foaming operations. Foam was also installed in selected tanks and portions of the engineering spaces. This estimate of 1,700 tons, like all subsequent estimates of foam buoyancy, was based on predicted or anticipated yield as opposed to actual yield.

The actual amount of buoyancy installed in the wreck was uncertain. Weighing and testing of foam samples during installation revealed that foam quality was poor. Analysts concluded that since the temperature of the two foam components was being cooled to below 70°F by air and water during delivery, it would be necessary to pre-heat the chemical tanks to 80° or 90°F. The salvors constructed a heating shed with several space heaters for the pair of chemical tanks on line. The shed was assembled on a flat scow (cargo barge) by 9 July and was used throughout the remainder of stern foaming operations. This method was effective in heating the tanks but the foam quality remained poor. The salvors had to install far more foam in the stern section than had been originally planned in order to achieve the required actual yield.

One minor setback to the foaming operations occurred on 13 July when a hatch cover above hold 5 began to break loose from the hatch coaming under the pressure of the installed foam. Although a large amount of foam escaped, much of it was trapped by a metal screen which salvors had placed downstream as a precaution against such accidents. Before installing new foam to replace what had been lost, the salvors installed turnbuckle jigs to secure the hatch covers more tightly against the coamings.

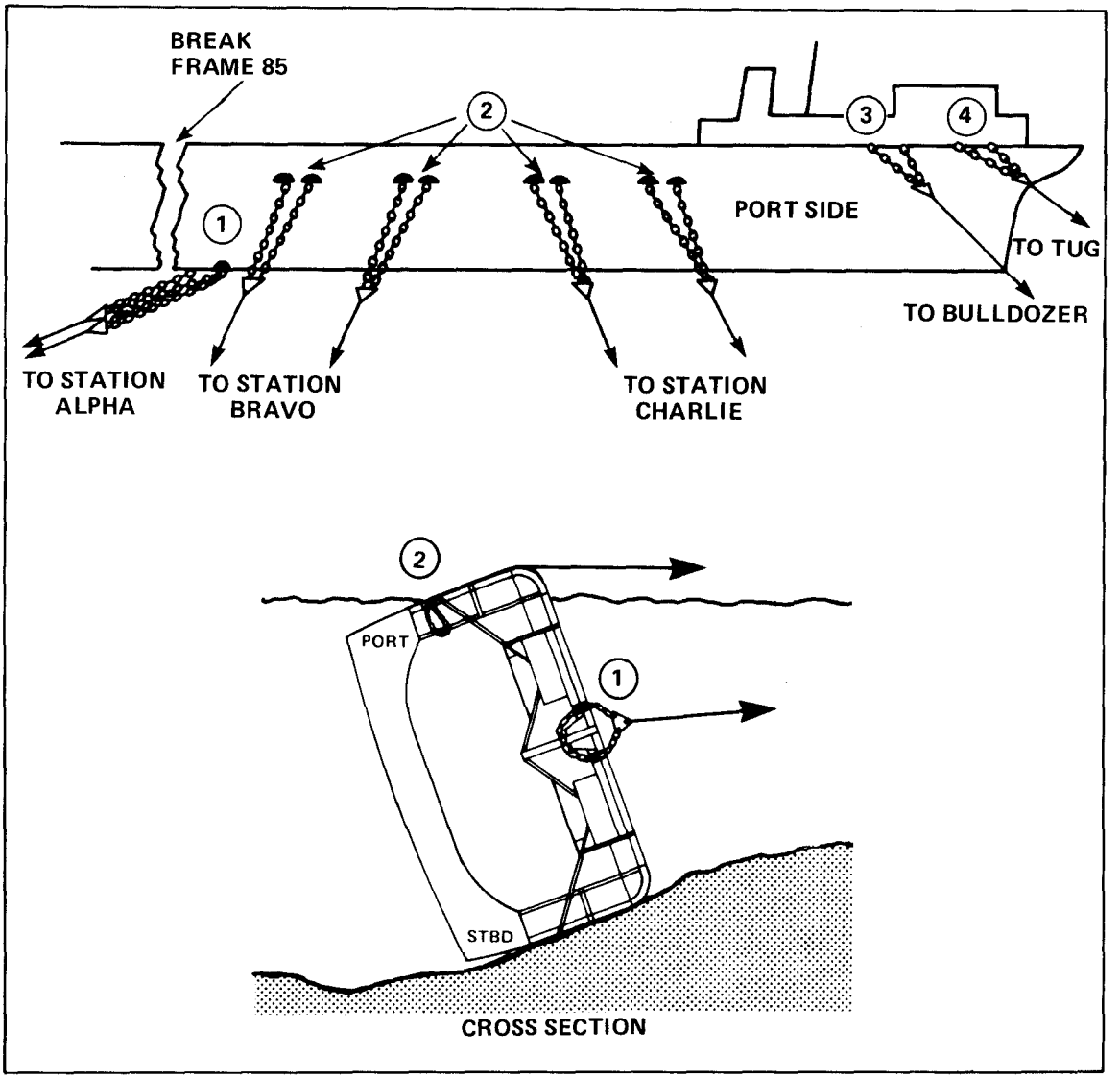
In spite of the quality problem, the installed foam effectively halted further settling of the stern section. Foaming operations were shut down for a day on 16 July in order to allow time for a portion of the pulling system to become operational. With additional foam, the wreck could become lively at any time and the salvors wanted it under control by the pullers before this should occur.

Rigging of Pull Points

Pull points were rigged on the stern section on 29 and 30 June. Their positioning reflected the pulling strategy and the conditions of the river current.

For holding the wreck against the 9-knot river current during the shoreward pull, divers looped two lengths of heavy 2 1/4-inch anchor chain around the keel at frame 94, 30 feet aft of the break. The 2-inch pulling wire from each of the two 100-ton pullers at Station ALPHA was then attached to the bitter ends of each chain with a flounder plate. To install the chain, a diver entered the conveyor tunnel beneath the hold and burned a hole on either side of the keel for passing through the ends of the chain.

The salvage plan called for parbuckling in mid-channel prior to shoreward pull to clear the wreck of a shallow, submerged ridge. If it had not been parbuckled, the salvors would also have risked losing the stern section in a deep depression during the shoreward pull.



(1) *To hold wreck against current, pulling wires were attached to 2¼" chains looped around keel at frame 94.*

(2) *For parbuckling and shoreward pull, four pull points were rigged high on port side. Flounder plates connected pulling wires to 2¼" chains attached to each of four strength members 24' apart in cargo holds 5 and 6.*

(3) *For additional 27-ton shoreward pulling force from bulldozer, pull point aft on port side was rigged.*

(4) *Tow wire from tug to stern of wreck was rigged in attempt to separate stern from bow section.*

RIGGING OF PULL POINTS ON STERN SECTION

Four pull points were positioned high on the port side, rigged by passing a loop of 2 1/4-inch chain through the port skin around each of four evenly spaced strength members in holds 5 and 6. The 1 5/8-inch pulling wires to the four 40-ton hydraulic pullers at Stations BRAVO and CHARLIE were attached to the bitter ends of their respective chain by a flounder plate.

On 17 July, the stern section was holding stable, its pull points rigged. However, salvors had to await the delivery of the four 40-ton pullers. As the 100-ton pullers upstream were tensioned and adjusted, salvors resumed foaming operations on the wreck. Additional foam was installed in hold 6 using the probe method.

On 19 July, the four pullers arrived and were set up at Stations BRAVO and CHARLIE. An HD-21 bulldozer with a 1 5/8-inch wire attached to the stern quarter was positioned downstream to aid in the shoreward pull.

First Pulling Effort

On 20 July, all pulling wires between the pullers and wreck were tensioned to 10 to 12 tons. No visible shoreward progress was evidenced, but the wreck had begun to right itself.

Foaming operations are nearing completion. Stern is held against shallow underwater ridge initially. River current washed away ridge peak, helping free the hulk for shoreward pull.

STERN SECTION JUST PRIOR TO FINAL PULL

Although pulling tension from Stations BRAVO and CHARLIE was maintained at 40 tons throughout the next day, there was still no apparent shoreward movement. Divers, sent down to inspect the break area, confirmed the suspicion that the bow and stern sections of the wreck remained joined by an unexpectedly strong connection of shell plating and longitudinal strength members on the submerged starboard side. Pull from a tug on the previous day had failed to separate the two sections. Divers then used plastic explosives to break the connection. However, pulling efforts bogged down again after a shoreward pull of only 12 feet.

On-Shore and Mid-Channel Modifications

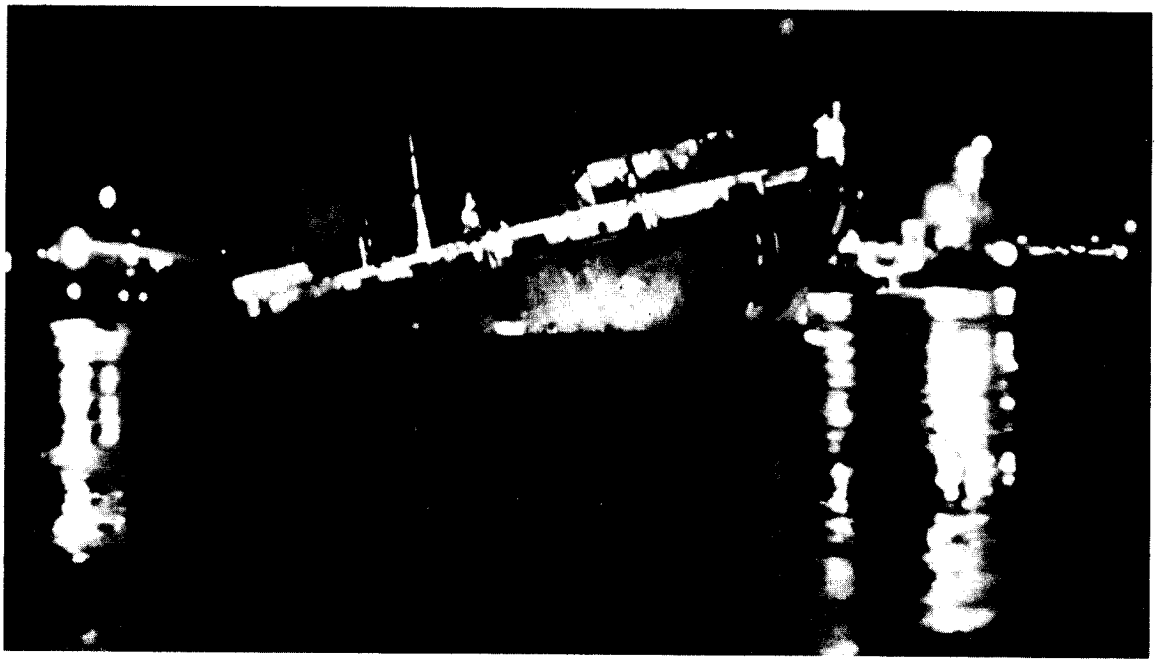
The salvors concluded that an increase in both buoyancy and shoreward pulling force was necessary. Thus, the 100-ton pullers at Station ALPHA were exchanged with the 40-ton pullers at Station BRAVO, and a second HD-21 bulldozer was placed downstream. The pulling wires from the two pullers at Station CHARLIE were doubled and deadended, and run through snatch blocks on the wreck to give the pullers a 2:1 mechanical advantage. During the week of 23 July, salvors installed more foam in the engine room and boiler room.

By 30 July, a 40-ton strain taken on all pulling wires, plus the additional foam brought the stern section up to a 24-degree starboard list, although it was still trimmed well down by the forward end.

After the installation of still more foam in hold 5, the wreck was brought in an additional 31 feet. In preparation for further foaming of holds 5 and 6 on 4 and 5 August, divers reset the hatch cover clips, installed 12-inch I-beams as strongbacks across the hatch covers, and rigged wire strapping athwartships across the entire cover assembly. This reinforcement was necessary since the vessel's list was reduced to only 8 degrees and the foam was pressing in full force upward against the hatch covers instead of the port side as before.

Final Pulling Effort

With the stern section maintaining an 8-degree starboard list in mid-channel, the pulling wires were kept tensioned to hold the wreck against the shallow underwater ridge. The salvors hoped that this would wash the peak of the ridge away and clear the path for a final pulling effort. The tactic worked and on 5 August, shortly after midnight, the pullers commenced hauling in the stern section.



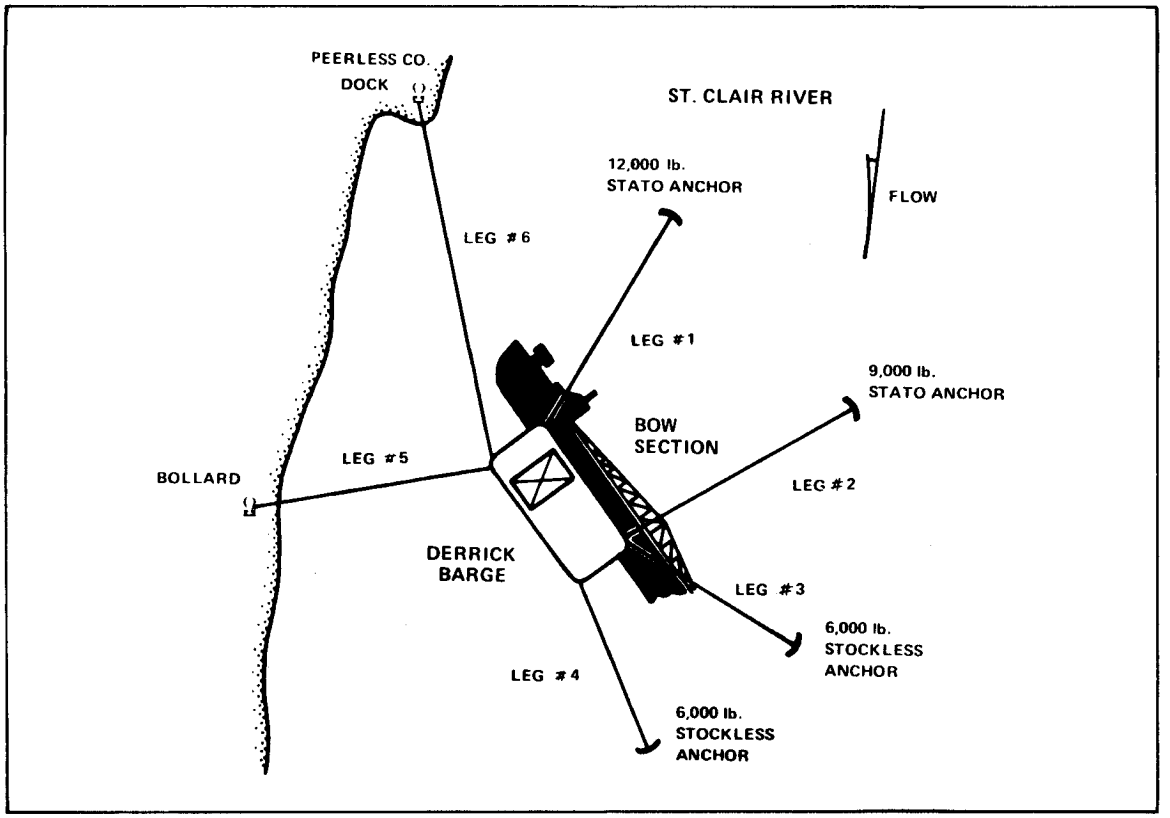
Final, 2-hour pull began just after midnight on 6 August. Stern section, broken end dragging bottom, came in easily, climaxing 41-day recovery effort.

MIDNIGHT PULL COMPLETES PHASE I SALVOPS

The wreck was pulled in without mishap, its broken end dragging bottom, and secured to the beach at 0230. The successful 2-hour retrieval climaxed 41 consecutive days of round-the-clock salvage operations.

PHASE II – BOW REMOVAL OPERATIONS – 7 AUGUST TO 22 SEPTEMBER

With the stern section removed from mid-channel and ready to undergo disposal operations, the salvage force turned its attention to the submerged bow section which was lying almost 25 feet below the surface of the river, laden with heavy machinery and topside weight. Scouring of the river bottom beneath the hulk had caused it to settle deeper below the surface every day.



Moor is designed for stability and precision maneuverability necessary for mid-channel salvops. Mooring legs use 1-¼" wire rope. Strongest anchors are positioned upstream.

CONFIGURATION OF BARGE'S MOOR OVER SUNKEN BOW SECTION

Although gaining access to the bow section was considerably more difficult than with the stern section, the same basic retrieval strategy was applied: the wreck was lightened with foam in mid-channel, then pulled ashore, this time using the hydraulic pullers and a pair of powerful Skagit winches.

Cofferdams were the keystone of the bow removal operation. Although similar in design and function to the diver access tubes used in the stern operations, the three cofferdams were longer (100 feet) and were placed outside the ship along the flat bottom to protect divers from the river current while travelling through the water column between the wreck and the barge. As such, the cofferdams comprised the vital link between barge and wreck, and made possible foaming and all other phases of the mid-channel bow removal operation.

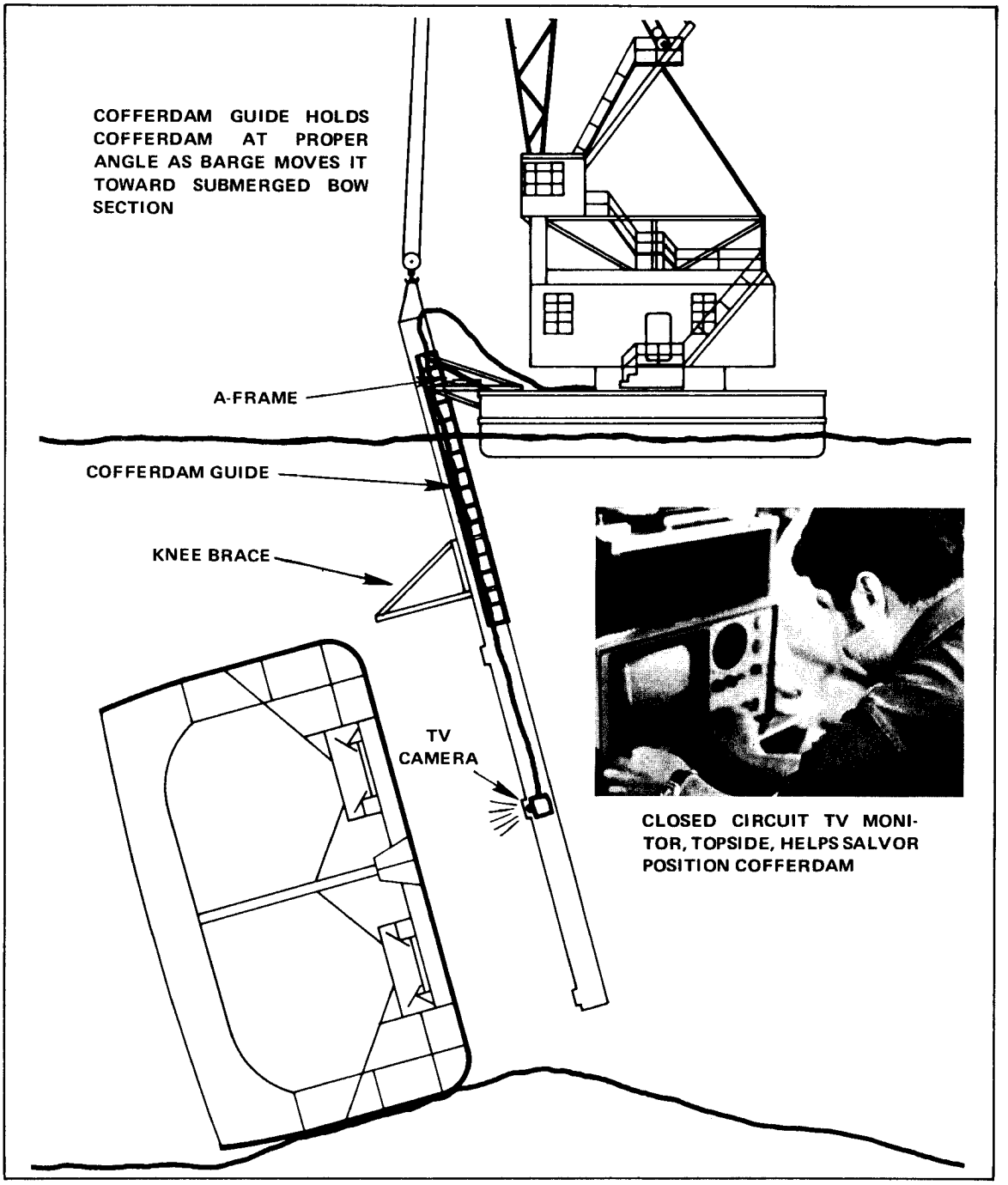
Mooring the Derrick Barge

Bow removal operations began with the mooring of the derrick barge over the wreck. To give the barge the stability and maneuverability necessary for cofferdam installation operations, the salvors decided on a 6-point moor using a combination of anchors in mid-channel and bollards ashore.

Special embedment anchors were chosen for the two upstream mooring legs. The fluked projectile of this newly developed anchor was designed to be driven into the bottom by an explosive charge. However, salvors had difficulty in implanting these anchors on 12 and 13 August. The first anchor was lost when a pin parted, and the second proved to have unsatisfactory holding power.

Salvors quickly implanted a 12,000-pound and a 9,000-pound large-fluked stato anchor at upstream legs 1 and 2, respectively, to replace the embedment anchors. By 15 August, two 6,000-pound stockless anchors were set downstream, and the final two mooring legs secured to bollards on shore, to complete the moor. Three-drum winches on deck allowed precise, omnidirectional maneuverability, and the barge was moved into position parallel to the bottom of the bow section.

Orange pennants were strung from the 1 5/8-inch wires that led from the barge to the bollards to keep ships and other river craft clear of the salvage area. A large, lighted traffic arrow was mounted on the barge for the same purpose.



Barge moves cofferdam into place alongside wreck with aid of closed circuit TV camera. Jack on A-frame makes precise adjustments to cofferdam to insure flush contact with bottom of wreck.

LOWERING COFFERDAM INTO PLACE AGAINST BOTTOM OF BOW SECTION

Cofferdam Installation

The salvors planned to place four cofferdams, one each at frame 63, 51, 36 and 24 in that order. Only the first three were installed. The hull curved sharply at frame 24 near the bow area, making installation of the fourth cofferdam very difficult. As it turned out, this cofferdam was not needed because divers were able to gain access to foaming spaces in the bow area using the cofferdam at frame 36.

With the barge in position on 17 August, the salvors made ready to place the first cofferdam at frame 63. To control the cofferdam as it was lowered by crane into the water, the salvors constructed an A-frame with a long steel cradle, called the cofferdam guide, and secured it to the edge of the barge. A screw-type jack mounted on the A-frame controlled the angle of the cofferdam and guide. During installation, however, this jack carried away under the stress created by the force of the current against the cofferdam and guide. As a result, both swung in sharply against the side of the barge, damaging the A-frame. The bottom third of the cofferdam also snapped off and became lost in the river.

Following the incident, a number of repairs were made. The A-frame and guide were equipped with strength members of increased size and number; the cofferdams were strengthened with lateral and longitudinal stiffeners (4-inch I-beams) and deep-welded at all joints. Finally, the screw-type jack on the A-frame was replaced with a pair of hydraulic cylinders.

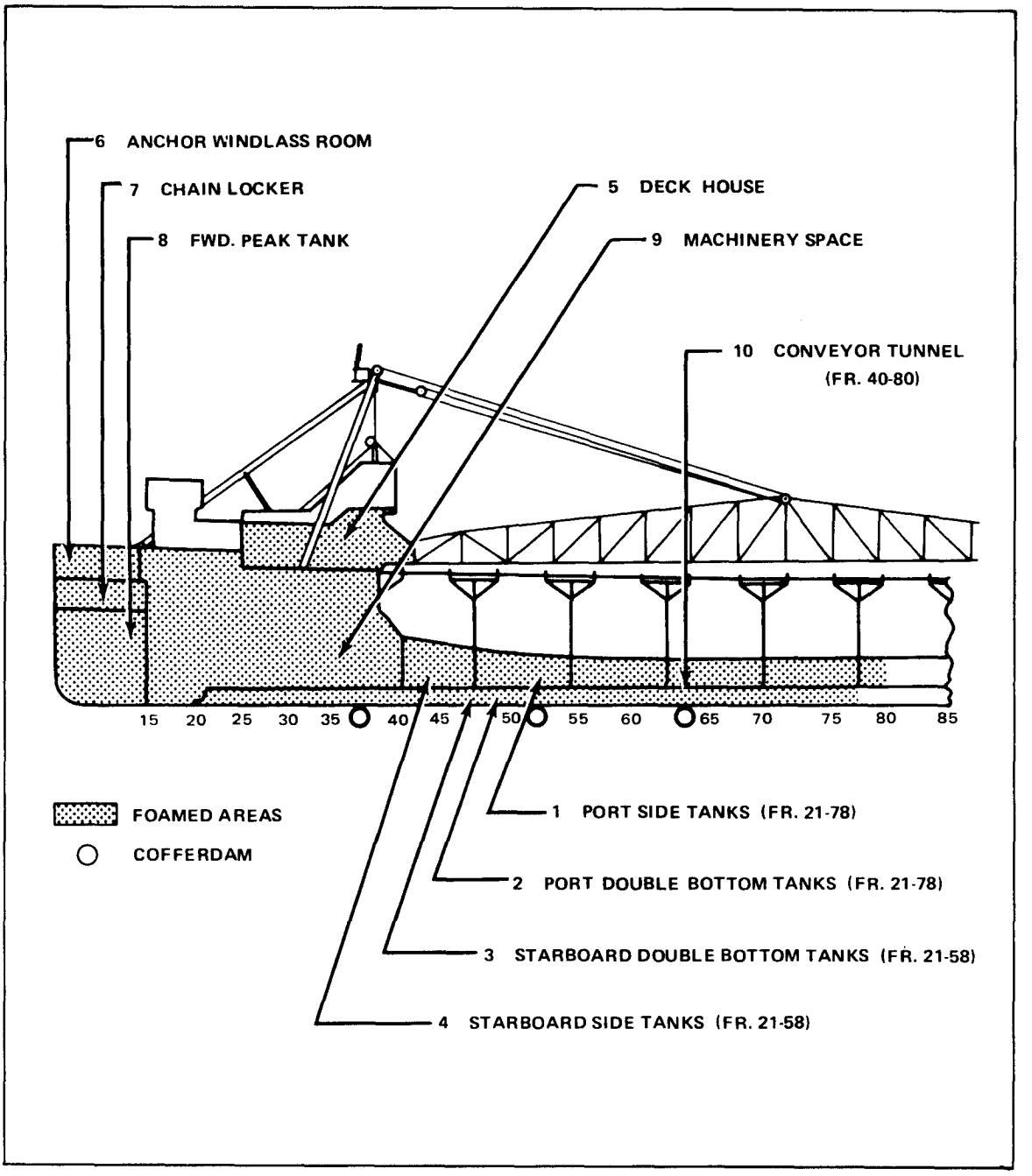
The second attempt to install the cofferdam took place on 27 August. The cofferdam, cradled in the guide at the proper angle, was moved in toward the wreck at frame 63. This initial positioning was accomplished with the aid of a closed circuit TV camera inside the cofferdam at the middle window. More precise adjustments from hydraulic cylinders that controlled the cofferdam guide brought the cofferdam flush against the bottom of the wreck.

A diver then descended into the cofferdam. Working from the top down, he burned an access hole into the double bottoms at each window site and then bolted the window frame to the wreck's shell plating. With the cofferdam thus secured to the wreck at the three window frames, he made the fourth attachment at the cofferdam's knee brace, a triangular frame which seated atop the wreck's port side.

Although the first cofferdam was loaded onto the barge from shore, the remaining two were filled with several large air bags and floated out to the barge at the wreck site. During the installation of these at frames 51 and 36 during the next week, the buildup of bottom sediment caused binding and alignment problems. But by 9 September, all cofferdams were securely in place, each equipped with a working platform topside and a gangway to the barge.

Derrick barge, moored over bottomed hulk, supports foaming operations. Divers use three cofferdams (foreground) for protected access to underwater spaces. Rigging of improved on-shore pulling system is also underway while bow section is being lightened.

PHASE II OF SALVOPS – REMOVAL OF BOW SECTION



From 16 to 21 September, divers installed more than 1700 tons of foam buoyancy in bow section's three structurally distinct areas: stem to frame 15; frame 15 to 40; and frame 40 to break. Numbers indicate sequence of tanks and spaces foamed.

SEQUENCE FOR FOAMING THE BOW SECTION

Foaming Preparations

Once each cofferdam was secured, divers were able to enter the submerged hulk at each window. They immediately began making dives to inspect the wreck, rig pull points, and prepare compartments for foaming.

Inspection of the wreck revealed no major structural damage, although considerable sand and gravel had been washed into the coal conveyor tunnel. In preparation for foaming, all spaces were cleared of debris and sediment, holes were patched, and canvas bulkheads installed in the long, open conveyor tunnel. These bulkheads would enhance foam quality by controlling lateral flow of the unhardened foam.

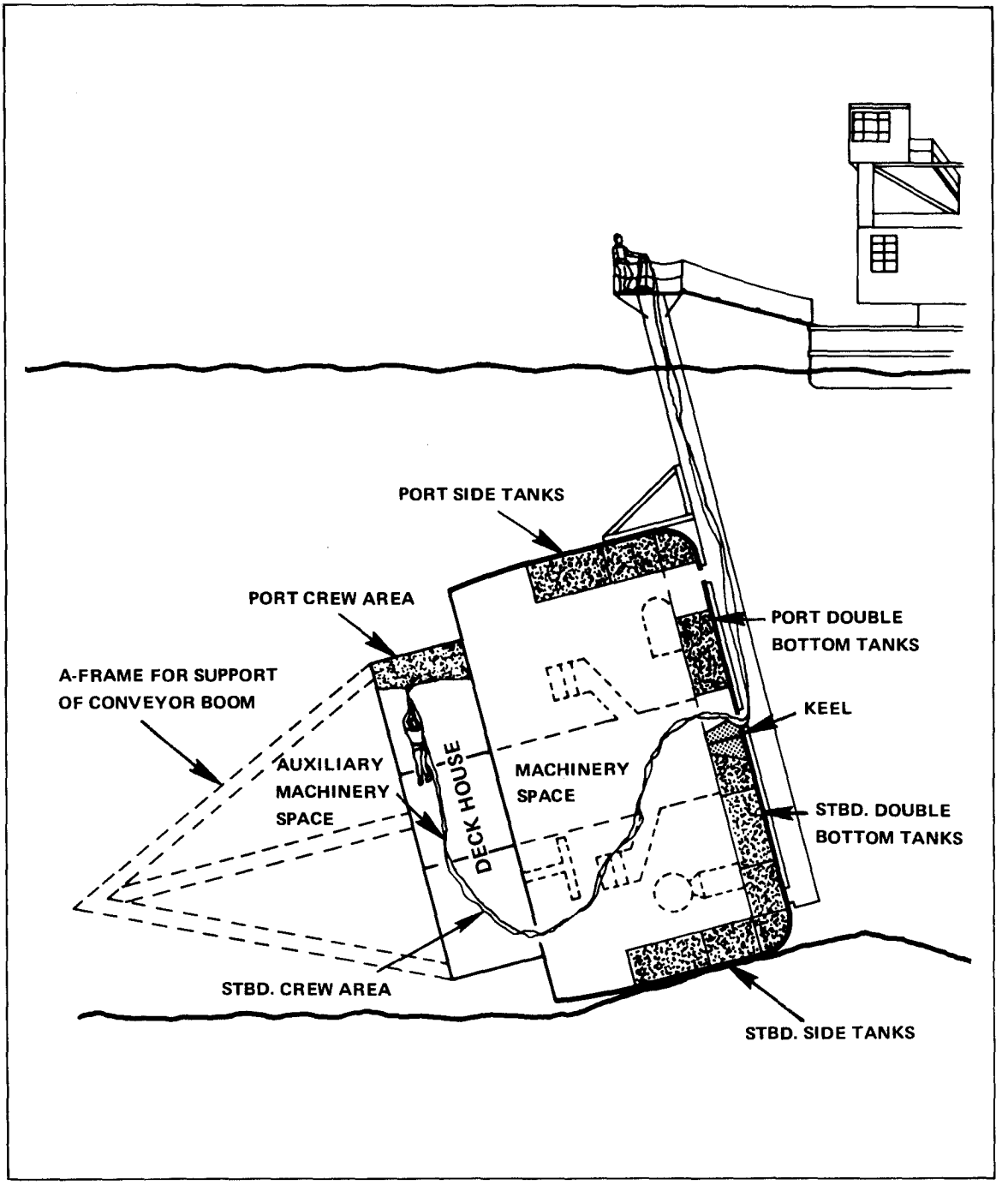
The bow section's cargo holds were open to the river and there was no way to seal them for foaming. They were too deeply submerged to permit installation of hatch covers as on the stern section. Thus, the salvors selected other areas for foaming: the forward spaces, machinery spaces, deck house, conveyor tunnel, and side and bottom tanks.

The deck of the barge was cleared to make room for the foaming equipment. The combination aerosol/mechanical delivery system required considerably more equipment than the aerosol system alone, including booster pumps, in-line heat exchangers, and more sophisticated controls for mixing and regulating the flow of foam to the wreck. At one point, the deck also accommodated 14 large polyol and isocyanate tanks.

Foaming the Bow Section

During the six days of around-the-clock operations from 16 to 21 September, divers installed an estimated 1,700 tons of foam buoyancy in the SMITH's submerged bow section. The foaming followed a carefully planned sequence: first, the port side and double bottom tanks; followed in order by the starboard side and double bottom tanks; deck house; anchor windlass room; chain locker; forward peak tank; machinery space; and, finally, the coal conveyor tunnel.

Although no major problems arose, the foaming of the bow section was by no means a routine operation. The divers had to be careful to keep their foam and access lines clear of obstacles while making their way through the wreck. Access to the foaming areas was difficult and very restricted in many instances. The area varied greatly in dimensions, volume, and location, requiring different techniques for efficient foaming. The probe method was used to foam many of the tanks, which were inaccessible or too small for divers to enter. The larger spaces were foamed by the diver method.



Diver foamed deck house after completing side and double bottom tanks. Completion of deck house marked half-way point; forward area, machinery space and conveyor tunnel remained to be foamed.

FOAMING THE DECK HOUSE, FRAMES 26 TO 35

Pulling System

Submerged and laden with heavy machinery and topside weight, the wreck required a more powerful pulling system to pull it ashore than the one used on the stern section. To meet this requirement for increased pulling power, the salvors leased two Skagit winches for use in conjunction with the hydraulic pullers. These heavy duty winches, a 200-ton RB-97 model and a 300-ton RB-150 model, were positioned at Station BRAVO. Heavy 2-inch wire bridles attached each winch to its respective anchor block. Both winches were equipped with twin drums, one for each of the winch's two pulling wires.

The two 100-ton hydraulic pullers were also stationed downstream, at Station CHARLIE. As a result, the combined shoreward pulling force of the two downstream pulling stations was boosted to nearly 700 tons. Upstream, an equalizing frame was built to utilize the four 40-ton pullers at Station ALPHA to hold the wreck against the current during the shoreward pull.

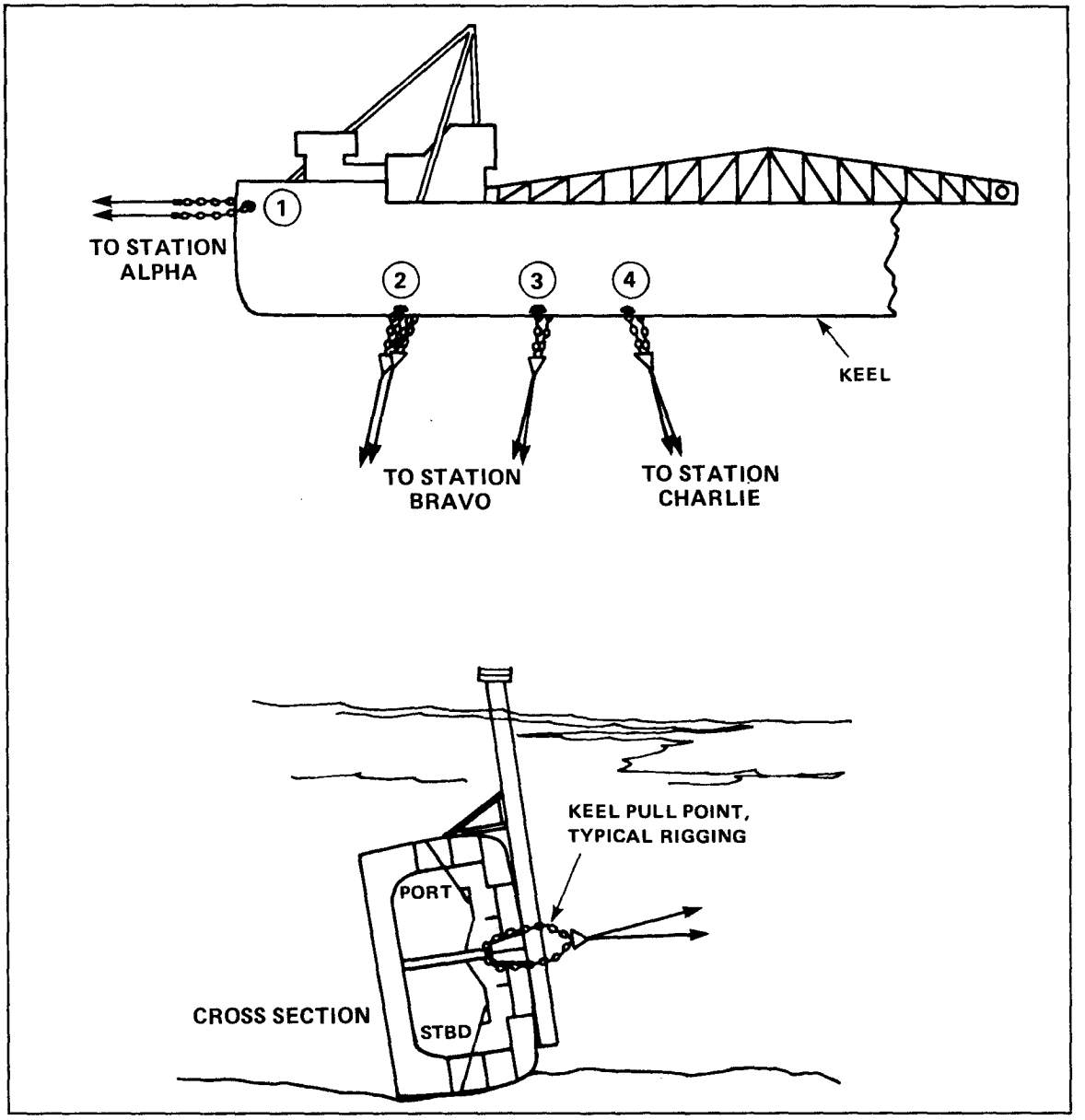
Rigging of Pull Points

While the pulling system was being set up ashore, divers rigged pull points on the wreck. The 1 5/8-inch pulling wires leading from each drum of the 200-ton winch at anchor block C were attached by flounder plates to the bitter ends of a double loop of 2-inch chain passed around the keel at frame 31. The 300-ton winch's two 2-inch wires were attached by a flounder plate to the ends of a single loop of 2 1/4-inch chain passed around the keel at frame 46. The two 2-inch wires running from the 100-ton pullers at Station CHARLIE were attached by a flounder plate to a single loop of 2 1/4-inch chain passed around the keel at frame 56. The 1 5/8-inch pulling wires from the 40-ton pullers at Station ALPHA were shackled to the ends of the SMITH's anchor chains, which led from the chain locker out through the vessel's hawse pipes.

Bow Section Pulled from Mid-Channel

On September 21, final adjustments to the pulling system were made, and the barge was moved downstream to clear the path for the bow section's shoreward pull. In early evening, pulling operations began. As the tension of the downstream pulling wires was increased from 10 to 20 tons, the wreck broke bottom suction and began moving toward shore.

A maximum pulling effort was then ordered from Stations BRAVO and CHARLIE to maintain shoreward momentum. The upstream holding wires, left slack at first to allow



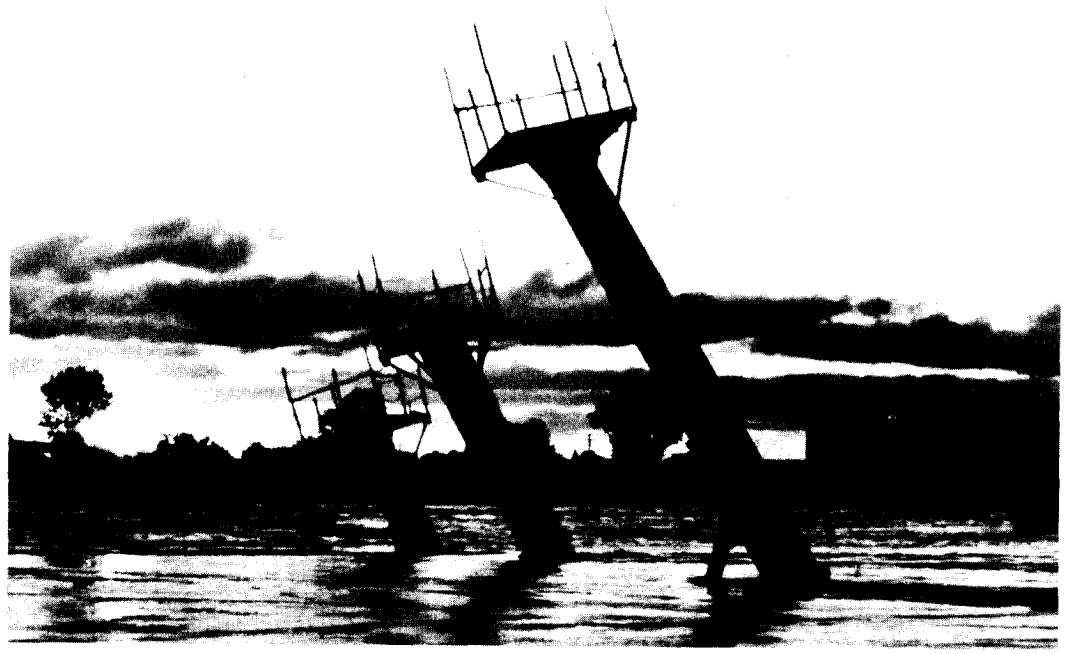
(1) *Anchor chain extending from hawse pipes for pulling wires to 40-ton hydraulic pullers.*

(2) *Double loop of 2" chain around keel at frame 31 for pulling wires to 200-ton Skagit winch.*

(3) *Single loop of 2¼" chain around keel at frame 46 for pulling wires to 300-ton Skagit winch.*

(4) *Single loop of 2¼" chain around keel at frame 56 for pulling wires to 100-ton hydraulic pullers.*

RIGGING OF PULL POINTS ON BOW SECTION



Bow broke surface 100 feet from shore near end of all night pull, 21-22, September, after 3½ months on river bottom.

INCREASING HEIGHT OF COFFERDAMS MARKS PROGRESS OF PULL

the wreck to move downstream, were now tensioned. A chain stopper aboard the wreck gave way, releasing the port anchor chain. The two holding wires connected to the anchor chain went slack as the chain began paying out. One of the other pair of holding wires parted as the load at Station ALPHA shifted completely to the remaining set of pullers. The bow section grounded at this time, pivoting on its broken after end, with the forward end swinging in toward shore. One of the anchor blocks at Station BRAVO was also damaged during this unsuccessful pulling attempt.

The salvors worked through the night to repair the damage at Stations ALPHA and BRAVO. As dawn approached on 22 September, pulling resumed. Within an hour, the hull of the vessel surfaced approximately 100 feet from shore, becoming visible for the first time in more than three months. The wreck was finaliy grounded 70 feet from shore, well clear of the shipping channel, bringing to a close Phase II of the SMITH salvage operation.

PHASE III – DISPOSAL OPERATIONS

Disposal operations on each wreck section began as soon as it was pulled from mid-channel. Thus, the stern section was already floating and stabilized by the time the bow section was pulled ashore on 22 September.

Both sections had to be transformed into floating objects for final towing to a disposal site. This involved restoration of each to a condition of minimum list and trim, removal of excess topside weight, and installation of additional foam buoyancy.

COE specifications required a 24-foot draft and a maximum 10-degree list for each section. With the wreck sections secured near shore in relatively quiet waters, the salvage team was able to conduct the remainder of the SMITH operation at a more relaxed pace using traditional salvage techniques.

Stern Disposal Operations, 7 August to 23 September

Because the derrick barge had been moored over the bow section in mid-channel, the salvors obtained a smaller cargo barge to serve as a working platform for stern disposal operations. Several mobile land cranes were also leased to support scrapping operations from the beach.

Phase III, disposal operations, began on each wreck section as soon as it was pulled from channel. Barges and mobile land cranes tended stern section (above) as it was refloated and stabilized for final tow to disposal site.

DISPOSAL OPERATIONS IN PROGRESS ON STERN SECTION

By 26 August, about 350 tons of scrap had been cut from the stern section and piled on shore, including the rudder and propeller, boat davits, deck winches, and most of the superstructure. Meanwhile, airlifting of sediment and debris continued. Divers patched holes and made compartment boundaries watertight in preparation for dewatering operations.

On 27 August, four 3-inch pumps and a salvage pump from a river tug began pumping the stern section. A 6-inch COE pump was received the next day, and by 29 August, the stern's rails had risen above water. The wreck was nearly trim fore and aft, with only a 3-degree list to starboard. After further pumping of the engineering spaces, the stern section rode with 5 feet of freeboard at the break, and drawing 20 feet aft.

Intermittent pumping kept the stern section roughly at this attitude. But even after installation of additional foam in holds 5 and 6, and several 25-foot air bags in the conveyor tunnel, the stern was not riding as well as had been expected. The salvors decided to remove a 70-foot section of the wreck forward of frame 108. Since it comprised the open and unfoamed cargo hold 4, the section was essentially dead weight.

On 11 September, the section was cut, then pulled from the main portion of the wreck using the 40-ton pullers at Station ALPHA. The salvors encountered considerable difficulty in moving the heavy section clear of Stations BRAVO and CHARLIE in preparation for pulling operations on the bow section. A 100-ton puller and the 40-ton pullers at Station ALPHA finally pulled it upstream on 17 September to a position where it could not obstruct the salvage work. The removal of this 200-ton piece brought the stern section of the SMITH to an almost even keel with a draft of 23 1/2 feet forward, and 21 feet aft. The truncated hulk was then towed and moored downstream to clear the area in front of Station CHARLIE and make room for the bow section which was ready to be pulled ashore.

Bow Disposal Operations, 23 September to 19 November

After the bow was removed from mid-channel, it lay grounded on its starboard side, 70 feet from shore. Before attempting to refloat it, however, the salvage team had to move it closer to shore, remove the huge cofferdams and conveyor boom, and then parbuckle it to an upright position.

The salvors first pulled the wreck 30 feet closer to shore, which brought about 30 feet of the port side several feet above water. The wreck was now more accessible and salvors

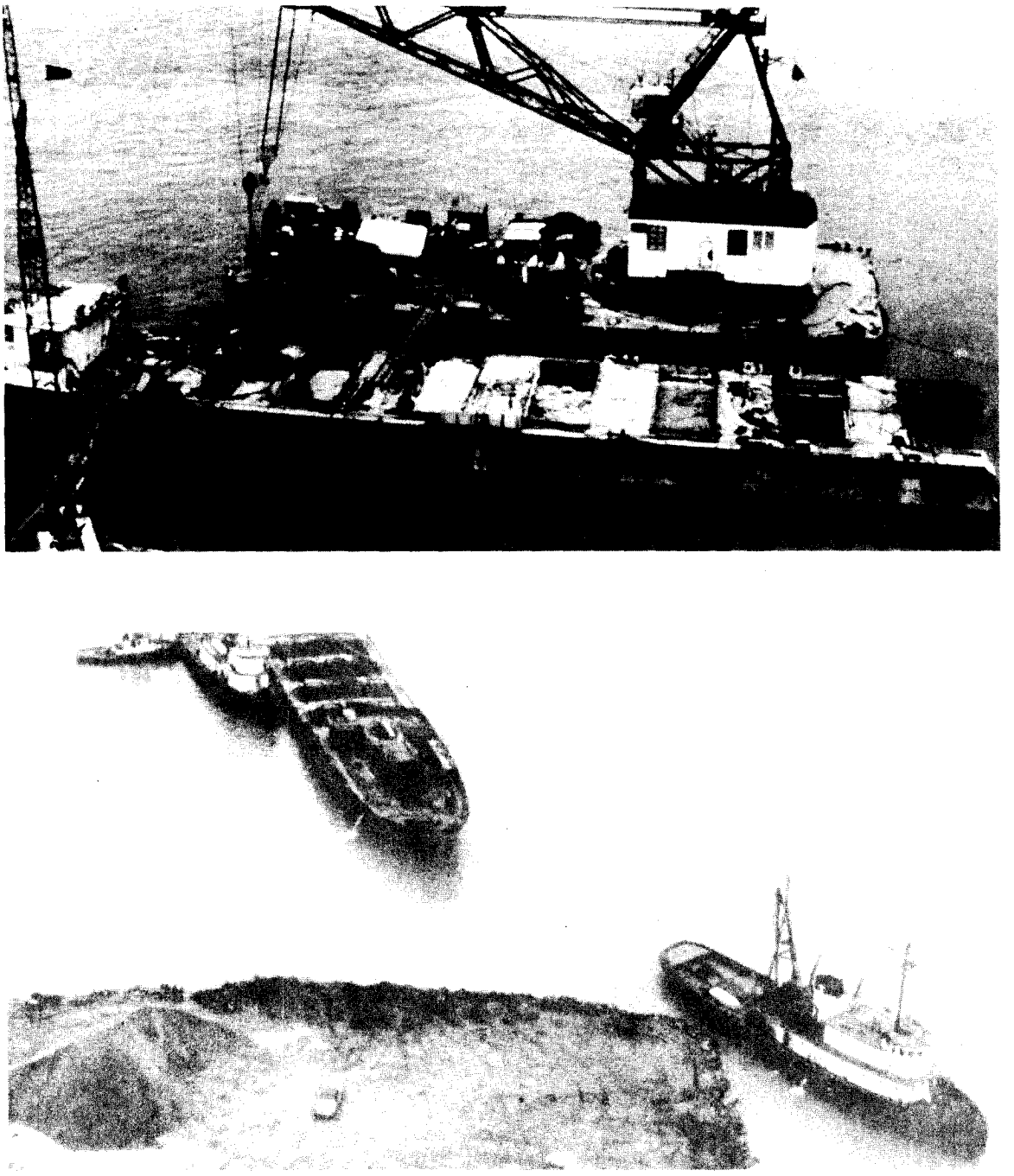
With pull points on wreck rerigged, bow section was brought to within 40 feet of shore and parbuckled to 40° starboard list. Further parbuckling reduced list to 22°, but efforts were hampered by presence of submerged pier pilings beneath wreck.

BOW SECTION PARTIALLY RIGHTED

began cutting connections to the conveyor boom and the three cofferdams. As the derrick barge lifted these from the wreck and placed them ashore, divers re-rigged the pull points on the wreck for the parbuckling attempt.

The 2-inch wires from the 300-ton Skagit winch at anchor block D were secured to the base of the SMITH's unloading machinery; the 100-ton pullers' wires were attached to the main deck centerline beam; the 200-ton winch's wires remained secured to the keel at frame 31; and four parts of 1 5/8-inch wire were rigged from the crane of the barge to the wreck's A-frame for additional lift.

On 3 October, a coordinated effort from the derrick barge, hydraulic pullers, and winches rolled the bow section up to a 40-degree list to starboard. Another effort, with



After bow section (top) was floated and stabilized, it followed stern section (bottom) in tow across St. Clair River to Sarnia, Ontario. Both were then sunk in excavations dredged along riverbank.

BOW AND STERN SECTIONS PRIOR TO FINAL DISPOSAL

the 200-ton winch's wires rerigged to the base of the A-frame, brought the wreck up even further, to a 22-degree starboard list.

For nearly three weeks after the parbuckling efforts, salvors installed foam in holds 1 and 2 and in the forward machinery spaces. This additional buoyancy, plus the removal of topside weight, brought the broken end up slightly. The vessel's attitude was now 10 degrees to starboard and 6 degrees down by the stern, but old submerged pier pilings prevented it from floating freely.

Another pulling effort on 26 October failed to free the wreck. But the installation of additional foam, plus the lifting and rocking efforts of the derrick barge, finally succeeded; the wreck was floating, trim fore and aft and listing only 6 degrees to starboard. Foaming operations continued throughout the ship for the next three weeks until 18 November. As the wreck rose to the required 24-foot draft, the salvage force was gradually disbanded.

Final Disposal

Several months later, the bow section was towed across the river to a private dock, joining the previously towed stern section. There, the hardened foam was removed from each. Both were then sunk in excavations along the waterfront, filled with sand and gravel and capped with a permanent concrete deck.

CONCLUSIONS

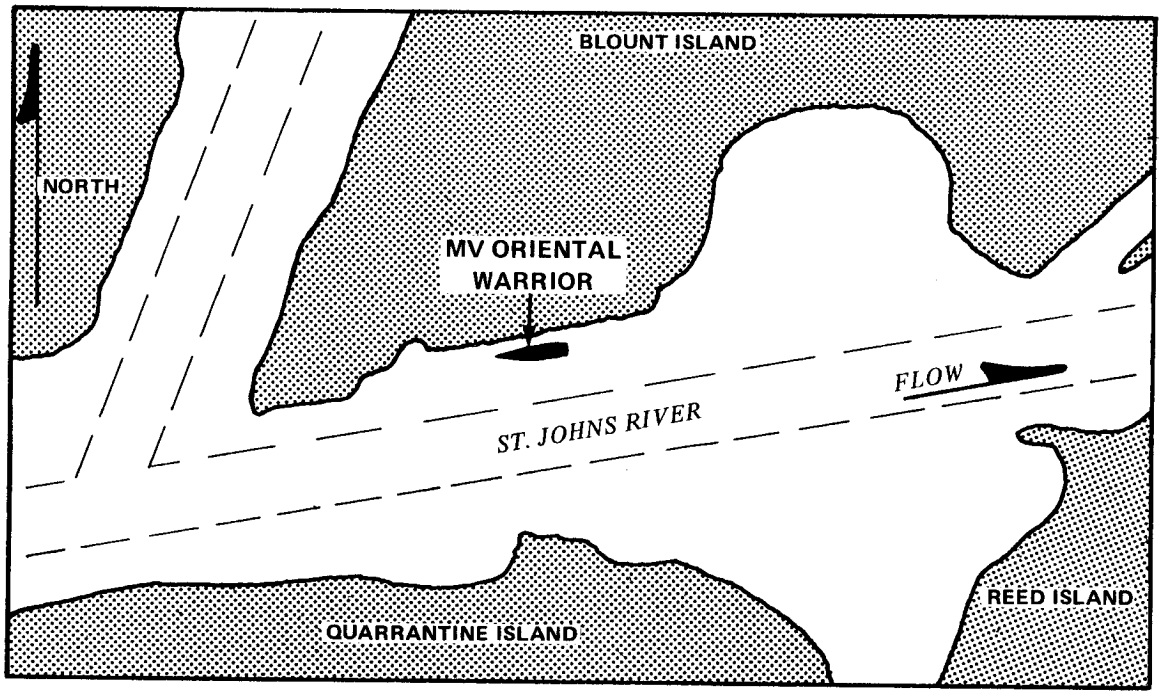
The retrieval and disposal of the SS SIDNEY E. SMITH, JR. was a monumental salvage effort that required more than five months to complete. More importantly, it was a safe operation conducted without serious mishap or injury, despite a grueling schedule and hazardous working conditions that left no margin for error.

Many innovative salvage techniques were successfully employed in the SMITH salvage operation. The cofferdams and diver access tubes that allowed foaming operations to be conducted inside the wreck sections proved highly effective. Also, the specially constructed hydraulic pullers, with their unique anchoring system, proved reliable during all retrieval and parbuckling efforts. After demonstrating their effectiveness as a salvage tool in the SMITH operation, hydraulic pullers quickly won acceptance within the salvage community.

Underwater implanted urethane foam provided the only feasible means of lightening the wreck sections so that they could be pulled clear of the navigation channel. Although the foam's buoyant quality was frequently poor or unpredictable, on-site data and future analysis of the problem by appropriate technicians should help determine the causes of poor foam quality and lead to the refinement of this promising salvage tool.

Despite the innovations of the SMITH salvage operation (foaming, cofferdams, hatch covers, hydraulic pullers and anchoring system), the salvage force did not shun the use of traditional salvage techniques. Traditional methods were applied in several important phases of the operation, including the rigging of pull points and in the refloating and stabilization of the wreck sections during disposal operations. The salvors also demonstrated their resourcefulness in overcoming problems that temporarily upset operations. The rapid construction of the hatch cover guide during stern operations, and the repair and redesign of the cofferdam guide and A-frame during bow operations, are two examples.

Finally, the SMITH salvage was a team effort involving the close cooperation of Navy, Army, Coast Guard and several commercial firms. Key provisions of the Salvage Act were exercised in order to obtain a significant advance of Federal funds for this task, thereby insuring that maximum salvage assets could be brought to bear in a timely manner.



LOCATION OF MV ORIENTAL WARRIOR AT JACKSONVILLE PORT AUTHORITY CONTAINER PIER

SCOPE OF THE OIL REMOVAL EFFORT

Although the initial efforts succeeded in averting a serious spill, the local team was merely containing the leakage and not stopping it at its source. It became evident that oil would have to be removed directly from the ship, and as quickly as possible. Thus, the Coast Guard requested SUPSALV assistance. SUPSALV assumed control of the oil removal operations on 10 June, and contracted the Murphy Pacific Marine Salvage Company to help formulate a plan of assistance and commence recovery operations.

The Recovery Problem

When SUPSALV assumed control, the WARRIOR remained bottomed in 34 feet of water, starboard side to the pier, and listing 17 degrees to starboard. During high tides, the vessel's main deck and aft deck house were substantially awash.

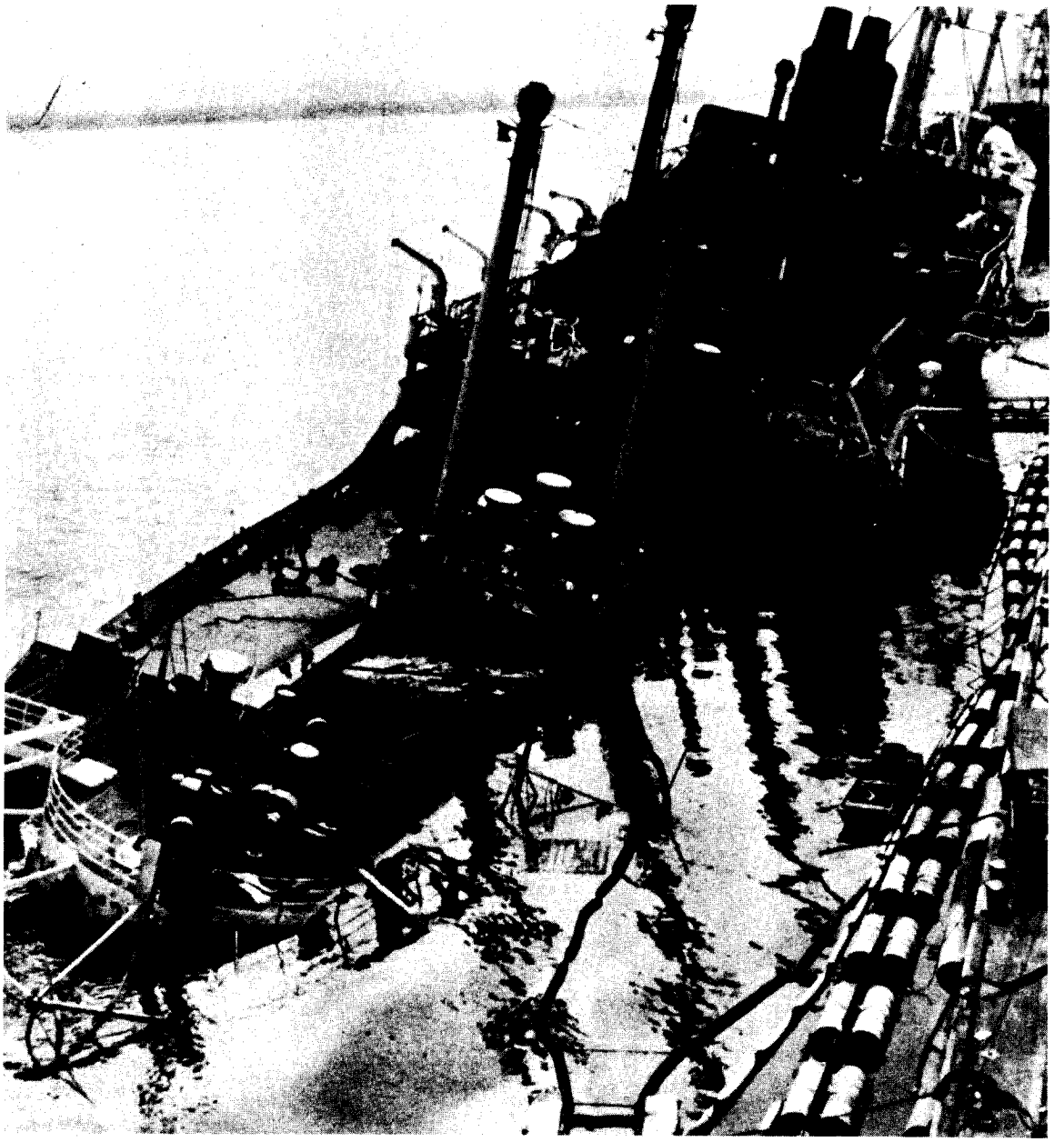
Oil containment booms had been deployed around the wreck by the Jacksonville spillage team. Two skimmers, and an 8,000-barrel oil barge, used for storage of recovered oil

MV ORIENTAL WARRIOR

OIL POLLUTION CONTROL

AND

DEBUNKERING OPERATIONS



MV ORIENTAL WARRIOR began leaking oil into St. Johns River at Jacksonville, Florida, as a result of fire and subsequent sinking. Carrying nearly 300,000 gallons of oil, vessel presented serious pollution threat to surrounding waters.

MV ORIENTAL WARRIER AFTER SINKING
AT PIERSIDE

MV ORIENTAL WARRIOR
OIL POLLUTION CONTROL AND DEBUNKERING OPERATIONS

INTRODUCTION

Following a fire at sea on 27 May 1972, the MV ORIENTAL WARRIOR was towed into port at Jacksonville, Florida. The badly damaged vessel sank alongside a pier during fire fighting operations. The estimated 303,240 gallons of fuel and lube oil on board posed a major oil pollution threat. Local forces, assembled by the City of Jacksonville, deployed a boom barrier and conducted skimming operations, recovering about 90,000 gallons which had escaped from the ship.

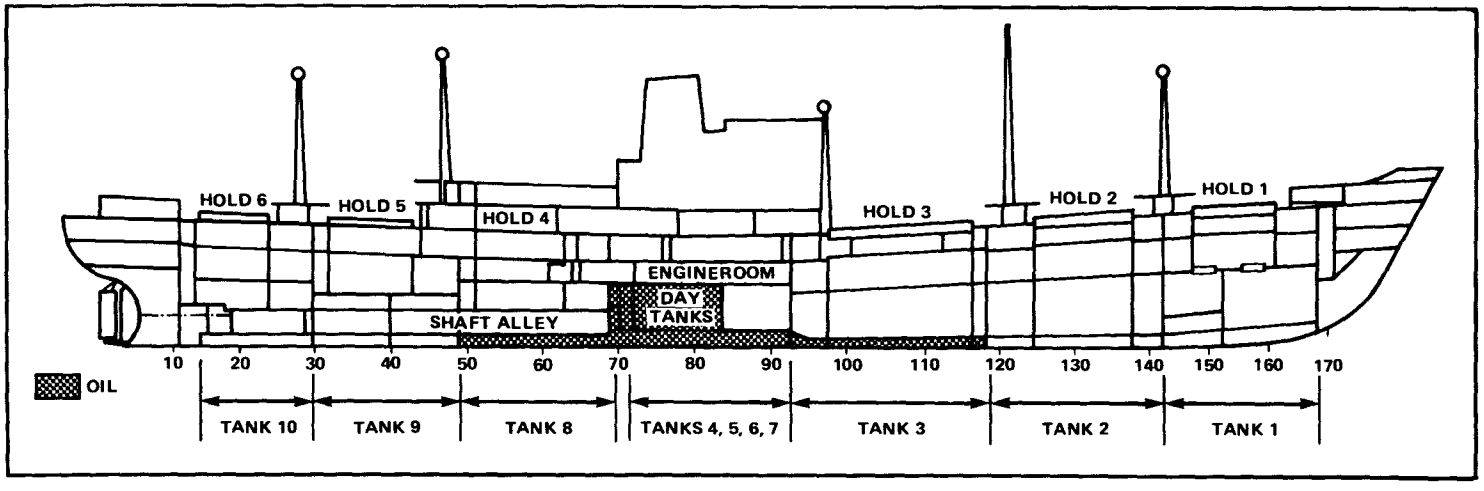
The U.S. Coast Guard requested the services of the Supervisor of Salvage (SUPSALV) to remove the remaining oil directly from the partially submerged hulk. A SUPSALV oil recovery team successfully debunkered the WARRIOR employing a variety of methods: vacuum pumping, skimming, blowing and hot tapping. This recovery effort eliminated the oil pollution threat and paved the way for subsequent salvage operations to refloat the hulk and dispose of it at sea.

LOSS OF THE WARRIOR

MV ORIENTAL WARRIOR caught fire at sea off Jacksonville, Florida, on 27 May 1972. The 535-foot passenger and cargo vessel was towed to the Jacksonville Port Authority Container Pier. During pierside fire fighting efforts, the flooded and badly damaged ship sank in 34 feet of water and began to leak oil.

Initial Oil Recovery Efforts

The casualty site, located at Blount Island, St.Johns River, is tidal; at ebb tide, the river current reaches 5 knots. Anticipating a large oil cargo on the WARRIOR, the city's emergency oil spillage committee set up a boom around the vessel and began recovering the oil with a skimmer. The local team was recovering approximately 10,000 to 15,000 gallons of oil from the surface per day prior to the start of full-scale recovery efforts on 10 June.



DEBUNKERING SUMMARY

METHOD	LOCATION	APPROX. AMT. RECD. (Gals.)
Vacuum Pumping	Engineroom, reefer passageway, holds 3 and 4	139,000
Bucket Skimming	Vicinity of engineroom and hold 4	25,000
Pressurization through sounding tubes	Double bottom tank 3	36,000
Hot Tap	Double bottom tank 8	0
Surface Skimming	Boomed-off areas around stern and stbd. side	90,000
TOTAL		290,000

Shaded areas show original locations of oil. Fire damage and flooding caused oil to spread to surrounding holds, passageways and engineroom, necessitating use of variety of oil recovery methods.

MV ORIENTAL WARRIOR TANK ARRANGEMENT AND DEBUNKERING SUMMARY

emulsion, were also positioned nearby. The Jacksonville crew had recovered approximately 90,000 gallons of oil when the SUPSALV team began preparations for removing oil from the ship directly. Containment and skimming operations would, of course, have to continue concurrently with the debunkering effort. The SUPSALV team made immediate arrangements to strengthen the boom barrier surrounding the ship.

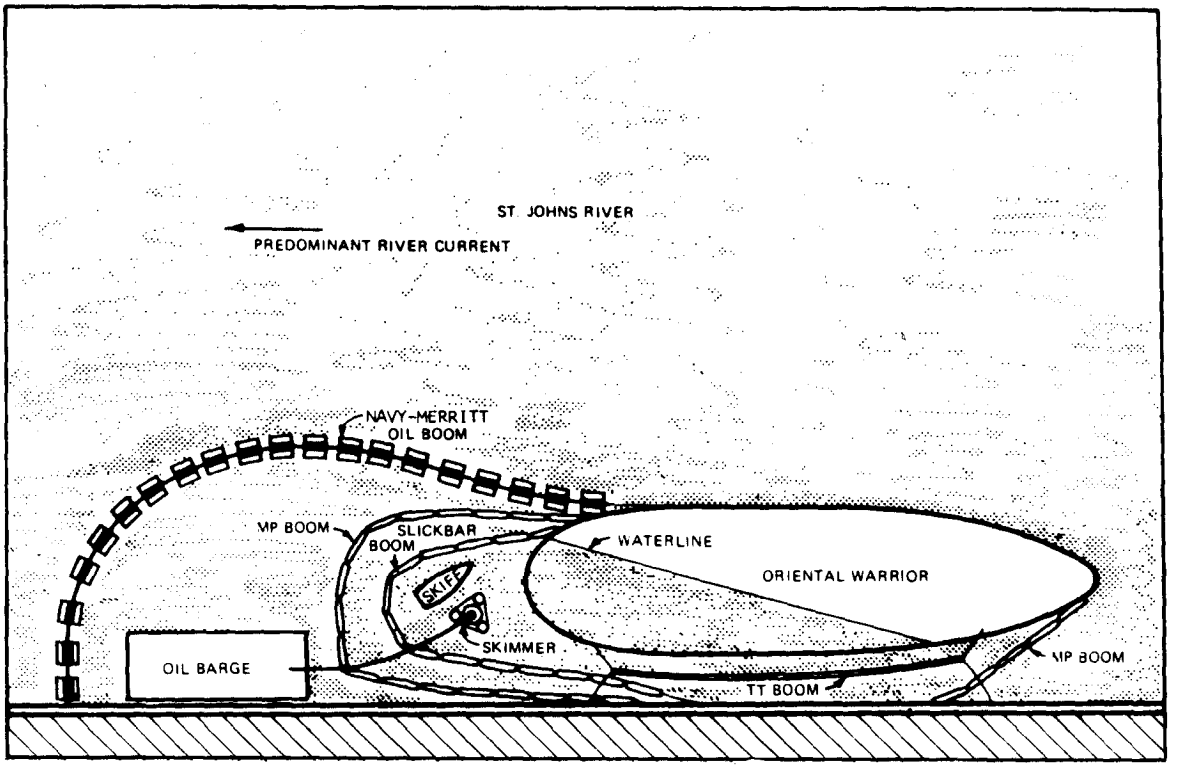
With respect to the hulk, itself, the salvors anticipated the requirement for a variety of recovery methods. Oil was continuing to seep throughout the ship from the various fuel tanks. It was thus difficult to predict exactly where it would be located and in what quantities.

Estimate of Amount and Location of Oil

Prior to the fire at sea, WARRIOR had taken on light fuel, gas and oil at Los Angeles (197,106 gal.), New York (148,974 gal.) and Savannah (16, 372 gal.). Based on this bunkering information, plus statements from the ship's engineering officer and inspection of daily log reports, it was estimated that the WARRIOR could have been carrying as much as 303,240 gallons of diesel and lube oils.

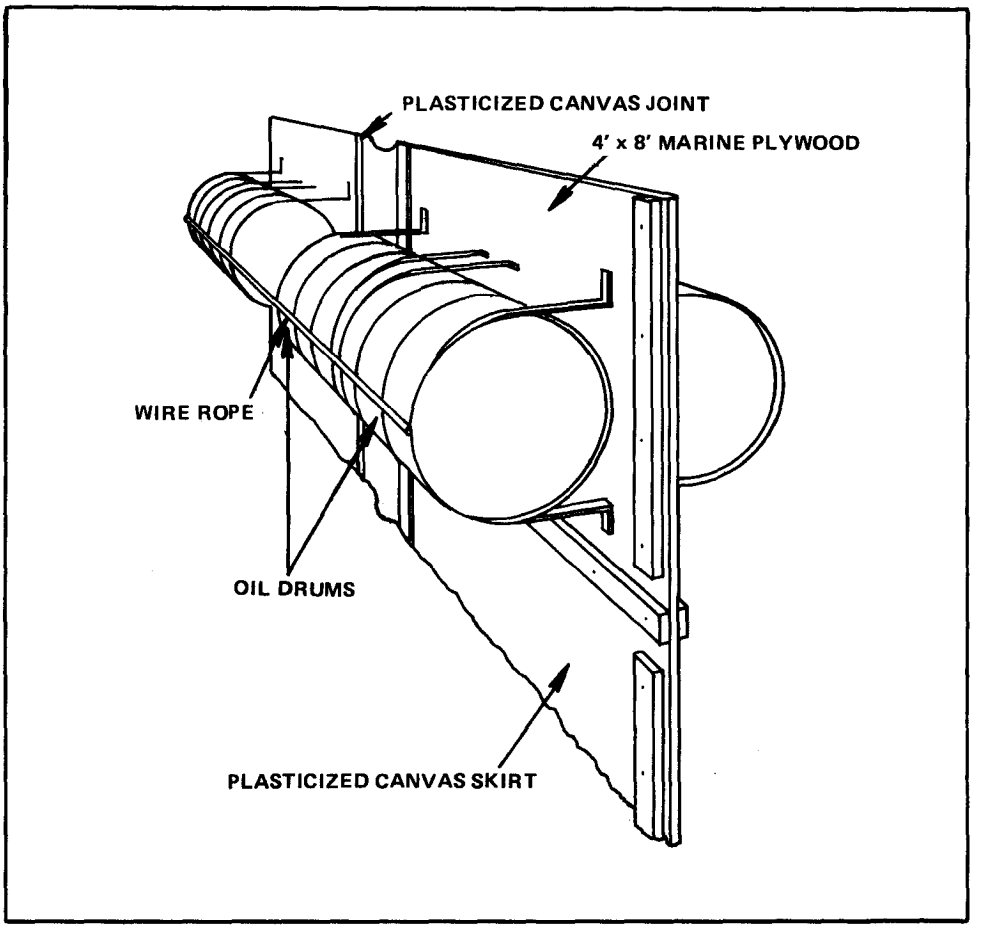
The WARRIOR had 10 double bottom tanks. The fore and aft tanks (1, 2 and 9, 10 respectively) had been carrying sea water for ballast when the fire occurred. Most of the oil was located in the amidships double bottom tanks (3-8). Significant amounts of oil were also being carried in the fuel tanks associated with the engineroom. These included deep tanks and day tanks, situated above double bottom tanks 4-7 from frames 69 to 87. These tanks and the various spaces above and round them, especially cargo holds 3 and 4, into which oil had seeped, became the principal targets for oil recovery operations.

However, an accurate determination of the total on board was impossible; the fire had consumed an unknown amount of fuel. In addition, structural damage resulting from the fire was causing oil seepage throughout the ship. Although the deep tanks alongside cargo hold 2 were found empty, oil was leaking through the flooded engineroom and into holds 3 and 4. It was impossible, however, to determine the condition of the fuel oil manifold (located at the engineroom's forward bulkhead) since fire damage and flooding prevented access to the compartment. Because oil also continued to escape from the ship, it was assumed that all tanks were open to the sea in varying degrees.



Three-boom barrier was placed around stern area to contain WARRIOR's leaking oil. A fourth boom (TT type) was placed between ship and pier. Ends of TT boom could be opened to form catch basin for skimmer (photo).

DEPLOYMENT OF OIL CONTAINMENT BOOMS



Navy-Merritt boom was largest and most substantial of four booms that contained WARRIOR's leaking oil. It extended 1,000 feet, from ship's port quarter to pier, and served as outermost protective barrier against river current and waves.

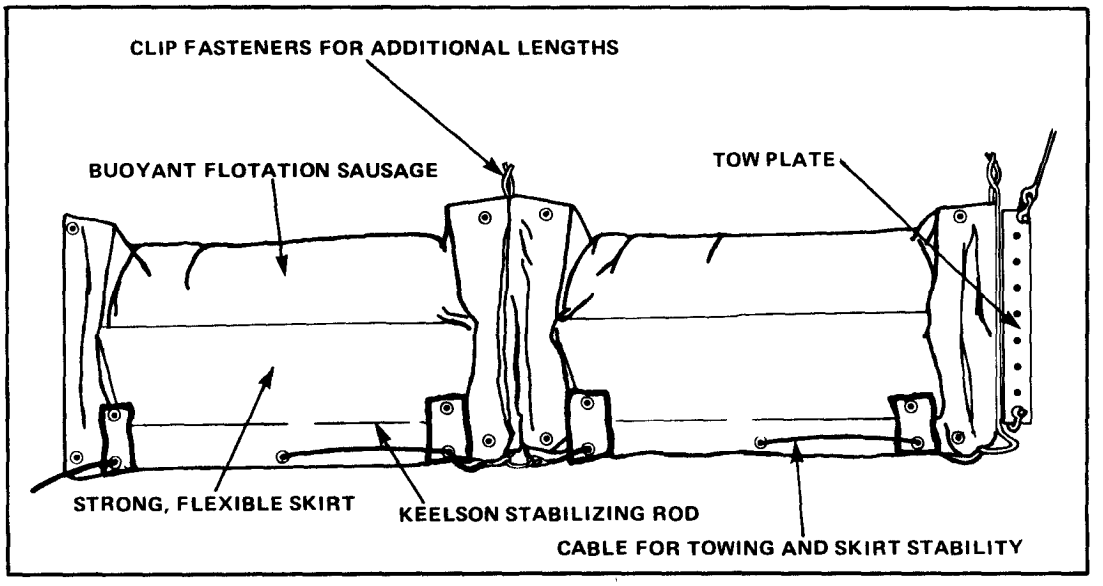
CONSTRUCTION FEATURES OF NAVY-MERRITT OIL BOOM

CONTAINING AND RECOVERING SPILLED OIL

Strengthening the Boom Barrier

Because of wind squalls and wakes from passing ships, the SUPSALV team placed a triple boom barrier around the WARRIOR's stern area. The largest, a Navy-Merritt type, extended 1,000 feet in a wide arc from the ship's port quarter to the pier.

The Navy-Merritt boom consists of segments of vertically positioned 4- x 8-foot pieces of marine plywood held afloat by oil drums strapped to each side. A plasticized canvas skirt



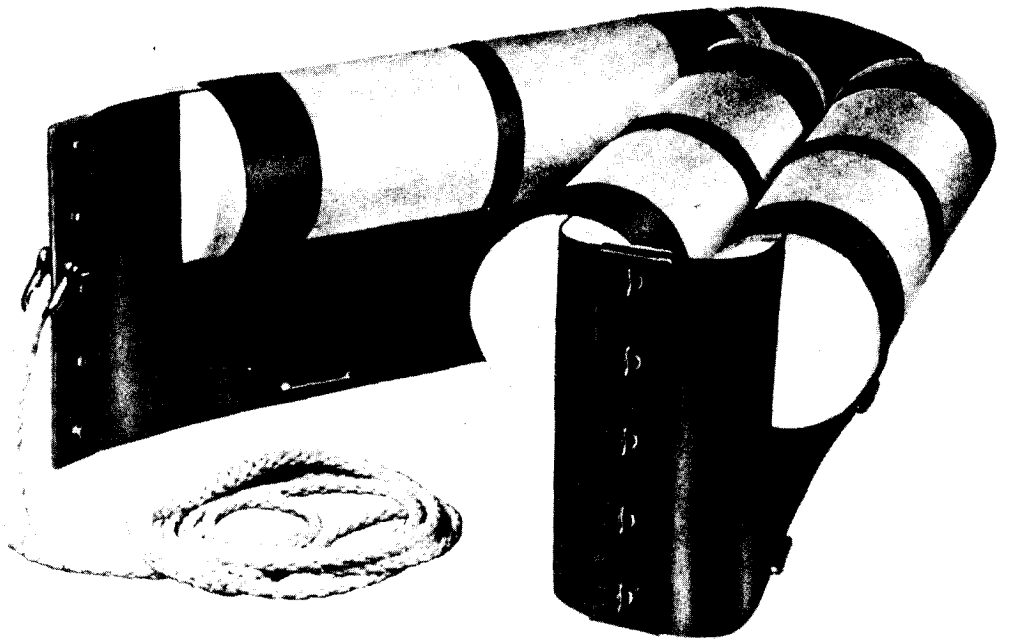
MP boom was placed inside area enclosed by Navy-Merritt boom and extended from stern quarter, along ship's starboard side, to bow. Each 100-foot length is held afloat by 6-inch diameter buoyant floats; boom skirt extends one foot below surface.

CONSTRUCTION FEATURES OF MP BOOM

attached to the lower edge of each piece of plywood extends several feet below the water surface. Plasticized canvas is also used to join the boom segments together, giving the boom flexibility in all three axes of motion. Developed by the U.S. Navy and the Murphy Pacific Marine Salvage Co., this simple and rugged boom had proved effective in containing oil spills in the open ocean on several previous occasions. With its deep draft and 3-foot freeboard, the boom provided a sturdy outside barrier against the choppy water of the St. Johns River.

An MP boom produced by the Metropolitan Petroleum and Petrochemicals Co., Inc. was placed inside the area enclosed by the Navy-Merritt boom. The MP boom extended outward from the WARRIOR's port quarter, around the stern area, and forward along the pier to the ship's bow. Each MP boom segment consists of a 6-inch-diameter buoyant flotation "sausage" with a strong, flexible skirt that extends 12 inches below surface. A 6-foot-long keelson is fitted at the base of each segment to stabilize the boom skirt.

Within the area enclosed by the MP boom, 300 feet of Slickbar boom were placed. Produced by Slickbar, Inc., this boom is lightweight and easy to handle. It consists of a 9-foot-long flexible plastic skirt supported by foam plastic floats. The skirt is constructed of .03-inch-thick polyethylene with small lead weights clipped to the bottom. Inside the innermost loop, between the Slickbar boom and ship, the pollution control team placed a skimmer and work barge. Oil removed by this skimmer was pumped into a large oil barge located alongside the pier between the MP and Navy-Merritt booms.

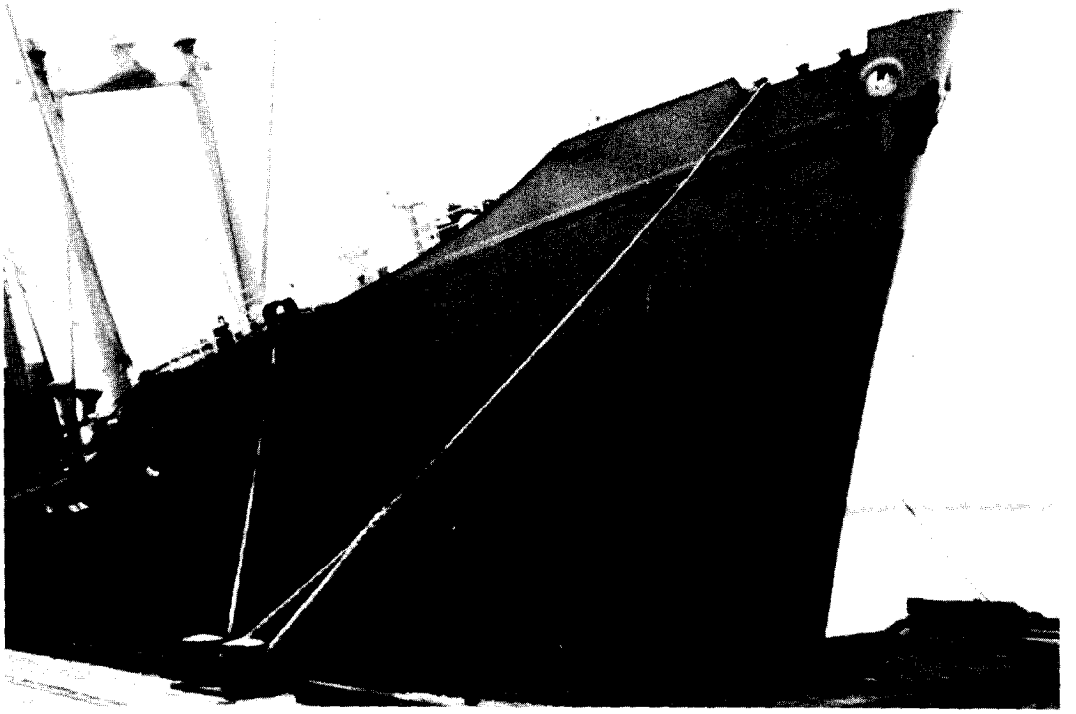


Foam plastic floats support 9-foot long segments of light-weight Slickbar boom. Slickbar was innermost boom, enclosing area for skimming operations.

9-FOOT LENGTH OF SLICKBAR BOOM

A fourth boom (750 feet of TT type) was placed between the ship and pier to guide the flow of oil toward the skimmer. The TT boom is manufactured by Trygve Thune of Norway and is constructed of a nylon skirt with PVC plastic pressed into the cloth on both sides. Foam plastic floats are attached to both sides of the boom, with lead weights at the bottom. Aluminum battens sewn into the sheet provide vertical stability. The boom is fabricated in sections 164 feet long x 3 feet high and weighs 1.5 pounds per foot. A calm water boom with just 1 foot of freeboard, the TT was best suited to aid in skimming in the sheltered waters inside the three-boom barrier.

To break the force of the river and tidal currents around the ship, the salvors moored an aircraft carrier type camel (a large wooden barrier, or "fender") upstream at the WARRIOR's bow. From the camel, the ship's hatch covers were suspended down into the water. This breakwater arrangement replaced a tug which had previously been moored at the bow for the same purpose.



Oil recovery team placed camel upstream at bow to break St. Johns River current, which reached speed of five knots at ebb tide. Ship's hatch covers were suspended from camel to provide additional water breaking action.

CAMEL BREAKWATER AT BOW OF ORIENTAL WARRIOR

Use of Sorbents

With the camel breakwater and four-boom arrangement surrounding the WARRIOR, leaking oil was generally prevented from spilling into the open river and harbor area. Occasionally, however, high winds or passing ships generated waves that disrupted the booms, allowing oil to escape.

To recapture this stray oil, an absorbent material called Ekoperl was used. Sorbents such as Ekoperl have an affinity for oil but not for water. The Ekoperl must be harvested from the surface manually using screens, shovels or vacuum hoses. It is made with aluminum silicate (perlite) and is non-toxic to marine life. Ekoperl proved to be a convenient recovery tool in the WARRIOR operation, particularly in absorbing oil that frequently strayed beneath the pier.

Recovery crew spread sorbent materials on water surface during skimming operations and whenever squalls or passing ships generated abnormal wave action. Cubic yard of Ekoperl absorbed approximately 47 gallons of oil.

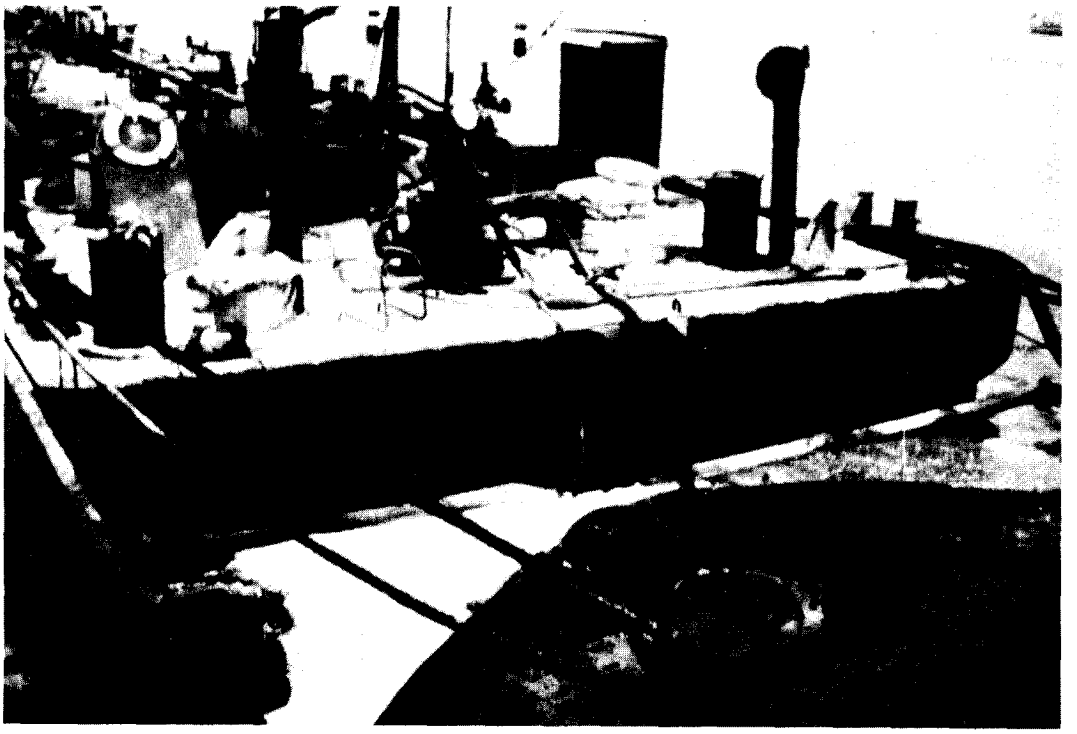
EKOPERL SORBENT SOAKS UP OIL NEAR BARGE

The most extensive use of the sorbent was during the passing of Hurricane Agnes, which caused a good deal of oil to escape from the boomed-off area. Based on on-site tests, one cubic yard of Ekoperl absorbed 47 gallons of oil.

Skimming Operations

A Rheinwerft skimmer was positioned in the water at the aft end of the ship within the area enclosed by the Slickbar boom. The oil-water mixture it collected was pumped directly into the nearby oil barge.

The Rheinwerft skimmer is comprised of three circular pontoons strutted together to form a triangular unit which surrounds a floating basin. Water is drawn toward this basin, or artificial well, by means of a pump. A second pump draws off the surface oil



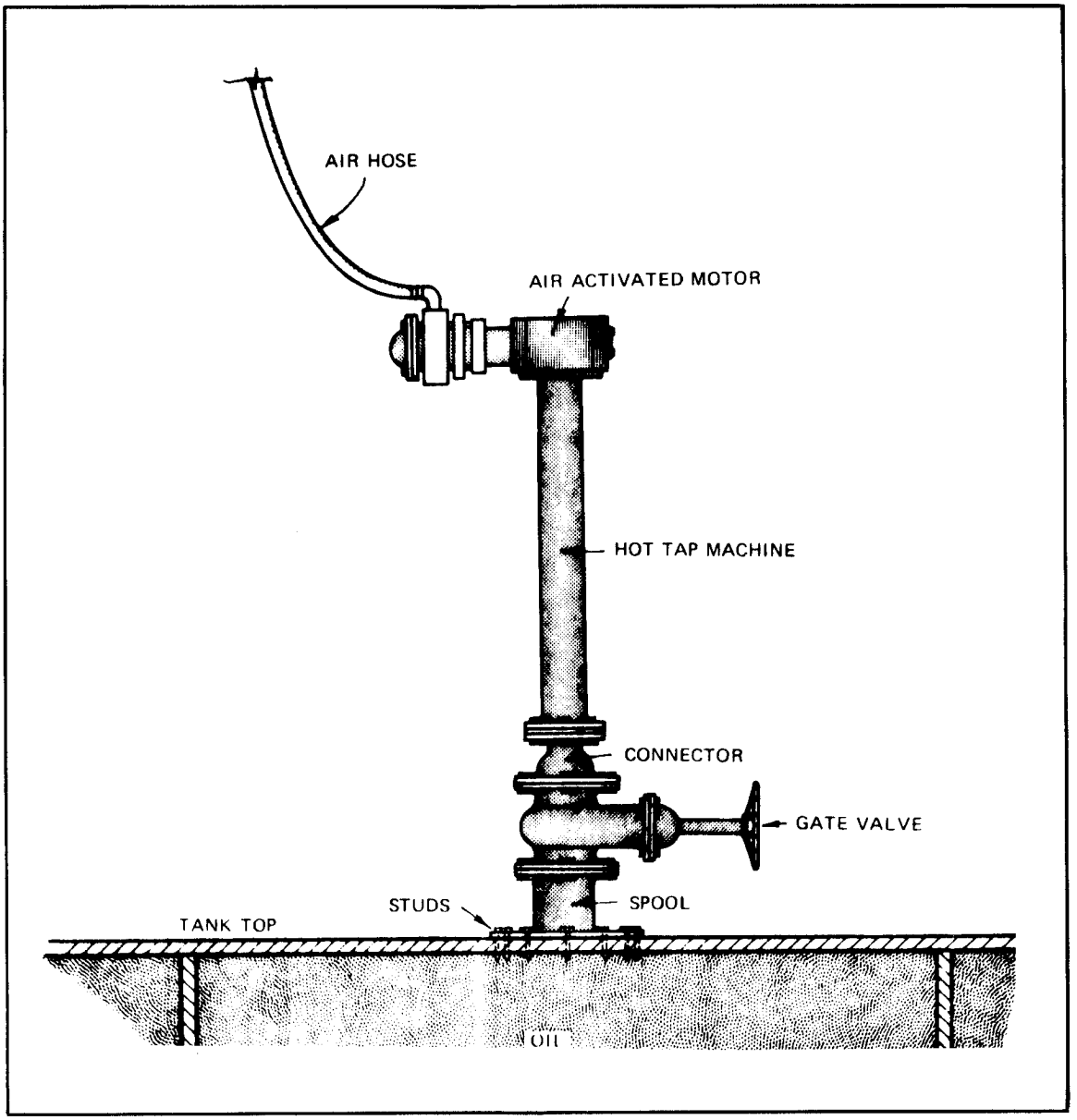
Screen surrounds three buoyant drums that hold Rheinwerft skimmer afloat. Oil trapped by boom is skimmed from water surface and pumped to barge (background).
RHEINWERFT SKIMMER IN OPERATION

from the well. The device is effective in skimming thick or thin slicks, and is best suited to non-turbulent waters such as harbors and inland lakes.

An Acme skimmer was used to collect concentrated oil. The Acme is a gravity skimmer with a self-contained pump. Both the Acme and Rheinwerft models were used with good results during skimming operations. Occasionally, the Rheinwerft had to be cleaned to remove trapped Ekoperl.

RECOVERY OF OIL DIRECTLY FROM THE SHIP

Since oil was present not only in the WARRIOR's tanks but in adjacent holds, compartments, and passageways as well, a variety of recovery methods was employed. These included use of vacuum trucks; pressurization of tanks through sounding tubes; bucket skimming; and hot tapping.



Divers bolted hot tap machines to top of inaccessible tank 8 in attempt to extract oil inside. Rotary cutter inside machine descends through spool to penetrate tank. Gate valve controls flow of oil leaving tank. Suction hose carries recovered oil to surface.

HOT TAP OIL RECOVERY METHOD

Hot Tap Method

SUPSALV had utilized the hot tap method to recover oil from the SS ARROW in 1970. The method was adopted from the oil industry which used it to tap high temperature refinery pumping systems. Applied to salvage work, the method allows removal of oil from submerged and inaccessible tanks.

On the WARRIOR, fire and flooding had either damaged or prevented access to certain oil manifolds. The hot tap method was therefore used to tap three tank tops below hold 4. Although divers encountered little difficulty in positioning the hot tap equipment and making cuts, the tanks were found empty. It was also the recovery team's intention to tap other tanks under the engineroom, but this action was ruled out when the oil flow began to decrease and oil recovery neared the total onboard estimate.

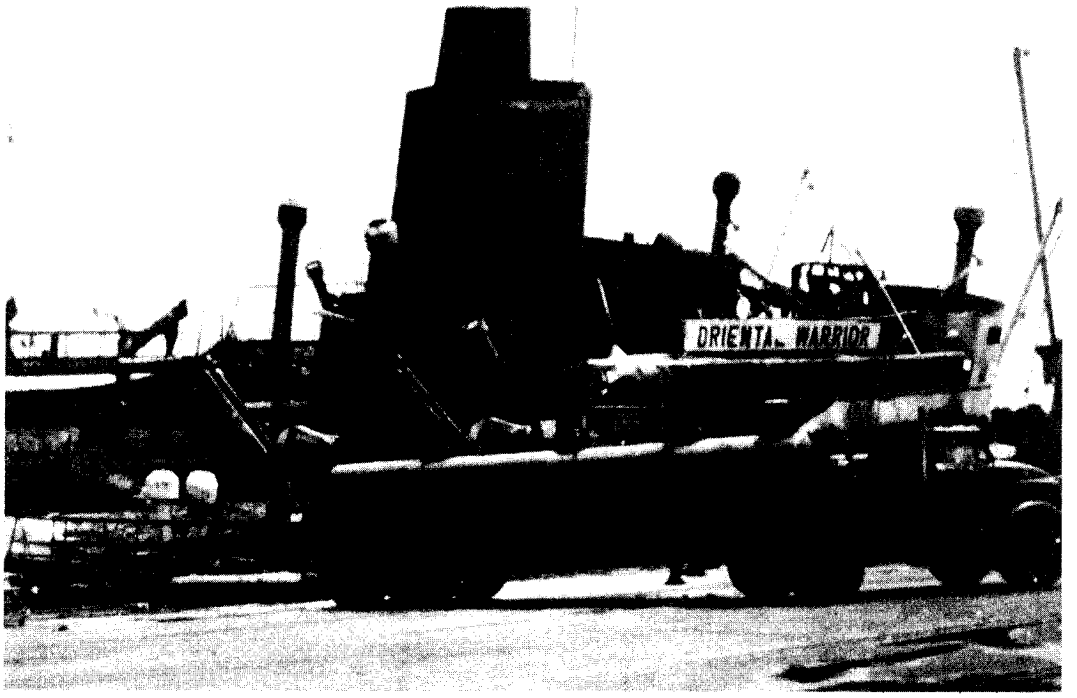
Vacuum Trucks

Approximately half of the WARRIOR's oil was recovered by two vacuum trucks which were positioned nearby on the pier. These trucks had a combined capacity of 1,800 gallons and were equipped with a holding tank, a vacuum pump with a capacity of 25 inches of mercury, and flexible metal hoses. Vacuum pumps recovered oil from holds 3 and 4, the engineroom, and the surrounding reefer passageway.

Recovery through Vents and Sounding Tubes

Oil was also recovered by pressurizing certain tanks. This was accomplished by hosing in fresh water through the sounding tubes, forcing oil in the tanks up through the vents. A small wooden cofferdam was built in the passageway between holds 2 and 3 to allow a vacuum hose to receive the escaping oil. In this fashion, approximately 36,000 gallons of oil were taken from the starboard and midships fuel oil tanks beneath hold 3.

Recovery of oil from other tanks using this method proved less successful. In some cases, oil was forced into the engineroom instead of up through the vents; in other cases, the tanks yielded little or no oil, indicating that the tanks had become essentially water-filled.



Two trucks equipped with vacuum pumps and hoses were used to recover surface oil from holds 4 and 5, engineroom, and adjacent passageways. The two trucks recovered approximately half of WARRIOR's oil.

VACUUM TRUCK SKIMMING OIL FROM CARGO HOLD 4

On the starboard side, the vents and sounding tubes were submerged. The crew broke these to allow the entrapped oil to bubble up and be collected by the skimmers inside the boom area.

Bucket Skimming

During the third week of June, following Hurricane Agnes, local tides were lower than normal. The low tides gave the crew an opportunity to view some spaces that previously remained flooded. Six inches of oil were detected in the passageway leading forward from hold 5, past the engineroom uptakes and on to the staterooms on the starboard side.

Since the only entrance to this passageway was down a companionway hatch and ladder forward of hold 5, bucket skimming was employed. This involved lowering a weighted, tilted bucket into the passageway by a small chainfall for several hours during each low tide

period. (Heavy fumes emanating from the ship prevented continuous skimming operations.) A suction hose to the vacuum truck then collected the accumulated oil from the bucket. With this bucket-vacuum method, approximately 25,000 gallons of oil emulsion were recovered from the vicinity of the engineroom and hold 4, second deck.

Diving Operations

Besides attaching and operating the hot tap machines during debunkering operations, a three-man diving crew conducted many vital inspections and oil location surveys of the ship. The information gathered during these dives such as cargo location and damage reports was also useful to the planners of the subsequent salvage and disposal operation.

Several difficulties were encountered during the five weeks of diving operations from 10 June to 16 July; among them, diver discomfort from high chemical concentrations in certain areas of the ship. In addition, debris and other obstructions often blocked access to key compartments, or otherwise interfered with diving and pumping operations.

Completion of Oil Recovery

The SUPSALV oil recovery crew terminated operations on 15 July. A total of approximately 290,000 gallons of oil had been removed from the ship in the six-week period since the Jacksonville Oil Spillage Committee began its emergency skimming operations.

SUPSALV returned custody of the ship to the Coast Guard on 16 July. Although skimmers remained on the scene to collect small quantities of oil that continued to seep to the surface, the vast majority of the WARRIOR's oil had been removed. Following the debunkering operation, the WARRIOR was ready to undergo salvage and disposal operations to eliminate potential secondary casualties such as fire, break-up, or capsizing at pierside.

CONCLUSIONS

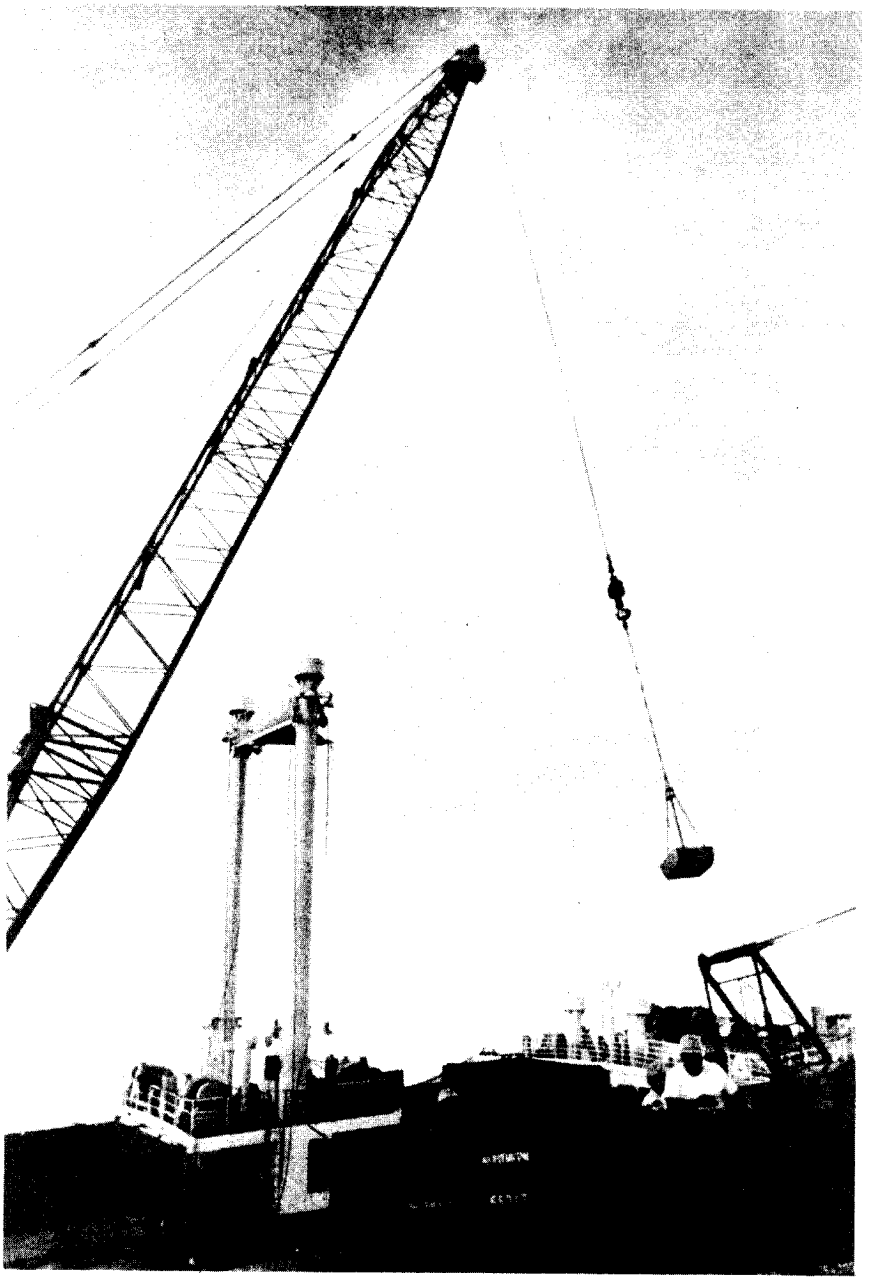
An exact determination of the amount of oil recovered was impossible. Although water-indicating paste was applied to the tapes used to sound the barge tank, accurate readings of the water level in the oil-water emulsion were difficult to make. A second complication was the periodic necessity of pumping some of the recovered emulsion from the barge back into the boom area to make room for more recovered oil.

Of the estimated 290,000 gallons of oil recovered, approximately half was recovered using the two vacuum trucks. Another 61,000 gallons were recovered by the bucket skimming method (25,000 gallons) and by the pressurization of various compartments through sounding tubes (36,000 gallons). Tanks targeted for oil removal by the hot tap method were found empty. The remainder of the ORIENTAL WARRIOR's oil (more than 90,000 gallons) was recovered by skimming the boomed-off area around the ship prior to and during the main recovery effort.

MV ORIENTAL WARRIOR

SALVAGE AND DISPOSAL

OPERATIONS



After successful debunkering operation, salvage team undertook task of refloating ORIENTAL WARRIOR. Strategic placement of solid ballast was necessary to prevent weakened ship from sagging and breaking up in midship area during reflotation efforts.

PLACEMENT OF LEAD BALLAST IN FORWARD HOLDS ASSURES SUCCESSFUL REFLOTATION OF ORIENTAL WARRIOR

MV ORIENTAL WARRIOR
SALVAGE AND DISPOSAL OPERATIONS

INTRODUCTION

At the request of the U.S. Army Corps of Engineers, the Office of the Supervisor of Salvage (SUPSALV) undertook the task of refloating the flooded and fire-damaged MV ORIENTAL WARRIOR, bottomed alongside a pier at Jacksonville, Florida, and disposing of the hulk by sinking it at sea. This harbor clearance effort, conducted during July-September 1972, was preceded by oil pollution control and debunkering operations. The latter operations are described in a separate article in this review.

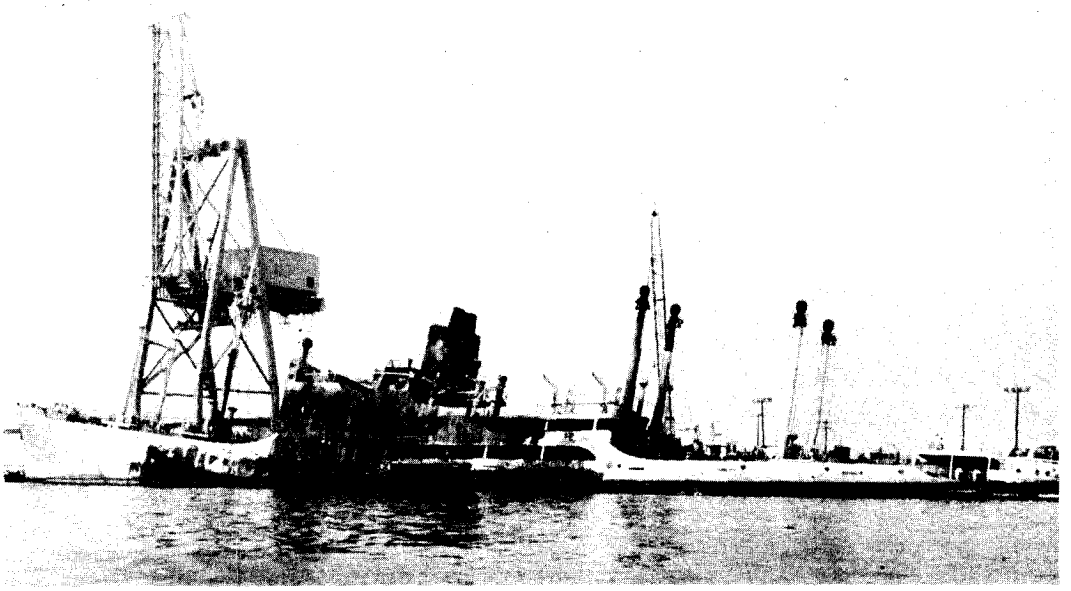
Raising the WARRIOR, although essentially a "patch and pump" salvage job, was by no means a routine operation. The hulk was severely weakened amidships. A delicate, carefully calculated, and controlled combination of dewatering, ballasting, and parbuckling was required to refloat it without creating stresses that could break the hull. The salvage force accomplished the task on schedule and then proceeded to dispose of the wreck at sea, sinking it with demolitions on 1 October 1972.

DEBUNKERING PHASE COMPLETED–WARRIOR SALVOPS BEGIN

Background

On completion of emergency oil pollution control work and debunkering operations on 16 July, the U.S. Coast Guard requested that the U.S. Army Corps of Engineers review the ORIENTAL WARRIOR's condition and proceed with necessary salvage actions.

The WARRIOR remained at the Blount Island pier facility, still submerged in 34 feet of water with a 17-degree starboard list. Although the oil pollution threat had been eliminated by SUPSALV and local efforts during June and the first two weeks of July, the vessel's condition was highly unstable. The 27 May fire had severely weakened the WARRIOR's structural strength and caused extensive flooding. Capsizing or breakup at pierside remained a dangerous possibility if a storm were to occur or if reflotation operations were not carefully planned and executed. The salvage operation would also have to be conducted before cargo decomposition could generate combustible gases.



Fire-scarred WARRIOR lies bottomed at stern and listing 17 degrees to starboard. Salvors established 10 pulling stations on pier and reeved pulling wires beneath hull to prevent wreck from capsizing during refloating operations.

MV ORIENTAL WARRIOR AT JACKSONVILLE PORT AUTHORITY CONTAINER PIER

Assembling the Task Force

Because of the complexity of the salvage problem, the Corps of Engineers requested SUPSALV assistance. SUPSALV assigned on-site representatives and tasked the Murphy Pacific Marine Salvage Company for additional services under an existing contractual arrangement. A Murphy Pacific representative was appointed Salvage Master for the WARRIOR operation. Two subcontractors, the Taylor Diving and Salvage Company and the Buck Steber Company, provided diving services and technical personnel, such as electricians, carpenters, and wreckers. Bateman and Associates, a local firm, was consulted in connection with residual oil containment efforts.

THE SALVAGE PROBLEM

Vessel Data

The MV ORIENTAL WARRIOR (ex-MV HAMBURG) was built in Germany in 1954. The passenger and cargo vessel carried a complement of 86 passengers and 91 crew members.

It had single shaft propulsion and was driven by twin seven-cylinder MAN diesel engines that produced a total of 10,560 horsepower. The ship was divided by eight transverse watertight bulkheads. The forward and after peak bulkheads extended up to the shelter deck, the other six to the second deck. The principal dimensions and tonnage values are as follows:

Length (over all)	535 feet
Length (between perpendiculars)	492 feet 1 inch
Breadth	63 feet 8 inches
Depth to shelter deck	39 feet 3 inches
Draft (maximum)	26 feet 2 inches
Deadweight	9,200 tons
Gross Tonnage	9,008 tons
Net Tonnage	5,278 tons

Weight and Loading Considerations

Determination of the WARRIOR's ground reaction (the weight of the vessel and cargo minus the force of buoyancy) was a difficult task. The salvors had access to the ship's trim and stability book, ship's manifest, and loading and offloading data, but it was impossible to make a precise determination of weight and tonnage for several reasons. The ship's manifest had not been updated to reflect the addition of any structural modifications or weight additions since construction; the loading and offloading data were not considered accurate or up to date; and, most importantly, fire had consumed an unknown quantity of cargo.

It became necessary to reconcile the loading and offloading data and ship's manifest with the actual cargo on board. After completion of numerous inspection dives to the WARRIOR's flooded cargo holds, it was determined that a total of 1808 tons of cargo remained on board, the bulk of it in hold 3. The cargo was general, and included such diverse items as animal hides, automobiles, machinery, paper goods, cotton, tea and artificial flowers. Floodwater was estimated at close to 14,000 metric tons.

To determine the ground reaction, the salvors first calculated the ship's light weight. This value was determined by adding the metric ton figure listed in the ship's manifest to

the estimated values for the forepeak, afterpeak and inner bottoms. The sum of the estimated cargo, floodwater and light weight values produced the ship's total weight. Subtraction of the ship's high tide displacement from the total weight yielded high tide ground reaction:

Floodwater	13,962 metric tons
Cargo	+ 1,808
Light Ship	+ 8,309
Total Weight	24,079 metric tons
Ship's Displacement	-22,074
Ground Reaction	2,005 metric tons

Structural Damage and Stability Considerations

Decks, beams, bulkheads and scantlings had collapsed or become deformed and weakened by the 27 May fire. It was difficult for the salvors to pinpoint all structural damage or to designate maximum loads that the hull could safely withstand. It was known that the greatest structural damage was in the mid-portion of the ship from frame 35 to 120 which included holds 3, 4 and 5, and the engineroom.

The forward holds, 1 and 2, remained unflooded and made the bow somewhat lively in wind and tides. However, there was no concern for the stability of the ship as long as it remained flooded and aground. Structural stresses would increase during lightening and reflotation operations. It would be during this interim period (between a flooded, aground condition and an afloat condition) that the dangers of breakup or capsizing would be greatest.

Salvage Plan

The salvors' primary concern in developing the plan to refloat the WARRIOR was the ship's structural condition. Since the midship area was more damaged and weaker structurally than the buoyant forward and after areas, the ship was in danger of sagging during the reflotation attempt. Raising the ship in sagging condition would almost certainly cause the ship to snap in half. To avoid this, the salvors devised a plan to raise the ship in a hogging condition, whereby the damaged midship area would be kept slightly higher than the ends. The addition of ballast to the ship fore and aft would maintain tension in the upper strength decks amidships, and prevent sagging and breakup.

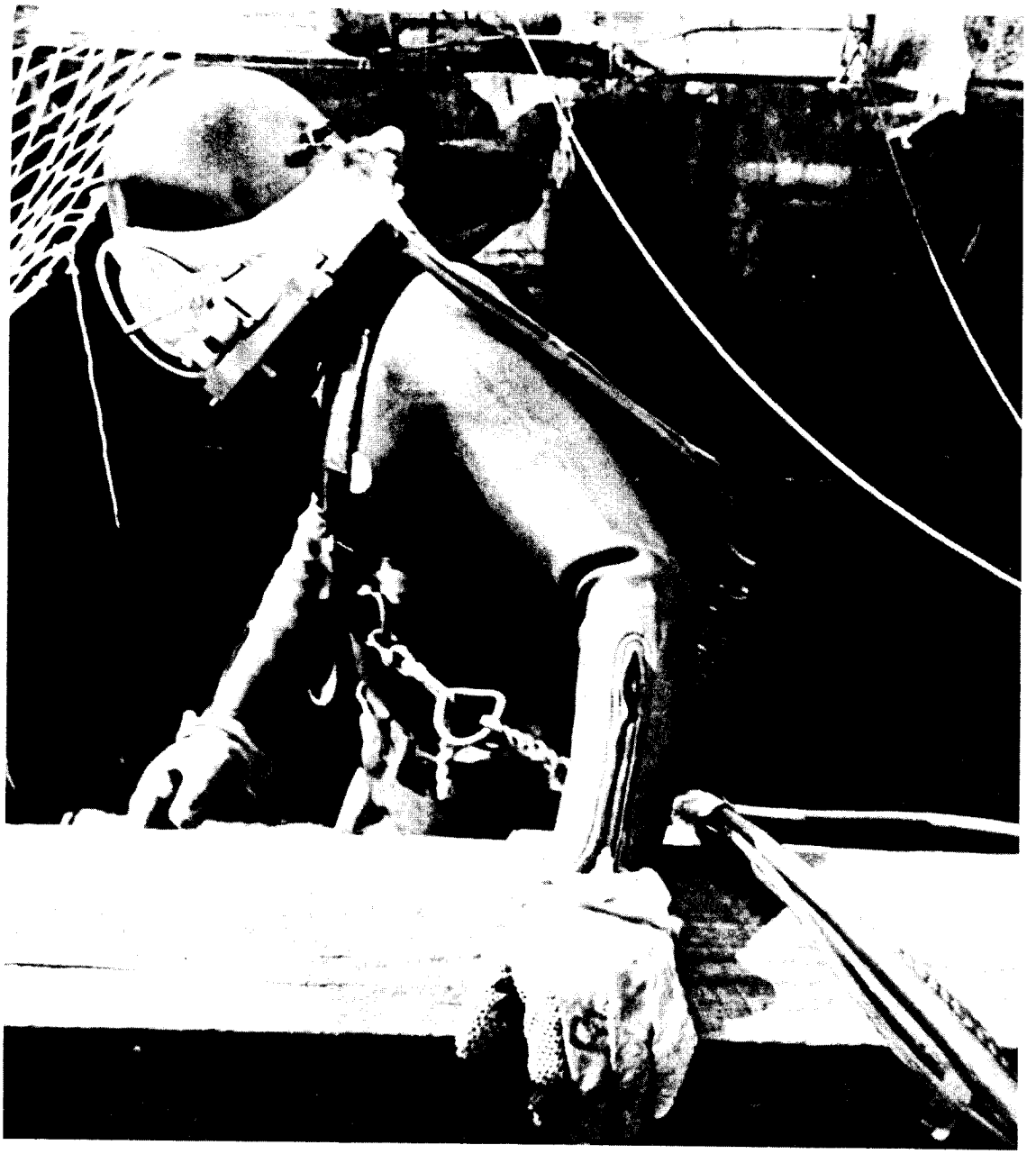
Fire aboard WARRIOR caused extensive structural damage and distortion, especially to midship area, main deck. Ability of this area to withstand stresses during reflotation attempt was primary concern of salvors.

VIEW OF FIRE DAMAGE AMIDSHIPS

It was also imperative to maintain rigid static and dynamic control over the vessel by means of the pulling system to prevent rolling or capsizing. The pier was located at a busy and important channel leading into the port of Jacksonville. If the WARRIOR were to roll into the channel during reflotation, an infinitely more difficult salvage operation would be necessitated.

The Salvage Plan was simple, consisting of the following:

- Selected compartments would first be sealed and made watertight in preparation for dewatering.
- To hold the ship stable alongside the pier, parbuckling wires would be passed around the hull and connected to pullers ashore.
- Ballast would then be placed inside the hull to lower the center of gravity and increase the ground reaction.



Divers performed variety of tasks, including hull and cargo inspection, damage estimates, reeving of parbuckling wires and placement of plugs and patches. Although presence of gases in some compartments bothered divers, problem was eliminated by placing pumps to circulate contaminated water.

DIVER EQUIPPED WITH FIBERGLASS HAT AND NEOPRENE WETSUIT

- The WARRIOR would next be refloated by removal of solid ballast and sequential dewatering of spaces to minimize free surface.
- It would then be secured for sea, towed to a disposal site, and sunk.

DIVING OPERATIONS

From 31 July to 27 September, over 300 working dives were made by the two to seven-man diving crew. Most dives were conducted to seal the ship or to pass messenger wires beneath it for fairleading the parbuckling wires; other dives involved surveys and inspections of the wreck, or rigging of oil containment booms.

Divers used a variety of masks, several brands of fiberglass helmets, and dry, wet and hot water suits. Most dives, however, were made with standard neoprene wet suits which gave divers the necessary flexibility and ease of movement to work within the ship.

As a result of the initial survey dives, the ship was divided into 20 stations spaced 20 feet apart and marked with painted numbers. Cargo and debris location, extent of fire damage, deck and bulkhead evaluation, and identification of openings in the ship were thus delineated. This information was continually updated as diving operations progressed.

Sealing the Ship

Divers located numerous openings throughout the ship, especially in the C deck between frames 40 and 100, and in the bulkheads between holds 3, 4, and 5 and the engineroom. Initially, the divers measured the size and configuration of an opening. Carpenters then fabricated a template which the diver placed over the opening to verify the fit. This process was often repeated several times until a good fit was obtained; only then would a patch be constructed and installed by the diver.

Contour patches were fitted to openings by strongbacks, and sometimes with stud-positioned tabs as well. The largest patches were those used to secure the double doors in the bulkhead between hold 4 and the engineroom on C and D decks. Numerous smaller patches were used to secure portholes, overboard discharges and suctions, and other openings through the skin of the ship.

Steber Co. wreckers modified ship's steel hatch covers, then welded them to coamings to insure watertight fit over aft cargo holds 4, 5 and 6.

WRECKERS PLACE HATCH COVER SECTION OVER CARGO HOLD 5

It often became necessary to use additional wedges, oakum or canvas to secure the patch and prevent leaking. Concrete was used to secure the tank tops on D deck in hold 1 as well as the shaft alley. Leaking seams, decks and bulkheads were secured with grout.

Securing of Piping and Ventilators

Far more difficult to secure were the numerous lines of cross-connecting pipe throughout the ship. Since no accurate piping or ventilation drawings for the ship existed and valves were damaged or difficult to locate, divers had to sever much of the piping and stop both ends with damage control plugs. Many lines had to be cut with power cutters or oxy-arc torches, while others were broken at the flanges. Most of the piping plugs were set in the engineering spaces and shaft alley. Approximately half of the dives were devoted to this frustrating and time-consuming process.

The B deck passenger accommodation spaces also proved difficult to secure, again due to the unavailability of piping and ventilation drawings. Numerous dives from 31 August to the end of September were required to secure the many drains, heads, showers and ventilators in these spaces.

Presence of Gas Detected

During the diving operations, divers experienced discomfort and numbness in their fingers and lips while working in certain spaces, particularly in the shaft alley and engine room. Diving operations were suspended on 10 August to determine the nature of the contamination.

Analysis of water samples showed concentrations of hydrogen sulfide, generated by the decomposition and physical/chemical reactions of the ship's cargo, as high as 399 parts per million in the engine room and hold 4. Lesser concentrations were detected throughout the ship. The chemical analysis report warned that, although concentrations of toxic gases were below established threshold limits, sensitive personnel risked experiencing irritated eyes, hoarse throat, dizziness or nausea. To combat the gas nuisance, the salvors procured a 6-inch and a 10-inch pump and placed them in the spaces where divers were working. The pumps succeeded in circulating the water throughout the contaminated spaces, thereby reducing the chemical concentrations and making working conditions less discomforting for the divers.

Passing Parbuckling Wires Under the Ship

To hold the ship steady against the pier during reflotation operations, parbuckling wires had to be passed under the ship and attached to the purchase gear ashore. Jetting operations began on 18 August to pass the first of 10 such parbuckling wires under the stern of the ship. For the next 10 days, divers struggled with jetting operations in attempts to break through the hard clay beneath the ship. Because only limited success was experienced with jetting, a submarine lance was later employed. Progress was again slow, and by 9 September, only seven of the 10 wires had been passed. After another week, nine parbuckling wires were in place. However, the salvors abandoned efforts to reeve the final, most difficult wire (from pulling station 3); instead, they rigged it directly to the port rail at frame 63.

PIERSIDE PREPARATIONS

Construction of the pulling system ashore proceeded concurrently with shipboard patching operations. Ten pulling stations, one for each set of parbuckling wires, were constructed along the pier opposite the wreck. Four newly introduced hydraulic pullers were placed at the two flanking stations at either end of the ship; standard beach gear purchases were rigged at the six interior stations.

Deadmen Construction

A design load of 50 tons was required to anchor each hydraulic puller or standing block of beach gear tackle. Several anchoring configurations were considered, including the common log and mat deadmen. Due to unstable soil conditions, a design utilizing a combination of pilings, anchor cap and holding point was chosen.

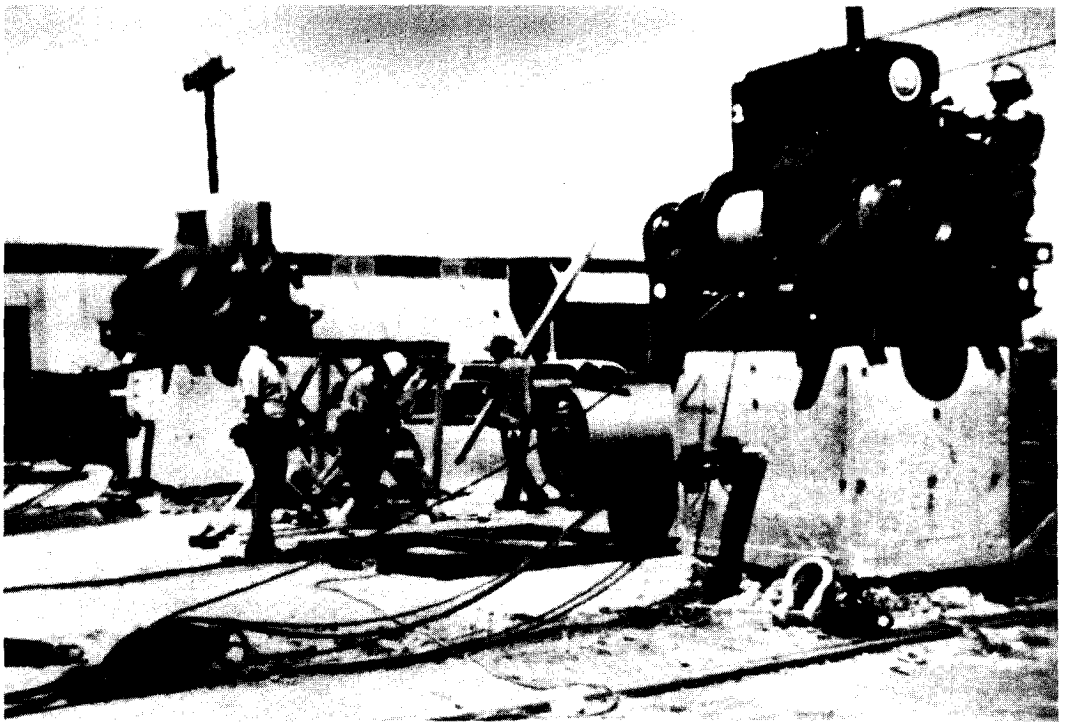
To withstand horizontal loading at each station, three 14-inch steel pilings were driven; two were driven in tension and one in compression. A 5- x 4- x 4-foot cap of 3,000 psi concrete, reinforced with number 9 bar, was poured above the pilings.

The contractor began pile driving on 17 August with a Vulcan single-acting air hammer, completing work on stations 1 through 4 by 20 August. Carpenters then commenced framing and placing reinforcing bars in preparation for casting concrete. By 24 August, pilings for all 10 anchor points were in place. Concrete casting was completed the next day.

On the six stations using beach gear purchase, the top of the concrete block was utilized as a winch platform. The top of each anchor block was inlaid with two 4-inch "I" beams to which the base of each winch was connected. The beams were cast in place and held internally by five number 9 reinforcing bars.

Purchase Gear Rigging

Conventional beach gear rigging was used at stations 3, 4, 5, 6, 7, and 8. Each beach gear purchase was pulled by a winch, positioned on top of the anchor block, and had an effective pulling force of approximately 6 tons.

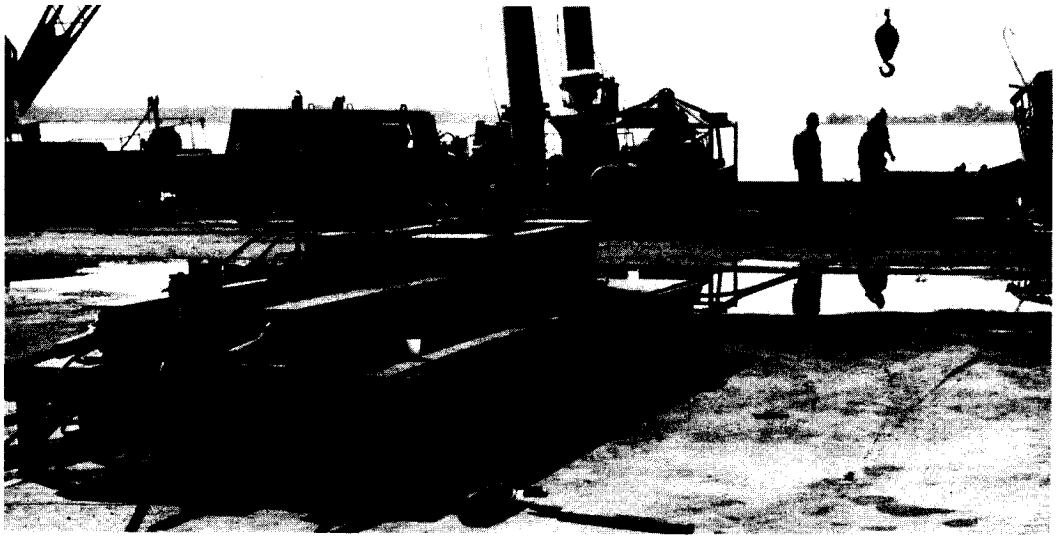


Six-ton winches were positioned atop deadmen blocks at stations 3 through 8. Base of each winch was bolted to two 4-inch I-beams cast in place on top of block. I-beams were secured to block's steel reinforcement bars.

DEADMEN ANCHOR BLOCKS AND WINCHES AT STATIONS 4 AND 5

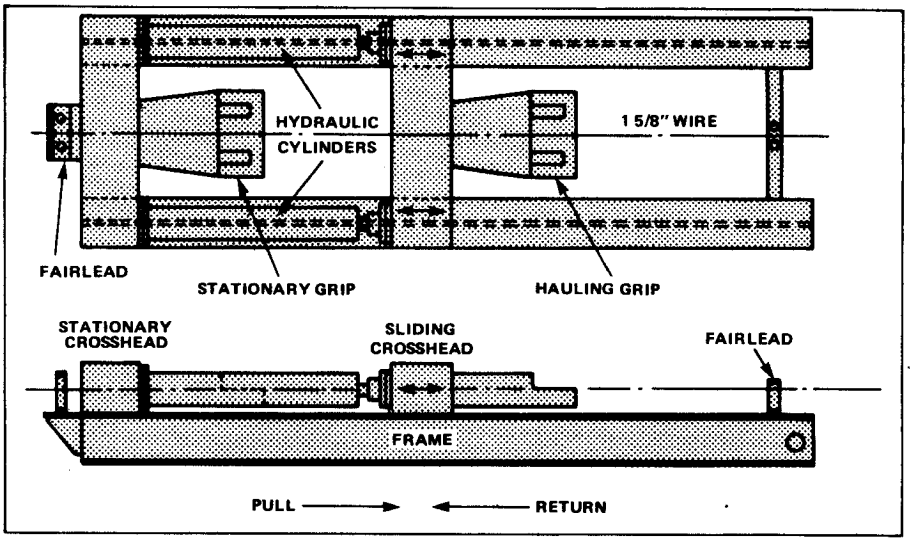
Hydraulic pullers, which had been introduced only a few weeks earlier in the SS SIDNEY E. SMITH, JR. salvage operation at Port Huron, Michigan, were placed at stations 1, 2, 9 and 10 to supplement the conventional beach gear purchase rigging. The hydraulic pullers were fabricated by the Lucker Manufacturing Company of Philadelphia, and were capable of a 40-ton pulling force.

Hydraulic pullers are essentially 3-foot by 16-foot steel frames with two crossheads on which spring-actuated grips are positioned. These grips hold 1 5/8-inch parbuckling wire. In operation, a pair of hydraulic cylinders moves the sliding crosshead and grip back, hauling in a length of wire. The stationary grip then holds the wire fast as the hauling grip returns to haul in another length. The pullers may be operated in a continuous or intermittent cycle, thus yielding a high degree of pulling control. The hydraulic pullers functioned without difficulty throughout the parbuckling operation.



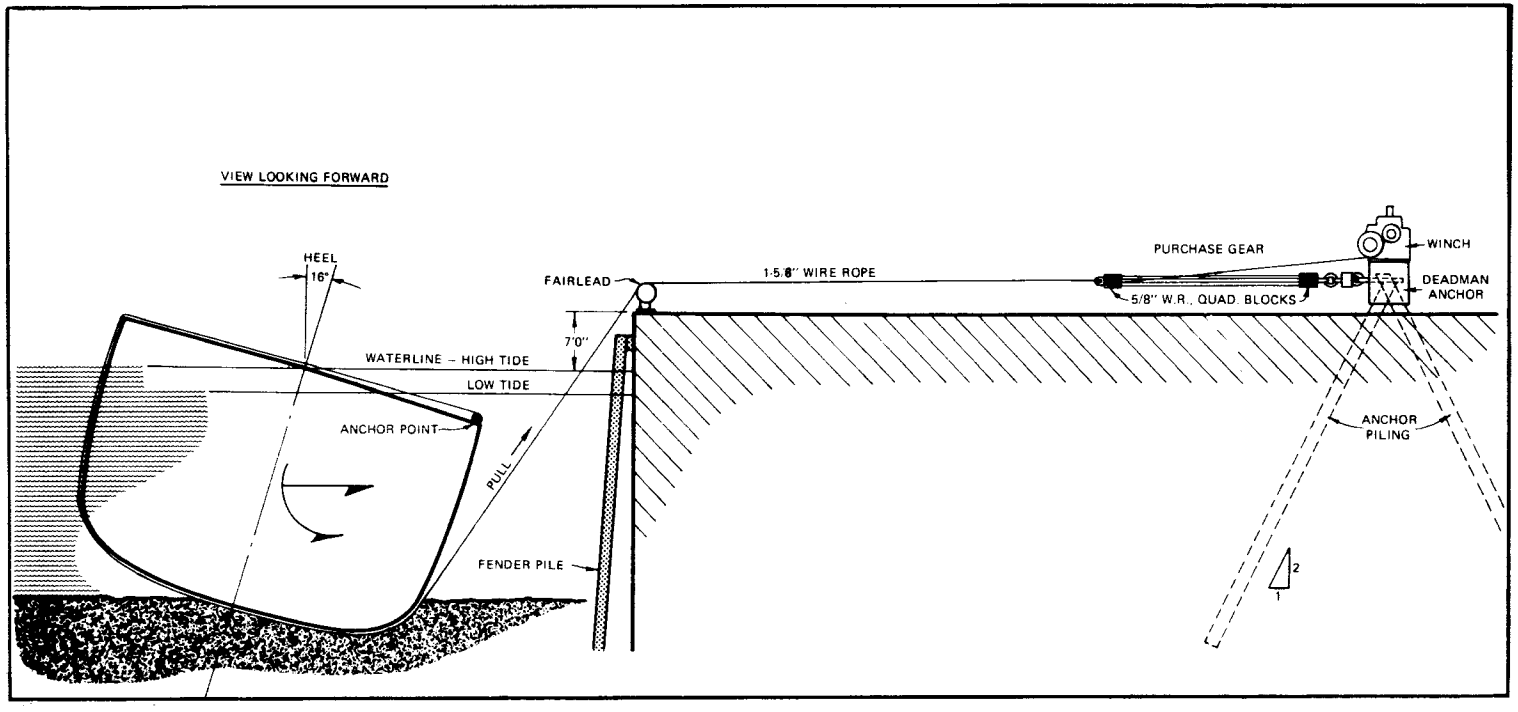
Hydraulic pullers at four outer stations were capable of hauling wire rope in continuous or intermittent cycles, giving salvors high degree of parbuckling control. Pullers were powered by diesel-driven hydraulic vane pump and controlled by remote console.

40-TON HYDRAULIÇ PULLER



Pressure of hydraulic cylinders moves sliding crosshead. Hauling grip moves with crosshead, pulling in length of wire. Stationary grip stops wire as cylinders retract, returning hauling grip to take in another length.

FUNCTIONING OF HYDRAULIC PULLER



Eight wires for parbuckling to port were passed underneath ship and secured to bitts or special pads on main deck, starboard side. (Two remaining wires for parbuckling to starboard were attached to port rail.) Wires ran over fairleads at face of pier to purchase gear or hydraulic pullers which were anchored by deadman blocks.

PARBUCKLING WIRE AND PURCHASE GEAR ARRANGEMENT

Fender Pilings and Fairlead Points

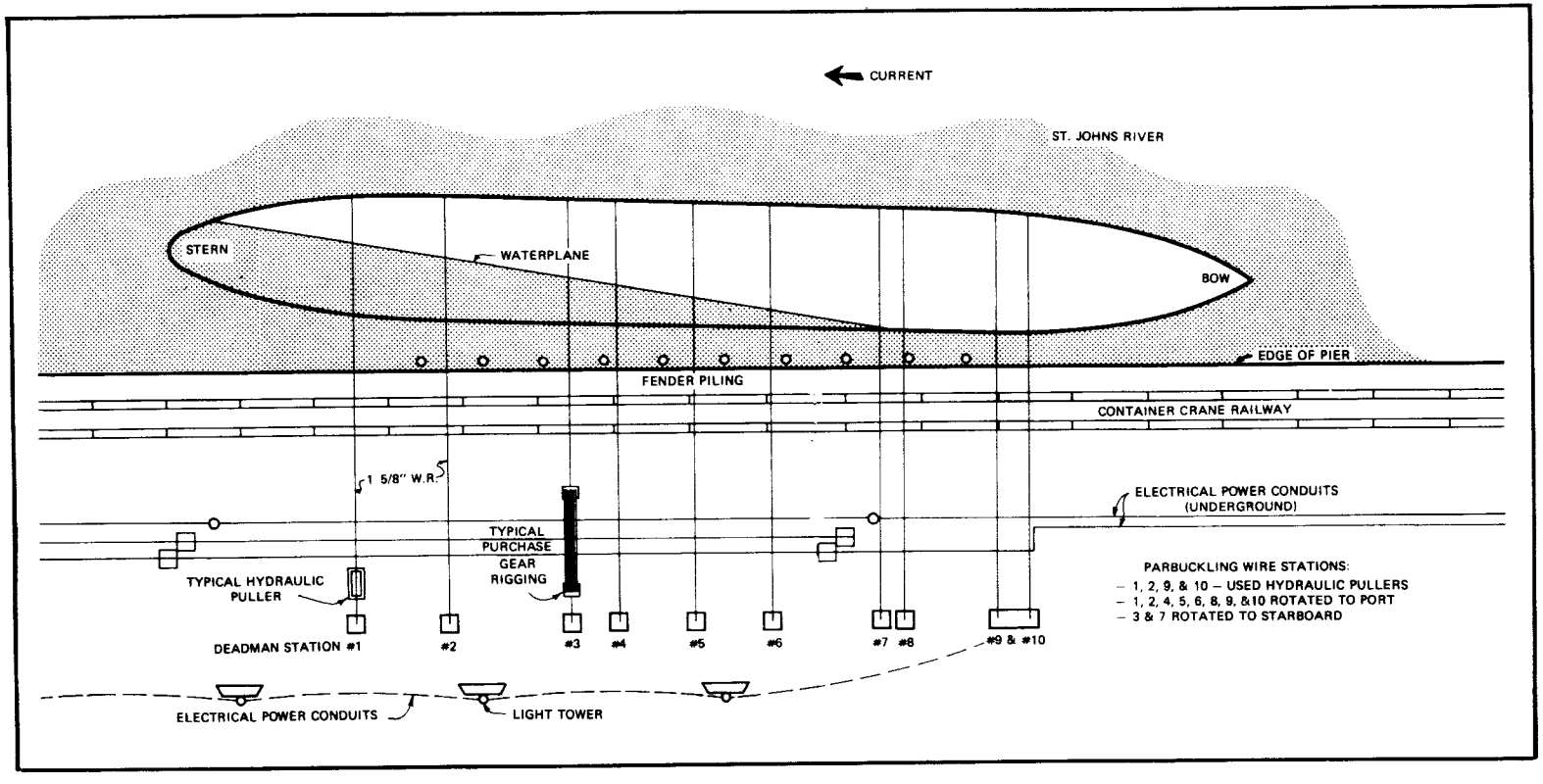
To effectively bring the ship alongside the dock, without causing it to hang up, and allowing a positive surface contact with continuity, it was necessary to drive 10 fender pilings on the face of the pier. All of the 10-inch, 60-foot-long pilings were jetted into place on 28 August, and fastened to the pier by 30 August. In position, the fender pilings afforded the necessary boundary surface for the ship to rest against, and made the parbuckling method of inducing stabilizing moments a practical evolution.

Fairleads for each of the 10 parbuckling wires were also required at the face of the pier to guide the wires and prevent chafing. The ten fairleads were fabricated from 8-foot sections of 30-inch steel pipe and filled with concrete to prevent collapse. The fairleads were attached to the pier with 7/8-inch bolts and "redheads." When one of the fairleads failed at the anchor bolts during operations on 22 September, stiffeners made of 1/2-inch flange beams were secured between the pier and each fairlead.

Parbuckling

Eight of the 10 parbuckling wires were rigged to rotate the ship to port. They were run from connecting points on the main deck, starboard side, around and underneath the ship to the pulling stations ashore. Wires 3 and 7 were run through and over the ship respectively from connecting points on the port side; these were used to rotate the ship to starboard.

Station Number and Type of Puller	Location of Parbuckling Wire
1 - Hydraulic Puller	Frame 28; fwd. end of No. 6 hatch
2 - Hydraulic Puller	Frame 45; fwd. end of No. 5 hatch
3 - Double Drum Winch	Frame 63; aft davit of fwd. pair of davits
4 - Double Drum Winch	Frame 73; aft end of stack
5 - Single Drum Winch	Frame 86; between radar mast base and stack
6 Single Drum Winch	Frame 100; aft end of No. 3 hatch
7 - Double Drum Winch	Frame 119; fwd. end of No. 3 hatch
8 - Double Drum Winch	Frame 122; fwd. of mainmast
9 - Hydraulic Puller	Frame 139; fwd. end of No. 2 hatch
10 Hydraulic Puller	Frame 145; aft end of No. 1 hatch



Pulling system ashore consisted of four hydraulic pullers flanking six purchase gear riggings to bring ORIENTAL WARRIOR alongside pier and prevent refloated vessel from capsizing.

POSITIONING OF PULLING STATIONS AND PARBUCKLING WIRES

It was expected that the primary upsetting moments would be to starboard due to loose water, off-center cargo, and the existing 17-degree starboard list. Thus, only wires 3 and 7 were rigged for parbuckling to starboard. The eight remaining wires were rigged for pulling to port.

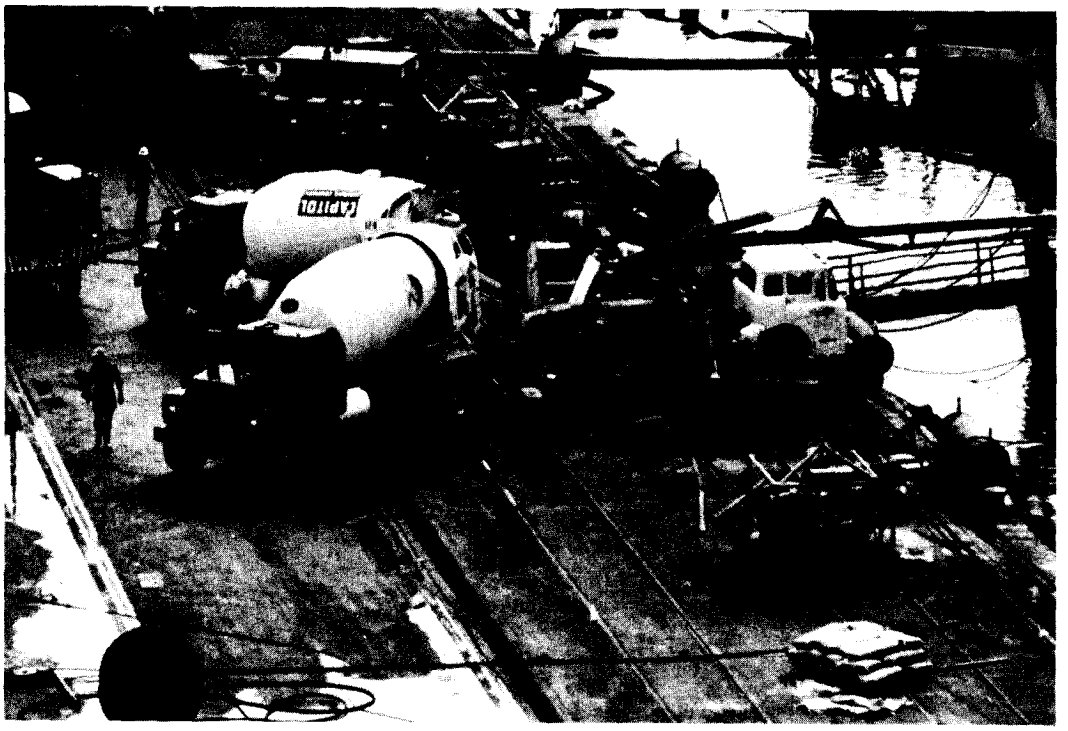
Connecting points were rigged on the ship with wire or chain. The salvors rigged parbuckling wires 3, 4, and 5 to the ship with chain to reduce the chafing potential. They connected wires 1 and 2 to bitts on deck on the starboard side, and wires 6, 7, 8, 9 and 10 to special pads welded to the deck.

A hydraulic load cell was positioned between each deadman anchor point and standing block of purchase tackle (or hydraulic puller). From a central console located between stations 5 and 6, tension from each of the 10 legs could be monitored. Due to the critical and delicate nature of the dewatering operations, a SUPSALV engineer and an assisting technician instructed each station operator to either tighten or slacken his parbuckling wire so that proper control of the vessel's attitude could be maintained.

ADDITION OF SOLID BALLAST

By the first week of September, rigging of parbuckling wires from the pulling stations to the wreck was more than half complete. Divers continued to plug remaining leaks and openings in preparation for dewatering operations. The addition of ballast was the next major step in the salvage plan.

Since the bulkhead between hold 3 and the engineroom could not be secured, both spaces would have to be pumped at once. These spaces held more than 5,000 tons of floodwater. The salvors knew that removal of such a large amount of water from low in the ship would quickly raise the ship's center of gravity and cause water in other holds and compartments to shift radically as the ship rose. This would cause a serious reduction in the ship's overall stability. Removal of the 5,000 tons of water without compensating for this free surface correction would also have put the ship in a sagging condition, which the salvors wanted to avoid as well. So, in order to enhance the ship's overall stability during the dewatering phase, the salvors planned to add solid ballast to the forward holds and shaft alley. Following dewatering, the solid ballast would be removed, thereby floating the ship and eliminating the undesirable free surface and sagging conditions.



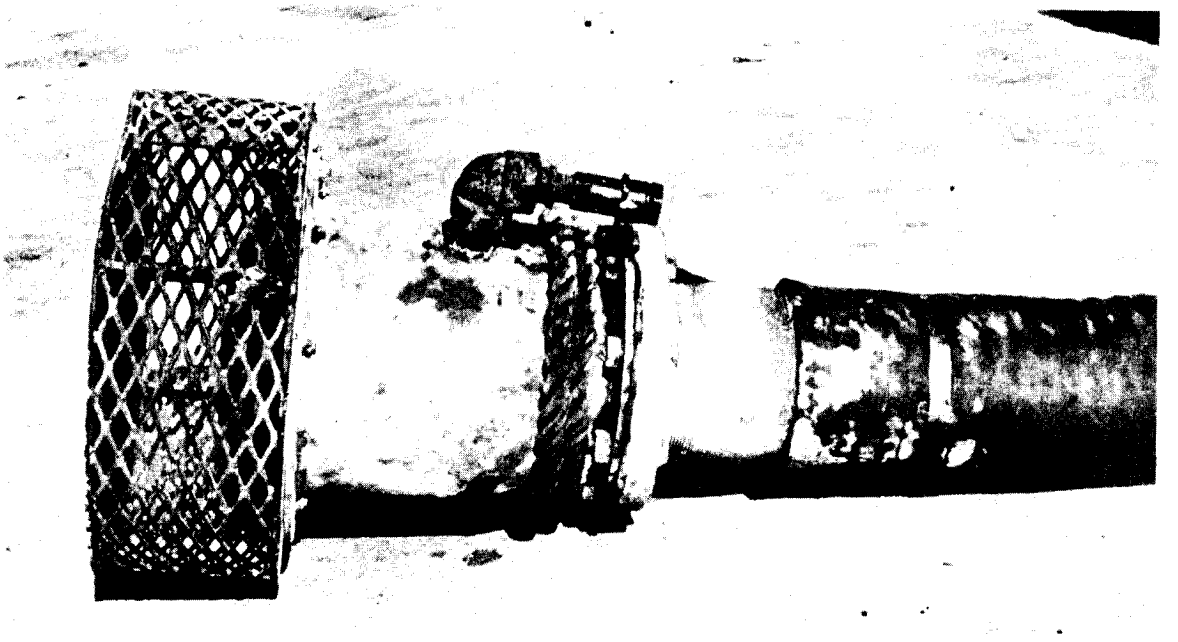
Salvors worked 20 consecutive hours pouring 400 yards of concrete to seal shaft alley and provide ballast for aft end of ship. Concrete was pumped to shaft alley through 3-inch and 4-inch hoses. Divers inside wreck positioned hoses to insure even distribution of concrete.

10-YARD CONCRETE TRUCKS AT SALVAGE SITE

Lead Ballast

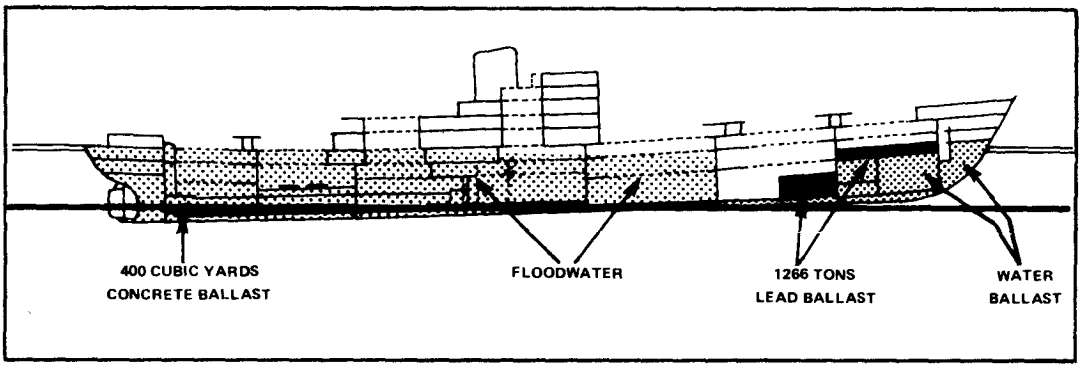
On 10 September, salvors began adding the first of 1266 one-ton lead pigs to the flooded vessel in holds 1 and 2. Lead pigs were chosen for their ease of handling and availability from a U.S. Government stockpile in Louisiana on a no-cost loan basis. With the assistance of shorebased cranes and longshoremen, placement of the lead pigs was completed by 15 September.

In preparation for receiving the 865 tons of lead intended for hold 2, salvors cleaned and dewatered the hold and installed a longitudinal timber bulkhead along the double bottoms from frame 106 to 117 for support. The remaining 401 tons of lead pigs were placed in hold 1, D deck, on a 4-inch concrete pad which had previously been laid to prevent water seepage.

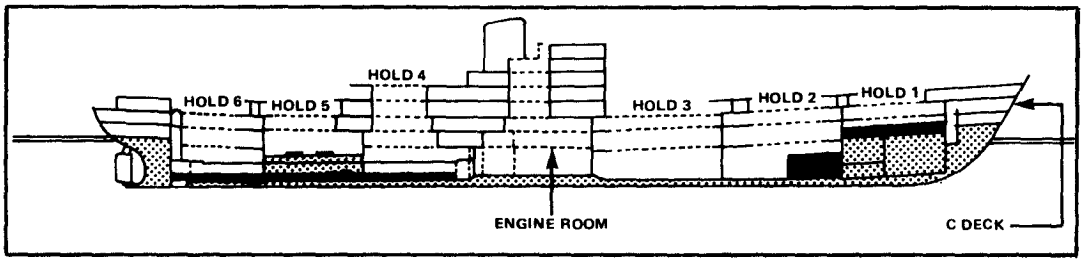


Salvage of ORIENTAL WARRIOR marked first use of hydraulic pumps in marine salvage. Pumps were operated by hydraulic power unit on pier and were used to circulate water in gas-contaminated holds as well as to extract water from vessel during refloating operations (top photo).

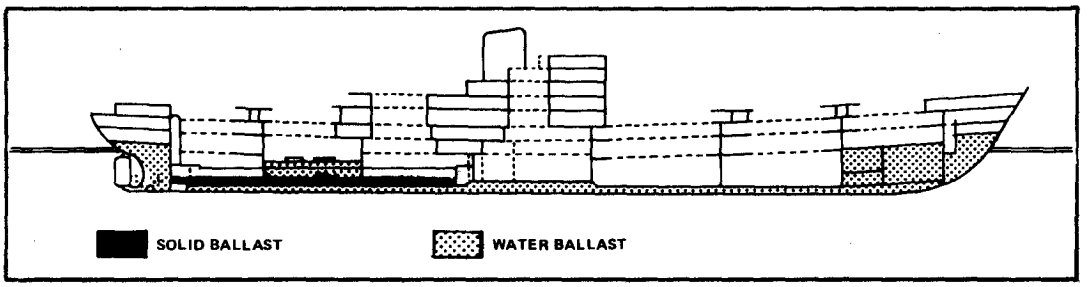
HYDRAULIC PUMP PROVES EFFECTIVE SALVAGE TOOL



First, salvors added water ballast to flooded vessel's forward tanks and placed solid ballast in forward holds and shaft alley.



Second, water was removed from C deck, engine room, afterhouse, and holds 3, 4, 5 and 6. Forepeak, afterpeak, double bottom tanks and deep tanks below holds 1 and 5 were left pressed with water for ballast, keeping vessel in desired hogging condition.



Third, lead ballast was removed from holds 1 and 2. Concrete ballast was left in shaft alley. All spaces were stripped of loose water prior to towing to disposal site.

BALLASTING AND DEWATERING SEQUENCE FOR REFLOATING MV ORIENTAL WARRIOR

During the placement of lead, the double bottom tanks were kept pressed with water to relieve the deck loading. For additional ballast, water was also added to the forepeak and to the four deep tanks below hold 1.

Concrete Ballast

Four hundred cubic yards of concrete provided an additional 400 tons (with appropriate displacement correction) of low weight in the shaft alley (frames 12-69). It also served to secure free communication of water in the shaft alley.

The concrete was poured into the shaft alley through delivery hoses from six 10-yard trucks which shuttled continuously between the batch plant and the wreck site for the 20-hour pouring operation.

Some difficulties were encountered, including collapse of the hydraulically operated truck boom, inadvertent opening of quick-disconnect hose couplings, excessive slumping of the concrete in the alley, and premature setting of the concrete in the hoses and pumps. These, and numerous other problems, were solved in a timely manner, and the work was completed satisfactorily.

FLOTATION OF THE WRECK

Dewatering Operations

By 20 September, rigging of pulling wires and installation of lead and concrete ballast was complete. Divers continued to make final patches to insure watertight integrity in preparation for dewatering.

Pumping and pulling operations to refloat the WARRIOR began on 22 September. A variety of pumps was used, including 3-inch gasoline and 6-inch diesel types. However, the primary pumps utilized were 6-inch and 10-inch hydraulic pumps. The WARRIOR operation marked the first use of hydraulic pumps in marine salvage.

The hydraulic pumps were well suited to this pumping operation. They were light in weight and could be easily positioned by divers without tackle or crane assistance. They were activated by a hydraulic unit on shore and could be controlled to any level of flow by adjusting the impeller revolutions.

The pulling wires were tensioned and pumping began in the engineroom and hold 3. The removal of floodwater from the mid-portion of the ship, plus the presence of ballast forward, kept the ship in the desired hogging condition and prevented the badly distorted upper strength decks from snapping.

Soon, however, it became apparent that the ship was taking on water faster than the pumps could remove it. The wires were slackened, and divers sent down to inspect the wreck. Air conditioning ducts, not shown in the original drawings, were determined to be the source of the leaks. Water was entering the ducts from hold 5 to hold 4 to the engineroom.

Divers quickly secured the ducts, and pumping operations resumed. The restraining wires were also tensioned. Wires 1, 2, 6, 8, 9 and 10 provided a righting moment to port; wires 3 and 7 were left lazy in case a righting moment to starboard became necessary; wire 4 was left slack since it did not have a satisfactory fairlead; and wire 5 was never used because the winch at that station failed to work properly. By 0330 on 24 September, the engineroom and hold 3 were dewatered and made watertight.

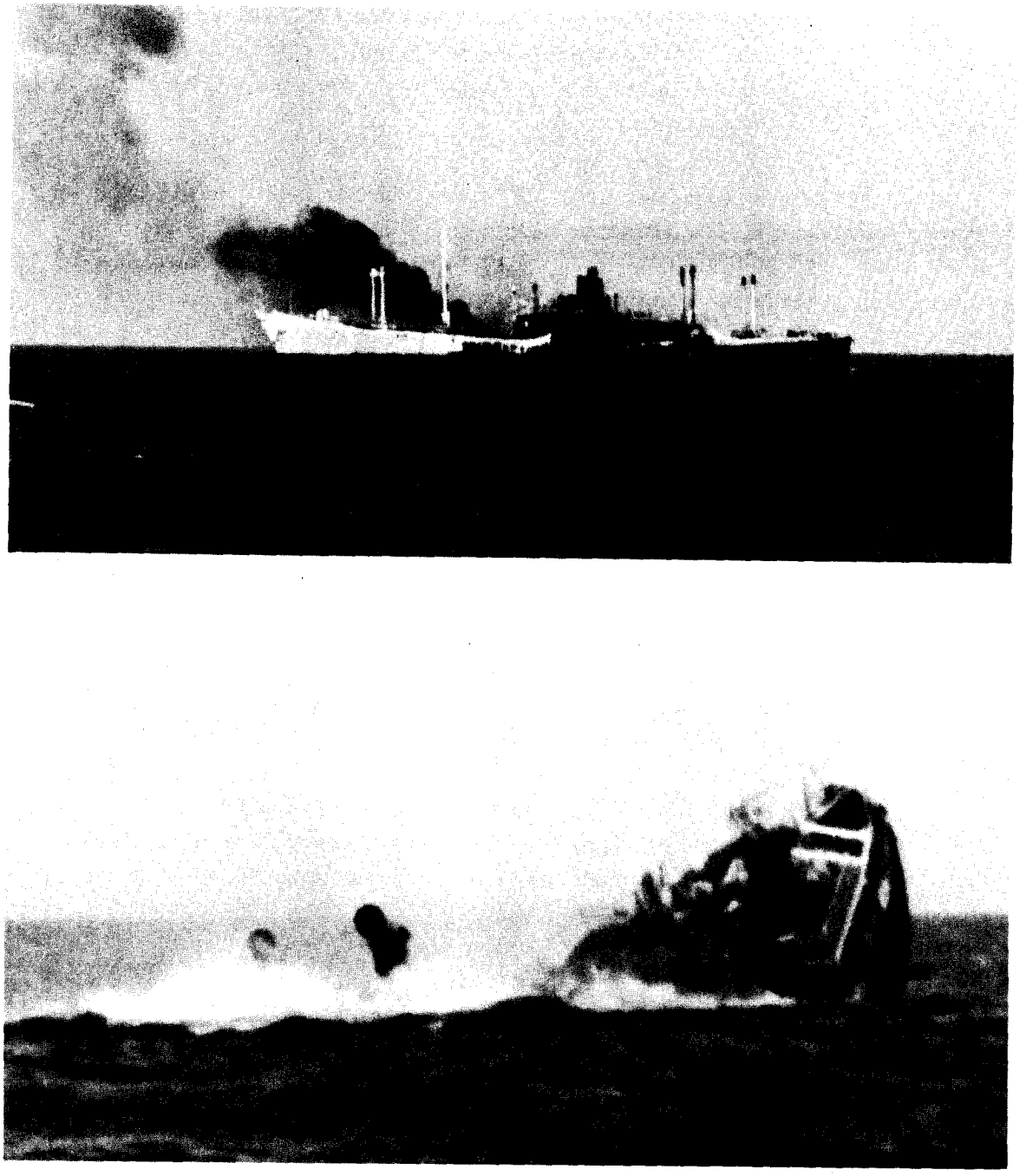
By midnight, dewatering of holds 4, 5 and 6 was complete. This brought the ship free of the bottom and reduced the list to 13 degrees to starboard. Stripping operations were immediately begun to remove free water from the ship. By maintaining tension on wires 1, 2, 6 and 8, the ship was brought to within 2 feet of the pier.

A tension of 8 tons on the pulling wires was maintained during the next two days, 25 and 26 September, to keep the refloated vessel alongside and provide restraining moments to overturning. Waterstripping operations and patching continued, but the ship maintained a 13-degree list to starboard due to the weight of off-center cargo and remaining floodwater.

During stripping of the engineroom, the starboard bunker tanks were found to be filled with lube oil. The salvors fabricated a cofferdam in place and inserted a vacuum line to transfer the oil to a vacuum truck. The deep tanks below hold 1 and 5, plus all double bottom tanks, were left filled with water.

Removal of Lead Ballast

With the ship alongside the pier and in a stable condition on 26 September the salvors commenced offloading lead from forward holds 1 and 2. During the night shift, 143 one-ton pigs were removed, reducing the starboard list to 9 1/2 degrees. All lead ballast was removed by 28 September.



Salvors rigged explosive charges to WARRIOR and towed ship to disposal site 115 miles east of Jacksonville. Moments after charges were detonated, ship took on water and sank to 400-fathom depth.

SINKING OF MV ORIENTAL WARRIOR AT SEA

DISPOSAL OPERATIONS

Choice of Disposal Plan

Despite the successful reflotation operation, the structural condition of the WARRIOR's decks and bulkheads was still basically unsound. The ship remained a casualty and had to be disposed of as quickly as possible.

Several disposal plans were considered, based on suggestions from the Coast Guard, Army Corps of Engineers, Environmental Protection Agency, and numerous local environmental groups. The suggestions included: putting the ship up for sale for scrap; sinking the ship at an advantageous site for a fish haven; and sinking the ship in deep water.

The WARRIOR's condition afloat remained fragile and cargo decomposition was sure to increase. Since these conditions could lead to fire, flooding, breakup or generation of toxic or combustible gases, both SUPSALV and the Corps of Engineers recommended that the WARRIOR immediately be towed to sea past the 100 fathom curve, and sunk.

Tow and Disposal

After reflotation and ballast removal, salvors continued stripping operations and minor patching. Wire and chain were removed from all parbuckling stations, and all purchase gear and anchor points dismantled.

On 28 September, riggers positioned hogging lines for demolition charges for holds 1, 2, 3 and 4 and the engineroom. The WARRIOR was taken under tow on 0820, 30 September, and reached the disposal site approximately 115 miles from Jacksonville (LAT 30° 23.3'N, LONG 79° 23.7'W) on the following morning. Twelve minutes after the explosive charges were set off, the ship disappeared beneath the surface and sank in over 400 fathoms of water.

CONCLUSIONS

The considerations utilized in formulating the original salvage plan proved valid throughout the salvage operation. A combination of wire restraining, ballasting, patching and judicious management of floodwater pumping rendered the ship stable during

the critical dewatering phase. The salvage operation progressed without unexpected difficulties, and was accomplished within four days of the scheduled completion date of 27 September.

Certain difficulties were experienced during diving operations, including presence of debris, oil and chemical concentrations; poor visibility; and difficulty in ascertaining accurate piping and structural information for patching. Salvors found that a certain degree of time and efficiency could have been gained if divers had been kept on specific jobs until completion, instead of rotating and assigning them to other duties in between.

Dewatering by hydraulic pumps was new to marine salvage. The high pumping volumes and remote location of the hydraulic power pack made these units highly suitable for the WARRIOR operation. They performed well.

Another new salvage tool, hydraulic pullers, also performed as expected. Salvors found, however, that pay-out or heaving-in of wire was slow with these pullers. In addition, care had to be taken to ensure that a sufficient length of wire was available to the puller while heaving-in since the puller's fairleads could not pass plate shackles.

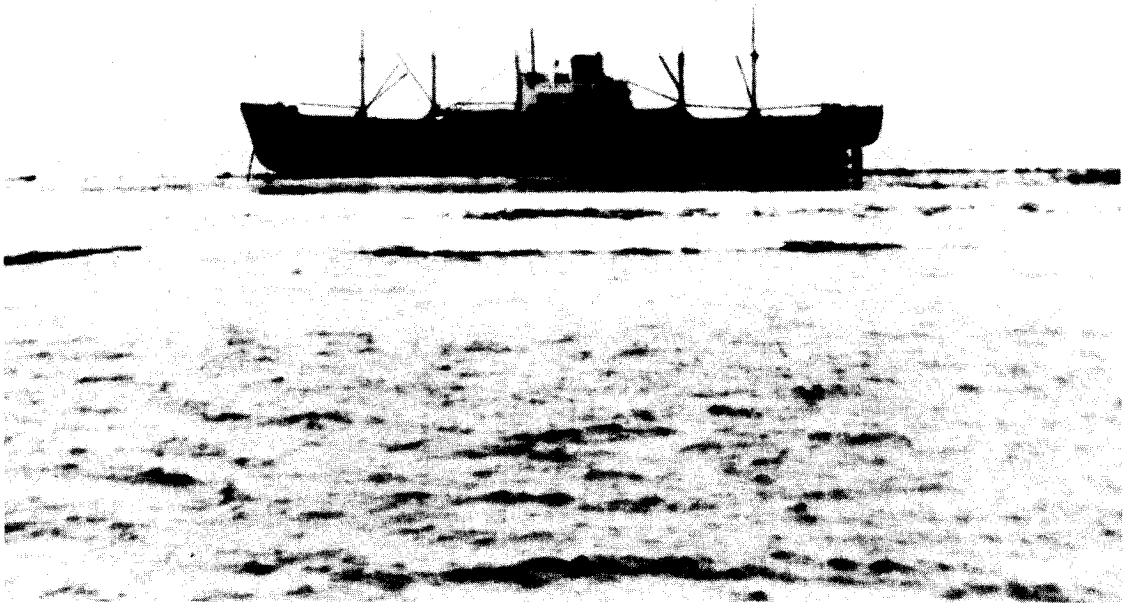
While use of the lead pigs as solid ballast proved effective, the logistics of shipping the ballast, and the manpower required to handle it, were considerable. Also, the process of loading and unloading the ballast was extremely time-consuming.

In pouring cement ballast in the shaft alley, the aggregate size had to be reduced to facilitate pumping, and some difficulty was experienced in determining the exact position, level, and slump of the concrete. But ultimately, both the sealing and ballasting quality of the cement proved excellent.

RECOVERY OF OIL FROM MV SOLAR TRADER

AT WEST FAYU ISLAND,

PACIFIC ISLANDS TRUST TERRITORY



Vessel rested on coral reef at approximately even keel, leaking oil at rate of 20 gallons per day. Danger of serious spill increased with passage of several typhoons which caused 20-foot surf to pound against vessel's torn starboard side.

MV SOLAR TRADER STRANDED ON REEF
AT WEST FAYU ISLAND

RECOVERY OF OIL FROM MV SOLAR TRADER AT WEST FAYU ISLAND, PACIFIC ISLANDS TRUST TERRITORY

INTRODUCTION

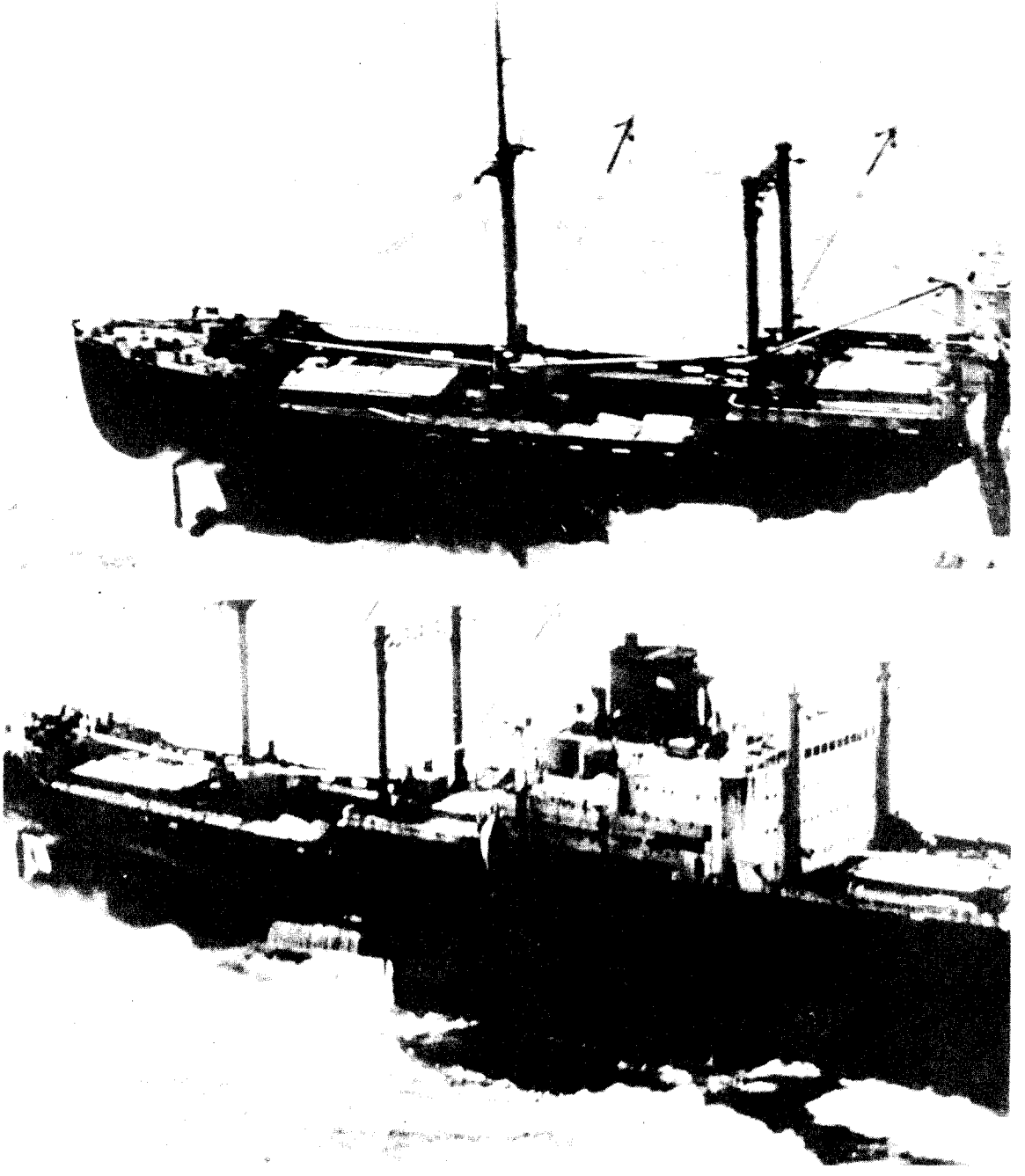
The merchant ship SOLAR TRADER ran aground on a shallow reef at West Fayu Island in the South Pacific Ocean in late December, 1971. It had been slowly leaking oil into the surrounding waters for some 6 months when SUPSALV received a request for oil pollution abatement assistance from the 14th Coast Guard District on 12 June 1972. SUPSALV accepted, dispatched an oil pollution abatement expert to the scene, and made arrangements for the assembly of an oil recovery team from a Philippines-based salvage firm. Despite recurrent typhoons and pounding surf breaking over the ship during recovery operations, the oil recovery team succeeded in removing the SOLAR TRADER's 45,000-gallon cargo of heavy diesel and lube oil. The oil removal operation was accomplished in 9 days and without harm to the fragile coral reef ecosystem.

BACKGROUND

On 20 December 1971, the Liberian-registered merchant ship SOLAR TRADER ran aground on a coral reef at West Fayu Island, a small atoll in the U.S. Pacific Islands Trust Territory approximately 1,500 nautical miles east of the Philippines and 325 nautical miles south of Guam. Oil was leaking from the vessel's after tanks at a rate of about 20 gallons per day. But due to administrative and legal problems, no attempt had been made, either by the owners of the vessel or the Coast Guard, to control the spillage or remove the oil.

SUPSALV Assistance

Finally, on 12 June 1972, nearly 6 months after the SOLAR TRADER ran aground, action was initiated to halt the pollution that was threatening the breeding grounds of the green sea turtle, a food staple of the people of the surrounding islands. Under the Water Quality Improvement Act of 1970, the U.S. Coast Guard (14th District, Hawaii) took over responsibilities from the owners of the SOLAR TRADER for the subsequent pollution abatement operation. The Coast Guard then requested assistance from the Office of the Supervisor of Salvage (SUPSALV). SUPSALV agreed to undertake the operation and dispatched an oil pollution abatement expert to meet with the SUPSALV representative and Coast Guard officials already there.



Invasion of sea water into aft cargo holds through gashes in starboard shell plating made access to aft double bottom tanks difficult and increased danger of oil spillage during recovery efforts.

VIEWS OF HULL DAMAGE, STARBOARD SIDE AFT

Only two weeks earlier, SUPSALV had sealed an agreement with the Luzon Stevedoring Company (LUSTEVECO) of Manila, Republic of the Philippines, for salvage services in the Western Pacific and Indian Oceans. Under this standing contract, SUPSALV tasked LUSTEVECO to supply a salvage master, salvage personnel, boats, and equipment to remove the SOLAR TRADER's residual fuel oil.

Initial Survey of the Vessel

On 16 June, the LUSTEVECO Salvage Master and the SUPSALV representative visited the casualty site at West Fayu Island and conducted an initial survey of the vessel. They estimated that the vessel's day tanks contained approximately 15,000 gallons of light diesel/lube oil, and that the double bottom tanks contained roughly 90,000 gallons of a heavy diesel oil/water mixture. The wreck was resting at an approximately even keel, heading west, port side to the reef. There was hull damage to the starboard side, but none of the fuel tanks was open to the sea. Although oil continued to seep from the after tank group at the rate of about 20 gallons per day, the prevailing winds kept the spill from invading the island.

The Oil Removal Plan

LUSTEVECO estimated that the oil removal operation would take 11 working days. The plan was to tow an oil receiving barge to the scene by tug and moor it on the SOLAR TRADER's starboard (seaward) side. If depth permitted, the tug would hold the barge with both bower anchors. Otherwise the barge would be held with the tug's engines maintained at dead slow.

Equipment and transfer of personnel to the vessel would be accomplished via high line from the receiving barge, or via a shallow draft boat. Electric power lines and an air line would be rigged from the receiving barge to the vessel.

The transfer of oil to the barge would be accomplished by tapping the SOLAR TRADER's pipe lines or sounding tubes and pumping the oil with positive displacement pumps. A back-up plan involved installation of prefabricated steel cofferdams around tank top manholes, then pumping the oil out through the open manholes using electric submersible and sump pumps.

To guard against spillage during the transfer operation, a workboat, the tug's lifeboat, an oil skimmer, and an oil containment boom would be kept ready and nearby at all times. In addition, a reserve boom and skimmer would be maintained aboard the barge or tug for immediate use if required.

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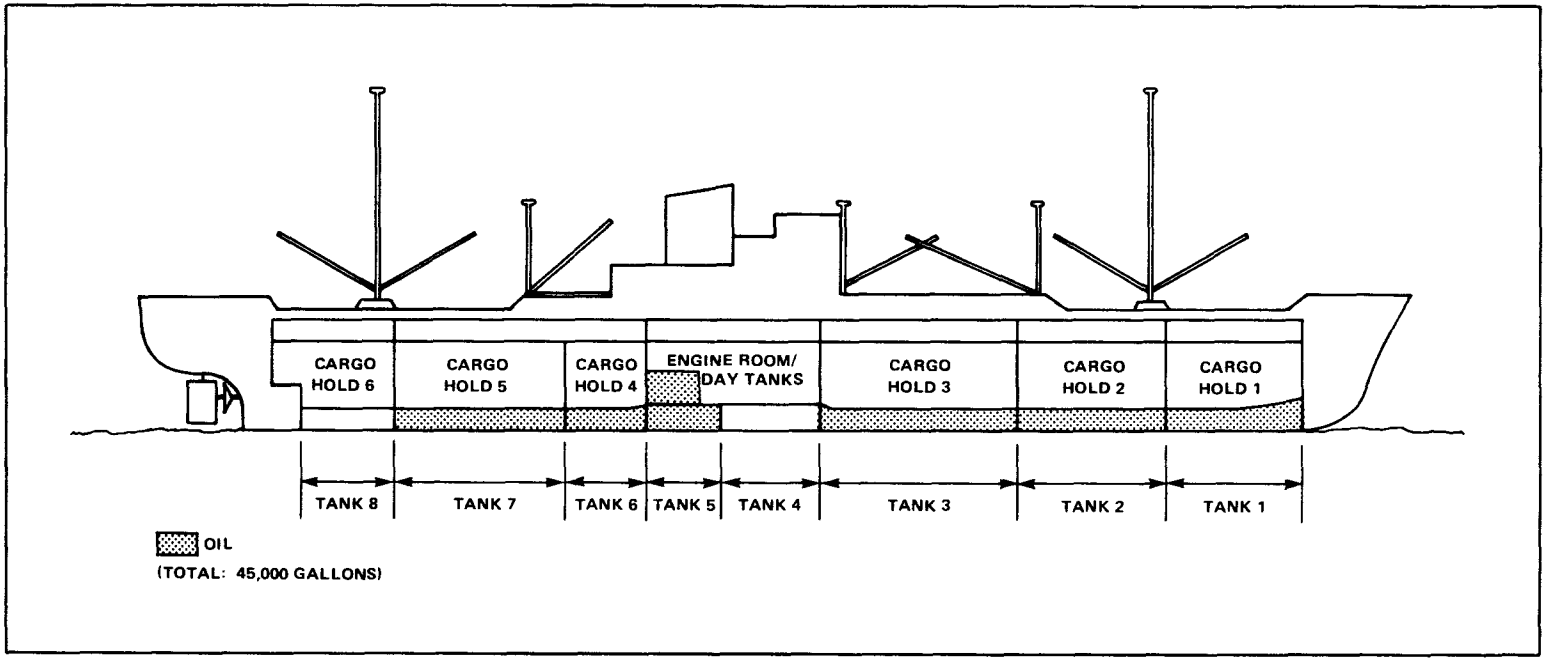


Salvors pumped oil from double bottom tanks to SOLAR TRADER's day tanks which served as central collection reservoir during debunkering operations. Soundings of double bottom tanks on 9 and 10 July showed presence of 1 to 5 inches of topoil, but later inspections revealed accumulations of up to 10 inches in several tanks, plus large amount of recoverable oil in tank 5 which was previously believed filled with sea water.

LOCATION OF OIL ABOARD MV SOLAR TRADER

Vessel Data

The MV SOLAR TRADER measured 470 feet in length (overall) with a 59-foot breadth. It was built by Hitachi of Osaka, Japan, and was owned by the Union Pacific Shipping Company of Singapore. Its gross tonnage was 7,145 tons.

Below decks the ship carried three cargo holds forward, a large machinery space, and three cargo holds aft. Above the cargo holds were six corresponding 'tween deck cargo spaces; below the holds, the ship had eight double bottom tanks. It was in these double bottom tanks that most of the oil aboard the SOLAR TRADER was believed to be contained.

CONDUCT OF OPERATIONS

Arrival of Salvage Team and Equipment

The LUSTEVECO salvage team departed for West Fayu Island from Manila by tug on 24 June. The 133-foot tug MT STANFORD was towing a 1,000-ton (dw) steel barge (L-1906) which was 144 feet long, 36 feet wide, and 12 feet deep. Due to the passing of Typhoon Ora, however, the tug and tow had to return to the harbor for shelter later in the day.

The tug and tow were under way again on the afternoon of 26 June. After a 13-day passage, they arrived at West Fayu Island. Since sea conditions were rough and Fleet Weather Central, Guam was forecasting continued high winds and rough seas for at least another 48 hours, the tug and tow circled the atoll in search of an opening through the reef to the sheltered waters inside the lagoon. After dropping STANFORD's anchor inside the lagoon, the salvors unrigged the 10-inch nylon tow-line and moored the barge alongside.

Inspections and Soundings

The next day, 9 July, adverse weather conditions continued, but the salvage team was able to board the SOLAR TRADER. As 20- to 30-foot surf pounded the starboard side, the salvors inspected the ship, finding holds 2, 3, 5 and 6 and the engine room open to the sea on the starboard side. Soundings taken on 9 and 10 July using a chemical water finder disclosed from 1 to 5 inches of topoil in eight of the vessel's 15 port and starboard

double bottom tanks. Minor discrepancies in the topoil content readings on 9 and 10 July, as shown below, raised doubts among the salvors about the chemical water finder's accuracy:

SOUNDINGS, 9-10 JULY

Double Bottom Tank	Contents (9 July Soundings)	(10 July Soundings)
No. 1	5" topoil	1 1/4" topoil
No. 2 (port)	sea water	sea water
No. 2 (stbd)	2 1/2" topoil	5" topoil
No. 3 (port)	5" topoil	5" topoil
No. 3 (stbd)	5" topoil	2 1/2" topoil
No. 4 (port)	fresh water	fresh water
No. 4 (stbd)	fresh water	fresh water
No. 5 (port)	sea water	sea water
No. 5 (stbd)	sea water	sea water
No. 6 (port)	1 1/4" topoil	5" topoil
No. 6 (stbd)	2 1/2" topoil	2 1/2" topoil
No. 7 (port)	1 1/4" topoil	5" topoil
No. 7 (stbd)	5" topoil	3 3/4" topoil
No. 8 (port)	sea water	sea water
No. 8 (stbd)	sea water	sea water

Further soundings showed the port side inway holds almost bare, while the starboard inway holds and engine room were flooded with 3 to 4 feet of water. A check of the engine room day tanks disclosed the presence of nearly 15,000 gallons of oil.

While soundings were being taken, the salvors worked to restore SOLAR TRADER's 75kW auxiliary generator and transfer pump to operating condition. It was decided to employ four portable pumps to pump oil from the double bottom tanks to the day tanks, which would act as a central collection reservoir. The transfer pump would then be used to push the collected oil to the receiving barge.

By 11 July, the generator and transfer pump were repaired and fully operable. Pipes connecting the portable pumps to the day tanks were then installed.

Change in Defueling Plan

The continued adverse weather created by the passing of Typhoons Phyllis and Rita to the north necessitated a change in the defueling plan. The salvors were forced to position the receiving barge inside the lagoon during transfer instead of outside, or seaward, of the ship. Thus the barge was moved close to the reef opposite the SOLAR TRADER while the salvors laid 1,900 feet of discharge hose across the reef. The hose led from the SOLAR TRADER's day tank to the receiving barge and consisted of 14 lengths (700 feet) of 4-inch hose and 24 lengths (1,200 feet) of 2-inch hose. The salvors secured the hose lengths to a 7/8-inch wire rope steadying line during installation. This prevented the cross current on the reef from carrying the hose lengths away. After installing the hose, which required 2 days of effort from 11 to 12 July, the salvors began pumping sea water to test the vessel's transfer pump and the discharge hose.

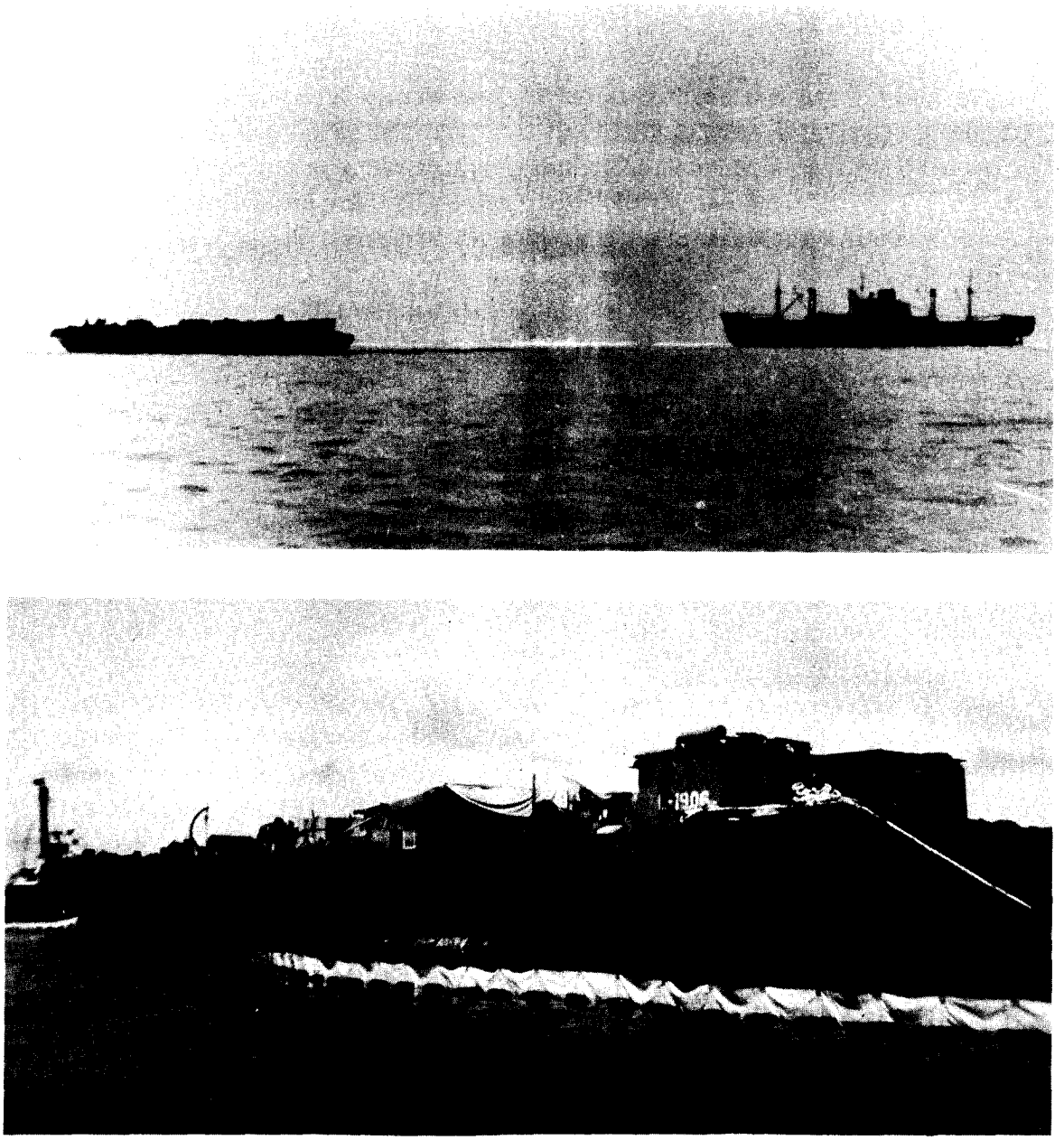
After 10 minutes of test pumping on 12 July, the 4-inch hose burst at two connections. The salvors worked to midnight making repairs. Test pumping resumed the next day, revealing more leaks at the hose joints. Further repairs and reinforcement of the joints made the hose leak-free by 1800 on 13 July.

Additional inspections on 13 July revealed cracks on the tank tops of double bottom tanks 6 and 7 (starboard). Although the tank tops were below water, no oil was leaking out. The tank tops to double bottom tanks 2 and 3 were also below sea level. In addition, the entire starboard air vent was missing, leaving openings on the tank tops. Fortunately, no oil was escaping from these vent openings. Double bottom tank 8 (starboard), however, was found open to the sea. The salvors also found a recoverable amount of diesel topoil in double bottom tank 5 (port and starboard) which was thought to contain sea water only; this was probably not detected when sounded earlier because of the oil's light viscosity.

Removal of Oil, 14-16 July

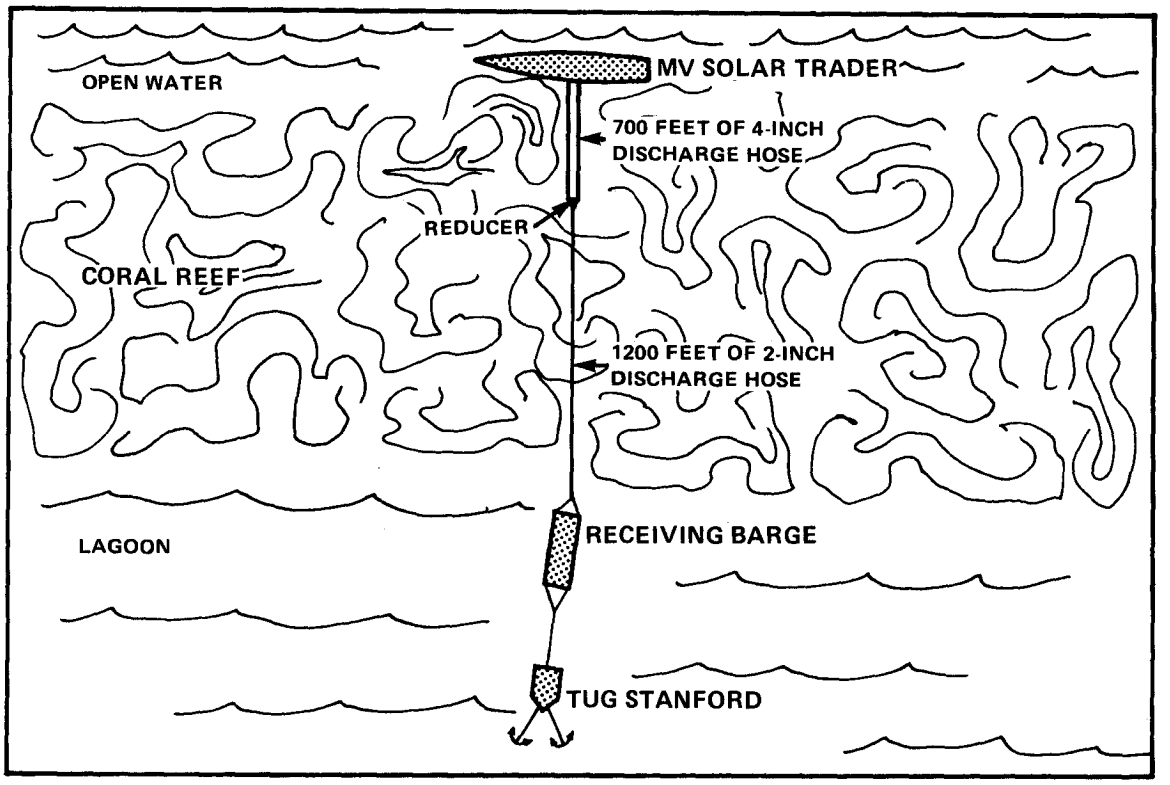
As a result of the tank soundings, the salvors estimated that the double bottom tanks contained from 20,000 to 25,000 gallons; the 15,000-gallon figure for the day tanks still held.

At 0600 on 14 July, the salvors began pumping the SOLAR TRADER's residual oil through the 1,900-foot discharge hose to the receiving barge. The oil was pumped intermittently instead of continuously to release the build-up of pressure in the hose and to



Heavy seas forced salvors to moor barge inside lagoon during oil recovery operations instead of adjacent to SOLAR TRADER as originally planned. Oil containment boom was placed around 144-foot long barge as precaution against accidental spills.

BARGE MOORED INSIDE LAGOON RECEIVES OIL FROM MV SOLAR TRADER



Oil discharge hose led from SOLAR TRADER across reef to barge along 7/8-inch wire rope steadying line. Barge's forward mooring line was secured to coral head with 1 1/2-inch (cir.) nylon rope to tug. Port and starboard anchors held tug in position.

CONFIGURATION OF DISCHARGE HOSE AND BARGE MOORING

facilitate the making of minor hose repairs. Pumping operations were secured at 1800 hours since hose leaks and spillage would have been difficult to detect and correct in the darkness. The amount of oil recovered on the first day totalled approximately 7,000 gallons.

Intermittent pumping resumed on the next morning following an inspection of the discharge hose. Ten to 20-foot surf continued to pound the SOLAR TRADER's starboard side, while the barge remained inside the lagoon in choppy seas. By sunset, an additional 5,000 gallons of oil had been recovered, for a total of nearly 12,000 gallons. However, re-inspection of double bottom tank 5 revealed an increase in its topoil content. The salvors worked into the night stripping and transferring this oil to the day tanks using a 2 1/2-inch submersible pump.

On 16 July, the salvors continued pumping oil to the receiving barge. By dusk, the engine room day tanks were stripped of remaining oil, raising the total recovery figure to

nearly 16,000 gallons. The salvors voiced confidence that the operation would be completed by the next day, 17 July.

Pumping Operations Extended

With the double bottom and day tanks believed stripped, the salvors washed down the vessel's compartments and water-pushed the remaining oil contents of the discharge hose into the barge. The total of recovered oil was now approximately 18,000 gallons and the salvage crew believed the operation to be very nearly ended. The Coast Guard and SUPSALV representatives then conferred and agreed that the access manholes to the double bottom tanks should be opened and left open before securing from defueling operations.

Upon opening the top of double bottom tank 1, however, the salvors discovered an unexpected accumulation of topoil. This finding confirmed the unreliability of earlier soundings by the chemical water finder. After cutting a portion of the main deck and 'tween deck, the salvors set out to remove the oil using a positive displacement pump.

At the same time, divers opened the manhole covers of double bottom tanks 6 and 7. When the tops were removed, oil spilled out and was washed into the lagoon by the heavy surf. The salvors quickly rigged 500 feet of containment boom and began stripping the oil that remained in hole 5 above double bottom tanks 6 and 7. The stripping operations continued into the night, resulting in recovery of approximately 2,000 gallons of heavy diesel oil. By 19 July, the 600 gallons of spilled oil had been fully contained. An additional 1,900 feet of spillage boom prevented the oil from washing onto the island's beach or back across the reef. The salvors rigged an oil skimmer to the STANFORD's lifeboat and successfully retrieved all of the spilled oil.

Further tank inspections revealed oil in double bottom tank 3. This was stripped and transferred to the day tanks on the evening of 18 July. The next morning, a leak was found in the discharge hose. The salvors contained the leak in a small, wooden utility boat, then made repairs. Oil removal operations resumed and continued through the day, bringing the total amount of recovered oil to 24,000 gallons.

Surf action over the reef during high tides had begun to cause wear in the discharge hose. The salvors made repairs on 20 July and resumed pumping from double bottom tank 3 (port), which had exhibited an alarming rise in topoil contents during the night from 1 inch to more than 10 inches. This oil was removed over the next two days, as was topoil from double bottom tank 5 (port and starboard), bringing the total to approximately 35,000 gallons.

Salvors placed 1,900 feet of oil containment boom inside lagoon to protect west side of island from 600-gallon spill which occurred on 17 July after heavy surf washed oil from double bottom tanks 6 and 7. Oil was completely recovered from surface by skimmer within 2 days.

OIL CONTAINMENT BOOM IN POSITION INSIDE LAGOON

By 22 July, the task of removing oil from the SOLAR TRADER's tanks was nearly complete. Only a small amount of topoil remained in double bottom tanks 1, 2 and 3; all other tanks were clear. Removal of this topoil plus assorted petroleum products and the oil contents of the discharge hose on the morning of 23 July boosted the total amount of recovered oil to 45,000 gallons, or 150 tons.

All engine room tanks and double bottom tanks were then opened, washed down with sea water and left open to the sea. All other accessible compartments, plus the main engine crankcase, were opened and inspected for possible oil content. With the vessel certified free of oil, the salvage team prepared for departure. By noon of 23 July, 1 month after leaving Manila, the STANFORD got under way for the return trip, towing the barge with 45,000 gallons of recovered oil. The tug and tow arrived in Manila shortly before midnight on 5 August.

CONCLUSIONS

The unexpected discovery that a substantial amount of topoil remained on board the SOLAR TRADER on 17 July proved that the chemical water finder on the sounding tape was a less-than-accurate means of topoil detection. The SUPSALV and Coast Guard representatives' decision to open all tanks to the sea prior to departure prevented a premature conclusion to the debunkering operation. Because of the representatives' diligence, an additional 20,000 gallons of oil were recovered from the wreck by the contract salvor.

Careful attention to leaks in the discharge hose prevented spillage onto the reef during the 9-day debunkering operation. The only serious problem was the 600-gallon spill from double bottom tanks 6 and 7 on 17 July. The winds and heavy surf conditions caused by the passage of several typhoons to the north of the island could easily have spread the spillage over a wide area. However, the oil was quickly contained and recovered. On 22 July, a Peace Corps marine biologist (who had arrived at the atoll to survey the nesting ground of the green sea turtle) certified that the oil recovery operation had not disturbed the turtles at West Fayu Island.

As a result of the SOLAR TRADER operation, SUPSALV and the Coast Guard forged a bond for future cooperation in marine salvage activities in the far Pacific. The operation also proved the value of maintaining standing contractual agreements with private firms for salvage services in remote areas of the world. In this case, the signing of a contract between SUPSALV and the Luzon Stevedoring Company just 2 weeks prior to the SOLAR TRADER operation proved especially timely.

Beaches of West Fayu Island served as nesting area for green sea turtles, valuable source of protein for neighboring islanders. Safe recovery of oil from stranded vessel averted potential danger to sand-covered eggs (top plate) and hatchlings.

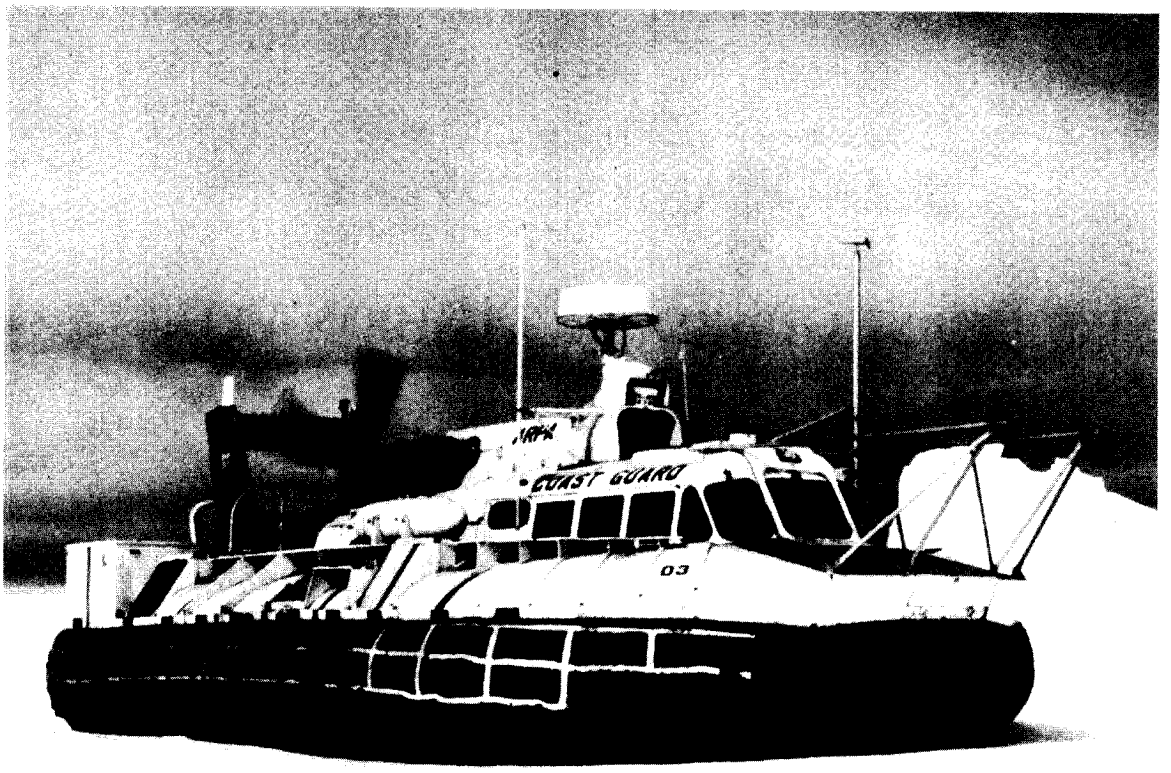
ISLAND'S NATURAL RESOURCES PROTECTED

SEARCH AND RECOVERY OF

U.S. COAST GUARD AIR CUSHION VEHICLE

FROM THE STRAITS OF

MACKINAC, LAKE HURON



ACV-3 sank in northern Lake Huron after wave broke over its bow and knocked out windshield. Craft, shown here during earlier assignment in Arctic, was participating in study to extend shipping season on Great Lakes when accident occurred.

COAST GUARD AIR CUSHION VEHICLE, ACV-3

SEARCH AND RECOVERY OF U.S. COAST GUARD AIR CUSHION VEHICLE FROM THE STRAITS OF MACKINAC, LAKE HURON

INTRODUCTION

SUPSALV provided assistance to the U.S. Coast Guard Ninth District during December 1971 and again in the spring of 1972, in the search and recovery of an air cushion vehicle (ACV) which sank in northern Lake Huron, Michigan, on 23 November 1971.

The hovercraft, ACV-3, was successfully located by sonar in 110 feet of water in mid-December. However, recovery operations were thwarted by severe weather conditions, forcing the salvors to suspend operations for the winter. Recovery efforts resumed in early June. Utilizing a lift sling which had been specially designed and fabricated during the early months of 1972, the salvors brought the ACV to the deck of the USCG Cutter SUNDEW which then returned the craft to Sault Sainte Marie for final disposition.

BACKGROUND

Loss of the ACV

On 23 November 1971, the U.S. Coast Guard's air cushion vehicle ACV-3 sank in 110 feet of water in the Straits of Mackinac, Northern Lake Huron. The hovercraft was running in 2- to 3-foot seas when a heavy wave broke over the bow and knocked out a windshield. The craft lost power, took on water and sank, stern first. The two-man crew and five-man relief crew from the nearby Martin's Reef Light Station, who were also on board, were saved. Water temperature in the lake was 40°F; air temperature was in the low 20's.

Vessel Data

Built by Hovercraft of Great Britain, the SK-5 Air Cushion Vehicle (ACV) was one of three of a kind turned over to the Coast Guard by the Navy after service in Vietnam. The Coast Guard refurbished the ACV's and initiated an operational evaluation of their applicability to a variety of all-weather coastal missions, including search and rescue, pollution control, law enforcement, logistic support, and maintenance of navigation aids.

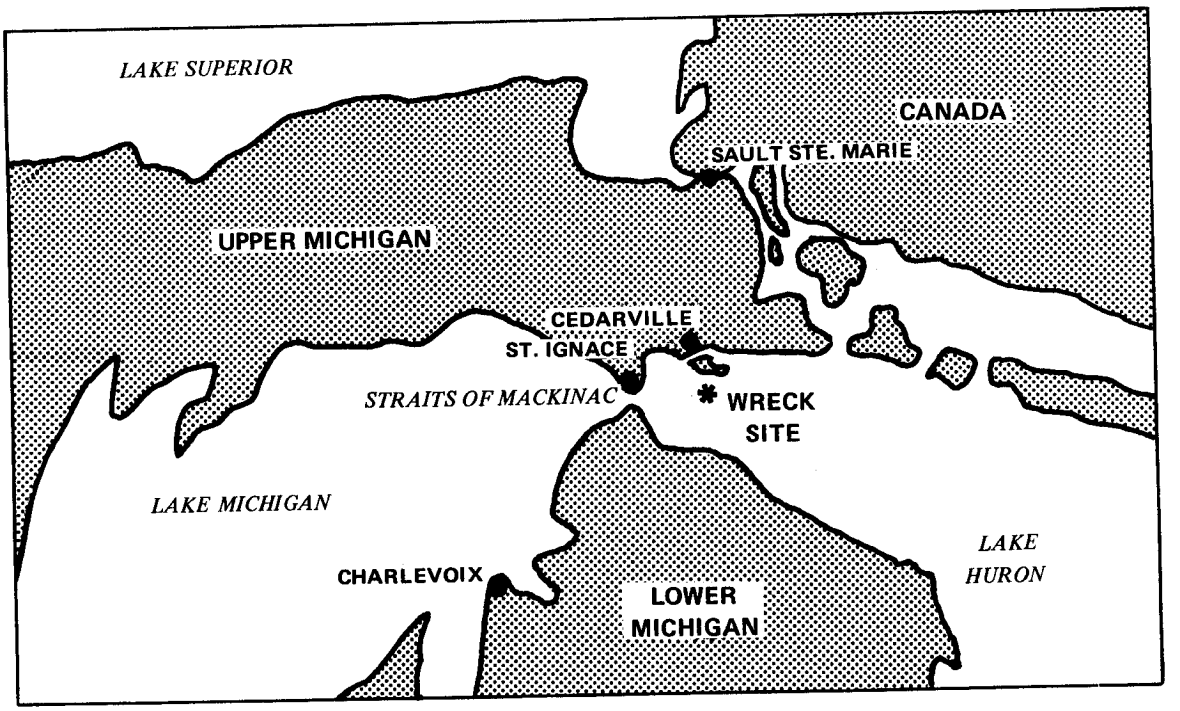
The program was conducted with two ACV's in the San Francisco Bay area. The third ACV was assigned to a test program conducted by the Defense Department's Advanced Research Projects Agency (ARPA) in Alaska, where the vehicle operated out of Point Barrow on the snow, ice, tundra and polar ice pack of the Arctic Ocean. After successfully completing the Alaska operation, ACV-3 was assigned to a Department of Transportation study into extending the shipping season on the Great Lakes. It was during this assignment that ACV-3 crashed and sank.

The blunt-shaped hovercraft weighed 10 tons and measured 38'10" in length, 23' 9" abeam, and 15'11" in height. A 1150-horsepower General Electric LM100 marine gas turbine engine gave the craft a 70-knot maximum speed, and a range of 300 nautical miles at 50 knots. A four-bladed, variable pitch, 9-foot-diameter propeller was mounted atop the craft forward of the 7-foot-diameter centrifugal lift fan.

SUPSALV Assistance

On 6 December 1971, the Office of the Supervisor of Salvage (SUPSALV), U.S. Navy, advised Ninth Coast Guard District Headquarters that SUPSALV personnel and material assets stood ready to assist in the ACV search and recovery operation if needed. On 10 December, SUPSALV received word from the Naval Ship Research and Development Center (NSRDC) that the Coast Guard desired such assistance. NSRDC officials had expressed an interest in locating the ACV to determine the cause of sinking since the craft had been assigned to NSRDC to conduct an Alaskan program earlier in the year for the Advanced Research Projects Agency (ARPA).

A Salvage Officer, designated by SUPSALV, then flew to Sault Sainte Marie to meet with the Coast Guard officials. He was briefed on the Coast Guard's initial search efforts which involved sonar scanning and discovery of an oil slick in an area approximately 8 miles southeast of Cedarville, Michigan. Following the briefing, the SUPSALV Salvage Officer proceeded to Charlevoix, Michigan, to await the arrival of operating personnel, sonar, navigation, and diving equipment previously ordered by Ocean Systems, Inc., a SUPSALV contractor. Arrangements were made to install sonar and navigational gear, when it arrived, aboard the U.S. Coast Guard Cutter SUNDEW. The equipment and personnel arrived on 13 and 14 December.



ACV-3 sank in 110 feet of water in Straits of Mackinac. SUPSALV representative first met with Coast Guard officials at Sault Ste. Marie, then mobilized salvage team and equipment at Charlevoix. Daily operations were conducted from CG Cutter SUNDEW out of St. Ignace.

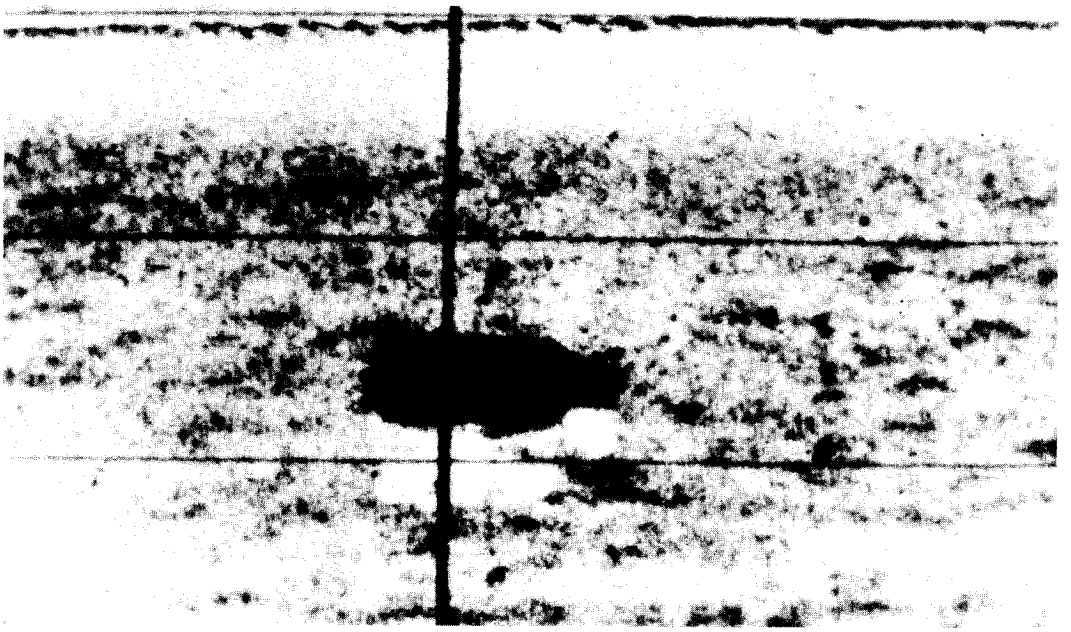
LOCATION OF ACV-3 IN NORTHERN LAKE HURON

FIRST RECOVERY EFFORT, DECEMBER 1971

Search and recovery efforts aboard SUNDEW from 15 to 21 December were hampered by severe cold and high seas. Although the search effort was successful, weather conditions thwarted recovery of the ACV, and a decision was made to postpone recovery until the arrival of more favorable weather in the spring of 1972.

Search Operations

Late arrival of the navigation equipment delayed the departure of SUNDEW and the salvage team by one day, to 2400, 14 December. The midnight underway time was selected in order to arrive at the casualty area at first light on 15 December.



Side scan sonar detected ACV-3 in 110 feet of water on 16 December. Craft's bow is at right; stern, with lift fan and propeller, appears as solid shadow at left.

SONAR TRACE OF ACV-3

At 0630, SUNDEW arrived on site off Martin's Reef Light Station in 30- to 40-knot winds and 8-foot seas. These conditions were too unfavorable to conduct an effective sonar search. After waiting briefly in hopes of improved weather, the search team postponed the effort and returned to port at the St. Ignace, Michigan, Coast Guard Station.

The search was resumed the next day, 16 December. At 0955, the sonar recorded a promising contact at 110 feet. Before returning to port, the search team made several sonar passes above the contact to pinpoint the position and refine the sonar picture.

Diving Operations

On Friday, 17 December, the SUNDEW again proceeded to the site despite 30-knot winds and weather that the salvors described as "abominable." A snowstorm had moved into the area, as well. The high winds hampered efforts to position SUNDEW in a 3-point moor above the sonar contact, but the salvors finally achieved the moor several hours after nightfall.

Two divers were then sent down to inspect the sonar contact and confirm it as the ACV. The snow and winds continued and the temperature had dropped to 17°F, causing the SCUBA regulators to freeze. However, a 16-minute confirmation dive to 95 feet was made. Divers found the ACV lying upside down and resting on the port side of the deck structure as suspected. After divers secured a marker buoy to a structural member in the after tail section, the salvage team returned to St. Ignace aboard the SUNDEW to pick up additional diving equipment and divers.

On 18 December, the salvage team returned to the site and positioned SUNDEW in a 2-point moor over the ACV. Again, the severe cold caused air leads and other critical diving equipment to freeze. Considerable delays were caused by the wind and cold; diving equipment had to be thawed before use and the SUNDEW was sometimes blown 50 feet from its proper position above the ACV. Although these unfavorable working conditions prevented a retrieval attempt, the divers were able to survey the ACV thoroughly and attach a 3-inch nylon line. When the salvors attempted to attach this line to a permanent buoy, however, it was lost over the side, ending operations for the day. The SUNDEW then returned to St. Ignace, battling the high winds and heavy seas.

Recovery Attempts Fail

Guided by the precision navigation system, SUNDEW returned to the casualty site on the following day, 19 December and was placed in a 2-point moor above the ACV. Divers then located the 3-inch line which was lost the previous day. This line was attached to a 2-legged nylon lifting bridle which the divers rigged to the hovercraft. The line led through two blocks across the deck of the SUNDEW and then to the anchor windlass, which provided the lifting power. The salvors planned to slowly lift the craft off the bottom to a depth of 40 feet where it could be worked on in a relatively shallow, no-decompression depth.

The lifting operation began at 1800. The lifting line at first threatened to part under the strain, due to its worn condition, but the salvors patched good line to the worn areas and the lifting operation continued until 1930. Suddenly, the line went slack; either the bridle or the line itself had parted. Divers were sent down to investigate, but were unable to locate the craft. When the line was retrieved, however it was apparent that the bridle had parted.

On the next day, the ACV was relocated and a second lift was attempted. This time, a 5-inch nylon rope was used as a lift line; two 1-inch wire straps replaced the original nylon bridle. Rigging was completed by 1200, and lifting operations began.

By 1400, the craft had been raised to a 60-foot depth, Divers then removed some metal duckwork (which covered the ACV's after lift pads) and reattached the original lifting sling to the forward and after lift pads. Progress was hampered by the rolling of the SUNDEW, by swirling clouds of silt which the ACV had brought up from the bottom, and by the presence of rubber boat fenders which had been shackled into the ACV's lifting pads. After 3 hours the lift sling was in position and the ACV was brought up to a 40-foot depth.

A tug and a barge were then called alongside to transfer the ACV to the barge's crane. At this point, however, the tug's screws were found to be fouled with her tow hawser. Divers freed the screws within an hour and a half, but in the meantime, winds freshened and created rougher seas. Since the forecast for the next 48 hours called for increasingly poor weather, the salvors were forced to either lower the ACV back to the bottom or try to ease it into shallower and calmer waters.

The second alternative was chosen; SUNDEW weighed anchor and slowly crept shoreward. After moving approximately 1 1/4 miles, however, the cutter hit a series of short, sharp rolls. This wrenched the lift pads out of the deck of the ACV and parted the forward legs of the sling, leaving the ACV hanging by the 5-inch line alone. The line soon became chafed, then parted, causing the ACV to drop to the bottom, 70 feet below the surface.

A marker buoy was dropped and the SUNDEW proceeded into port for the night. The salvors returned to the site the next morning, 21 December, but were prevented from mooring due to severe winds. An attempt was made to photograph the ACV in its shallower location, but the weather also prevented this. The salvors then agreed to postpone further salvage efforts until spring or early summer.

PREPARATIONS FOR SECOND RECOVERY EFFORT

Preliminary Planning

Key personnel of SUPSALV, ARPA, NSRDC, and the Coast Guard remained in contact with each other through the winter, making preliminary plans for a renewed salvage effort. The SUPSALV Salvage Officer prepared an outline plan with cost estimates in February for consideration by NSRDC and ARPA. Upon approval of this plan, NSRDC on 31 March 1972 formally requested the Supervisor of Salvage to proceed with the recovery effort, further asking that the SUPSALV Salvage Officer coordinate selection and acquisition

of the necessary services, resources, and assets with appropriate Navy and Coast Guard commands.

The target date to begin recovery operations at St. Ignace was set initially as 1 May, predicated on predictions of earliest favorable weather. As planning proceeded, this date was deferred about a month in order to permit assembling of forces and preparation of equipment. The deferral also took advantage of improving weather. The basic recovery plan envisioned a 3-day operation to relocate the sunken ACV, lift it, and return it to port at Sault Sainte Marie. The primary objective of the undertaking remained the same as in the December effort: to recover the craft with minimum damage in order to ascertain the cause of failure. NSRDC officials were particularly interested in preserving the ACV's engine and plans were developed to provide a shipping container with liquid preservative on site to start preservative measures as soon as possible after recovery.

Commitment of Forces

SUPSALV arranged with COMSERVLANT to provide one diving officer and four divers from HCU-2 to assist the SUPSALV Salvage Officer, who was himself a diver, in diving operations. The key diving tasks that would be required were as follows:

- Relocate and buoy the sunken craft and inspect it for damage and other factors which could affect lifting operations.

- Attach a lift line to the craft's after tow lugs for winching it up to a depth of 20 feet using SUNDEW's anchor windlass.

- At the 20-foot depth, install a special lift sling for the remaining lift with the SUNDEW's boom, and hoist the ACV aboard the cutter.

Salvage equipment was drawn from selected Emergency Ship Salvage Material (ESSM) bases and deployed to St. Ignace. Murphy Pacific Marine Salvage Company was assigned the task of fabricating the special lift sling based on design drawings originated by the Salvage Officer. Ocean Systems, Inc. was tasked to provide precision navigation services similar to those it performed in the December recovery attempt. Confirmation was also obtained from the Coast Guard that the SUNDEW would again be committed as the primary salvage platform.

SPECIAL LIFT SLING – KEY TO RECOVERY OPERATION

Requirement for a Cradle Type Sling

The salvage force had used the ACV's normal lift sling during the abortive December recovery attempt. Divers had attached this sling to the four lift pads on the craft's deck. The rigging failed in two ways when the SUNDEW began rolling in choppy seas with the craft suspended at a depth of 40 feet. First, the after lift pads were wrenched out of the deck and then the forward legs of the sling parted. These failures, even though they occurred as a result of unusually severe stresses with the cutter towing the submerged craft, convinced the salvors that a much more substantial sling would be required for the renewed recovery effort.

The basic purpose of the sling was not to lift the ACV from the bottom but rather to support it on an even plane as the craft is hoisted from the water and maneuvered in the air for depositing on deck. The ACV is first winched up to a shallow depth where divers attach the sling. The weight of the craft is then transferred to the sling for the final lift. The sling must be strong enough to withstand the forces encountered in pulling the craft from the water as well as to support it in air once it clears the surface.

Considering these factors, the SUPSALV engineer determined to design a sling that would cradle the entire craft, supporting it beneath the hull rather than from lifting points on the deck. Adequate lifting points were no longer available on the deck, in any event, with the destruction of the after lift pads. A cradle sling would not only be more substantial but would also be easier to control, an important consideration during the hoisting procedure.

Considerations in Designing the Lift Sling

The craft's bottom was too fragile to rest directly on the lifting beams of the sling. There were only four places which could support any significant weight. These were the ACV's landing pads which are designed to support the craft when grounded. The locations and dimensions of these landing pads, projecting down from the bottom, became crucial in the design of the sling. The lifting beams had to be configured with sockets for the four landing pads to rest in, providing support points for raising the ACV.

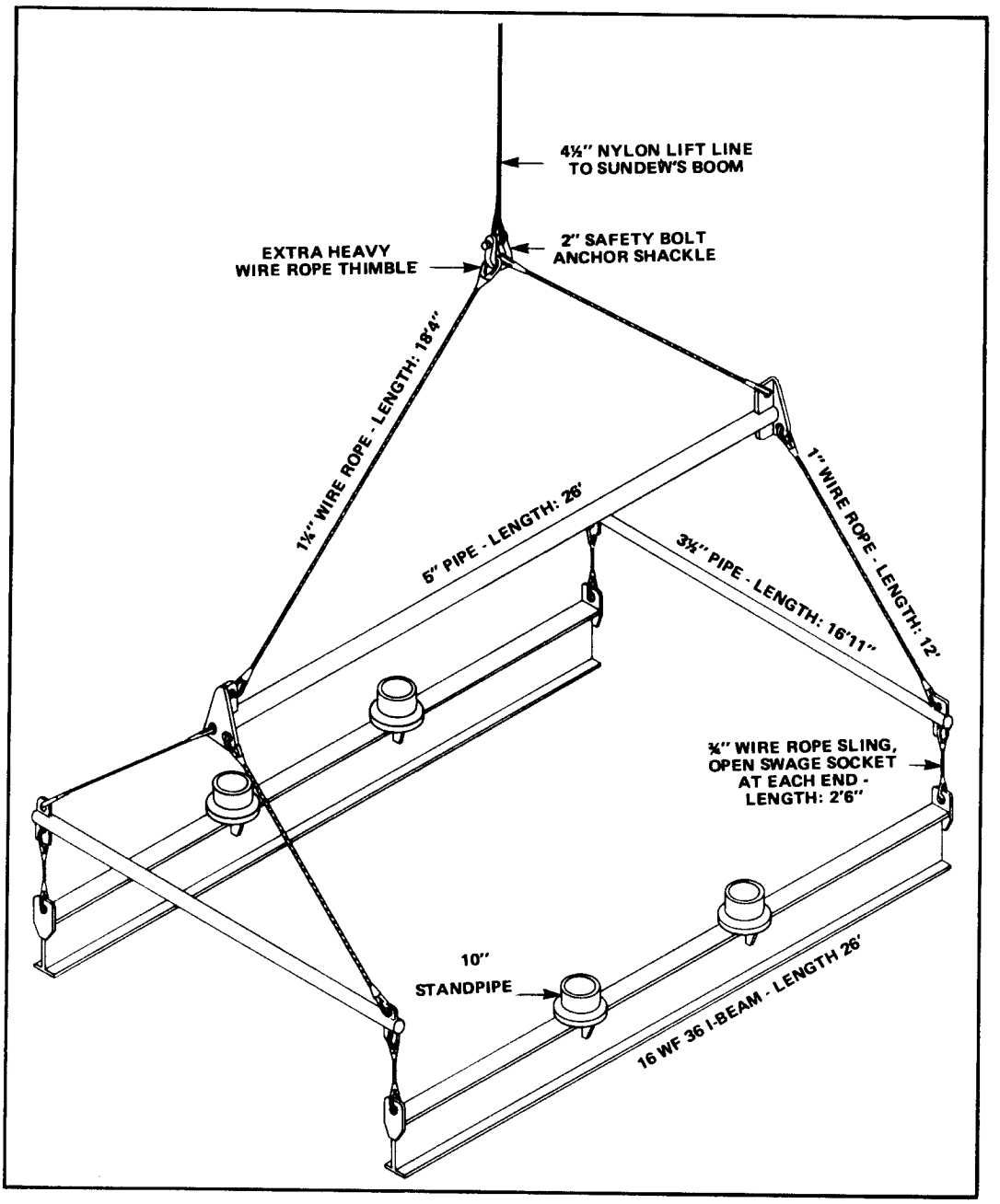
The significance of the landing pads became apparent during late March and early April when SUPSALV representatives inspected the underside of a sister ACV at Norfolk, Virginia. Measurements of the pads' locations and dimensions taken during this inspection were applied in design calculations for the sling. The four pads formed a rectangle along the centerline of the hull, with long sides 16 feet, 11 inches fore and aft. The short sides, 7 feet, 8 inches, were equidistant from the centerline. The craft was heavier in the after portion than up forward. Therefore, the rectangle was positioned slightly aft so that the craft's overall weight would be balanced on the four pads when grounded.

A total weight of 25,000 pounds (including fuel) distributed fore and aft in a 40-60 ratio was used in calculating basic lift requirements. The after load of 15,000 pounds would be supported at the two after landing pads, each bearing 7,500 pounds. The length of the lifting beam was selected as 26 feet, just long enough to clear the sides of the hovercraft which measured 23 feet, 9 inches abeam. Applying this data and appropriate "g" forces, it was determined that a 15 WF 36 I-beam would be adequate for the after beam (and therefore for the forward beam as well, since it bore a lesser load).

A steel I-beam of this size and length weighs in excess of 1,000 pounds. This weight, although not a critical addition to the overall lift requirements, would severely limit the divers' ability to maneuver the beam into place under the two landing pads. Provisions were therefore made to attach foam blocks to each lifting beam, achieving neutral buoyancy to permit its emplacement under water.

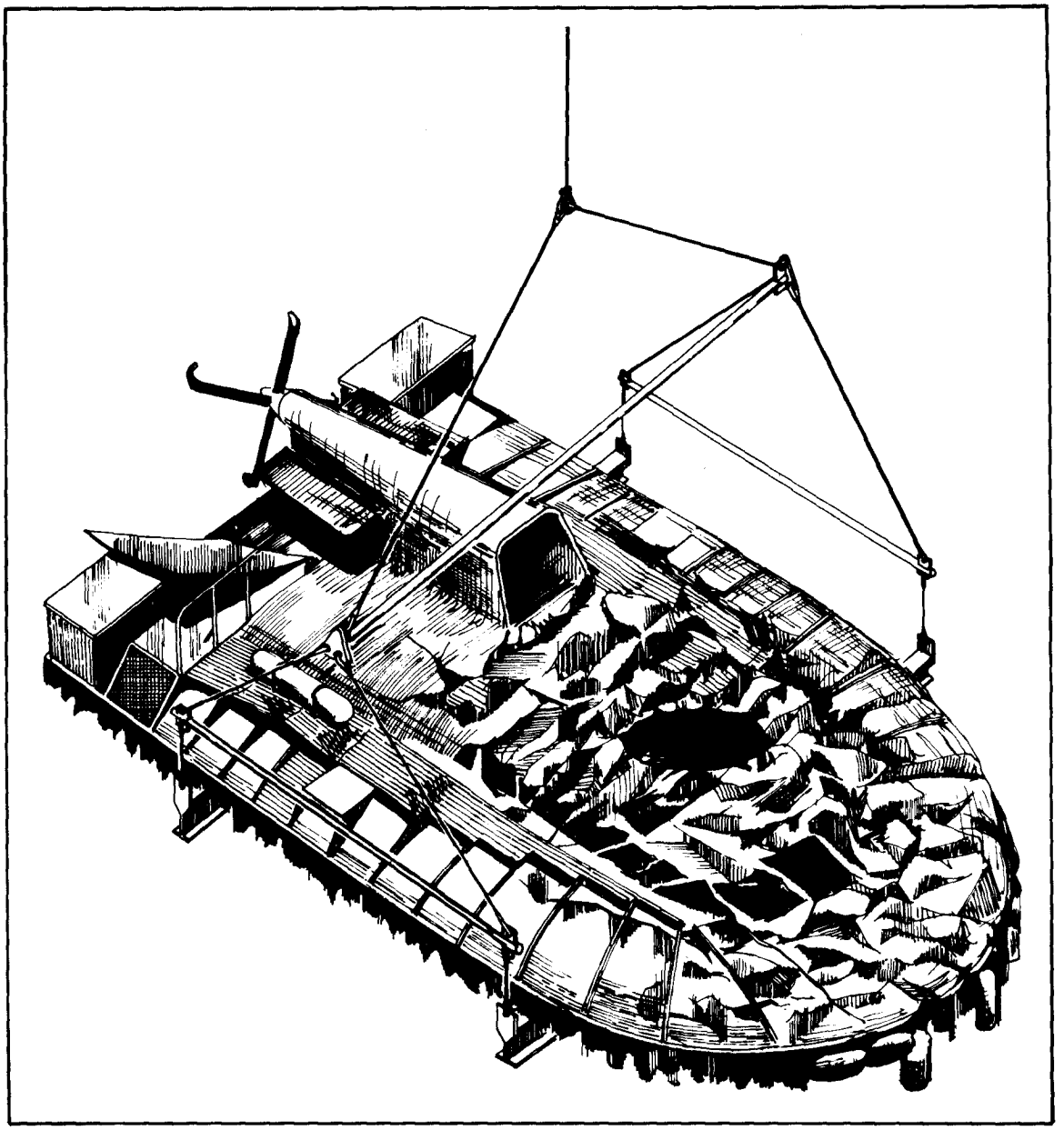
The two after landing pads would thus have to withstand a greater load than the forward pads as the craft was pulled up through the water and hoisted aboard. The base of the sling was composed of two steel I-beams. Each beam would run laterally under the forward and after pair of landing pads respectively. Sockets for the landing pads would be made up of 10-inch standpipes, 5 inches high, welded to each beam. This 5-inch height was slightly less than the vertical length of the landing pad so that the base of the pad would rest directly on the I-beam when fitted into the socket. In calculating the required size of the I-beams, the greater lift requirement of the after beam was used as the criteria for both beams.

The salvors had planned to hoist the ACV aboard a barge during the December recovery attempt after winching it up near the surface with the SUNDEW's anchor windlass. This plan failed when choppy seas prevented maneuvering the barge close to the cutter. Although a barge was not ruled out for the spring effort, the salvors planned primarily to bring the recovered craft aboard SUNDEW. The cutter's boom was more



Lift sling, constructed after abortive December 1971 recovery attempt, was key to successful recovery of ACV-3 in spring 1972. To support craft while in sling, ACV-3's four underside landing pads fit into corresponding standpipes welded to sling's I-beams.

DESIGN OF LIFT SLING FOR ACV-3



Sling was designed to hold ACV-3 on horizontal plane during hoist from shallow depth to deck of Cutter SUNDEW. Damaged craft rested in sling slightly forward to compensate for heavier weight aft.

ACV-3 IN LIFT SLING

than adequate. It was about 50 feet long and could lift 20 tons when angled at 45 degrees. Located amidships, it could lift the craft and swing it, suspended by the sling, onto the ship's forward deck. The overall height of the sling was kept within the capacity of the boom to maneuver the load.

A 26-foot section of extra strong 5-inch pipe was used for the main spreader bar of the sling. This longitudinal bar, the same length as the two lifting beams, was a key component in maintaining the craft in an even plane and transferring the distributed weight on the lifting beams to the lift line. The two latitudinal spreader bars on each end of the sling were made up of smaller, 3 1/2-inch pipe sections. Each was 16 feet, 11 inches long, the same length as the distance between the forward and after landing pads.

Wire rope of varying dimensions was used to make up the legs of the sling connecting its metal structural members, and to attach the cradle formed by these connections to the lift line itself. The strongest wire rope would be at the top of the rigging where the stresses would be greatest.

CONDUCT OF OPERATIONS – SECOND RECOVERY EFFORT

Locating the Hovercraft

Most of the salvage equipment was assembled at St. Ignace by the first week of June. However, the SUNDEW was not scheduled to arrive until 7 June and the newly fabricated lift sling until 8 June. Since the HCU-2 divers were on site, the salvors decided to proceed with diving operations to relocate the ACV pending the arrival of the SUNDEW.

Navigational data of the wreck's location were obtained by radio from the SUNDEW. Using the SUNDEW's records, the salvors were able to fix the wreck's location despite the fact that its marker buoy had been lost during the winter. The HCU-2 divers located the ACV late on 4 June, reporting that it was in 80 feet of water, upside down on a rocky bottom. A damage inspection was deferred until the following day because the divers had expended most of their allowable bottom time when they discovered the wreck.

Underwater inspections on 5 and 6 June revealed the following information about the ACV's condition:

- The craft was resting upside down on the port side of the cabin and decking area.
- Stabilizing fins were torn loose and after tow pads were unusable.
- Forward tow and lift pads were undamaged.
- Bottom of craft was undamaged except for portion attached to stabilizing fins.
- Damage to craft's upper forward portion could not be assessed.

Employment of the Lift Sling

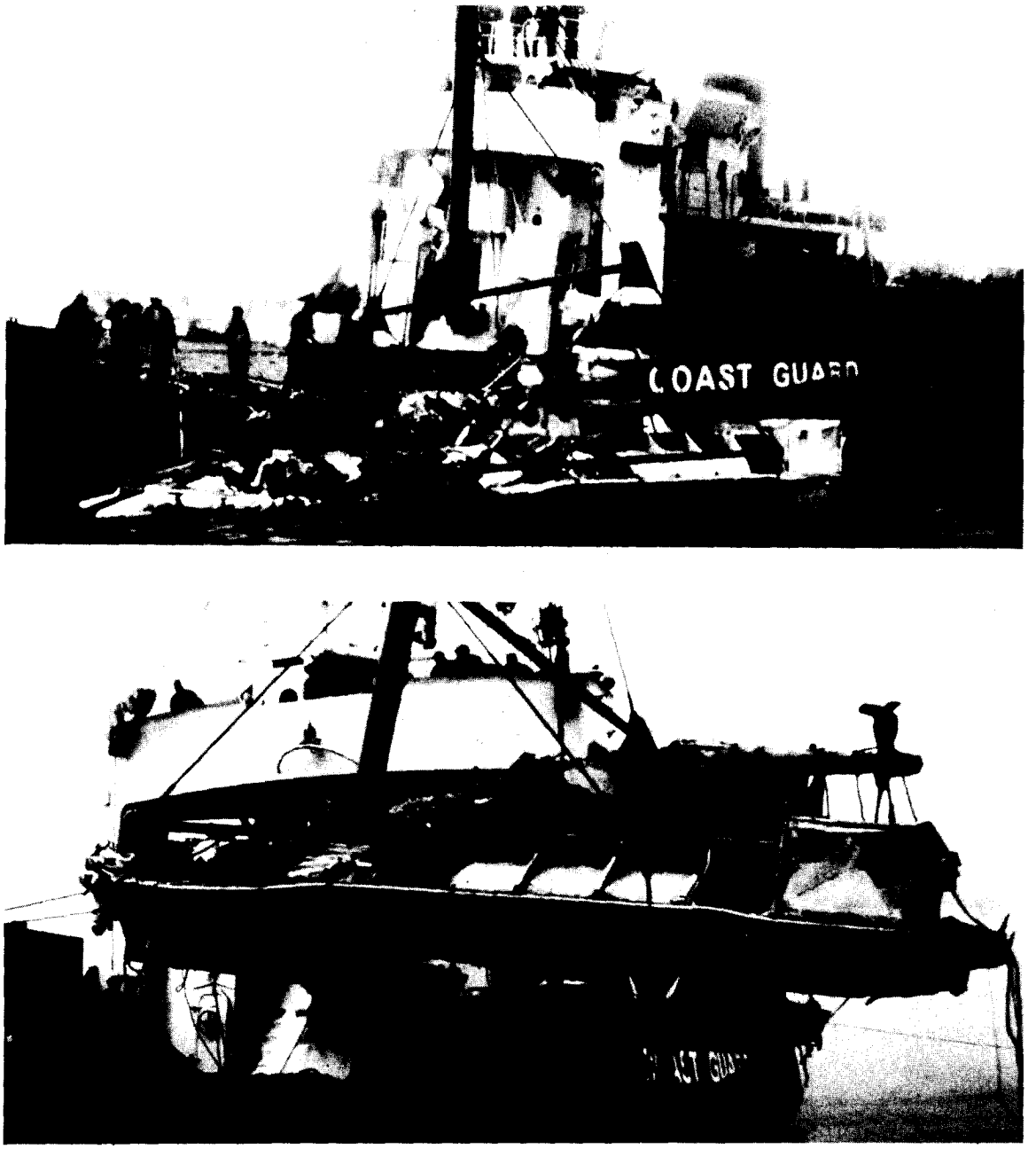
The SUNDEW arrived on station on 7 June. The salvors loaded their salvage and diving equipment aboard the cutter and deployed to the wreck site. The SUNDEW established a 4-point moor over the wreck and divers proceeded to clear obstructions from the hovercraft in preparation for the slinging effort. It then returned to port on 9 June to pick up the lift sling which had just arrived from New York.

Rigging of the sling occurred essentially as planned. Divers first attached a lift line to the forward end of the bottomed craft. The forward end was selected as the lifting point instead of the after end as originally planned because the divers' inspections had shown the after tow pad to be unusable. The ACV was then winched up to a depth of 20 feet where the divers descended again to rig the sling.

The sling was lowered into the water by the SUNDEW's boom with the cutter's anchor windlass holding the craft, suspended vertically at the working depth. The divers first fitted the standpipe sockets on the sling's lifting beams onto the four landing pads projecting from the bottom of the hovercraft. They then proceeded to complete the rigging, enabling the boom to maneuver the craft into a horizontal plane.

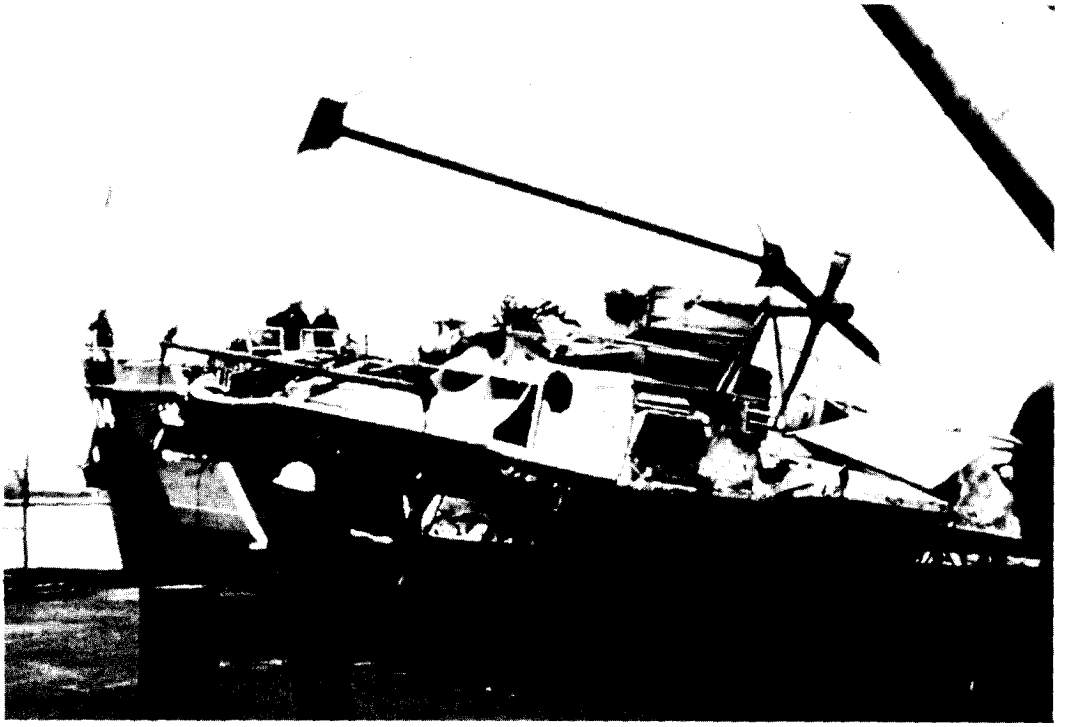
The craft was hoisted aboard without undue difficulty. The SUNDEW radioed interested commands that the ACV was recovered and on deck by the evening of 12 June, signaling the successful culmination of the salvage operation. The cutter put into Sault Sainte Marie on 13 June where the craft was offloaded. Salvage operations terminated this date.

A survey team from ARPA and NSRDC inspected the craft at Sault Sainte Marie. The engine and other high priority components were removed and packaged for preservation and shipping. The craft was ultimately trucked to the Coast Guard Air Station at Traverse City, Michigan, for final dispostion.



As SUNDEW's anchor windlass held ACV-3 suspended at 20-foot depth, cutter's boom lowered sling into water. Divers then rigged sling around ACV-3, enabling boom to hoist craft on deck on even plane.

ACV-3 BREAKS SURFACE AND IS HOISTED ABOARD SUNDEW AFTER NEARLY 7 MONTHS ON BOTTOM



Recovery operation was successfully concluded on 13 June when SUNDEW delivered ACV-3 to Coast Guard officials at Sault Sainte Marie for inspection of craft's critical components.

ACV-3 OFFLOADED AT SAULT STE. MARIE

CONCLUSIONS

The salvors nearly succeeded in recovering the ACV during the first salvage attempts in the winter of 1971. The northern Lake Huron region's harsh weather, however, forced a cancellation of these early efforts. Although the Coast Guard and NSRDC were anxious to recover and examine the ACV, there were considerable risks involved in continuing the operation in that weather. Freezing temperatures affected the readiness and performance of diving gear, making diving operations potentially hazardous. Also, any further recovery attempt in the rough seas could have led to another loss of the craft, and the possibility of damaging it even further. The salvage team therefore focused its attention on the design and fabrication of the lift sling that would guarantee the success of the second recovery. Delivery of the sling in early June coincided with the occurrence of more favorable weather, and the ACV was recovered as planned.

DEBUNKERING AND SALVAGE

OF

DREDGE ATLANTIC

AT ELIZABETH RIVER,

NORFOLK, VIRGINIA

DEBUNKERING AND SALVAGE OF DREDGE ATLANTIC AT ELIZABETH RIVER, NORFOLK, VIRGINIA

INTRODUCTION

SUPSALV assistance was requested by the U.S. Coast Guard on 11 August 1972 to halt the spread of oil pollution from the sunken Dredge ATLANTIC on the Elizabeth River in Norfolk, Virginia, and to remove the dredge and two smaller submerged vessels adjacent to it.

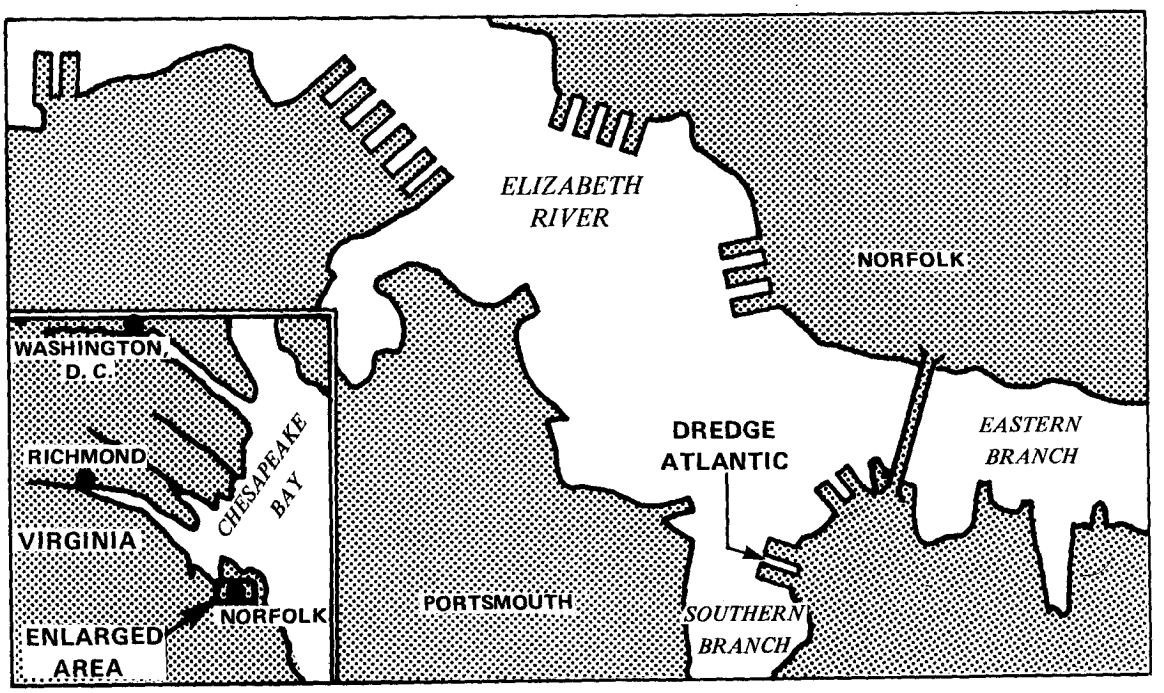
Within approximately one month, the dredge's Bunker "C" oil was recovered and the vessel refloated. Oil surrounding the casualty site was first contained by booms, then skimmed from the surface. Next, removal of oil from the dredge began. The smaller vessels were then pulled clear of the 12-foot dredge. Following patching and plugging operations and installation of a large plastic sheath around the hull, Dredge ATLANTIC was dewatered and refloated using 3-inch and 6-inch pumps. Previously inaccessible oil was then removed and the dredge was towed to a private shipyard for dismantling and final disposition.

PLANNING AND PREPARATIONS

Background

During the summer months of 1972, Dredge ATLANTIC lay partially submerged in approximately 30 feet of water in a cove at the intersection of the southern and eastern branches of the Elizabeth River, Norfolk, Virginia. The dredge had been plagued by a leaky hull and valves, and needed to be pumped out each day. One evening, however, a crewman failed to pump the dredge; ATLANTIC quickly flooded and sank.

The Dredge ATLANTIC's estimated 18,000 to 20,000 gallons of Bunker C fuel oil immediately began leaking and continued to leak at a steady rate into the surrounding waters for several weeks before salvage and abatement activities were begun. Two other vessels, a tug and a fishing boat, were also bottomed in the cove adjacent to Dredge ATLANTIC. Both had been tied up alongside the ATLANTIC and were carried down with the dredge when it sank. Neither the tug nor the fishing boat, however, presented a pollution threat.



LOCATION OF DREDGE ATLANTIC IN ELIZABETH RIVER, NORFOLK, VIRGINIA

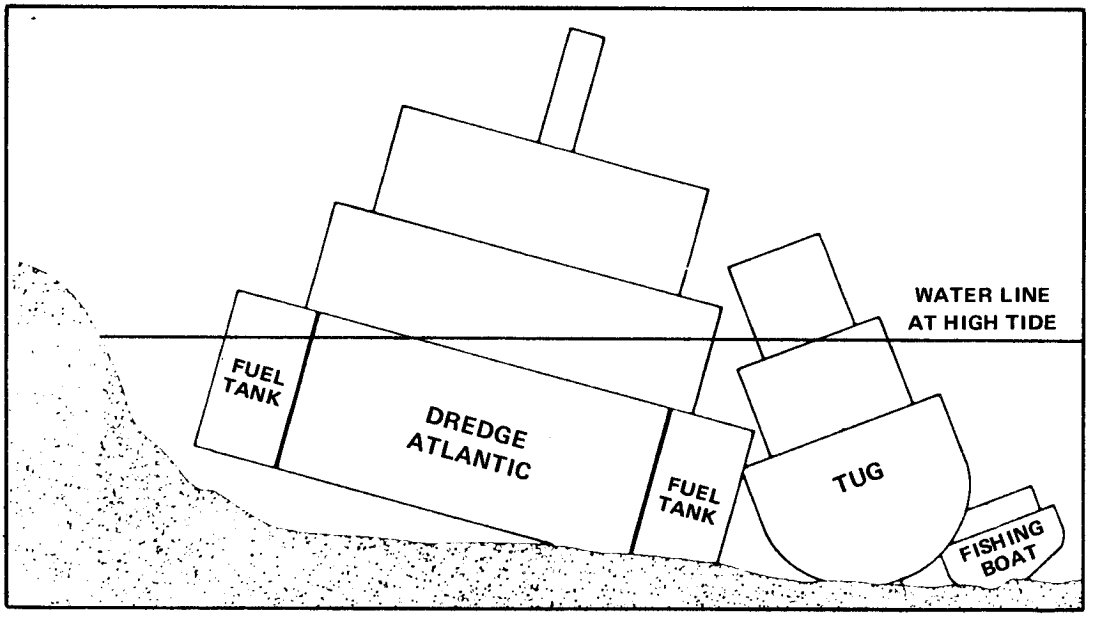
Assembling the Salvage and Pollution Abatement Force

On 11 August the U.S. Coast Guard (5th District) requested assistance from the Office of the Supervisor of Salvage, U.S. Navy, in undertaking the salvage of the sunken dredge and eliminating the pollution hazard it was posing to the Norfolk waterfront. The same day, SUPSALV requested assignment of the Fleet Salvage Officer to supervise and coordinate the efforts of contractor and fleet units.

By 13 August the Salvage Master, appointed from Murphy Pacific Marine Salvage Company, was on scene, along with divers from Harbor Clearance Unit Two of Norfolk. A floating crane (YSD-53) was acquired as a salvage platform and for use in lifting and removing the dredge's superstructure and excess topside weight. Clean Water, Inc. of New Jersey was contracted to provide pollution abatement services.

The Salvage Problem

An inspection of the casualty site by divers in mid-August revealed the dredge, tug and fishing boat resting adjacent to each other in various degrees of submergence.



Casualty site consisted of three craft in various degrees of submergence: 120-foot Dredge ATLANTIC, 60-foot Tug MARQUETTE and 30-foot fishing boat. Only Dredge ATLANTIC posed pollution threat.

ARRANGEMENT OF VESSELS PRIOR TO SALVAGE OPERATION

Of this grouping, Dredge ATLANTIC was the largest and closest vessel to shore. The wooden-hulled vessel measured 120 feet in length and had a 40-foot beam. It lay bottomed in approximately 30 feet of water and was listing 19 degrees to starboard. At high tide, freeboard on the port, or inboard, side was approximately 2 feet; the starboard side remained completely submerged to the 01 level. The dredge's port and starboard fuel tanks flanked the large and uncompartmentalized space below decks. Bunker C fuel oil had been seeping into the river from these tanks for weeks before pollution abatement and salvage assistance was requested.

The tug, MARQUETTE, measured half the length of ATLANTIC and was leaning against the dredge, submerged to the 01 level. The fishing boat, in turn, measured half the length of the 60-foot tug and was resting totally submerged beneath the hull of the tug.

Salvage Plan

The salvage team decided to first contain the leaking oil by booming off the area. Recovery of oil by skimming and pumping could then begin. Next, the dredge would

Oily water surrounds Dredge ATLANTIC and tug as salvors inspect casualty site aboard derrick barge YD-53. Top photo shows port side of dredge at high tide, looking forward; bottom photo is of starboard side at low tide, looking aft.

VIEWS OF CASUALTY SITE AT START OF SALVOPS

be patched and plugged, then dewatered. Meanwhile, beach gear would be required to hold the vessel stable until completely dewatered since the flooded, uncompartmentalized area below decks created a potentially serious free surface condition.

Before dewatering the ATLANTIC, the fishing boat would be pulled to the opposite bank of the cove. The flooded tug would then be parbuckled to an upright position and incrementally dragged to shallower water to maintain its ground reaction. With the work area cleared of the tug and fishing boat, the salvors would refloat the dredge, pump out remaining oil, and prepare the wreck for disposal.

CONDUCT OF OIL POLLUTION ABATEMENT AND SALVAGE OPERATIONS

The initial stages of the Dredge ATLANTIC operation began with an underwater survey of the wrecks by HCU-2 divers using SCUBA gear from 14 to 19 August. The divers measured and recorded all hull damage so that patches could be fabricated. Diving operations were made unusually hazardous and foul by the presence of a considerable amount of spilled oil.

Pollution Abatement Operations

On 15 August, oil containment booms were placed around the dredge and across the mouth of the cove to halt further pollution. With the oil thus contained, the pollution abatement team began skimming oil from the water surface. Both the skimmer and boom were supplied by Clean Water, Inc. Double diaphragm air pumps were used to eliminate pockets of oil from within the dredge. Recovered oil was discharged into a 6,000-gallon tank car ashore.

Also, an absorbent material, Sorbent C, was liberally spread over the water and throughout the dredge. Sorbent C is a fibrous material with a density of 4.5 pounds per cubic foot. It is non-toxic and non-flammable and absorbs oil only. Application of one cubic foot of the material resulted in recovery of up to 4 gallons of oil. The oil-soaked sorbent was subsequently picked up with nets, shovels, and buckets, and deposited in 50-gallon drums for disposal.

Removal of oil from the wreck itself was facilitated by patching the starboard side of the deck house, thereby creating a cofferdam from which oil could be collected and

pumped. Around-the-clock efforts by the pollution abatement crews resulted in successful recovery of nearly all of the ATLANTIC's Bunker C oil.

Patching and Pumping Operations

With the completion of underwater inspections on 19 August, patching of the dredge's hull openings commenced. As oil removal efforts continued, internal valves for the fuel tanks were also plugged. In addition, the salvors fabricated and installed a large 6-foot by 9-foot patch over a double door access on 28 August.

Pumping operations began on 31 August using three 10-inch pumps. Both the tug and the fishing boat had been pulled clear of ATLANTIC. In addition, two legs of beach gear were rigged from the dredge to a concrete anchor block which the salvors constructed on the beach. These wires would act to prevent the dredge from capsizing or becoming too lively during the reflotation effort.

As the pumping progressed, however, the newly-installed double door patch failed to hold. Pumping operations were halted and postponed until a stronger, plywood patch could be fabricated and installed.

A second pumping effort on 9 September, however, was also unsuccessful because of excessive leakage through two winch accesses in the main deck. Several days were spent removing the two winches to allow placement of two 6-foot by 4-foot patches, fabricated from 1/4-inch mild steel plate with stiffeners. The winch access patches were installed on 12 September and were made watertight with a 4-inch-wide, 1-inch-thick, neoprene gasket; all other patches were fitted with hard rubber gaskets.

The second pumping effort also disclosed extensive hull leakage. The dredge's wooden timbers were in such disrepair that salvors were forced to sheath the entire hull with heavy plastic sheeting to insure watertightness during dewatering operations. The sheeting was wrapped around the hull in five large pieces and tacked to the main deck.

Dredge ATLANTIC Refloated

The third attempt to refloat Dredge ATLANTIC began on 13 September. The wire preventers were tensioned as the six 10-inch pumps and two 3-inch pumps were started up. This time, pumping operations were successful. The patches and plastic sheeting held, and ATLANTIC gradually rose to the surface. It was completely refloated the next day, 14 September.

Following containment of oil pollution by boom (foreground) and removal of tug and fishing boat (left), salvors began pumping operations to refloat Dredge ATLANTIC. Wire attached to A-frame (right) led to deadman anchor block on beach and acted to prevent dredge from capsizing during dewatering operations.

DEWATERING OPERATIONS IN PROGRESS

Following the successful reflotation operation, oil removal efforts were directed at previously inaccessible spaces. Divers removed the plastic sheeting and began caulking the hull. Dredge ATLANTIC, watertight and oil-free by 25 September, was then delivered to the Norfolk Shipbuilding and Drydock Company for dismantling and final disposition. At a later date, the shipbuilding company acted to remove the sunken tug and fishing boat.

CONCLUSIONS

Containment of Dredge ATLANTIC's Bunker C oil was accomplished within a day of the start of pollution abatement operations. Although most the dredge's oil had already escaped into the river in the weeks and months prior to the start of the operation, more

than 2,500 gallons of oil were eventually recovered by skimming and pumping. The spilled Bunker C oil caused considerable damage to equipment and was a constant nuisance to the salvage team.

The salvors concluded that the double door patch which was carried away should have been more stoutly constructed and shored from the inside to support the substantial pressure against its large, 6-foot by 9-foot area. The replacement patch was constructed from three layers of 3/4-inch plywood with 2-inch by 6-inch framing and mid-section support. Only marginal success was experienced with the hard rubber gaskets that were used for all but the two steel patches. The neoprene gaskets for the steel patches, however, stopped leakage completely.

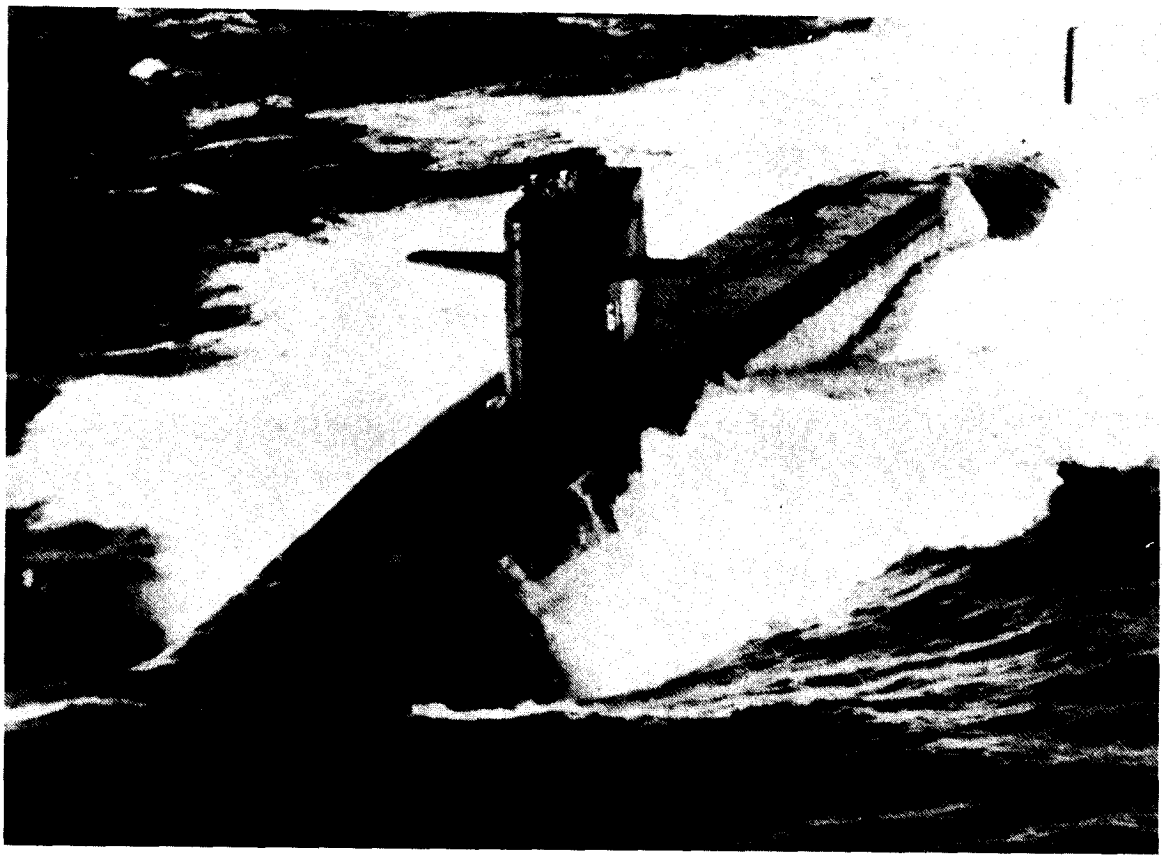
SEARCH AND RECOVERY

OF

USS GEORGE BANCROFT (SSBN-643)

ANCHOR AND CHAIN

OFF PORTSMOUTH, N.H.



Fleet ballistic missile submarine USS GEORGE BANCROFT (SSBN-643) lost anchor and chain during post conversion seatrials off Portsmouth, N.H., on 5 July. Objects were located and recovered by salvors within 24 hours of start of operations on 11 July.

FLEET BALLISTIC MISSILE SUBMARINE UNDERWAY

SEARCH AND RECOVERY OF USS GEORGE BANCROFT (SSBN-643) ANCHOR AND CHAIN OFF PORTSMOUTH, N.H.

INTRODUCTION

The nuclear submarine USS GEORGE BANCROFT (SSBN-643) lost an anchor and chain in over 400 feet of water off Portsmouth, New Hampshire, on 5 July 1972. Following a COMSERVLANT request for salvage assistance, the Office of the Supervisor of Salvage (SUPSALV) arranged for the assembly of equipment and personnel to locate and recover the lost objects. The operation commenced on 11 July using electronic search equipment, dragging equipment, an oceangoing tug and an ocean minesweeper.

After rapid sonar detection of the anchor and chain on 11 July, a nighttime recovery operation ensued. By morning, 12 July, the tug had successfully recovered the anchor and chain and returned them to Portsmouth. There, they were offloaded for eventual reinstallation on the submarine.

LOSS OF THE ANCHOR AND CHAIN

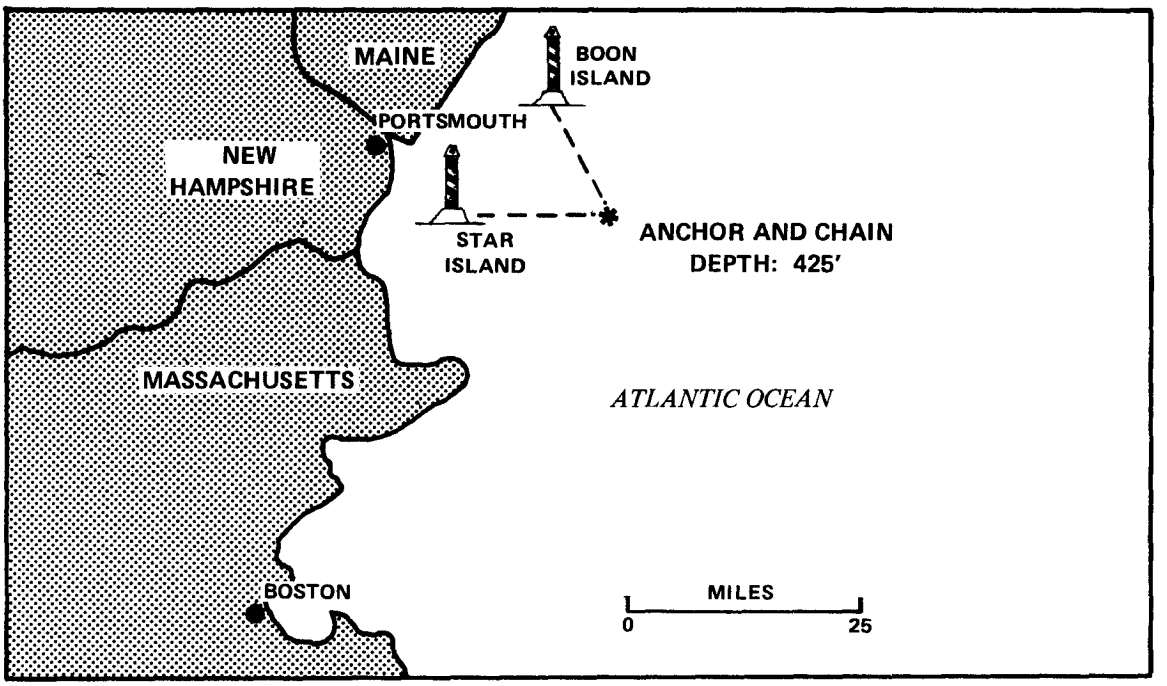
While undergoing post-conversion sea trials in the Atlantic Ocean on 5 July 1972, the nuclear submarine USS GEORGE BANCROFT (SSBN-643) reported losing an anchor and 135 fathoms of chain.

From a satellite fix and visual bearings, the BANCROFT determined its position to be LAT 42°59'N, LONG 70°22'W, approximately 25 nautical miles east of Portsmouth, New Hampshire. The water depth was recorded at 400 feet; bottom conditions were muddy.

ASSEMBLING THE SALVAGE FORCE

SUPSALV Assistance

Since replacement of the BANCROFT's anchor and chain would have necessitated drydocking, scheduling delays, and costs in excess of $100,000, the Commander of Service Force, Atlantic (COMSERVLANT), requested SUPSALV assistance in conducting an



Nuclear submarine BANCROFT's anchor and 135 fathoms of chain was detected by side scan sonar in 425 feet of water 25 miles east of Portsmouth, N.H. Salvors set up ranges for precision navigation system at Boon Island and Star Island lighthouses.

LOCATION OF USS GEORGE BANCROFT (SSBN-643)
ANCHOR AND CHAIN

immediate search and recovery operation. On 7 July, SUPSALV alerted two contractor salvage firms, Murphy Pacific Marine Salvage Company and Seaward, Inc., to the impending search and recovery task. Mobilization of personnel and equipment was begun on 9 July. A thorough survey of all pertinent background information and positioning data by the assembled search team was accomplished on 10 July, as was installation of electronic search equipment on one of the two Navy vessels assigned to the search and recovery operation. Boon Island Lighthouse and Star Island Lighthouse off Portsmouth were chosen as shore navigation ranges for a precision navigation system to be used during the search effort.

Vessels and Equipment Used

On 7 July the ocean minesweeper USS DETECTOR (MSO-429) was selected to serve as the search and navigation platform. An E. G. & G. side scan sonar system and a Cubic

DM-40 Autotape precision navigation system were installed on board when the ship arrived at Portsmouth Naval Shipyard.

The side scan sonar system consists of a streamlined body, or "fish," containing two hydrophones and two projectors. High frequency sound pulses emitted from this fish scan the ocean bottom; backscattered energy from objects and topographic features is then recorded on a paper trace, yielding a shadow picture of the bottom terrain. Significant objects appear on the picture as darker shadows, contrasting with the lighter, more uniform background shadow. Side scan sonar is often used in downed aircraft search operations and may be operated in several depth modes. For the BANCROFT operation, the deep mode was selected.

The precision navigation system was chosen for its proven plotting and repeatability accuracies of within 10 feet. The system employs two battery-powered shore responders which a shipboard unit interrogates for a digital range readout. The two shore navigation sites were established at Boon Island Lighthouse and Star Island Lighthouse on 10 July.

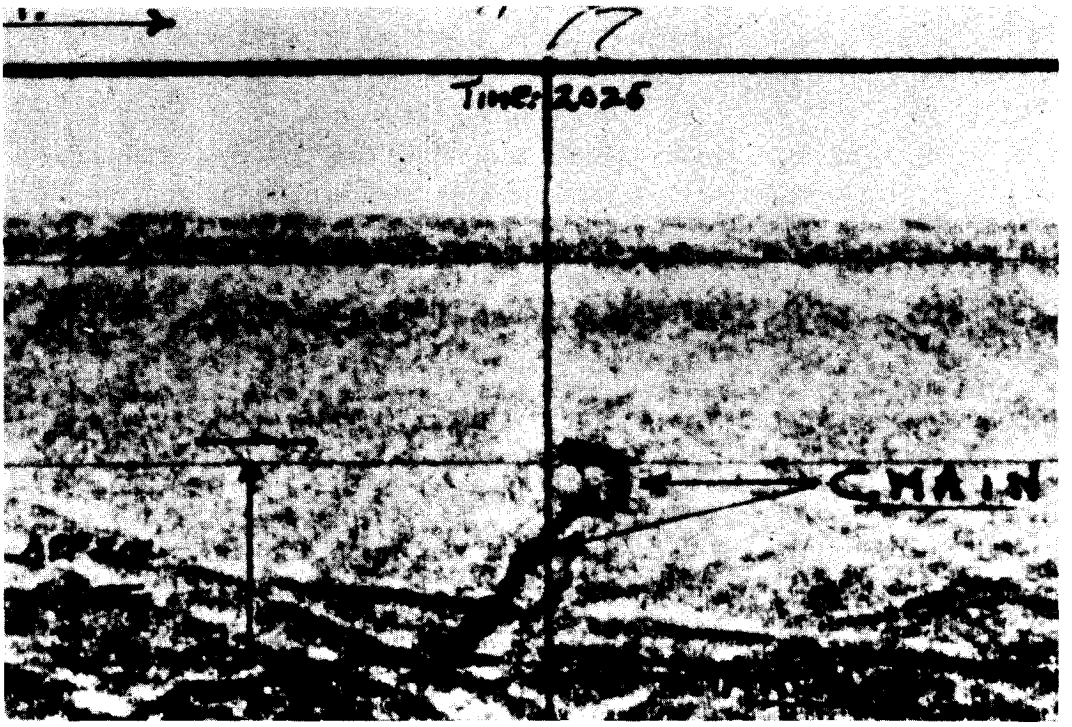
The second vessel assigned to the recovery operation was the ocean tug USS NIPMUC (ATF-157), which was engaged in towing operations with the aircraft carrier USS WASP at Quonset Point, Rhode Island, at the time. Upon completion of that assignment, NIPMUC proceeded to the Portsmouth Naval Shipyard, arriving on the evening of 10 July. The tug received 1,600 feet of 1 1/8-inch wire rope and a 1,570-pound steel anchor hawk. The stock-type anchor would be trailed from NIPMUC by the wire rope in an effort to snag or "hawk" BANCROFT's lost anchor and chain once the objects were detected by the sonar.

CONDUCT OF SEARCH OPERATIONS

Fortunately, BANCROFT had taken a position fix after the anchor and chain mishap occurred. The salvage force was therefore able to proceed directly to the casualty area and commence sonar scanning with relative assurance of quick detection of the lost objects.

At 0700 on 11 July, the navigation personnel got under way for the lighthouse stations. Their departure had been scheduled for the previous day, but was delayed due to local thunder squalls.

At 0800, DETECTOR and NIPMUC departed together for the search area. They arrived on station at 1000; NIPMUC assumed Officer in Tactical Command. DETECTOR began



After side scan sonar detected missing anchor and chain on 11 July, USS NIPMUC successfully hooked onto objects on fourth dragging attempt. Anchor and chain were brought aboard NIPMUC within hours.

SONAR TRACE OF BANCROFT'S ANCHOR AND CHAIN

sweeping the area at 1135 utilizing its own ship's sonar and the side scan sonar provided by the private contractor.

Within 7 minutes, DETECTOR located the lost anchor and chain 98 yards northwest of the reported position at a depth of 425 feet. Sonar runs continued into the afternoon to analyze the contact and localize the position precisely. Meanwhile, NIPMUC made a practice run with the hawk equipment.

CONDUCT OF RECOVERY OPERATIONS

In early evening, 11 July, DETECTOR led NIPMUC along the target line for an initial hawk drag at 4 knots. This and two further attempts were unsuccessful, but on the fourth

dragging run, NIPMUC hooked onto the chain and commenced recovery. NIPMUC utilized its towing machine and bullrope to haul the chain on board, securing it after each pull with chain stoppers.

NIPMUC remained on station to retrieve BANCROFT's anchor while DETECTOR returned to Portsmouth on the early tide. In the early morning hours of 12 July, the recovery team raised the missing anchor, secured it to the tug's starboard quarter, and got under way for the return trip to Portsmouth.

NIPMUC tied up at the Naval Shipyard at 0900 on 12 July and proceeded to offload the recovered anchor and chain while DETECTOR offloaded the side scan sonar and navigation equipment. With recovery operations completed, the search team began demobilizing at 1800. By the next day, all ships, personnel and equipment involved with the BANCROFT operation off Portsmouth were returned to their respective home bases.

CONCLUSIONS

Planning and execution of the salvage operation were virtually flawless. Thanks to the accuracy of the fix taken by BANCROFT at the time of the mishap, the search team was able to quickly locate the site with the precision navigation equipment. Actual sonar contact with the anchor and chain by DETECTOR followed almost immediately. The NIPMUC team then routinely accomplished hook-up and recovery. Weather conditions throughout the operation were optimal. From time of departure from Portsmouth to time of return, the salvage operation by NIPMUC and DETECTOR took only 23 hours. BANCROFT's anchor and chain were salvaged at a fraction of what replacement would have cost.

RECOVERY OF

USS TUCUMCARI (PGH-2)

FROM CABALLO BLANCO REEF

OFF PUERTO RICO

Hydrofoil gunboat USS TUCUMCARI crashed into reef east of Puerto Rico during special night operations on 16 November. Main struts became embedded in coral, making retraction of craft by salvors highly difficult.

USS TUCUMCARI (PGH-2) STRANDED
AT CABALLO BLANCO REEF OFF PUERTO RICO

RECOVERY OF USS TUCUMCARI (PGH-2) FROM CABALLO BLANCO REEF OFF PUERTO RICO

INTRODUCTION

The U.S. Navy hydrofoil gunboat TUCUMCARI struck a coral reef off Puerto Rico on 16 November 1972. The gunboat was traveling at high speed, causing injury to five crewmen and severe hull damage forward. The stern of the stranded craft was held above water by the after struts; the punctured bow region was below water due to the collapse of the forward strut.

To remove the TUCUMCARI, the salvage team blasted a channel through the coral, rigged pontoons and two sets of beach gear, and pulled with two harbor tugs and the salvage vessel MV RESCUE. The coral reef's hold on the TUCUMCARI forced the salvors to modify the pulling system several times and ultimately use a helicopter to lift the stern of the craft free.

LOSS OF THE TUCUMCARI

On 16 November 1972, the U.S. Navy hydrofoil gunboat USS TUCUMCARI (PGH-2) struck Caballo Blanco Reef approximately 2 miles north of Vieques Island off the eastern coast of Puerto Rico. The craft was on special night operations and was foilborne at a speed of 45 knots when the mishap occurred.

Upon striking the coral reef, the TUCUMCARI's forward foil and strut collapsed, severely tearing and puncturing the hull in the bow region.(1) The craft came to rest, nose down, in approximately 3 feet of water and began taking on water forward. The stern remained above water, supported by the main foil struts. Five crewmen injured in the accident were quickly evacuated by helicopter and taken to the Roosevelt Roads (Puerto Rico) Naval Hospital where they were treated, then released.

The hydrofoil gunboat was constructed of aluminum and weighed approximately 64 tons. It measured 71 feet in length and had a 25-foot beam. A total of 10 tons of fuel was estimated to be on board, but was in no danger of spilling.

(1) This damage to the PGH may seem extensive. However, had a conventional gunboat grounded on a reef at 45 knots, its entire bottom would have been ripped open and the craft rendered unsalvageable.

TUCUMCARI suffered extensive bow damage as a result of crash. Although surf conditions over reef were frequently rough, main struts held stern of craft above water, preventing flooding aft of frame 8.

STRANDED TUCUMCARI ESCAPES SERIOUS FLOODING

SUPSALV ASSISTANCE

Observing that hull damage and flooding were confined to the TUCUMCARI's bow region, the Commander of Amphibious Squadron Ten (COMPHIBRON TEN) deemed the vessel salvageable and requested SUPSALV assistance in removing it from the reef. SUPSALV dispatched representatives to the scene on the day following the crash to meet with the PHIBRON TEN On-Scene Commander. Harbor Clearance Unit Two (HCU-2) of Norfolk, Virginia, provided six enlisted divers and designated a salvage officer for the TUCUMCARI operation.

Inspection of the TUCUMCARI

Following a meeting of the salvage participants on 17 November aboard the amphibious transport ship USS FRANCIS MARION (LPA-249), an internal and external survey of TUCUMCARI was made, disclosing the following:

- The craft was hard aground in 3 feet of water, down by the bow approximately 25 degrees, and listing 3 degrees to port. Its after end was supported by the after struts.

- The forward berthing space showed surging water through holes in the port and starboard side of the keel. Collapse of the forward strut punctured the hull aft of the bowthruster tunnel.

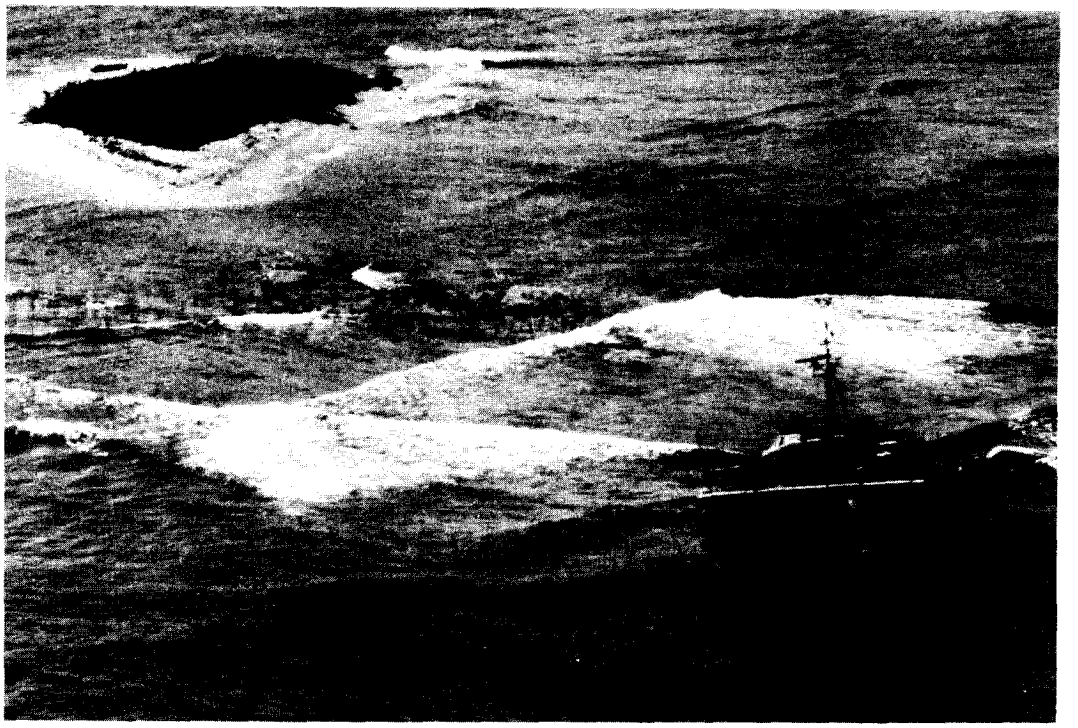
- There was no detectable structural damage to the hull aft of the forward berthing compartment.

- The after struts supporting the craft appeared structurally sound, although the foil on the port strut was torn away.

- A fine grain survey conducted by Underwater Demolition Team personnel revealed the presence of several coral heads astern of the craft.

Salvage Plan

On 17 November, following the inspection of the TUCUMCARI, the salvors again met aboard the FRANCIS MARION and formulated a plan to retract the stranded gunboat from the reef.



Salvors planned to blast a channel through coral to deeper water astern of TUCUMCARI, raise midships area with pontoons, and pull with beach gear off craft's starboard quarter.

TUCUMCARI'S POSITION DICTATES RETRACTION FROM STERN

Key aspects of the salvage plan were as follows:

- Blast a channel through the coral. Blasting was necessary to remove the coral heads astern of the vessel and allow it to be towed to deeper waters. The foil struts of the TUCUMCARI extended well below the surface and required a 14-foot-deep channel.

- Attach 8-ton salvage pontoons to the hull of the vessel to increase buoyancy and stability. Although the salvors originally planned to remove the estimated 10 tons of oil from the TUCUMCARI to reduce excess weight, they decided to keep the oil on board for added stability.

- Utilize a salvage ship to lay two legs of beach gear and to provide the pulling power needed to retract the stranded craft. The beach gear would be rigged off the starboard quarter of the TUCUMCARI for pulling over the bow of the salvage ship. The salvage ship's towline would be connected

to two legs of 1 5/8-inch x 600-foot beach cables chain-rigged by divers to the TUCUMCARI's port and starboard struts.

- Position a tug off the port beam of the TUCUMCARI to line the craft up properly with the channel during towing.

SUPSALV tasked Murphy Pacific Marine Salvage Company to provide a salvage ship, salvage crew, and equipment to assist SUPSALV and the HCU-2 divers in conducting the TUCUMCARI operation. Murphy Pacific ordered MV RESCUE to proceed to the casualty site from her station dock in Kingston, Jamaica, 800 miles to the west. Within 5 hours of receiving this order, the Murphy-owned, former U.S. Navy ARS vessel had assembled her crew and was under way for Puerto Rico with salvage gear including 3-inch pumps, two 8,000-pound Eells anchors, beach gear and a motor launch.

RIGGING THE BEACH GEAR

Preparation

While MV RESCUE was en route to the casualty site off Viequest on 18 November, the on-scene salvage team was engaged in preparations to retrieve the stranded gunboat. Using USS FRANCIS MARION as a support platform, the salvors first began rigging chains around the TUCUMCARI's after struts. Two bridles of 1 1/4-inch chain were doubled around each strut, which would act as pull points for the beach lines to MV RESCUE.

Underwater Demolition Team personnel also began operations on 18 November by setting explosives on the coral formation astern of the TUCUMCARI. Later in the day, the explosives were detonated, clearing a channel through which the stranded vessel could later be towed. With this 14-foot-deep channel, the vessel's after struts would clear bottom during towing to deeper water. Although removal of the struts was considered, the salvors decided that they should remain since they served as convenient and sturdy pull points for the towing lines.

Another major step in the salvage plan was also accomplished on 18 November. The salvors arranged four 8-ton salvage pontoons like a belt under the TUCUMCARI forward of the after struts, and secured their lines to cleats on deck. The two inner pontoons rested against the underside of the hull, while the two outer pontoons extended up along the curve of the hull against the port and starboard sides.

The TUCUMCARI was partially flooded in the forward berthing area which extended aft to frame 8. The salvors prevented other areas of the gunboat from flooding by sealing off this compartment. They then packed it with life preservers to add buoyancy in the event of further flooding.

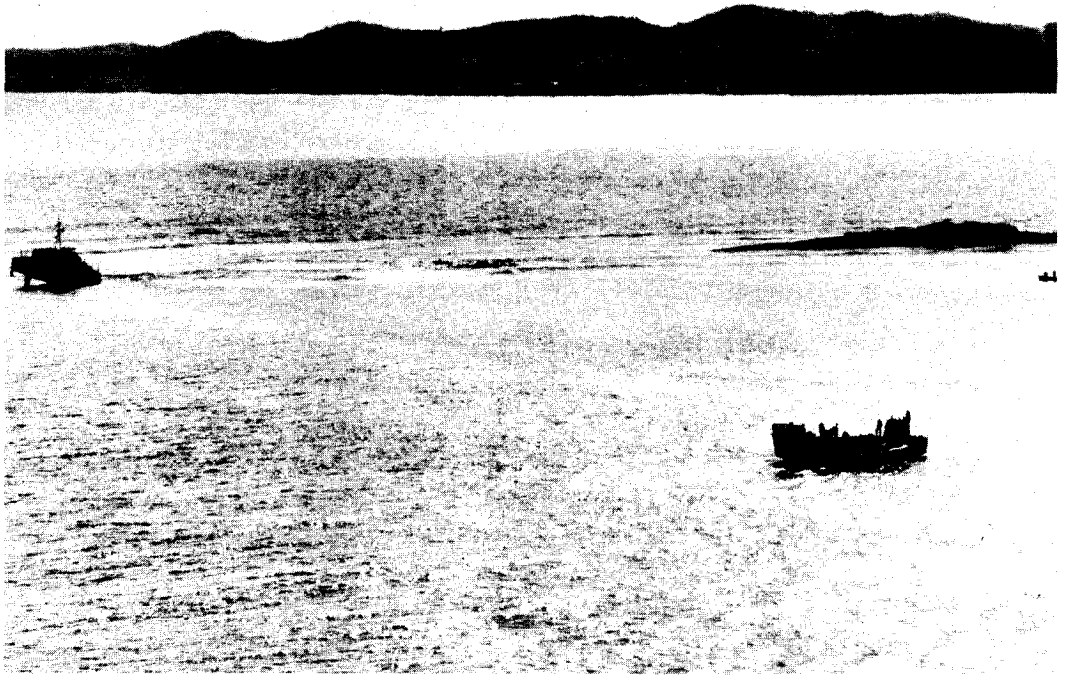
Rigging to MV RESCUE

MV RESCUE arrived at the salvage site at daybreak on 19 November and anchored close by FRANCIS MARION. The salvage master of RESCUE immediately boarded MARION and met with the salvage team to discuss the laying of the two sets of beach gear. Both sets of beach gear were the same and consisted of the following:

- 8,000-pound Eells anchor
- 2 1/4" x 90' stud link chain
- 1 5/8" x 600' beach cable
- 7/8" x 60' crown buoy wire
- Heavy beach blocks and falls
- Cable shackles, bitt straps and barrel buoy
- 1 5/8" carpenter stopper
- 2 1/4" patent links

Shortly after noon, the salvage crew aboard the RESCUE weighed anchor, positioned the ship 310 degrees off the TUCUMCARI's starboard quarter and dropped one 8,000-pound Eells anchor in about 42 feet of water. RESCUE then brought the beach cable toward the stern of the casualty and dropped the end over the side. A buoy was attached so that the cable could be picked up after the towline was made fast to the TUCUMCARI.

In the same manner, the salvors laid the second set of beach gear, bearing about 300 degrees off the gunboat's starboard quarter. It was then discovered that the buoy cable to this set of beach gear had become tangled in the RESCUE's port propeller. Divers were sent down to clear the wire. The beach cable was brought back aboard RESCUE and relaid toward the stern of the TUCUMCARI. By nightfall, the second set of beach cable, with the buoy attached, was again in place. Before securing operations for the night, the salvors coiled the beach cables in a Navy workboat which would run the cables to the stranded vessel at daybreak.



Salvors utilized "Mike" boat from nearby Roosevelt Roads Naval Station to rig beach gear for pulling effort. Workboat performed task of passing beach cables and messenger wires from TUCUMCARI's struts to salvage ship RESCUE.

SALVORS ABOARD NAVY WORKBOAT LAY BEACH GEAR OFF TUCUMCARI'S STARBOARD QUARTER

Early on the next morning, 20 November, salvors aboard the RESCUE, TUCUMCARI and the workboat made ready to complete the rigging of the beach gear. After soundings were taken near the reef, the RESCUE moved in and received the messenger line to the end of the first leg, which was to be connected to the ship's towline.

Meanwhile, the Navy workboat ran the end of the beach cable to the TUCUMCARI. When divers attempted to connect the cable to the chains around the gunboat's starboard strut, however, they discovered that the eye in the end of the cable was too small to take the connecting shackle. The end of the beach cable, therefore, had to be hauled back aboard the RESCUE for modifications.

At 0800, the end of the beach cable was returned to the Navy workboat, which then ran it to the TUCUMCARI for attachment to the strut. The RESCUE again passed

a messenger line to the workboat, hauled the beach cable aboard and made it fast to a 1 5/8-inch carpenter stopper.

The second leg of the towing bridle was then rigged. The workboat ran the end of the beach cable to the reef where it was connected to the TUCUMCARI's port strut. The RESCUE then hauled the beach cable aboard. By 1000, both cables were made fast to the RESCUE's towline, completing the rigging of the pulling system.

CONDUCT OF PULLING OPERATIONS

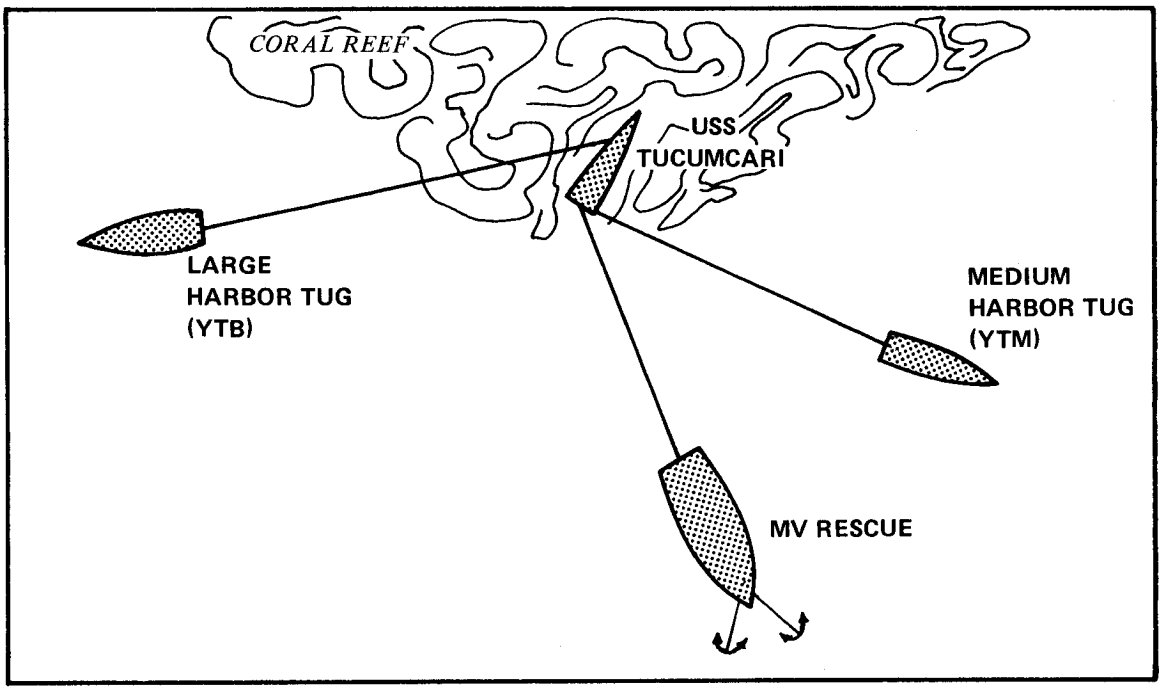
The salvors planned to pull the TUCUMCARI off the reef with the RESCUE's towline while a large harbor tug (YTB) kept the craft aligned with the channel which had been previously blasted and buoyed off. The YTB's 8-inch towline was secured to the TUCUMCARI's port beam.

At 1013, 20 November, the RESCUE weighed anchor, payed out the towline to 1,200 feet and secured it into a 2-inch carpenter stopper. A medium harbor tug (YTM) then came alongside the RESCUE's port bow to keep the ship up into the wind during pulling operations.

At 1015, the RESCUE began pulling at full power. Although the TUCUMCARI swung approximately 15 degrees toward the channel, there was no apparent seaward movement. In addition, the YTB had parted its towline.

At this point, the salvors decided to pick up the two sets of beach gear, heave them over the bow rollers and attach them to the beach fall. With the YTM's assistance, RESCUE was positioned near the second leg of beach gear which was then heaved aboard over the port bow roller. The first set was heaved over the starboard roller. By 1400, both sets of beach gear were made fast to the beach falls while the towline was made ready for a second pulling effort.

Pulling resumed at 1410 with the RESCUE taking a heavy strain on the beach falls and the YTB pulling again from the TUCUMCARI's port beam. An hour later, the gunboat's bow bitts were torn away by the force of the tug. The RESCUE continued to pull, increasing the turning speed to 70 rpm's. This caused the TUCUMCARI to swing several more degrees toward the channel, but the craft remained locked onto the reef by its struts.



Two pulling efforts with YTM, YTB and MV RESCUE on 20 November failed. On first effort, YTB's 8-inch towline parted. During second effort, shank on one set of beach gear to RESCUE parted; also, TUCUMCARI's bow bitts were torn away under pull of YTB.

PULLING ARRANGEMENT FOR INITIAL RETRIEVAL EFFORTS

To avoid tearing the struts, the salvors reduced the strain to 60 rpm's at 1700 hours. Two hours later, the pulling effort was forced to a halt when a shank on the first set of beach gear broke away. Only a slight strain was maintained on the towline through the night.

Pulling Strategy Altered

On the following morning, 21 November, divers inspected the broken set of gear which led to the gunboat's port strut. Meanwhile, the strain on the starboard set was increased to 70 rpm's. When divers reported that TUCUMCARI's port strut was embedded 6 inches into the coral, however, the salvors implemented a second change in the salvage plan.

Instead of repairing the beach gear to the port strut, the salvors called in a CH-53 helicopter. The helicopter would be used to raise the TUCUMCARI's stern area and free the embedded port strut. Also, the salvors planned to connect the YTM's towline

to a wire strap and lead it from the starboard strut up the port side and across the fantail. This would also ease weight off the port strut. Finally, the YTB would pull with its towline attached to the TUCUMCARI's forward gun mount.

While waiting for the helicopter's arrival, RESCUE pulled full ahead with additional help from the YTM. This effort succeeded in moving the TUCUMCARI 6 to 8 feet astern. The medium tug then cast off its towline from the RESCUE and hooked up to the gunboat's starboard strut as planned.

The salvors were preparing to lay a second set of beach gear for the RESCUE but abandoned this effort when the CH-53 helicopter arrived. The salvors immediately attached a lifting sling to the gunboat's port stern lifting pad.

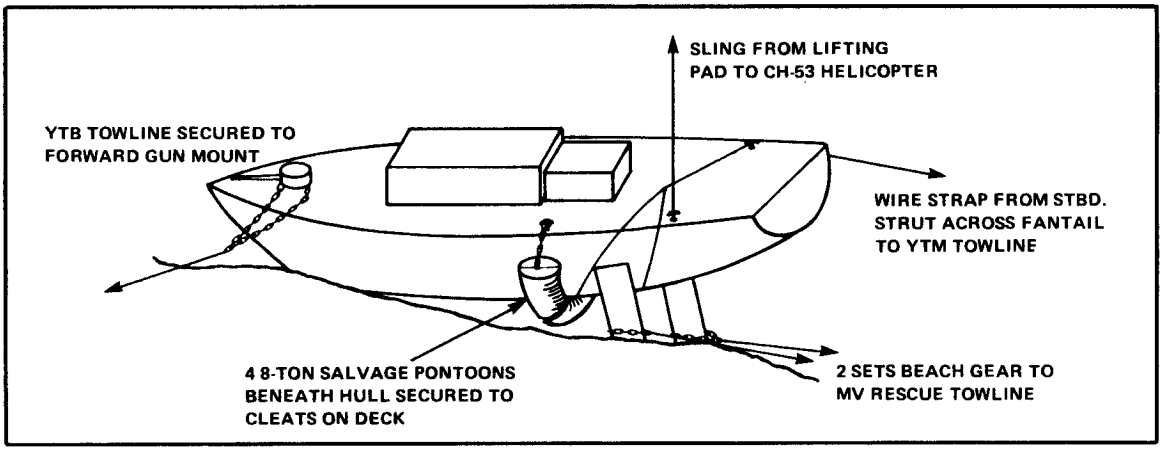
TUCUMCARI Pulled from Reef

At 1400 on 21 November all units began pulling to free the stranded craft: RESCUE pulled full ahead with its towline leading to the struts; the YTB pulled from the craft's port bow area; the YTM pulled from the starboard quarter; the helicopter applied 5 tons of lift from above.

The gunboat's reaction to the modified pulling and lifting arrangement was unexpected. Fifteen minutes after operations began, the TUCUMCARI abruptly rolled over on her starboard side. Fortunately, the vessel had also moved back 30 feet and was able to quickly right itself in the deeper water. The vessel's after lifting pad, however, was torn out by the helicopter. In addition, the foil on the starboard strut had broken off, causing the chain bridle to the RESCUE's towline to slip off. The bridle around the port strut remained secure.

A one-foot-square hole had also been punctured in the starboard side amidships, 5 feet above the waterline, as a result of the brief capsizing of the vessel. The salvors patched this and then rerigged the pulling system to complete the retraction. Another bridle was rigged from the starboard strut to the YTM which was repositioned off the TUCUMCARI's stern.

MV RESCUE and the YTM began pulling, but when the YTM reached full power, the bridle on the starboard strut parted. Another bridle was rigged and the pulling effort resumed with the YTM and YTB pulling in tandem on the starboard strut. At 1858, USS TUCUMCARI was pulled from the reef, completing the recovery effort.



Pulling system was modified to free port strut embedded 6 inches into reef. Pulling and lifting efforts on 21 November caused TUCUMCARI to capsize to starboard briefly, but moved craft back 30 feet. Retraction was completed later by YTB and RESCUE pulling in tandem from starboard strut.

REVISED PULLING ARRANGEMENT FREES TUCUMCARI FROM REEF

The salvors continued working into the night recovering beach gear and preparing the TUCUMCARI for tow. At 2230, the TUCUMCARI departed the salvage area for Roosevelt Roads under tow of the YTB. The hydrofoil gunboat was then loaded aboard USS FORT SNELLING (LSD-30) and transported to the Naval Amphibious Base at Little Creek, Virginia, for repair.

CONCLUSIONS

Retrieval of USS TUCUMCARI from Caballo Blanco Reef was a formidable task. The vessel's port strut had anchored itself into the tenacious coral formation with a holding power that caused the breakup or slippage of towlines and pull points on several occasions. A helicopter was ultimately required to lift the aft end of the vessel from the grip of the coral.

Even then, the pulling task was not a simple one. MV RESCUE and the two powerful harbor tugs finally succeeded in pulling the vessel free of the reef on 21 November, benefited by a high tide and continued fair weather.

Following the retrieval of the TUCUMCARI, the salvage officer and two divers picked up the TUCUMCARI's two after foils and two bow doors with the CH-53 helicopter. Only

the channel blasted through the coral reef remained as evidence of the operation. (Permission to blast the coral was granted after an inspection by the Puerto Rican Environmental Quality Control Board.)

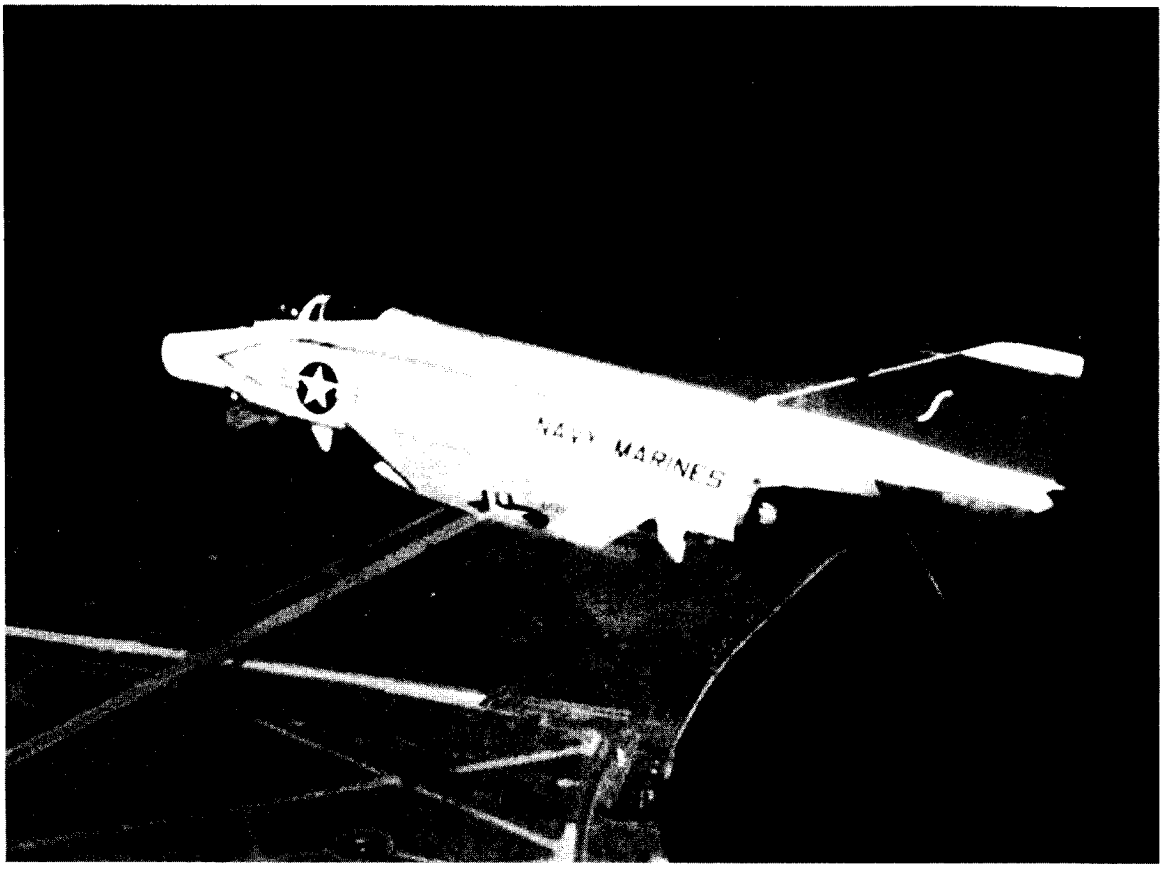
An indication of the difficulty of the operation was the final condition of much of the salvage gear. The pontoons were severely ripped by the coral and surf action; one Eells anchor fractured so that only the shank was recovered; and the two 1 5/8-inch x 600-foot wire ropes were recovered in such a damaged condition that they were no longer usable.

SEARCH AND RECOVERY

OF

U.S. AIR FORCE F-4E AIRCRAFT

OFF COAST OF TURKEY



U.S. Air Force F-4E similar to Marine Corps Phantom shown above, crashed into Mediterranean Sea off coast of Turkey on 8 September. Ensuing search and recovery effort utilized SUPSALV and contract salvor assets, including electronic search equipment.

F-4 (PHANTOM) IN FLIGHT

SEARCH AND RECOVERY OF U.S. AIR FORCE F-4E AIRCRAFT OFF COAST OF TURKEY

INTRODUCTION

Following the crash of a U.S. Air Force F-4E in the Mediterranean Sea off the coast of Turkey on 8 September 1972, an unsuccessful preliminary search of probable impact areas was conducted by the U.S. Navy salvage vessel USS PRESERVER (ARS-8). A more intensive search using additional SUPSALV personnel and electronic search equipment was initiated on 18 September. Although the body of the pilot was never found, successful detection and recovery of the aircraft were accomplished within 10 days.

The salvage effort was hampered by erroneous eyewitness accounts of the crash location and by an ever-present threat of terrorist attack from the Syrian border only 30 miles away from the shore station. However, side scan sonar and precision navigation equipment enabled detection of the wreckage by 25 September. The 4-day recovery effort that followed yielded sufficient wreckage to enable the Air Force Accident Investigation Board to make a determination of the cause of the crash.

LOSS OF THE AIRCRAFT

On 8 September 1972, a U.S. Air Force F-4E aircraft crashed into the Mediterranean Sea off the southern coast of Turkey in an area used as an aerial gunnery range. The aircraft, flying out of the Incirlik Common Defense Installation at Adana, Turkey, was not held on radar at the time, nor were there any communications from the plane prior to the crash.

Approximately 2 1/2 hours after the crash, a C-131 from Incirlik sighted an oil slick and some debris 5 to 7 miles from the coast at LAT 36°30'N, LONG 35°15'E. An eyewitness, however, insisted that the crash occurred much closer, about 1 mile from shore.

PLANNING THE SEARCH EFFORT

In response to a request for search and recovery assistance from the U.S. Air Force on 10 September, the Office of the Supervisor of Salvage, U.S. Navy, dispatched the Sixth Fleet Salvage Officer from Naples, Italy, to meet and discuss the salvage problem with Air Force

Accident Investigation Board personnel in Adana, Turkey. At SUPSALV's request, a representative from Seaward, Inc., a contractor salvor, was also sent to Turkey for the 13 September meeting.

Upon completion of a survey of all details of the crash and probable salvage time and cost, the Air Force authorized SUPSALV to proceed with the search and recovery effort. A U.S. Navy salvage vessel, USS PRESERVER (ARS-8), had already received orders on 9 September to proceed to the crash area for preliminary exploratory operations. Further personnel and equipment were urgently requested from SUPSALV, Washington, D.C., on 15 September upon receipt of messages from the PRESERVER recommending use of electronic search equipment. On 17 September, SUPSALV dispatched four contract salvor personnel, side scan sonar, and precision navigation equipment to Adana to aid in the search for the F-4E aircraft.

INITIAL SEARCH ACTIVITIES, 13-18 SEPTEMBER

On 13 September, the USS PRESERVER arrived at the sighted oil slick and commenced exploratory diving operations to 120 feet. The search was halted the same day, however, for several reasons. Bottom visibility was less than 3 feet; the 120-foot depths permitted only short duration SCUBA dives; and, since no buoy had been placed over the oil slick at the time of the first sighting, the search area could have been as large as 18 square miles.

PRESERVER then steamed to the site where the eyewitness, a 16-year old Turkish national, had claimed to have observed the aircraft maneuvering and crashing into the water. After 7 hours of diving operations and grapple towing on 14 September, this search effort was also suspended. Again, bottom visibility was poor and the crash area too inexact.

In an effort to determine the accuracy of the eyewitness account, an F-4 was flown four times over the course the boy claimed to have observed the downed aircraft flying at the time of the crash. When the boy marked the crash site at the same point each time, the search team moved accordingly (to a point 3 miles to the east), and continued diving and grapple tow operations.

The PRESERVER continued its bottom search for 4 more days (until 18 September) over a 200-yard by 1000-yard area of the probable flight path. Numerous searches were

conducted by divers on sleds towed by the PRESERVER's 35-foot workboat. In addition to this, extensive dragging of the various sectors of the probable impact area was conducted, but no wreckage was located.

During this 4-day search, bottom visibility was too limited and the search area too large to result in successful detection of wreckage by exploratory diving and dragging alone. The only wreckage salvaged by the search team to date was a hydraulic pressure accumulator and a seat cushion pocket which a local fisherman had found. These, plus pieces of hydraulic debris recovered earlier by the Air Force, indicated severe break-up of the aircraft following the crash.

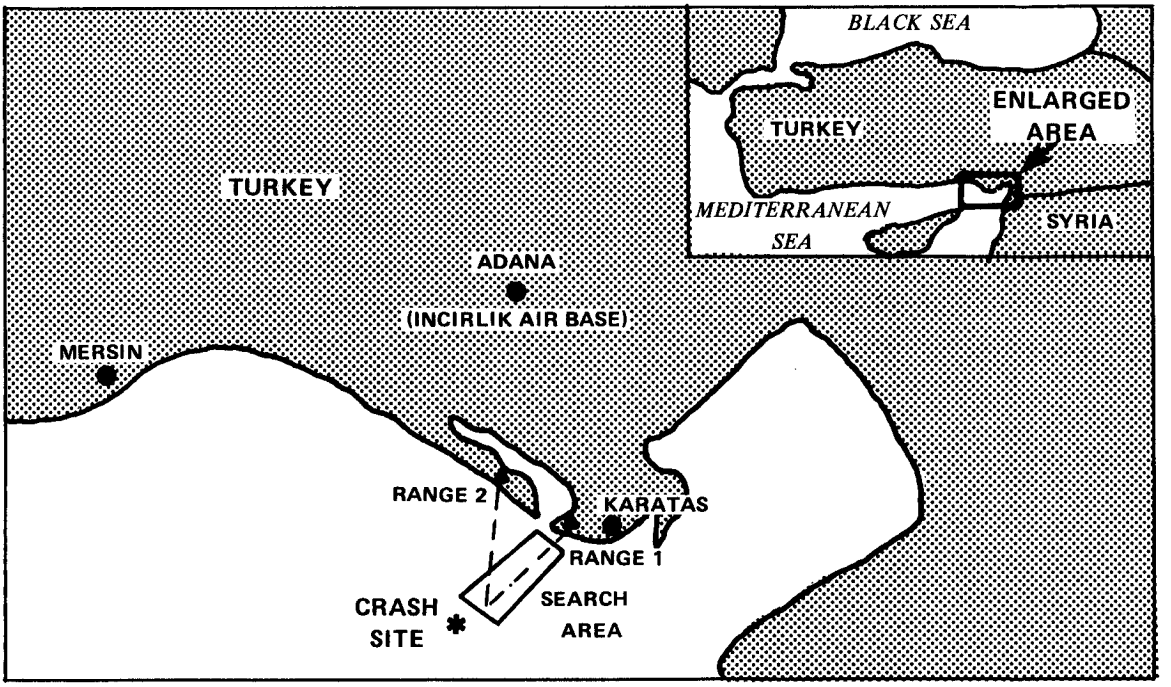
ELECTRONIC SEARCH EQUIPMENT

Side Scan Sonar

Following the unsuccessful preliminary search effort from 14 to 17 September, PRESERVER headed for Mersin, Turkey, to receive the additional salvage personnel and electronic gear from the United States. This equipment included an E. G. & G. side scan sonar system and a Cubic DM-40 Autotape precision line-of-sight navigation system.

The side scan sonar consists of two projectors and two hydrophones housed in a streamlined body which is towed behind the survey vessel during search operations. High frequency sound pulses emitted from both sides of the body strike the ocean bottom in a scanning pattern much as a slanted beam of light elevated above the topography would highlight the panorama below it. When the sound reaches the ocean bottom, part of the sonic energy is reflected back toward the body as backscatter from the irregular topography. The amount of backscatter energy is a function of the bottom composition and the angle at which the sonar beam strikes the bottom.

Each reflected sound pulse is then displayed by an oscilloscope and a paper recorder conveying a shadow picture of wreckage distribution and topographic features to the observer. The side scan sonar was an invaluable search tool since visibility was generally poor and since sunken targets littered the bottom of the aerial gunnery range at the crash area.



Acting on eyewitness account of F-4E aircraft crash, search team set up ranges for precision navigation equipment and covered 23-square mile area with side scan sonar. Wreckage was detected on eighth day of search, just outside original search area, 8.5 miles from shore.

SITE OF U.S. AIR FORCE F-4E CRASH

Precision Navigation System

The utilization of a Cubic DM-40 Autotape precision line-of-sight navigation system ensured that the area would be fully covered and that a sonar contact would be returned to with a high degree of reliability. It also allowed the PRESERVER to moor precisely above each piece of wreckage to be inspected by divers, thereby reducing the amount of time a diver would have to spend locating wreckage and increasing his bottom time significantly . The system employs two battery-powered shore responders which a shipboard unit interrogates for a digital range readout. Shore stations for the Cubic system were established along the coast at Karatas on 18 September.

SEARCH EFFORTS, 18-24 SEPTEMBER

The PRESERVER, serving as the diving and sonar towing platform, and later as the recovery platform, departed Mersin to resume the search on the morning of 18 September.

Following lock-in of the navigation system at 1300, the search team began sonar scanning, working seaward from a point 2,000 feet from shore. Rock formations and 25-foot depths, however, prevented the sonar "fish" from being towed at the ideal 30- to 50-feet depth. Therefore, scans of only 300 feet in width were obtainable instead of the normal 600-foot-wide scan.

As the search progressed seaward over the next few days water depths increased, allowing full 600-foot scanning. But by 23 September, with nearly 20 square miles of search area scanned, there was still no trace of the wreckage. On 19 September, another eyewitness to the crash was located and interviewed, but the area he described was searched without success.

Search operations were interrupted for about 1 hour on 20 September and again on 21 September due to electronic problems with one of the navigation stations ashore. Jamming was later suspected to be the cause; the inability of the navigation stations to stay in synchronous operation coincided with seemingly jammed radio communications with Incirlik.

Still another problem facing the search team during this period was the threat of terrorist attacks on the shore-based support units. Syrian terrorists from just 30 miles away had targeted the Incirlik area with the intent to attack installations and kidnap Americans. The search team had hoped to work past sunset each day but the threat of attack prevented this. And although the Turkish army responded by posting a security guard, this guard was secured each night at 1900.

During 20-21 September a search area of 9 square miles was covered A contact was made, but it was not convincing on sonar. Aircraft wreckage of the type the team was hunting usually exhibited a component separation that was lacking in this sighting. Divers went down to check the sighting and found an ancient and broken shipwreck.

On 22 and 23 September the search team continued scanning, covering an area from 5 to 8 miles from shore. Divers were sent down to inspect every probable contact, but again, all proved negative. Since the entire theoretical impact area had now been scanned, the search team decided to reinspect the shoal areas close to shore.

Depths were as shallow as 10 feet nearer shore, so the sonar gear was again mounted on PRESERVER's 35-foot workboat. It was necessary to rig a 5kW salvage generator in the boat to supply power to the sonar gear when an electrical converter malfunctioned. After this brief delay, the search resumed over a 1.4-square mile area. Again, however, no trace of the wreckage was detected.

CONTACT MADE, 25 SEPTEMBER

The search team then decided to make one last search of the area past the furthermost sector to an arc 9 miles from shore. If this effort on 25 September was unsuccessful as well, operations would be terminated.

The PRESERVER was on station at 0500 on 25 September. Within 4 hours, a strong contact disclosed the presence of possible aircraft wreckage in three piles at a 130-foot depth, 8.5 miles from shore. A buoy was placed over one pile, and divers were sent down to confirm the contact. They returned with a portion of the wreckage and reported sighting the numerals 264 on the tail section, thus positively identifying the missing F-4E aircraft.

RECOVERY OPERATIONS, 25-28 SEPTEMBER

Following positive identification, the PRESERVER was kept in its 2-point moor above the wreckage. Ten recovery dives were made before securing for the day at 2000 hours. Approximately 10 percent of the wreckage was recovered, including the main tail section (with stabilizers intact), drag chute assembly, and a large piece of lower fuselage from the rear of the aircraft. Eight additional dives were made on 26 September to recover more pieces from the after part of the aircraft.

The next day, the moor was shifted to another contact thought to be the engine. This proved to be an afterburner with no other debris nearby. More wreckage was located and recovered by divers working a circling line. Major components recovered this day included a portion of the ejection seat, the left wing fuel pump, attitude monituring instrumentation and a 15-foot section of the fuselage containing both cockpit areas. Interior parts of the wreckage were extensively damaged but were identifiable; the ejection seat mechanism appeared not to have been fired.

A series of seven dives on 28 September resulted in recovery of the starboard engine, complete with the fuel package accessories and one wing. The port engine was also located but was embedded deeply in mud. Since an inspection of the turbine blades of this engine by divers revealed bending damage similar to that of the recovered engine, the Air Force deemed further recovery efforts unnecessary. Several dives were made in a special effort to locate the remains of the pilot. However, only a single boot was found.

CONCLUSIONS

The two-week search and recovery operation for the Air Force F-4E was accomplished in favorable weather and sea conditions. Functioning of all electronic search equipment was also good, except for the breakdown of a DC converter. This problem was quickly overcome by using a 5kW portable generator from the ready salvage gear aboard the PRESERVER. Excessive yawing of the sonar fish when under tow astern of the PRESERVER also occurred. Streaming the sonar fish out over the ship's bow rollers proved more successful.

Although the threat of terrorist activity was always present, an actual attack never materialized. The shore party also faced logistic difficulties due to the lack of suitable docking or pier facilities. Stores and equipment had to be loaded onto a rubber raft from the beach, floated out to the workboat through rough surf, then transferred finally to the PRESERVER.

All diving was accomplished using SCUBA gear. Due to the presence of silt on the bottom, visibility conditions were generally quite poor. The divers, moreover, had to rely on hand signal communications since more sophisticated communication systems were not made available. Divers also encountered the normal amount of sharp debris from the aircraft wreckage and received numerous cuts.

The major problem encountered was the undue length of the search effort itself. This was caused by the erroneous estimation of the crash location by the young Turkish eyewitness. Despite the boy's 7-mile error, however, the salvage operation was completed within the original time estimate.

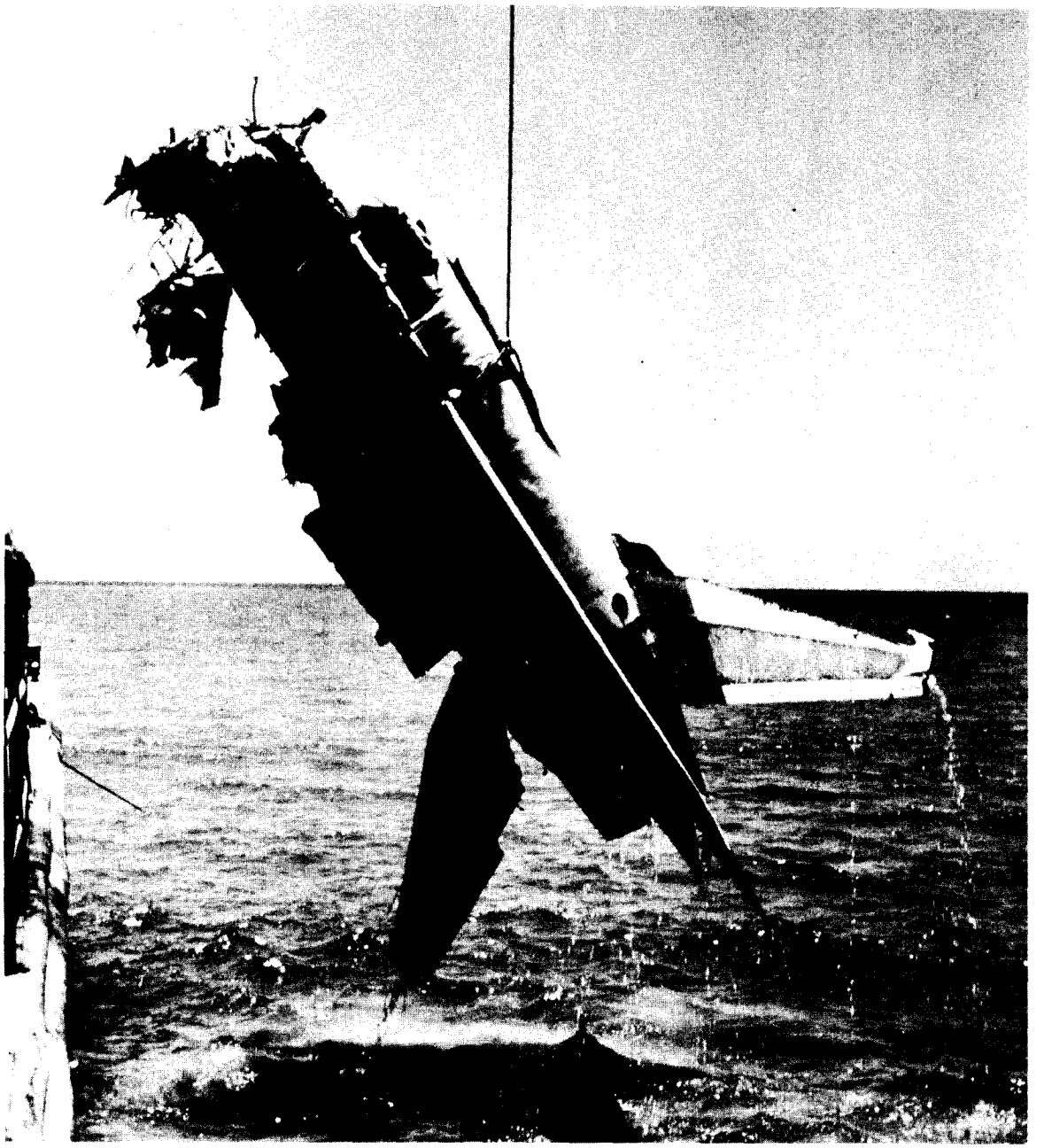
SUMMARY

OF

DOWNED AIRCRAFT

SEARCH AND RECOVERY OPERATIONS

IN 1972



SUPSALV provides technical and operational assistance in a variety of downed aircraft search and recovery operations throughout the world each year. Examination of recovered wreckage provides clues to cause of each crash and helps prevent future mishaps from occurring.

AT-SEA RECOVERY OF FIGHTER AIRCRAFT WRECKAGE

SUMMARY OF DOWNED AIRCRAFT SEARCH AND RECOVERY OPERATIONS IN 1972

INTRODUCTION

Recovery of downed aircraft from inland waters or the open sea involves unusual salvage problems. Often, location of an aircraft is the most difficult and time-consuming part of such an operation. Breakup on impact with the water often occurs, scattering wreckage in all directions and sometimes to great depths where bottom conditions may be muddy and visibility poor.

Yet recovery of certain wreckage components is essential in the interest of future aviation safety. Hence, SUPSALV resources and capabilities are often solicited to conduct or assist in especially difficult aircraft salvage operations. The five cases summarized in this article, and the case which is the subject of a previous article in this review, testify to the difficulty of aircraft salvage, and to the expertise of those who conduct such operations.

Each of the following operations is summarized in this article:

OPERATION	DATE OF CRASH
Recovery of U.S. Navy TA-4J in Aransas Pass Channel, Texas	5 February 1972
Search and Recovery of U.S. Navy HH-2C Helicopter off San Diego, California	11 May 1972
Search and Recovery of U.S. Navy F-14 (Tomcat) in Chesapeake Bay, Maryland	30 June 1972
Recovery of U.S. Air Force F-4E in Sarasota Bay, Florida	7 September 1972
Search for Crewmen and Wreckage of U.S. Air Force RF-4C off Myrtle Beach, South Carolina	24 November 1972

RECOVERY OF U.S. NAVY TA-4J
IN ARANSAS PASS CHANNEL, TEXAS

Date : 5 February 1972
Location : Aransas Pass Channel, Texas
Condition : Wreckage in 246 feet of water
Task : Search and Recovery

Background

On 5 February 1972, a U.S. Navy TA-4J aircraft from the USS LEXINGTON (CVT-16) unexpectedly throttled up after release from arresting gear and dropped off the flight deck. The aircraft stayed afloat in the waters of the Aransas Pass Channel near Corpus Christi, Texas, for 37 minutes before sinking to a 246-foot depth. Divers from LEXINGTON examined the cockpit prior to the sinking, but the crewman, a student pilot from VT22 (NAS, Kingsville), was found missing; his body was never recovered. LEXINGTON took a LORAN fix when the plane went off the deck but not when it sank 37 minutes later nor did it place a marker buoy down.

Planning the Search Effort

SUPSALV was contacted by VT22 personnel from Naval Air Station, Kingsville, and assumed operational responsibility for search and recovery operations on 17 February. Recovery of the aircraft was necessary to determine whether the accident was caused by pilot error, or by a mechanical failure, such as a jammed throttle.

An estimation of LEXINGTON's position at the time of the crash was made using a previous LORAN fix and dead reckoning. Consultations with the navigator and other personnel aboard LEXINGTON further narrowed the aircraft's probable location to a 2-square mile area. In preparation for the upcoming search, SUPSALV, through its S&R contractor, provided side scan sonar equipment and installed it aboard the 90-foot offshore shrimp boat, "ANTHONY D.S."

Conduct of Search Operations

Initial search efforts began in late February with the side scan sonar. The search was shorted due to weather conditions.

On 1 March, a second search effort was launched. This time, several good contacts with the sonar were made, and by 4 March, the location of the aircraft was determined to be at LAT. 27°31.9'N, LONG. 96°28.8'W. Positive identification of the TA-4J was made several days later by means of an underwater closed circuit television camera.

Conduct of Recovery Operations

During the first week of March, SUPSALV requested the services of a salvage vessel to recover the 6-ton aircraft from the channel. On 6 March, USS TRINGA (ASR-16) was ordered to proceed to the crash site and undertake the recovery effort. This assignment would delay TRINGA's scheduled Mediterranean deployment until completion of the salvage operation.

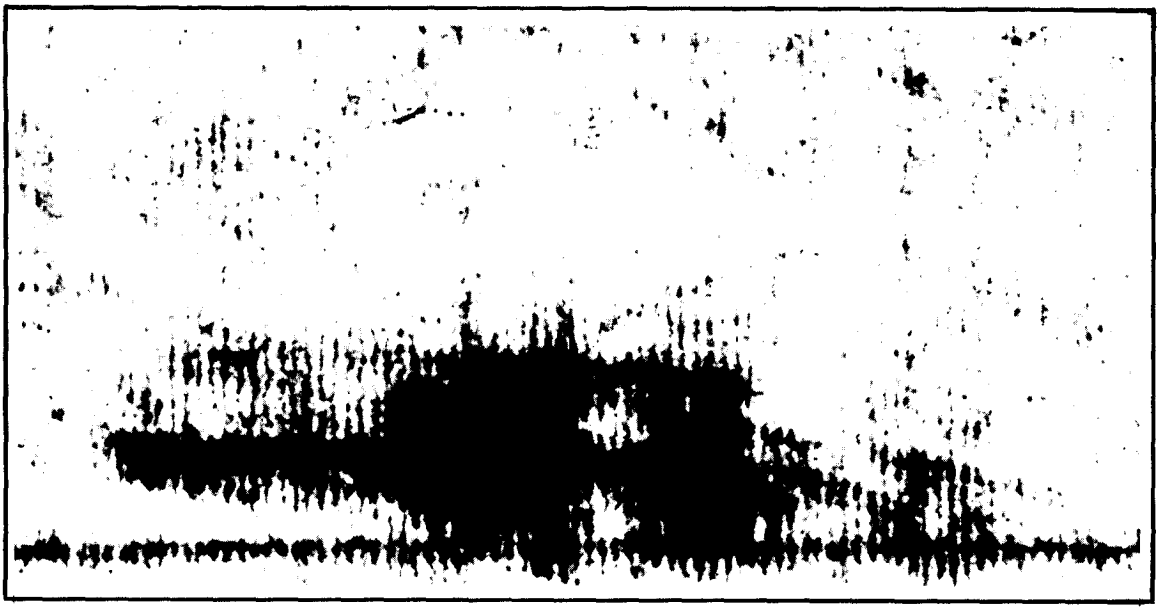
On 13 April, TRINGA arrived at Corpus Christi carrying 15 first class divers, two diving medical personnel, a master diver and a diving officer. After a salvage briefing, the recovery party boarded TRINGA and proceeded to the crash site.

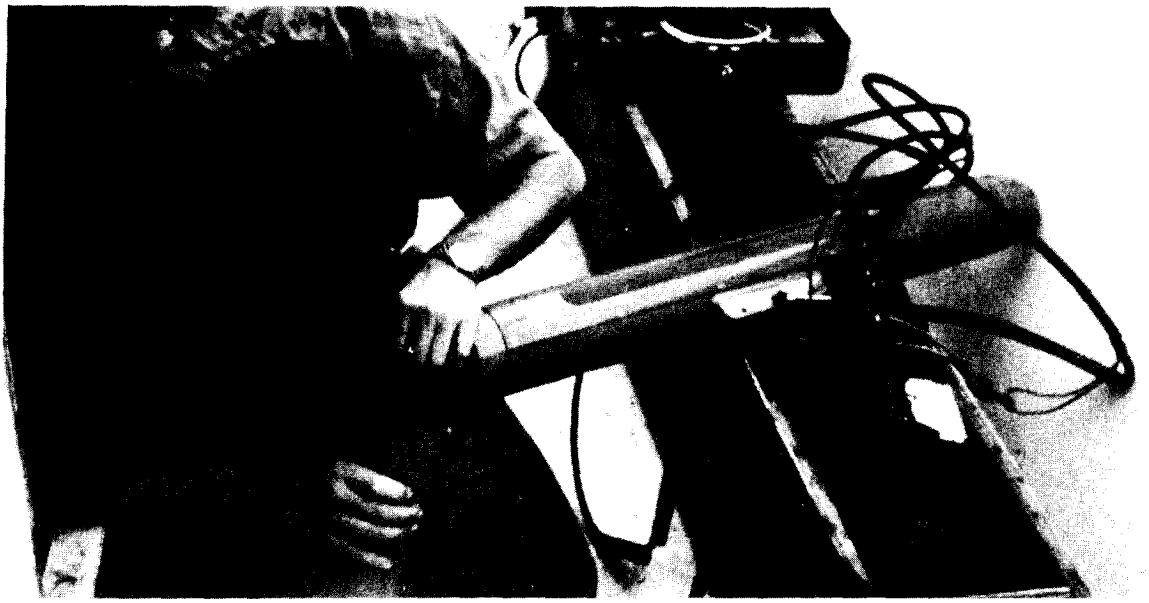
Winds blew at 20-25 knots, with gusts up to 35 knots, during transit. When TRINGA reached the crash site, it was placed in a 4-point moor, but the high winds and 15-foot swells caused two legs to break loose. The deteriorating weather made repositioning impossible for several days.

On 18 April, the recovery team was able to replace and strengthen TRINGA's moor. The area was scanned to relocate the aircraft, but wind and weather postponed recovery operations for several more days. On 22 April, helium divers were able to descend to within 30 feet of the wreckage, but, due to soft bottom, were unable to reach the aircraft.

High winds and rough seas later in the day again uprooted the moor and postponed diving operations. In addition, the sonar went out of commission and had to be repaired. After riding out the continued rough weather for two more days, the divers again descended to the aircraft. The dives had to be aborted, however, due to TRINGA's moor dragging. The divers were sent down again on 25 April, but the surging of the ship above prevented them from positioning the diver stage close to the aircraft.

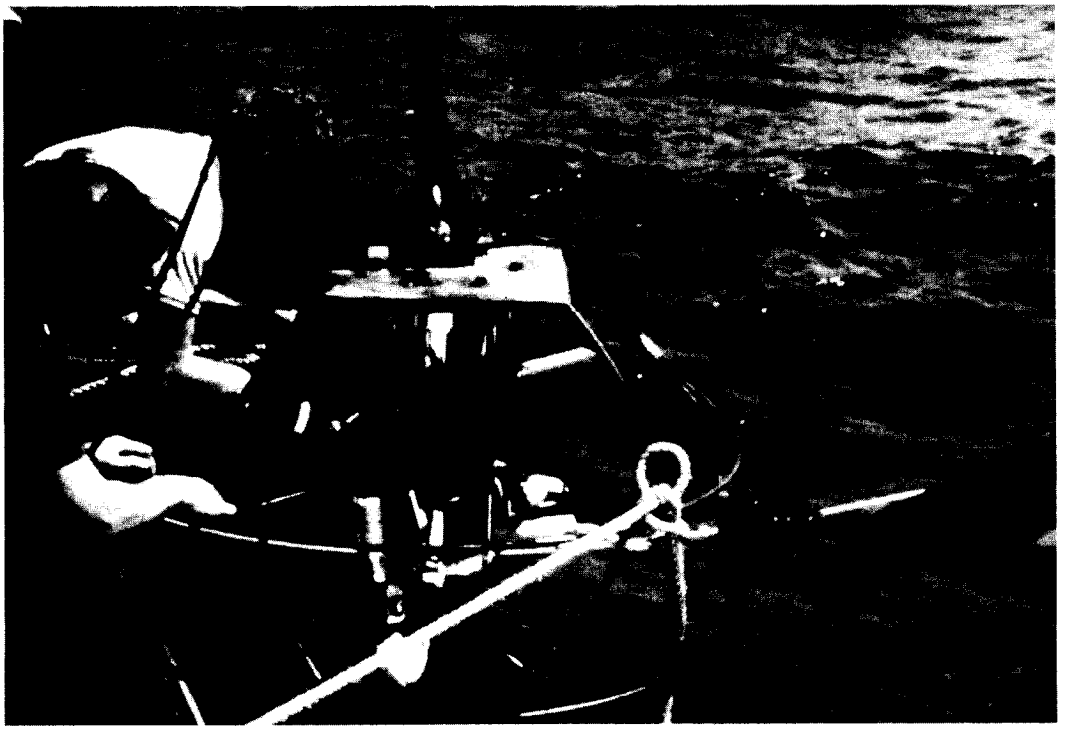
Weather conditions precluded further recovery attempts for the next several days. Frequently thunderstorms, winds of 30-35 knots, gusting up to 50 knots, and 12- to 18-foot seas made it impossible to maintain TRINGA in its moor over the wreck site. The





Streamlined capsule, towed from search vessel, emits high frequency sound pulses. Sonic energy is reflected back to capsule, then transmitted to recorder, yielding shadow picture of bottom features. Wreckage appears as large, dark mass against more regular bottom topography.

SIDE SCAN SONAR DETECTS TA-4J WRECKAGE IN 246 FEET OF WATER



Salvors rigged underwater closed circuit TV camera to special sled to make positive identification of wreckage and to monitor divers' activities during recovery operations.

SALVORS PREPARE TO LOWER TV SLED ASSEMBLY TO TA-4J WRECKAGE

salvors had no choice but to ride out the bad weather, anchored near the moor. This delay was especially frustrating because TRINGA was scheduled to depart the area on 1 May to meet another operational commitment.

Another recovery attempt was made on 29 April although the seas and weather remained unfavorable for diving and salvage operations. TRINGA was maneuvered into its moor and positioned correctly over the wreck despite winds of 12-17 knots and seas of 6-8 feet. Divers were sent down to attach a hook, attached to a 5-inch lift line, to the aircraft's tail hook. They experienced great difficulty in maintaining their position alongside the wreck and working under water because the TRINGA had begun to surge violently in its moor as the weather again worsened and swells increased to 8-12 feet. A sonar/TV camera sled was attached to the down line and lowered near the aircraft to help position the down line next to the tail hook. Divers were then lowered on the stage, using the same down line to position themselves next to the tail hook. They eventually succeeded in attaching the lift line to the hook.

The aircraft's nose and right wing were buried in 4-5 feet of mud. TRINGA took a medium strain on the 5-inch nylon line while waiting for the divers to be decompressed. This tension, coupled with the forces generated by the continued surging of the ship, broke the aircraft free from the bottom suction. The salvors were then forced to start to the surface, using the sonar/TV equipment to observe the ascent.

The aircraft, suspended from its tail hook, was lifted to a depth of 40 feet and then held at this point, well below the turbulence nearer the surface, to attach a second lift line. Two divers descended and shackled this 7-inch nylon line also to the tail hook, just below the shackle for the 5-inch line. After about 10 minutes, however, the salvors noticed that both lines had begun chafing on the side of the TRINGA due to the ship's surging. But, since the divers were still on the stage, lifting the aircraft to the deck could not be accomplished.

The aircraft was immediately lowered in an effort to relieve the stresses on the lift lines. However, at a depth of about 70 feet, the 7-inch line parted, followed almost immediately by the parting of the 5-inch line. The aircraft sank back to the bottom.

The sonar/TV camera equipment was recovered although the sonar cable remained fouled on the sunken aircraft. The salvors made a brief effort to relocate the aircraft utilizing the fouled sonar cable as a plumb line. However, it too parted after a short time, due again to the surging of the ship. With both the sonar and TV inoperative, the aircraft's position could not be fixed. It was by now early evening on 29 April. The salvors, faced with TRINGA's impending departure on 1 May, were finally forced to admit defeat. Another lift attempt was not feasible.

CONCLUSIONS

Severe sea and weather conditions plagued the salvage force throughout the operation, affecting all phases of the search and recovery efforts. These conditions made it almost impossible for TRINGA to maintain a stable, precise position over the wreck. Surging of the ship in its moor, caused by the heavy seas, hampered and finally defeated the salvors' efforts.

The circumstances for the final, unsuccessful recovery effort on 29 April were unfavorable; indeed, so unfavorable that the salvage force could not have been faulted for deciding not to undertake the effort. The effort was made because it was clearly the last reasonable chance, however slim, of making the recovery before the departure of TRINGA. It very nearly succeeded, proof that the chance was worth taking.

SEARCH AND RECOVERY OF U.S. NAVY HH-2C HELICOPTER OFF SAN DIEGO, CALIFORNIA

Date: 11 May 1972
Location: Pacific Ocean off San Diego, California
Condition: Wreckage in 170 feet of water
Task: Search and Recovery

Background

A U.S. Navy HH-2C helicopter crashed into the Pacific Ocean approximately 7 miles southwest of San Diego on 11 May 1972. The helicopter had been conducting a night training exercise and was carrying a crew of four.

Another helicopter sighted flashing lights in the water and proceeded to the crash area, discovering three crewmen in life jackets. A fix was taken and an immediate search was begun for the fourth crewman. Although some debris was recovered, no trace of the pilot was found, and he was assumed lost with the aircraft.

On 12, 13 and 14 May, the Navy and Coast Guard conducted an intensive follow-on search of the crash area. MAD-equipped aircraft, Coast Guard vessels, and Navy divers were used to conduct a sonar and drag sweep over a 2,000-yard-radius area. Several good contacts were made in depths to 180 feet, but diver investigations of the contacts proved negative.

Planning the Salvage Effort

SUPSALV, which had been kept informed of the progress of the initial search operations, was called in for assistance on 13 May. SUPSALV notified Murphy Pacific Marine Salvage Company, a contractor salvor, for additional services and equipment. Murphy Pacific then contacted Seaward, Inc., and assembled the necessary deep search and recovery equipment, including an E.G.&G. Mark 1A dual channel side scan sonar system and a Cubic DM-40 Autotape precision navigation system. The operation would be conducted from the MV GEAR, a Navy-owned, Murphy Pacific-operated, salvage vessel out of San Pedro, California. On 14 May, shore navigation stations were set up and area pre-plots drawn.

HH-2C helicopter lies intact in 170 feet of water after crashing while on night operations off San Diego. Helicopter was detected by side scan sonar and later recovered with body of pilot still aboard.

SONAR TRACE OF HH-2C HELICOPTER

Conduct of the Search and Recovery Operations

MV GEAR arrived in San Diego on 15 May. Following an afternoon conference at the Naval Station, the search and recovery team boarded the vessel and got under way for the search area.

The search began at 1740 and continued into the night until 0100 on 16 May. A strong contact was discovered and plotted. Early the next day, divers were sent down to investigate. The contact, however, turned out to be two 4-foot-high concrete objects, and the search was renewed to the east.

By noon, another strong sonar contact was made. Divers this time verified the contact as the HH-2C helicopter. The body of the pilot was discovered inside.

Preparations then began to place GEAR in a 2-point moor above the helicopter. Winds hindered the initial rigging efforts, but the moor was successfully in place by 1900. After Submarine Development Group One divers secured lines to the helicopter, a smooth and expeditious nighttime recovery was accomplished.

Conclusions

Once the precision navigation equipment and side scan sonar were acquired, the helicopter was quickly located. There were no serious equipment problems or time delays during the operation. An initial recommendation of the salvors, however, proposed the installation of acoustic locating devices, or "pingers," in all aircraft engaged in operations over water. Such a device aided in the swift location and recovery of another aircraft, a U.S. Navy F-14, on the East Coast later in the year.

SEARCH AND RECOVERY OF U.S. NAVY F-14 AIRCRAFT IN CHESAPEAKE BAY, MARYLAND

Date: 30 June 1972
Location: Chesapeake Bay; off Patuxent River, Maryland
Condition: Wreckage in 32 feet of water
Task: Search and Recovery

Background

On 30 June 1972, a U.S. Navy F-14 (Tomcat) crashed into Chesapeake Bay shortly after takeoff from the Naval Air Test Center (NATC) at Patuxent River, Maryland. The aircraft was undergoing contractor demonstration tests at NATC when it crashed into water approximately 32 feet deep, 3 miles southeast of the runway.

An immediate surface and aerial search was launched for the pilot of the aircraft, but he was not found. The search team placed buoys to mark the oil slick and debris locations. An air station crash boat was dispatched to the scene and anchored nearby to warn off pleasure boats.

Wreckage Located by Acoustic Pinger

Location of the wreckage and commencement of recovery operations occurred within hours of the crash. This rapid location was made possible by an acoustic locator beacon, or "pinger," which had been installed inside the aircraft by the contractor prior to the crash. The pinger device, which measures 4 inches in length and weighs only 9 ounces, sends out a 37.5 kHz signal and has an operating life of 30 days.

Within 90 minutes of the accident, a boat carrying a portable acoustic receiver was under way to the crash area. A diver then entered the water with the portable receiver and began to track the source of the signal. The pinger guided the diver over a distance of 100 yards through waters with only 1 foot of visibility. Upon reaching the wreckage, the diver attached a marker buoy and returned to the surface.

Planning the Search and Recovery Effort

Following the crash, SUPSALV tasked a private contractor, Seaward, Inc., to provide a Search Manager and sonar team for the subsequent search effort. Harbor Clearance Unit Two (HCU-2) was also contacted and dispatched a survey team. By 1 July, divers from HCU-2, the Naval Ordnance Facility at Solomons, Maryland, and the Naval Air Test Center had arrived on the scene.

With the arrival of the contractor representatives on 3 July, investigative personnel and search and recovery personnel conferred and established the search strategy. After the planning conference, the search team proceeded to the crash site and calibrated all buoys for reference. Area plots were drawn up using the on-base theodolite system as the navigation coordinator. A side scan sonar system was procured and installed on board a 65-foot crash boat (AVR) later in the afternoon.

Conduct of Search and Recovery Operations

Prior to the arrival of the side scan equipment, the HCU-2 diving team had been conducting preliminary diving operations at the wreck site using a seaplane wrecking derrick (YSD) and two 45-foot range craft from the Naval Ordnance Facility at Solomons. The range boats conducted a circle search line drag of the crash area on 1 and 2 July and succeeded in recovering the port engine, engine intake, starboard portion of the cockpit, starboard wheel and strut assembly, and numerous small sections of the aircraft.

Although the circle search operations had succeeded in locating and recovering a good deal of the aircraft by 3 July, including both wing sections intact, the wreckage was found to be scattered over a wide area. Since visibility was poor, it became evident that sonar scanning would greatly expedite the search and recovery of the remaining wreckage.

The 65-foot AVR with side scan sonar arrived on the scene on 3 July and began search operations. At the end of the day, all sonar readings were reviewed and all navigational information fed into a computer for follow-on recovery and charting purposes.

On 4 July, the AVR returned to the crash area and continued sonar scanning operations. Fifteen to 20-knot winds were causing heavy chop in the bay, and difficulties were experienced with the sonar wiring, but scanning of the area was successfully completed by early evening, and the AVR returned to port.

A search diagram based on the sonar returns was drawn up on 5 July while the diving team continued its recovery efforts in the deteriorating weather on the bay. The search diagram was developed with further inputs from the three theodolite stations and tracking radar. The resultant chart was shown to the recovery team and Accident Investigation Board and then used in conjunction with the computer records to assist recovery divers in their follow-on search.

On 6 July, the recovery team began laying out a jackstay in the northeast and southwest portions of the newly-charted crash site. The jackstay was laid out from a NATC LCM-8 using a 500-pound mechanical winch and hand-operated bow anchors. In this initial impact area, engine components and underbody portions of the aircraft were located and recovered. The YSD continued its circle search 390 feet south of the jackstay area and recovered portions of the cockpit and upper wing surfaces.

Over the next 2 days, the recovery team continued working the jackstay with the LCM in a two-point moor and recovered numerous underbody sections, engine accessories, a nose wheel, aircraft skin, and special component wiring.

On 9 July, four additional HCU-2 personnel arrived on the scene to assist in the recovery effort. The bad weather continued, however, and the heavy chop damaged the jackstay. It was relaid, its ends rigged with 150-pound weights. The recovery team succeeded in recovering additional wreckage, including engine components, external cockpit sections, and hydraulic accessories. The YSD recovered the afterburner section and several large skin sections.

Radical, shifting winds and adverse currents continued on 10, 11 and 12 July, requiring the LCM to be placed in a 4-point moor. Recovery proceeded, however, and a variety of wreckage was brought in, including the gear box, wheel assembly, fuselage and cockpit pieces, and the aircraft recorder.

On 12 July, a second jackstay was laid out in the southern area. An LCM warping tug, which had arrived earlier in the day, was used as the lifting and diving platform for this area. With this supplementary craft, recovery of the cockpit instrumentation was accomplished. Weather conditions continued to upset the jackstay rigging, but the LCM's mooring held. Gradually, the area between the two jackstays was closed.

By 16 July, the jackstays were worked into each other, completing a sweep of the crash area. After the starboard engine and numerous cockpit control components were recovered, diving operations were secured and all moors and marker buoys were recovered. Boats, equipment and personnel were returned to their respective bases, ending the recovery operation.

Conclusions

The 16-day salvage operation resulted in 80 to 90 percent recovery of the F-14 aircraft wreckage. This was an unusually high percentage, given the wide (300 x 2,900 feet) area of the crash site, the poor underwater visibility, and the severe weather and current conditions in the bay following Hurricane Agnes.

The E. G. & G. dual side scan sonar was operated in the shallow mode for the 30- to 35-foot-depth search. Despite rough seas, some minor wire cabling difficulties, and interference from the concentrated shellfish beds, the sonar performed well. In conjunction with the theodolite navigation information, an accurate wreckage diagram was obtained, enabling a rapid and thorough recovery operation to be conducted. Initial search efforts were also conducted in an expeditious and well-coordinated manner due to the valuable acoustic locator beacon instrumentation and the responsive action of nearby units.

The HCU-2 divers were exposed to several hazardous working conditions, including an abnormally swift current, near-zero visibility, and danger of skin laceration from the exceedingly sharp and tough boron fabric of the aircraft wreckage. The boron material easily penetrated any point of contact on the divers' bodies; even heavy gloves failed to protect their hands. The shortage of available L.P. air compressors and lack of a diver-to-diver communication system also made diving operations difficult. However, the perseverance of the 12 HCU-2 divers throughout nearly 100 hours of bottom time contributed immeasurably to the success of the recovery operation.

RECOVERY OF U.S. AIR FORCE F-4E IN SARASOTA BAY, FLORIDA

Date: 7 September 1972
Location: Sarasota Bay, Florida
Condition: Wreckage in 4-10 feet of water
Task: Recovery

Background

On 7 September 1972, a U.S. Air Force F-4E aircraft on a flight mission from MacDill Air Force Base in Tampa crashed into Sarasota Bay, Florida.

The wreckage was located about 1 mile from Long Boat Key in water from 4 to 10 feet deep; most was concentrated in a 30-yard-diameter circle, although some was scattered as far as 60 yards. Although the water depth was shallow, the harbor bottom was covered with a thick layer of soft mud. Some of the wreckage was later found to be embedded in nearly 30 feet of this mud.

Planning the Recovery Effort

The day after the crash, the Air Force requested Navy assistance in recovering the wreckage. In response to this request, one officer, a master diver, and six enlisted divers from Harbor Clearance Unit Two were dispatched to the crash site on 11 September. The Coast Guard sent a cutter to buoy off the wreck site, and supplied a crane barge to serve as a platform for the recovery operations.

Conduct of Recovery Operations

Recovery operations began on 12 September. A 100-cubic-foot expanded metal basket, suspended from the crane, was used with some success during the first few days in picking up wreckage located by the divers, such as pieces of the right wing and fuselage. Washout techniques were also employed in this initial recovery phase, but proved difficult and time-consuming due to shifting bottom conditions and cave-ins.

On 15 September, after the disappointing tunneling efforts, the Air Force acquired an 8-inch spot dredge. This was installed on the barge and used with success during the remainder of the recovery operation.

Salvage efforts progressed slowly over the next few days due to the need for extensive dredging. By 22 September, 35 percent of the wreckage had been recovered, including pieces of the tail section. The dredge continued to function well, but by 29 September, 55 percent of the wreckage remained buried and unrecovered, including major engine components. The amount of recovered wreckage was still insufficient to meet the Accident Investigation Board's needs.

During the recovery operation, divers periodically inspected the dredged area to locate pieces of wreckage and determine the progress and direction of dredging efforts. The presence of JP-4 and hydraulic fluid, however, began to destroy the rubber material of the divers' wet suits, and exposed divers to the danger of painful skin burns. To reduce these hazards, petroleum jelly was applied to the exposed areas of the divers' bodies, and heavy coveralls were worn by recovery personnel.

By 6 October, with approximately 60 percent of the wreckage recovered, Air Force and Navy recovery forces held a meeting to determine the future course of operations and decided to continue operations for at least another week.

By the end of this week's time the salvors had recovered a full 90 percent of the F-4E wreckage. After 17 October, 98 percent of the wreckage had been recovered, including all components desired by the investigation board. The salvage operation was then terminated.

Conclusions

The 6-week dredging and lifting operation resulted in recovery of nearly the entire aircraft from the muddy bottom of the bay, thus enabling the Accident Investigation Board to conduct an appraisal of all necessary components.

A total of 54 hours of bottom time was logged by the diving team, which used SCUBA and KMB-8 equipment. Visibility was often less than 1 foot in the muddy, dredged waters, making location and identification of the widely scattered debris difficult. The spot dredge, acquired by the salvors as an alternative to the unsuccessful tunneling method, proved reliable and effective in locating buried wreckage.

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On the following day, the sonar and navigational equipment arrived at the scene and was installed on board the INLET PRINCESS, a 65-foot chartered fishing vessel that would serve as the search platform. Navigational ranges were erected on shore to the north (Pawley's Inlet) and to the south (Georgetown light station) of the casualty area.

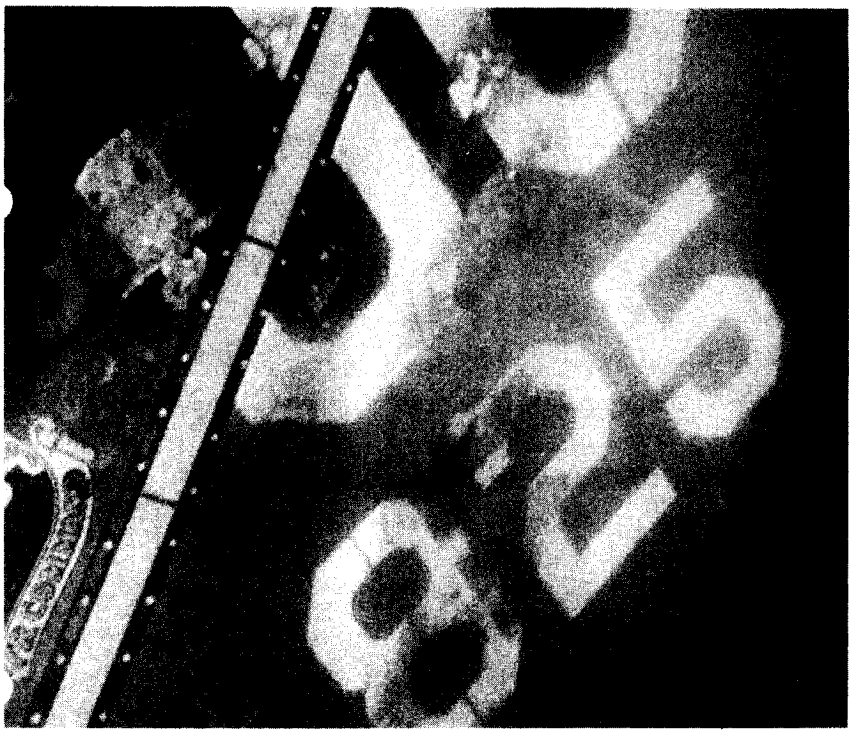
Conduct of Search

INLET PRINCESS was under way for the 2-hour voyage to the search area early the next morning. Sonar scanning in a north-south direction commenced at 0940. Within an hour, contact was made with an object at LAT 33° 15.6'N, LONG 78° 50.8'W. However, there was no sign of the two missing crewmen. Search efforts continued through the afternoon. After planting marker buoys above the sonar contact and logging the navigational readings, the search team returned to port.

A 7-man diving team from Harbor Clearance Unit Two arrived at Myrtle Beach AFB later in the evening to assist in the search. At a meeting that same evening, it was decided that the divers would join the existing search team aboard the INLET PRINCESS for the subsequent operations. The search team planned to place a buoy above each promising sonar contact, then moor the vessel and send divers down with hand-held sonar to make positive identification. Arrangements were made for radio communications with the Myrtle Beach AFB control tower, and a helicopter placed on scramble call to assist in the event of a diving accident.

On the morning of 29 November, the search team again departed for the crash site. Weather conditions, however, were highly unfavorable. Winds were blowing from the northeast at 18 to 25 knots; seas were from 6 to 8 feet. The vessel arrived on station at 0940, but navigational readings were erratic due to the rocking motion of the antenna. The rough seas also made sonar and diving operations impossible, and the search was terminated later in the morning. The search party assembled at the boat again the next morning, but weather conditions had worsened and operations had to be cancelled for the day.

Improved weather allowed the search to continue over the next 3 days. The storm had swept away the original marker buoy and the wreck site had to be relocated. Sonar soon picked up the wreckage and divers were sent down. They found a large piece of wreckage lying on a firm sandy bottom at a depth of 55 feet. The fuselage (aft of the cockpit), right wing, and tail section were still intact. The plane number was visible on



Positive identification of aircraft 650825 was made by divers on fourth day of search. Wreckage of second aircraft involved in mid-air collision was discovered 1,000 yds away. No trace of crewmen of second aircraft was found.

RIGHT WING OF USAF RF-4C AIRCRAFT IN 60 FEET OF WATER

the wing, identifying the wreckage as that of the aircraft flown by the two rescued crewmen. Divers then located the left wing of the aircraft approximately 120 yards east of this area.

Wreckage of the aircraft flown by the missing crewmen was located on 2 December. The fuselage and numerous badly damaged smaller pieces were resting approximately 1,000 yards southeast of the first aircraft. However, no identifiable trace of the cockpit was found.

Upon returning to port, the SUPSALV representative requested and received permission to conduct an additional day of search operations. On 3 December, sonar scanning and diving continued. Divers found several large pieces of charred wreckage, indicating that heavy fire damage had occurred. Despite the finding of additional wreckage through the afternoon, there was still no sign of the missing crewmen and the search operation was terminated.

Conclusions

The side scan sonar equipment operated very well; initial sonar contact with the wreckage was obtained just 47 minutes after the search began. Some problems were experienced with one range of the navigation system due, in part, to an electrical failure (which was corrected), but mainly to the extremely long base leg (20 miles) and low height obtainable from the shore antenna.

Six divers from HCU-2 logged a total of 7 hours and 42 minutes bottom time during 13 dives. SCUBA gear was used exclusively. Depths ranged from 53 to 63 feet, and visibility was generally less than 15 feet. Surface conditions were quite rough following the storm, but there was no turbulence under water; currents were less than 1 knot. The dives were for inspection purposes, and no attempt was made to recover any of the wreckage.

The primary goal of the operation, recovery of the missing crewmen, was not achieved. Chances of recovery, however, were narrowed by the lack of information about the collision and its aftermath. Location of the wreckage of both aircraft was an achievement in itself, considering the altitude at which the crash occurred (4 miles) and the rough weather conditions during much of the search.

INDEX ALPHA

SALVAGE OPERATIONS 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

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/Crafts/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 REQUIRING ASSISTANCE

II AIRCRAFT SEARCH/RECOVERIES

III MISCELLANEOUS ASSISTANCE TASKS

IV SALVAGE VESSELS, CRAFT, UNITS

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

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
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- 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 1969 ARTICLES

Recovery of Deep Research Vehicle ALVIN

ALVIN, a manned submersible, was lost in 5050 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, dove 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 re-evaluation 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 MELBORN. 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, enroute 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 A4-F and a USAF F-106 could not be recovered.

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 5850 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 CHAWANOC (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 A6A 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.

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, 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.

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.

MV 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.

MV 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 MV SOLAR TRADER at West Fayu Island, Pacific Island Trust Territory

The MV 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 BANCRAFT (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 MV 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.