

I. Salvage of the USS GUITARRO (SSN 665)I.1. Brief

USS GUITARRO (SSN 665) was in an advanced state of construction at the San Francisco Bay Naval Shipyard (Mare Island Division). On the evening of 15 May 1969 uncontrolled flooding caused the GUITARRO to sink. Salvage operations were conducted by the Supervisor of Salvage.

The submarine was refloated at 1119 on 18 May 1969 by dewatering with pumps through cofferdams which had been constructed for that purpose. Though the initial salvage plan envisioned expelling water by means of compressed air through the salvage air fittings, this plan was abandoned in favor of pumping when it became obvious that pumping would be much faster.

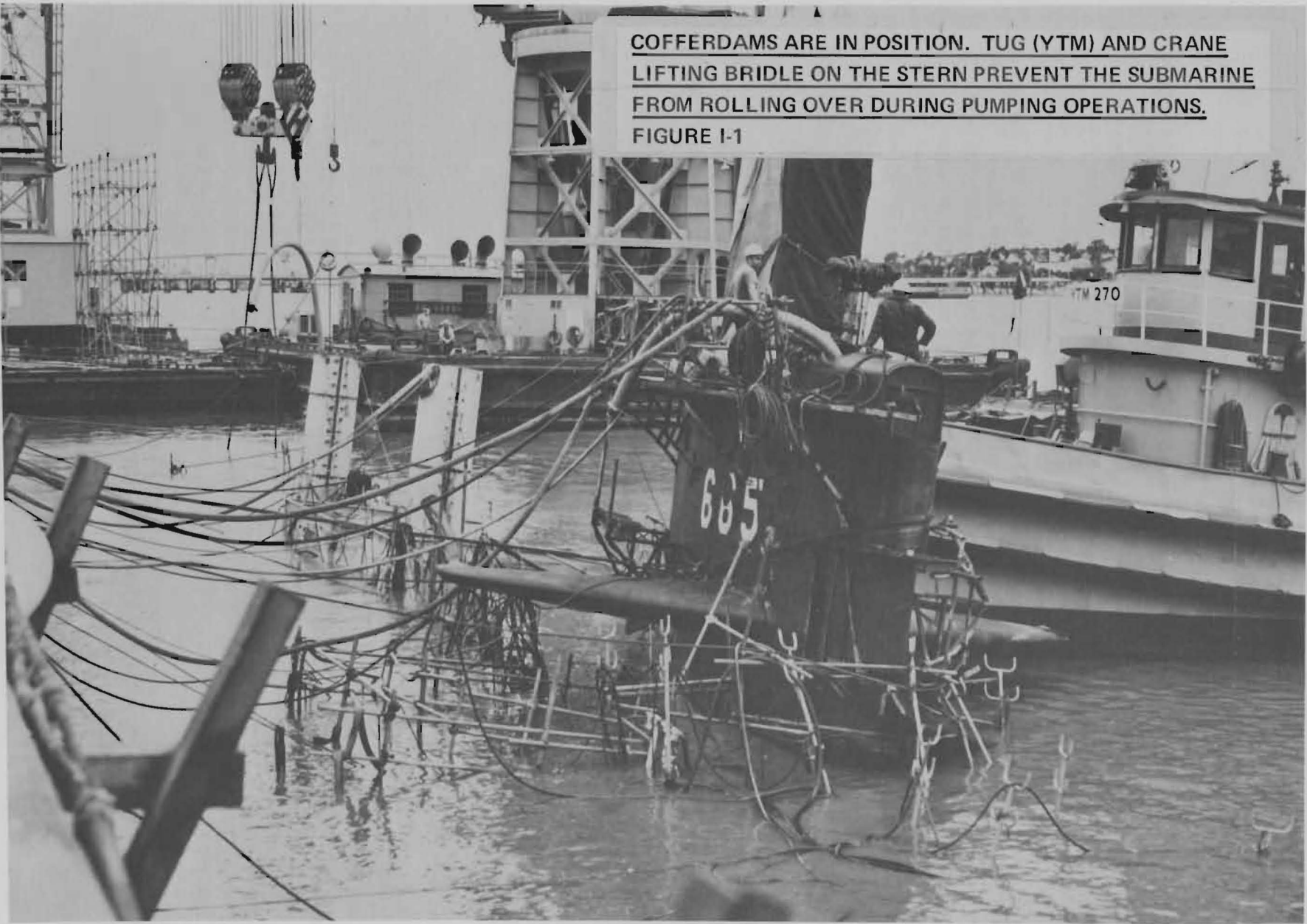
After the submarine was surfaced, residual water was removed from GUITARRO until a condition satisfactory for drydocking was reached. Salvage operations were completed when GUITARRO was docked at San Francisco Bay Naval Shipyard on the evening of 18 May 1969. The salvage operation, from beginning of mobilization through successful recovery, was particularly short; only 3 days passed between the date of sinking and drydocking of GUITARRO. The shipyard industrial assistance and complete availability of all services, especially cranes, made the salvage of GUITARRO possible in such a short time. A similar submarine sinking, far removed from the industrial plant capacity available at the San Francisco Bay Naval Shipyard, would present a much more complex problem and probably require much more time and effort for recovery.

I.2. Narrative

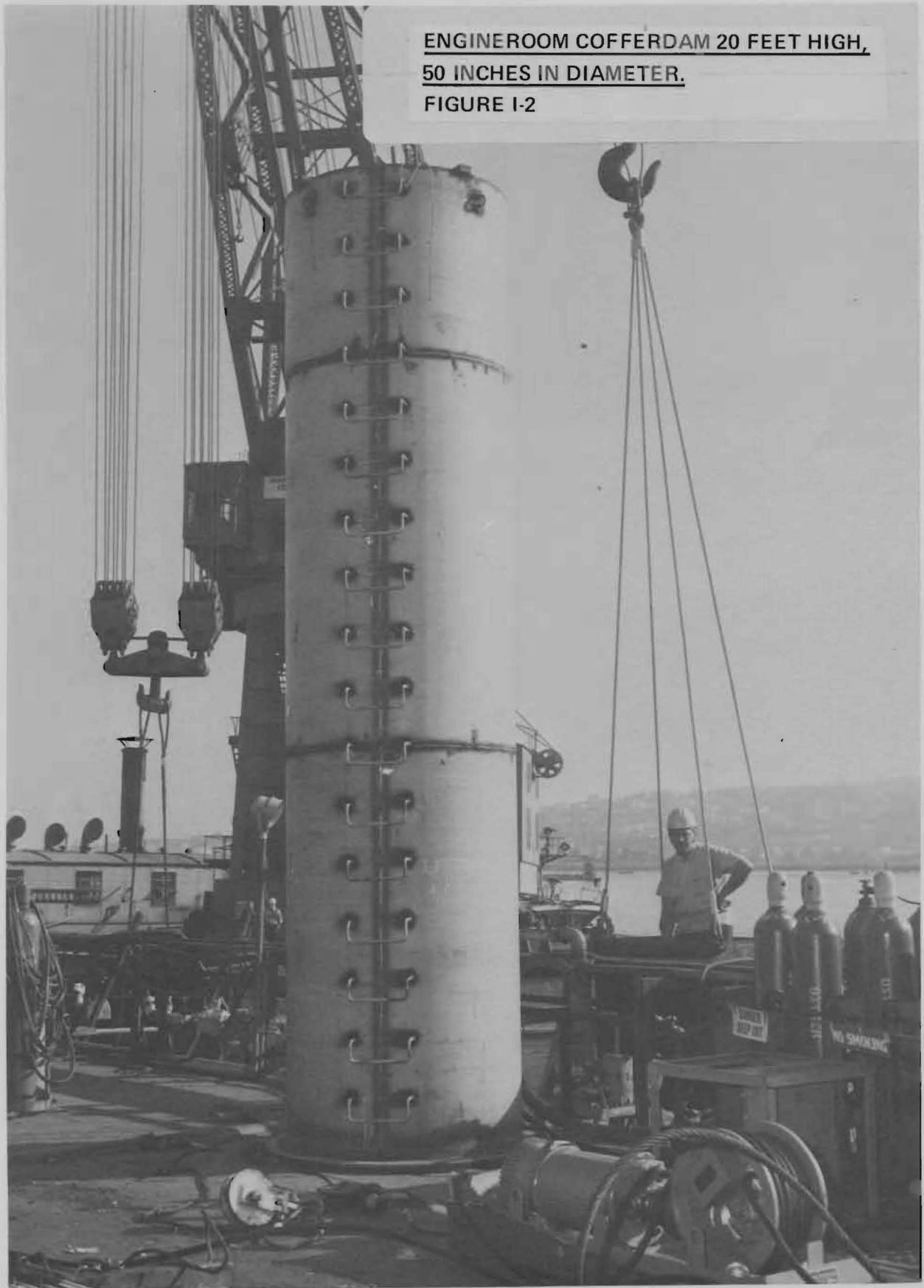
On the evening of 15 May 1969, at approximately 2130 local time, USS GUITARRO (SSN 665) sank alongside the pier at Mare Island Naval Shipyard, Vallejo, California. The ship sank due to uncontrolled flooding which originated in the forward part of the ship. After sinking, the ship came to rest with approximately a 6° port list; the fairwater above the sail planes remained above water, as did the conning tower access trunk. At the time of sinking no fissionable material was aboard. The ship was in an advanced state of construction. With the exception of the reactor, essentially all equipment was aboard. Ballast tank flood ports were temporarily welded closed and temporary covers were installed on ballast tank vents. The forward and after access trunks were open for normal personnel access. The following temporary openings existed:

COFFERDAMS ARE IN POSITION. TUG (YTM) AND CRANE
LIFTING BRIDLE ON THE STERN PREVENT THE SUBMARINE
FROM ROLLING OVER DURING PUMPING OPERATIONS.

FIGURE I-1



ENGINE ROOM COFFERDAM 20 FEET HIGH,
50 INCHES IN DIAMETER.
FIGURE I-2





- Sonar space. On the top side of the hull were two openings. A bolted access cover had been removed. A temporary access about 22 inches square had been cut. Two normally tight cable ways into the sonar space at FR.11 were not watertight due to work in progress.
- Reactor compartment. A temporary access (approximately 12 feet square) existed in the top of the hull for installing reactor components.
- Auxiliary Machinery Room Two (AMR-2). A temporary services opening existed in the top of the hull for power and ventilation. A temporary services trunk was welded to this opening, but was non-tight at the top where cables and ventilation ducts entered.
- Hole for missing engineroom high salvage air fitting.

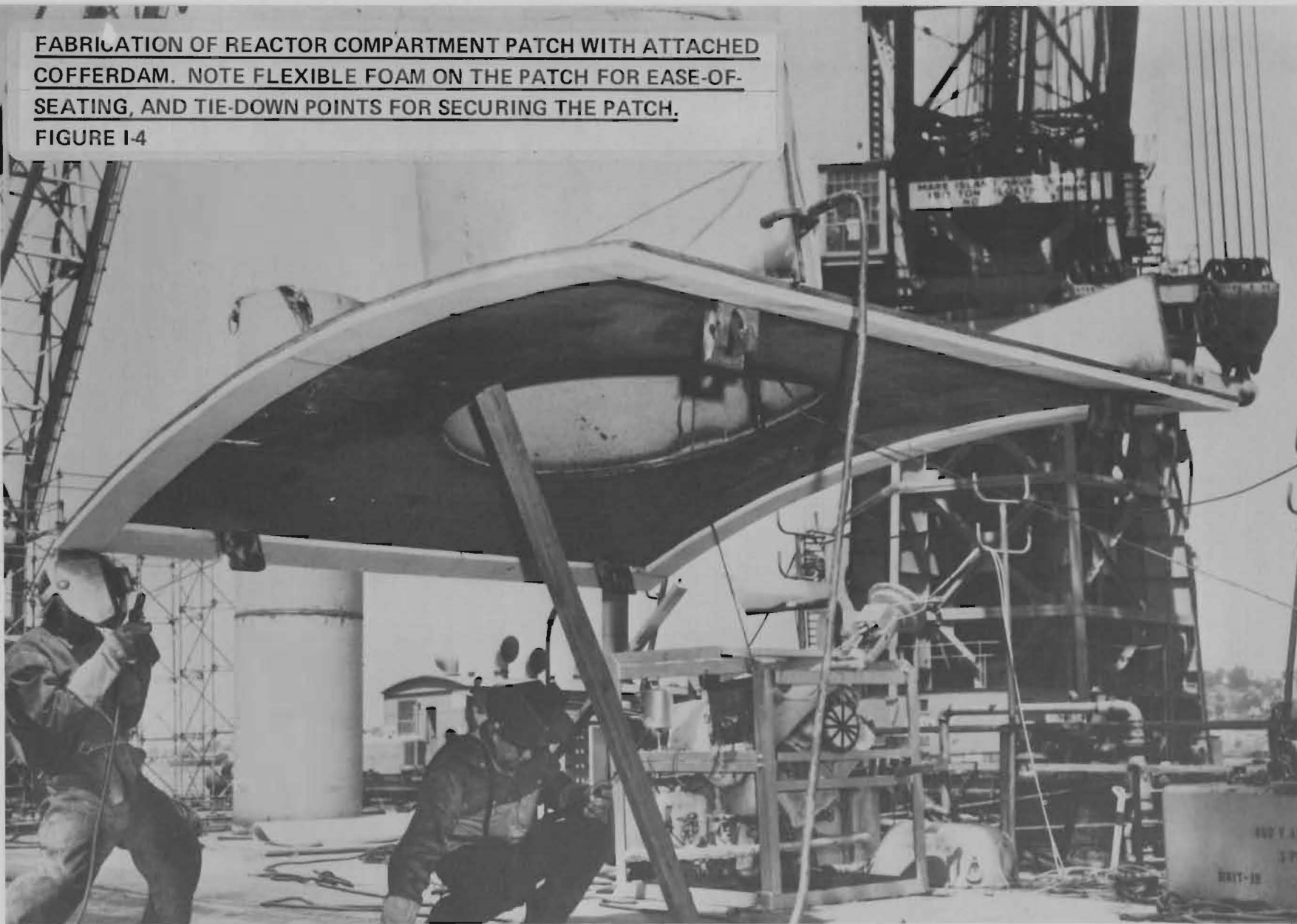
Initial efforts through the night and early morning of 15 - 16 May were concerned with closing internal watertight doors and hatches, clearing some of the maze of temporary service wires that cluttered the topside of the submarine, and closing or patching temporary access openings. Air hoses were rigged to the salvage air fittings in the forward two spaces (crew's living and operations spaces). Pressure was applied and these spaces were found to be watertight.

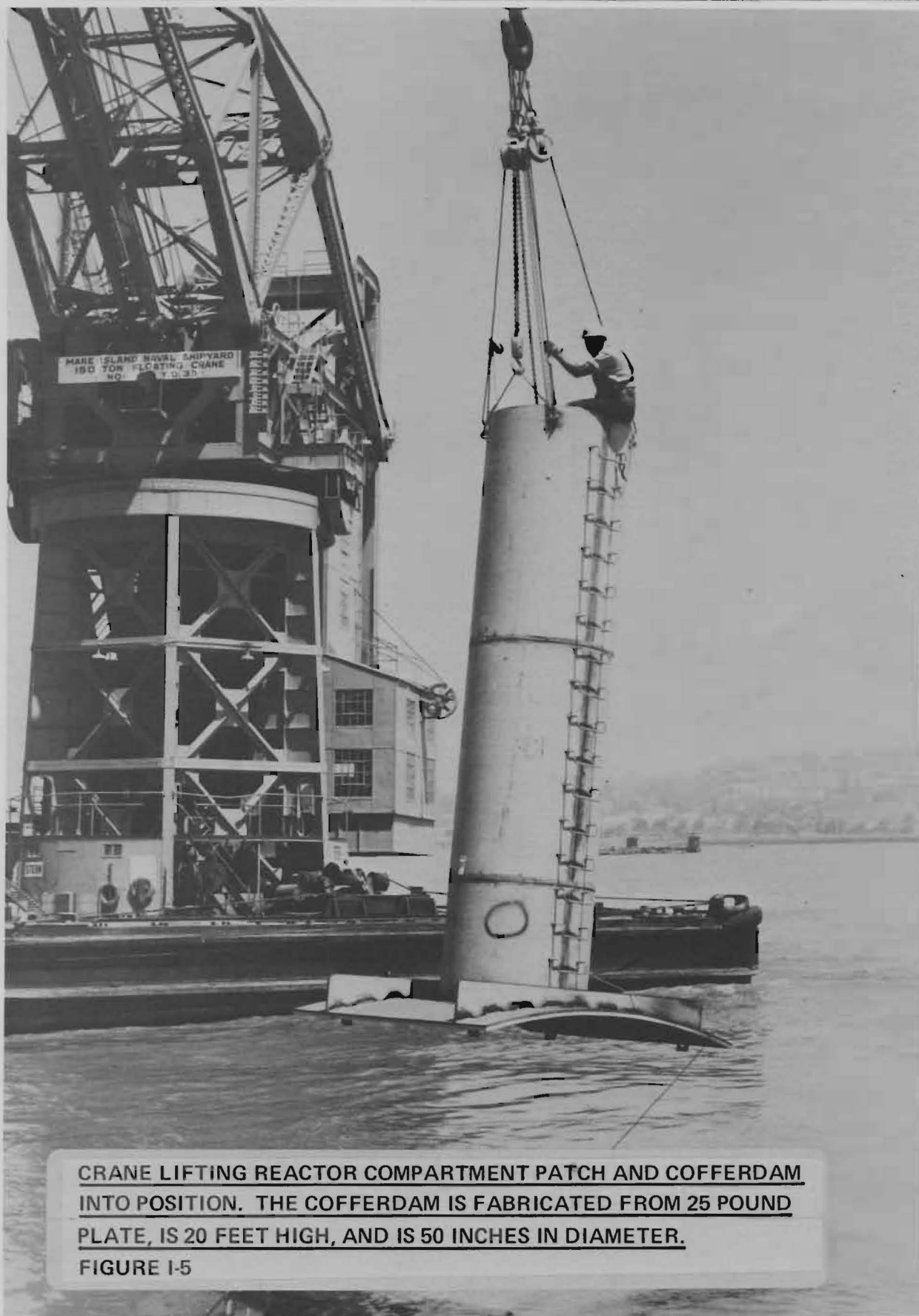
At 0830 on 16 May, after a review of the situation, it was determined that essentially all of the flood water must be removed from the submarine. Since approximately one-third of the hull was sunk into the mud, it was anticipated that some positive buoyancy would be required to overcome the effect of mud suction. The basic salvage plan was to make the hull watertight, then remove the flood water. Two basic means were available:

- Air Blow - The preferred way to raise a sunken submarine is by expelling flood water with air through the salvage air system.
- Erect Cofferdams - Since the conning tower access hatch was above water and the after access hatch and reactor compartments were only about 15 feet below the surface, it was feasible to pump water out through cofferdams.

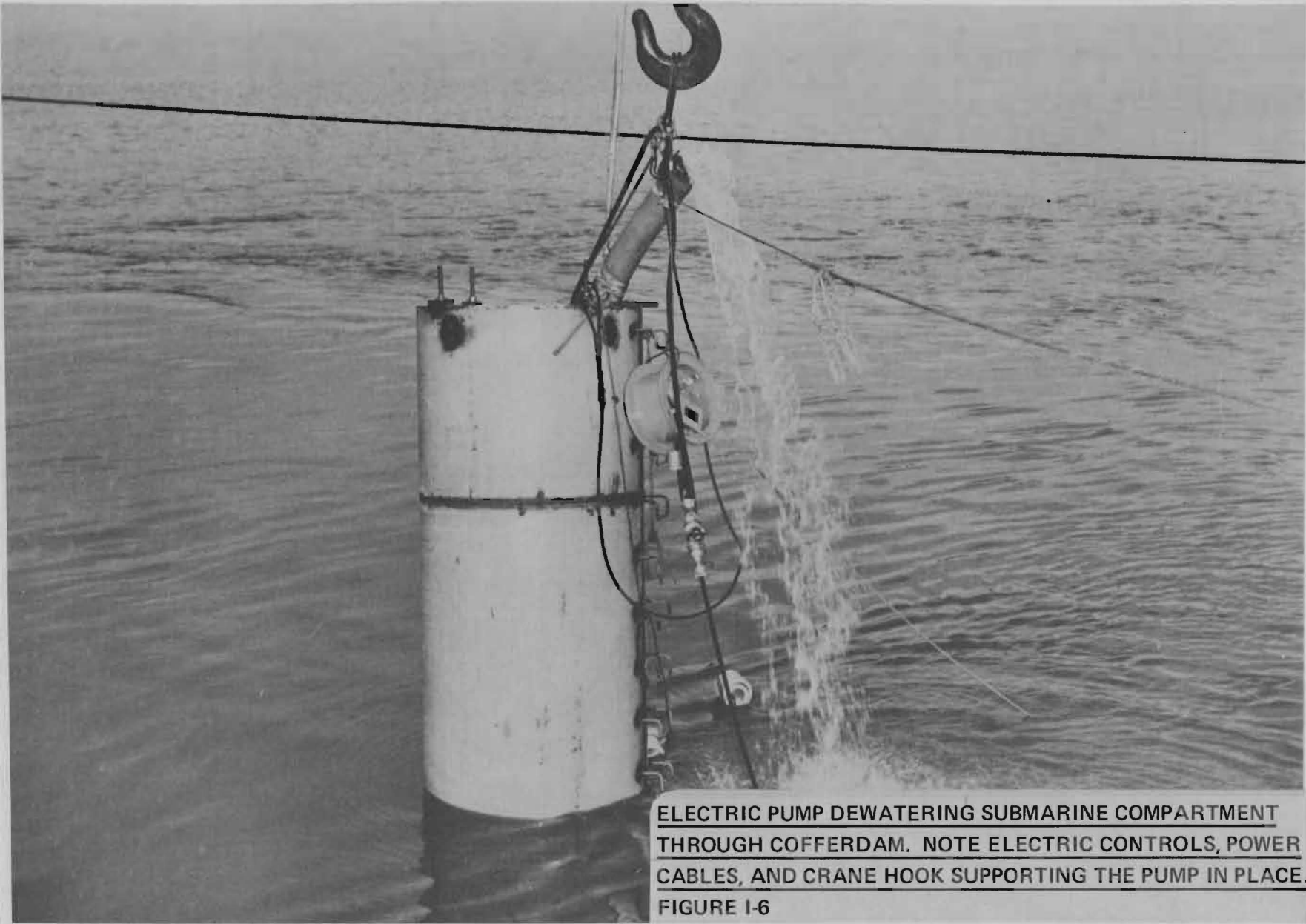
FABRICATION OF REACTOR COMPARTMENT PATCH WITH ATTACHED
COFFERDAM. NOTE FLEXIBLE FOAM ON THE PATCH FOR EASE-OF-
SEATING, AND TIE-DOWN POINTS FOR SECURING THE PATCH.

FIGURE I-4





CRANE LIFTING REACTOR COMPARTMENT PATCH AND COFFERDAM
INTO POSITION. THE COFFERDAM IS FABRICATED FROM 25 POUND
PLATE, IS 20 FEET HIGH, AND IS 50 INCHES IN DIAMETER.
FIGURE I-5



ELECTRIC PUMP DEWATERING SUBMARINE COMPARTMENT
THROUGH COFFERDAM. NOTE ELECTRIC CONTROLS, POWER
CABLES, AND CRANE HOOK SUPPORTING THE PUMP IN PLACE.
FIGURE I-6

The salvage plan actually used both methods. The forward two spaces were blown for about eight hours. When it became obvious that pumping would be much faster than blowing, the blow was secured and pumping became the primary means for dewatering. Pumping had two additional advantages:

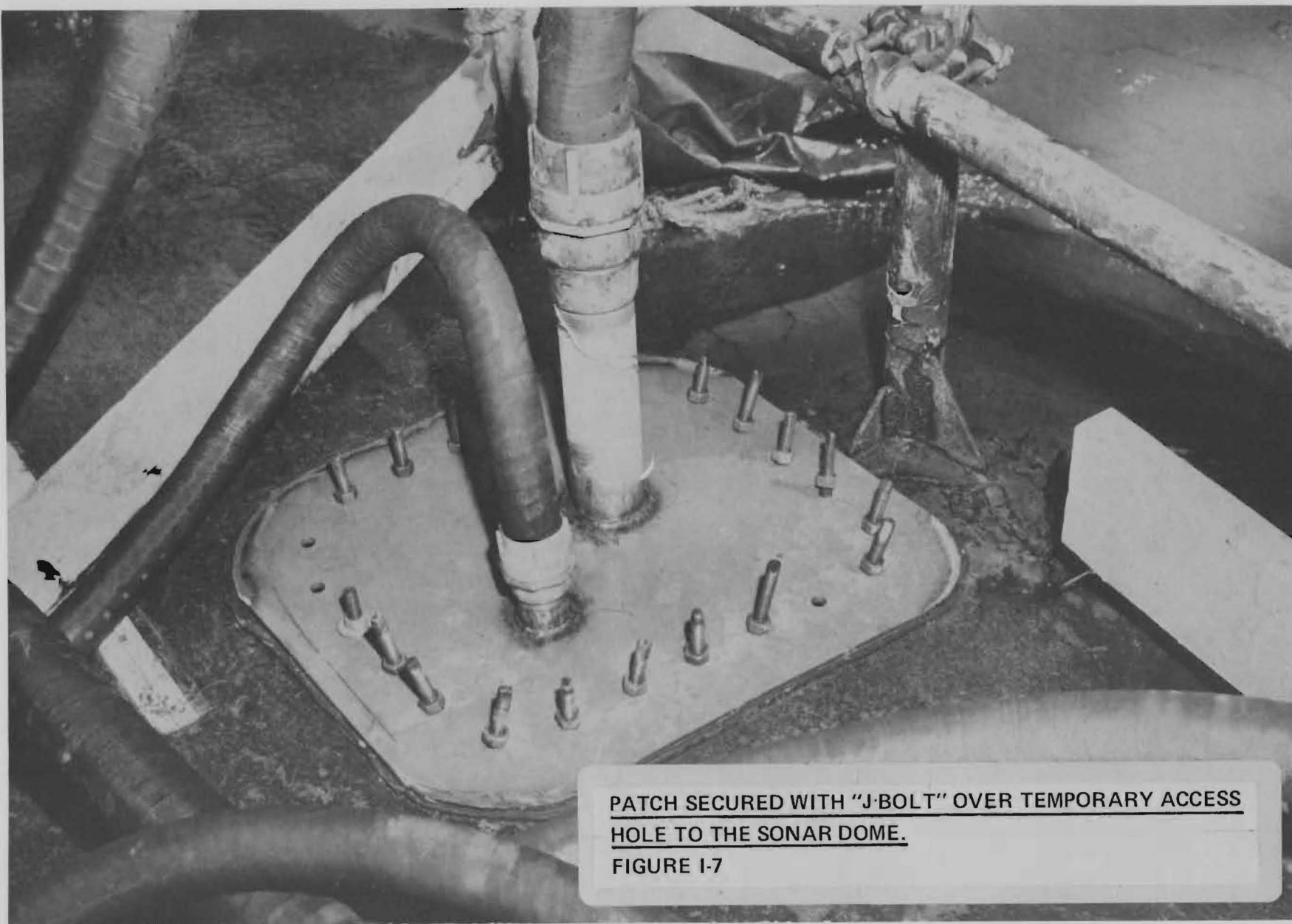
- Since the submarine could be entered during pumping operations, the exact status of buoyancy was known at all times. This permitted the final refloating to be a controlled operation.

- Pumping permitted the removal of residual water that could not be expelled by blowing. Low reserve buoyancy made the removal of this water essential.

Calculations indicated that the ship was in a stable condition, though righting arms were quite low due to the flooding water. As flooding water was removed stability continually improved because of the lowering of the center of gravity. The only concern was the possibility of developing an upsetting moment caused by a free surface effect on the watertight deck of the torpedo room. This was avoided by stripping this space of all water prior to the refloating effort.

The daylight hours of 16 May were spent in clearing an access through the maze of temporary service lines by divers so that all hull openings could be identified, templated, and made ready for patches. Cofferdams had been designed and were being constructed by shipyard personnel. The 150 ton crane was connected to GUITARRO aft to provide additional stability. During the evening of 16 May preparations were made to blow the main ballast tanks forward. Temporary protective plates over the vent valves were removed by divers. Since three vent valves were closed hydraulically, it was necessary for divers to remove the entire vent valve mechanism. This job was completed with the assistance of a dockside crane on 17 May.

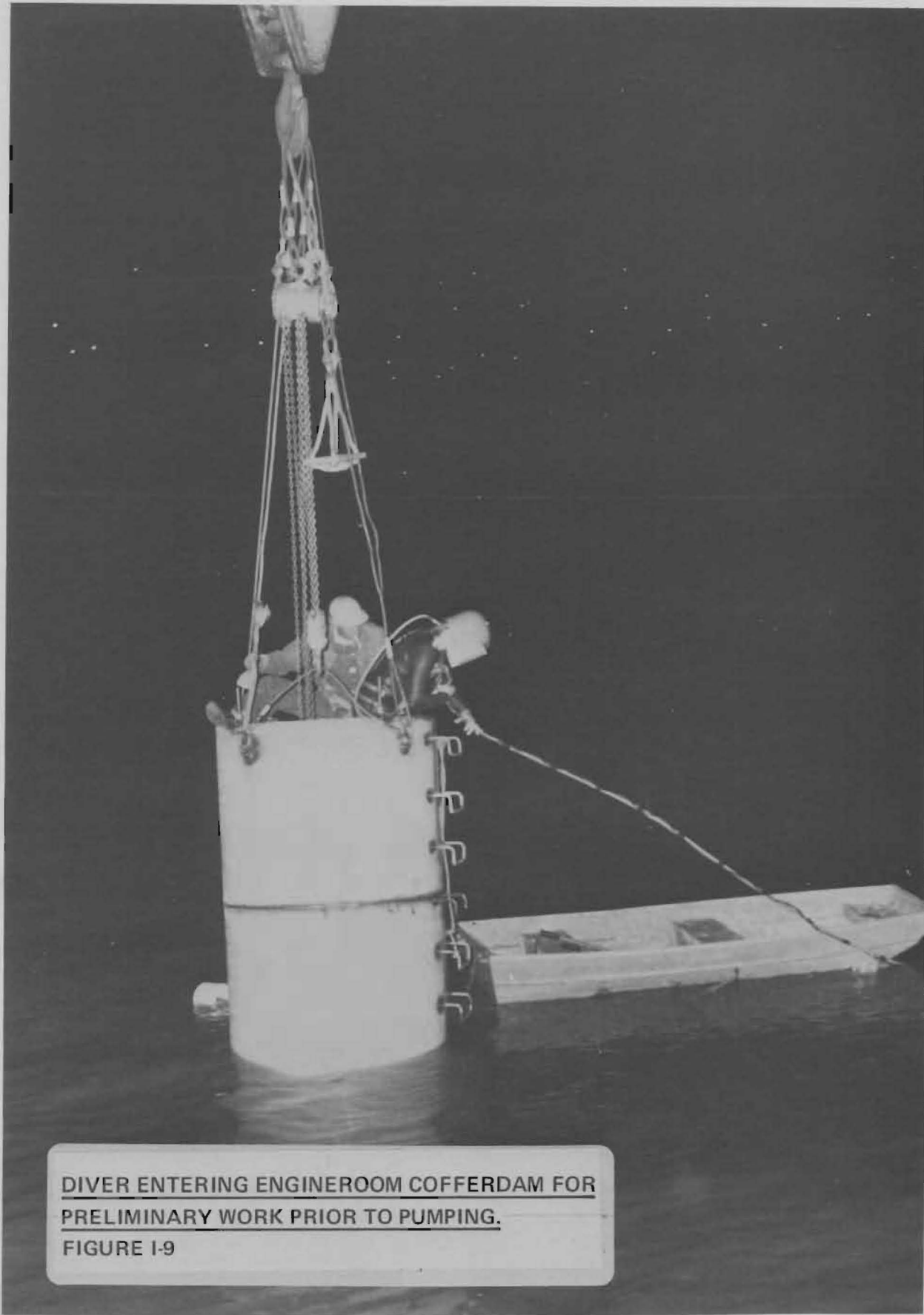
On 17 May all patching was completed. Cofferdams were installed on the after access hatch and on the patch for the reactor compartment. Blow fittings were installed on main ballast tanks forward, and a fitting to pump the sonar dome underwater was installed. At 0500 the forward two spaces were pressurized and water expulsion commenced. This blow continued until 1240, when it was decided to shift to pumping. These spaces were vented, and at 1825 the conning tower access hatch was opened. Salvage crews entered the submarine and found the water level forced down to about three feet below the upper level. Prior to the entry of personnel into the submarine, careful checks were made for chlorine and hydrogen gas; none was found.



PATCH SECURED WITH "J-BOLT" OVER TEMPORARY ACCESS
HOLE TO THE SONAR DOME.
FIGURE I-7

FORWARD BALLAST TANK PATCH IN POSITION.
FIGURE I-8





DIVER ENTERING ENGINE ROOM COFFERDAM FOR
PRELIMINARY WORK PRIOR TO PUMPING.
FIGURE I-9

At 1700 pumping commenced through the reactor compartment cofferdam and at 2355 pumping commenced through the engineroom cofferdam. The recommended dewatering sequence was followed as a guide, but when it became apparent stability would not be a problem, the sequence was modified. It was decided to completely dewater the submarine with the exception of AMR-2. This flood water was used as ballast to prevent the submarine from surfacing until all preparations had been made.

Pumping and stripping operations continued through the early morning of 18 May. By about 1030 pumping and stripping operations had been completed with the exception of AMR-2. All was now in readiness for the first refloating effort. At 1057 pumps were started on AMR-2 and a 20 ton strain was taken on the floating crane shackled to the stern. At 1119 the submarine rose to the surface. On surfacing the submarine trimmed by the stern, with the top of the rudder below water. The after trim was probably caused by water from AMR-2 moving aft into the engineroom as the submarine surfaced. Salvage crews then entered the submarine for the final stripping effort. At about 1700 stripping operations were complete and the submarine was sufficiently buoyant to enter drydock.

On the evening of 18 May USS GUITARRO entered Drydock #3, Mare Island Naval Shipyard, and salvage operations were terminated.

I.3. Detail Discussion of Weight, Buoyancy, Stability,
and Recommended Sequence of Actions to Float
GUITARRO (SSN 665)

Buoyancy - Weight Factors (A)

Available evidence indicates that the submarine was floating at the top of the boot topping (which is 6" above normal diving trim draft). This indicates the displacement, prior to start of accidental flooding, was 4266 tons.

At the time Main Ballast 1, 2A, and 2B were full, Main Ballast 3A and 3B contained 30 tons, the forward sonar tank was dry.

Estimating the initial condition on the basis of the condition A weight of the SSN 662, on the assumption that SSN 662 and SSN 665 are both very close to calculated (which was the case in 662), gives:

NOTE : Reference Submarine Guidance Plan, Figure I-15
 for compartmentation details.

Condition A 4002 Tons - Including Sonar Tank
 - 143 - Sonar Tank
 3859
 + 273 Main Ballast Tank 1, 2A & 2B, Partial Main
 Ballast Tank 3A & 3B and Variable Ballast
 4132
 - 49 Internal Tanks
 4083 Tons

Therefore, initial condition range was between 4083 tons and 4226 tons.

The flooded weight on the bottom is based on design dimensions minus permeability factor times density of water (measured). Variable ballast tanks are also considered on the basis of the reported initial condition which is calculated to be 80.18 tons. Minimum weight calculation assumes no further flooding occurred. Maximum weight calculation assumes complete flooding of remaining volume which would be about 78 tons. Main Ballast Tank 3A and 3B flooded an additional 58 tons. Forward sonar dome flooded 143 tons.

Based on the recommended sequence of actions in the following section, Recommended Sequence, the estimated minimum and maximum weights are shown in Table I. The net weight holding the ship on the bottom is shown in Table II.

Stability (B)

Condition on bottom with all internal compartments flooded, Bow Sonar Tanks and Main Ballast Tanks 1, 2, & 3 flooded, Main Ballast Tanks 4, 5, and 6 dry, and assuming that all internal tanks are dry, which would be the worst case, positive stability (BG) equals about 0.17A.

Dewater Operations Compartment, Forward Room, and
Sonar sphere BG = 0.53 ft.

Dewater Engine Room BG = 0.82 ft.

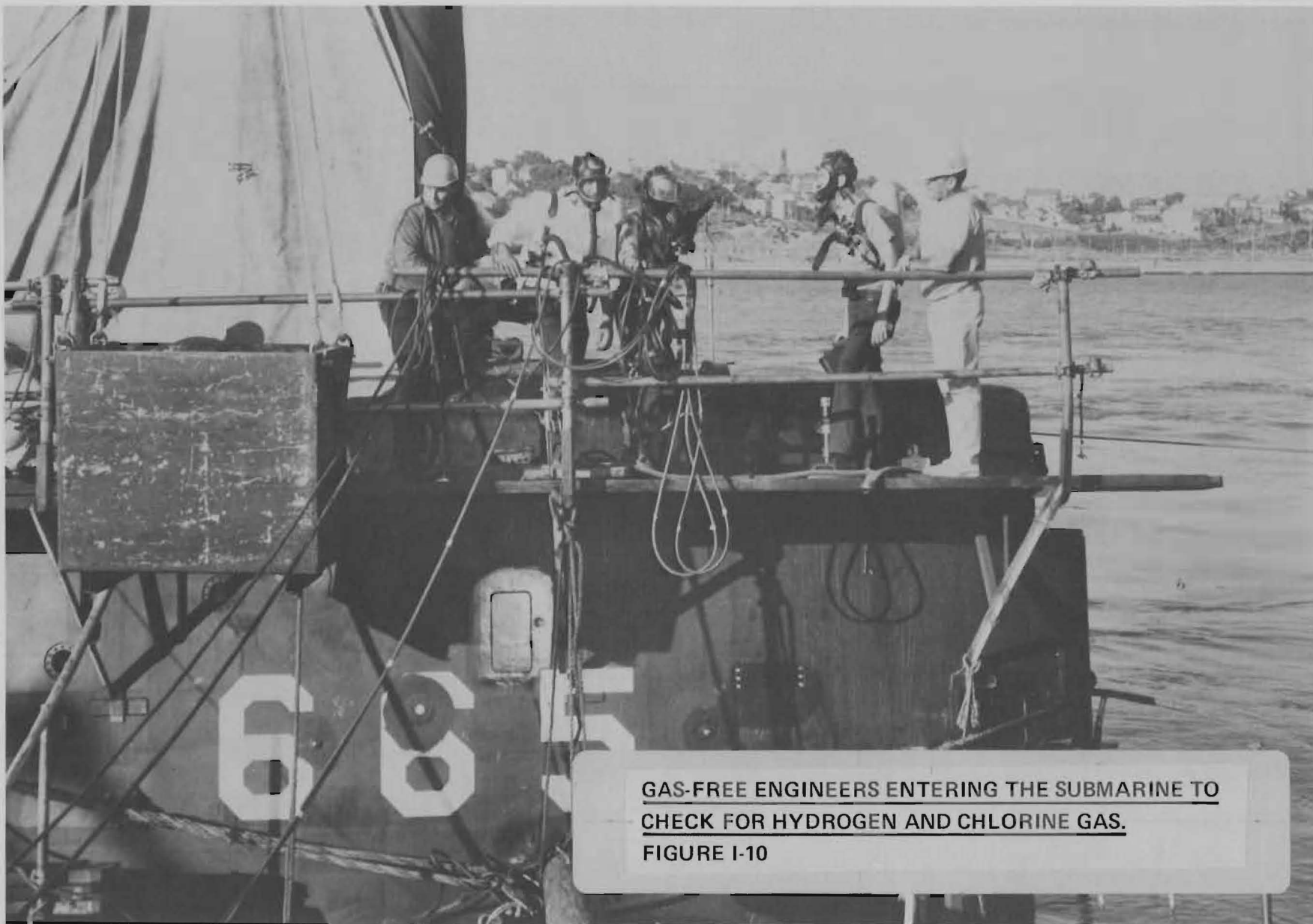
Fill Main Ballast Tanks 4 and 5 BG = 0.80 ft.

Dewater Auxiliary Machinery Room BG = 0.82 ft.

Blow Main Ballast Tank as recommended ... BG = will increase

Recommended Sequence (C)

The submarine should remain on the bottom until a controlled effort to raise it is ready.



GAS-FREE ENGINEERS ENTERING THE SUBMARINE TO
CHECK FOR HYDROGEN AND CHLORINE GAS.
FIGURE I-10



150 TON FLOATING CRANE CONNECTED TO GUITARRO STERN TO PROVIDE
STEADYING MOMENT. NOTE DEBRIS CLEARANCE IN PROGRESS.

FIGURE I-11

Precise weights and conditions are not achievable; a bandwidth of possible error, on both sides of the best estimate, is required to insure control. The potential error quantities are:

- condition of variable tanks
- amount of residual water remaining
- lack of precise knowledge of initial weight of the ship before the casualty

An excessive trim circumstance is undesirable during the transitory conditions.

The following sequence is proposed:

- Dewater Operations Compartment and Forward Room and strip to lower flat (deck).
- Dewater Engine Room and strip to bottom of bilges.
- Fill aft Main Ballast Tank group Tanks 5A and 5B.
- Dewater Auxiliary Machinery Room.
- Do not dewater Reactor Compartment or Forward Sonar Tank.
- Blow Main Ballast Tanks in following sequence:
 1. 5A, 5B, and 1
 2. 3A and 3B
 3. 4A and 4B and 2A and 2B

Ship should rise (See Table II)

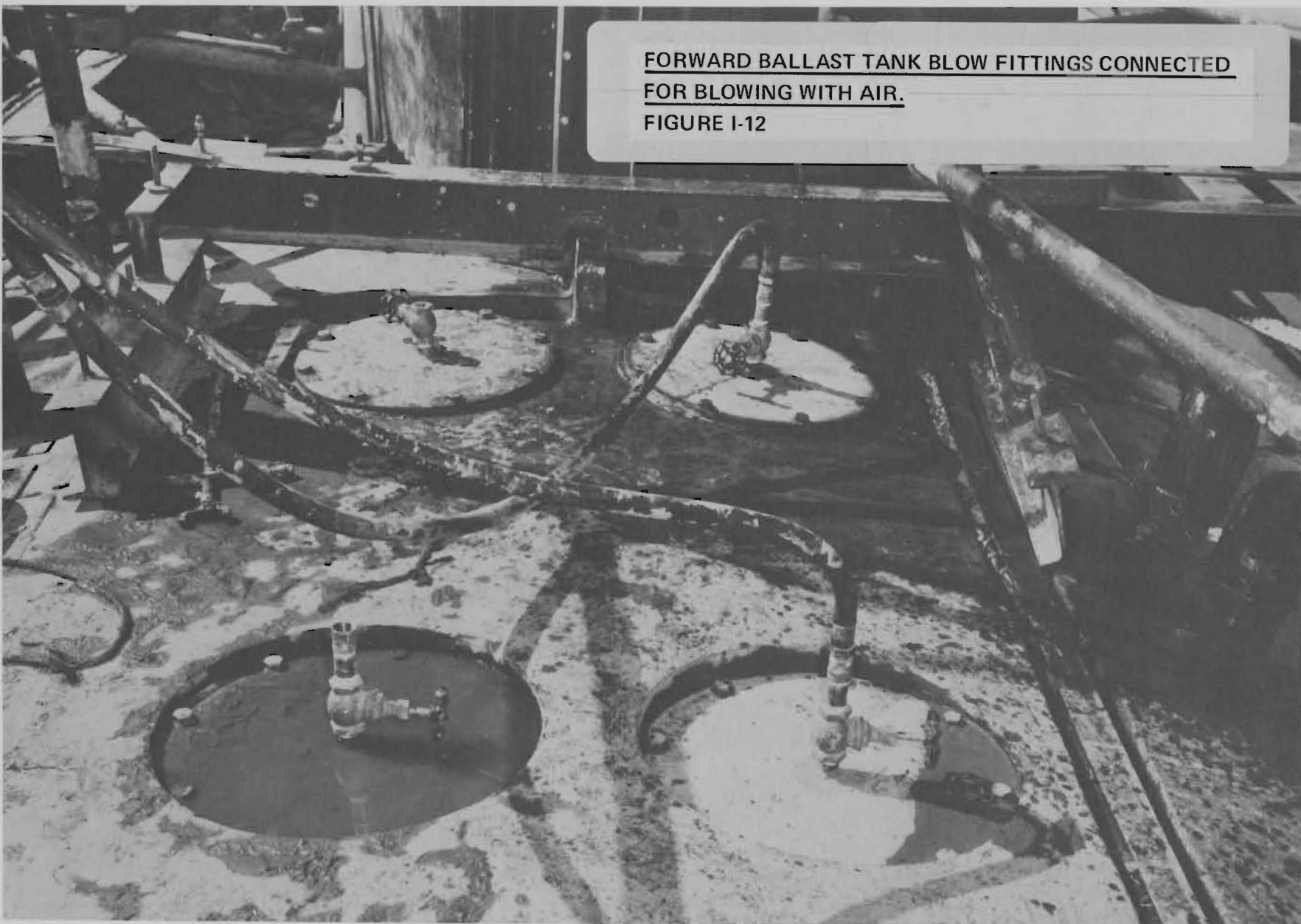
- If ship does not break free, refill main ballast tanks and pump down Reactor Compartment.
- Blow forward and aft main ballast tanks per prior sequence.

I.4. Bottom Breakout Forces

When GUITARRO sank approximately one-third of the hull settled into a very soft mud. In view of the anticipated difficulty in completely dewatering GUITARRO, it was feared that bottom breakout forces due to mud suction might become important.

Preparations were made to overcome the mud suction effect if required. These included (1) hydraulic lances connected to a jetting pump for washout of mud, (2) the use of tugs to rock GUITARRO, and (3) the use of a 150 ton crane to provide additional lift. GUITARRO surfaced before any of these actions were required. The initial surfacing displacement of GUITARRO was about 80 tons. This force is estimated to be approximately the bottom breakout force.

FORWARD BALLAST TANK BLOW FITTINGS CONNECTED
FOR BLOWING WITH AIR.
FIGURE I-12





GUIRARRO SALVAGE OPERATION. LOOKING FORWARD.
FIGURE I-13

GUITARRO SALVAGE OPERATION. LOOKING AFT.
FIGURE I-14

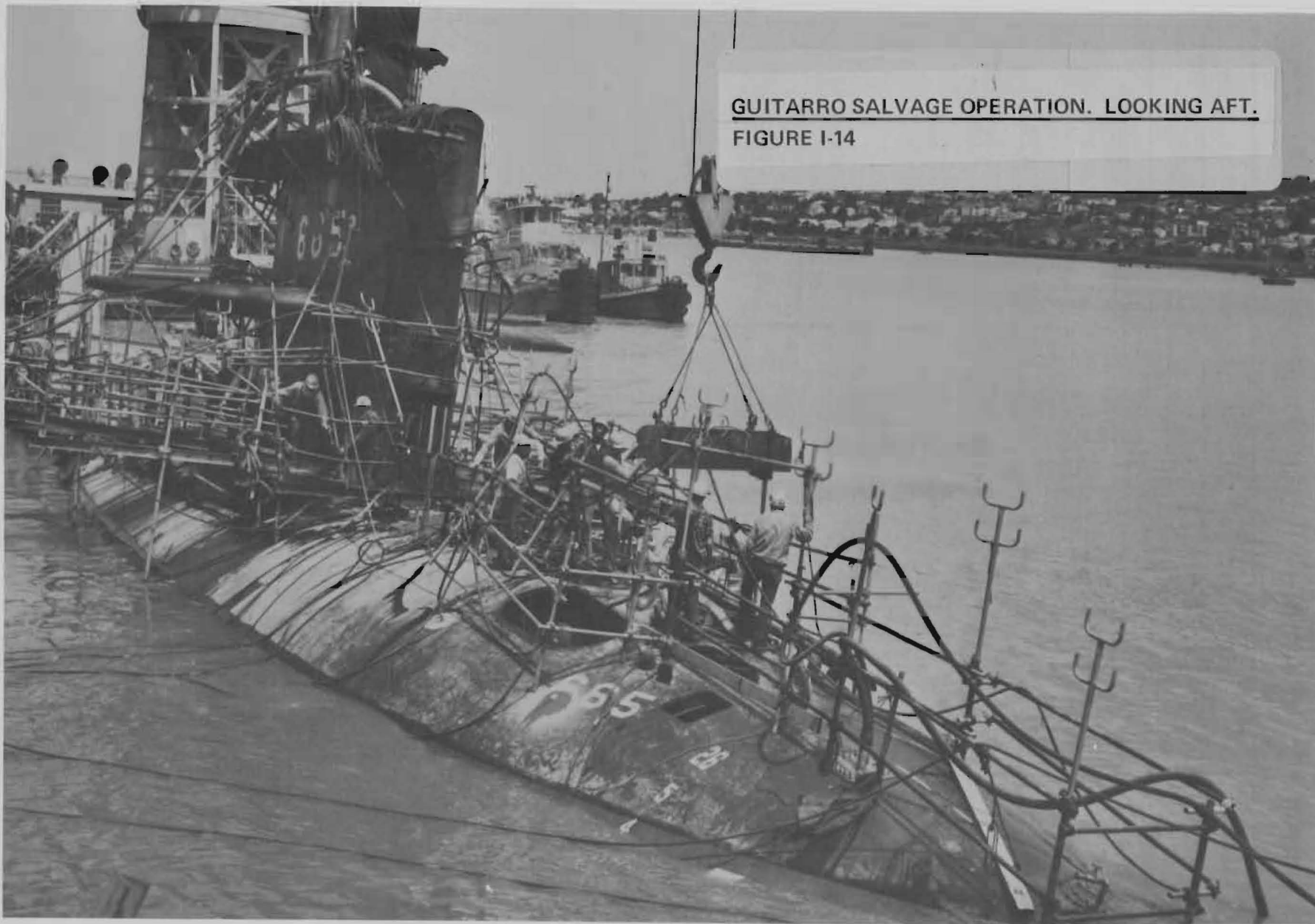


TABLE I

ESTIMATED MINIMUM AND MAXIMUM WEIGHT FOR VARIOUS CONDITIONS		
	ESTIMATED WEIGHT	
	Minimum	Maximum
Original Condition (Calculated Displacement)	4083	4226
All Compartments ..	2752	2752
Flooded Condition Sonar Dome	143	143
Internal Tanks and Partial Main Ballast Tank 3	0	136
	6978	7257
Dewater Operations Compartment (-1103)	5875	6154
Dewater Forward Compartment (-262)	5613	5892
Dewater Engine Room (-804)	4809	5088
Fill Main Ballast Tank 5A and B (+137)..	4946	5225
Dewater Auxiliary Machinery Room (-281).	4665	4944
Retain Reactor Compartment Water and Sonar Tank (301 and 143)	4665	4944

ESTIMATED MINIMUM AND MAXIMUM WEIGHT FOR VARIOUS CONDITIONS.

TABLE I-1

TABLE II

WEIGHT, DISPLACEMENT, AND NET WEIGHT HOLDING SHIP ON BOTTOM, ASSUMING REACTOR COMPARTMENT FLOODED			
	MINIMUM WITHOUT RESIDUAL	MAXIMUM WITHOUT RESIDUAL	MAXIMUM WITH 150 TONS RESIDUAL
Weight Submerged	4665	4944	5094
Submarine Displacement	4684	4684	4684
Net Weight Holding Ship to Bottom	-19	260	410
Blow Main Ballast Tanks 5A and B Plus Main Ballast Tank 1.	-221	58	208
Blow Main Ballast Tanks 3A and B	-309	-30	120
Blow Main Ballast Tanks 2A and B	-391	-112	38

WEIGHT, DISPLACEMENT, AND NET
WEIGHT HOLDING SHIP ON BOTTOM,
ASSUMING REACTOR COMPARTMENT
FLOODED.

TABLE I-2

I.5. US NAVY Submarines

The US NAVY operates several classes of submarines. For complete specifications, booklet of general plans, stability information or other information necessary for submarine salvage, contact:

Supervisor of Salvage
(Ships OOC)
Naval Ship Systems Command
Department of the Navy
Washington, D.C. 20360