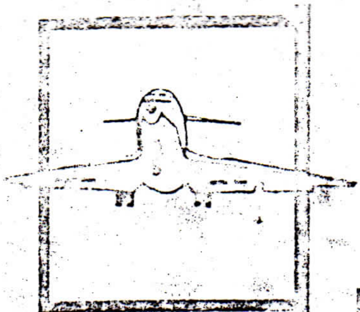

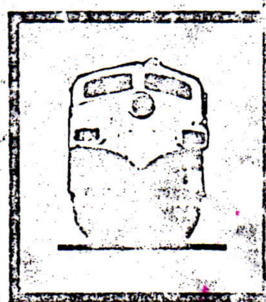

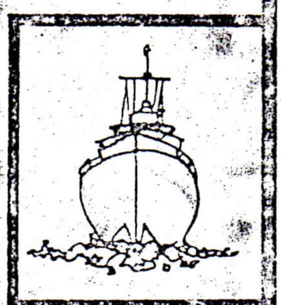

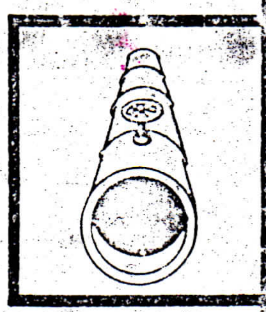

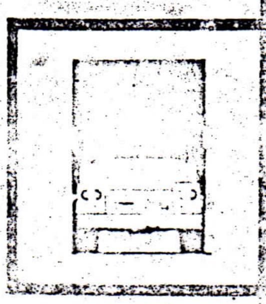

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

MARINE ACCIDENT REPORT

SINKING OF THE M/V CHESTER A. POLING NEAR CAPE ANN, MASSACHUSETTS JANUARY 10, 1977

REPORT NUMBER: NTSB-MAR-78-7

UNITED STATES GOVERNMENT

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16. Abstract About 1040 e.s.t. on January 10, 1977, the M/V CHESTER A. POLING, a 281-foot coastal tankship broke in two about 6 nmi ESE of Cape Ann, Massachusetts, while en route from Everett, Massachusetts, to Newington, New Hampshire, during a severe winter storm. The vessel was partially ballasted and carried no cargo; only minor pollution resulted. Of the seven persons aboard, six persons were rescued and one person is missing and presumed dead.

The National Transportation Safety Board determines that the probable cause of the accident was the brittle fracture of a bottom longitudinal stiffener, which led to buckling of the adjacent bottom plating panels and subsequent failure of the complete bottom and sides. The bottom longitudinal stiffener failed because of the high stresses created by the improper distribution of ballast water and the heavy seas. Contributing to the accident were the lack of a loading manual to indicate proper ballasting procedures, the speed of the vessel, and the inaccuracy of the National Weather Service's weather forecasts.

Contributing to the loss of life were the lost seaman's failure to wear a personal flotation device, and the improper handling of the Coast Guard helicopter's rescue basket by the POLING's crew, which resulted from the crew's lack of training and their inability to hear Coast Guard instructions over the noise created by the helicopter, high winds, and breaking seas.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

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Adopted: September 14, 1978

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INVESTIGATION

The Accident

About 2200 [1] on January 9, 1977, the coastal tankship M/V CHESTER A. POLING arrived at the Exxon Terminal, Everett, Massachusetts, fully loaded with 21,000 barrels of kerosene. The master of the POLING was standing his customary 1800 to 2400 watch. During this watch, he listened to the National Weather Service (NWS) marine weather forecast for the following day. About 2330, cargo offloading commenced, and the master was relieved by the chief mate at 2400.

1/ All times are Eastern standard time based on a 24-hour clock.

During his customary 2400 to 0600 watch, the chief mate spoke with a person on board the M/V POLING BROS. NO. 7 about 0130 by VHF radio as that vessel was approaching Cape Ann, Massachusetts. The person told the chief mate that the weather "wasn't too bad" at that time. He also listened to the current NWS marine forecast. When the master relieved the chief mate about 0530, January 10, 1977, they briefly discussed the prevailing weather conditions and the communication with the POLING BROS. NO. 7. When cargo offloading and voyage preparations were completed, the POLING departed the terminal about 0615, for Newington, New Hampshire.

The main propulsion engines, auxiliary machinery, steering system, navigation equipment, and communications equipment were operating normally. The two seamen on watch maintained a wheelhouse lookout and ballasted the vessel as the master instructed. Shortly before departure, the master had ordered the Nos. 3 and 5 tanks, port and starboard, to be filled with saltwater ballast. These tanks were completely filled by 0720 when the POLING passed buoy "NC" outside the entrance to Boston Harbor. (See figure 1.)

At 0730, the POLING was rolling slightly and traveling about 7 kns. The master testified that the vessel was handling well and pitching slightly but not pounding. However, based on the marine weather forecast that the master received at this time, he decided that additional ballast was necessary and ordered the No. 4 tanks, port and starboard, to be filled. These tanks were filled by about 0820 when the vessel began pounding slightly in the vicinity of buoy "DG" east of Nahant Bay. The normal trackline for this part of the voyage was 048° 2/, but the master had found it necessary to steer various headings between 050° and 060° to correct for the vessel's wind-induced drift. He reduced speed in order to reduce the vessel's rolling, which had been steadily increasing. The master altered course temporarily to 341°, which was the normal heading toward Newington after passing Cape Ann, to see how the vessel would handle on that heading. The master concluded that the POLING rode satisfactorily on the 341° heading, and testified that there was nothing unusual about the voyage at this point. He said he considered returning to Boston because of the weather, but decided to continue the voyage. About 0840, he noticed that the wind and seas were increasing; he estimated the wind to be about 30 to 35 kns from the east-northeast and the seas to be about 10 to 15 ft.

The master ordered the No. 2 tanks, port and starboard, to be filled and further reduced speed while the seaman on watch went aft on the deck to operate the ballasting equipment. This speed reduction was necessary to decrease the amount of spray and water coming over the starboard side, which made working on deck difficult and hazardous. By about 0930, the No. 2 tanks, port and starboard, were almost full, and the master believed he had sufficient ballast on board (tanks Nos. 2, 3, 4, and 5, port and starboard) for the existing weather conditions. No problems had been experienced with the ballasting system, and the master determined it to be unnecessary to fill tanks Nos. 1 and/or 6.

2/ All compass headings reference true north.

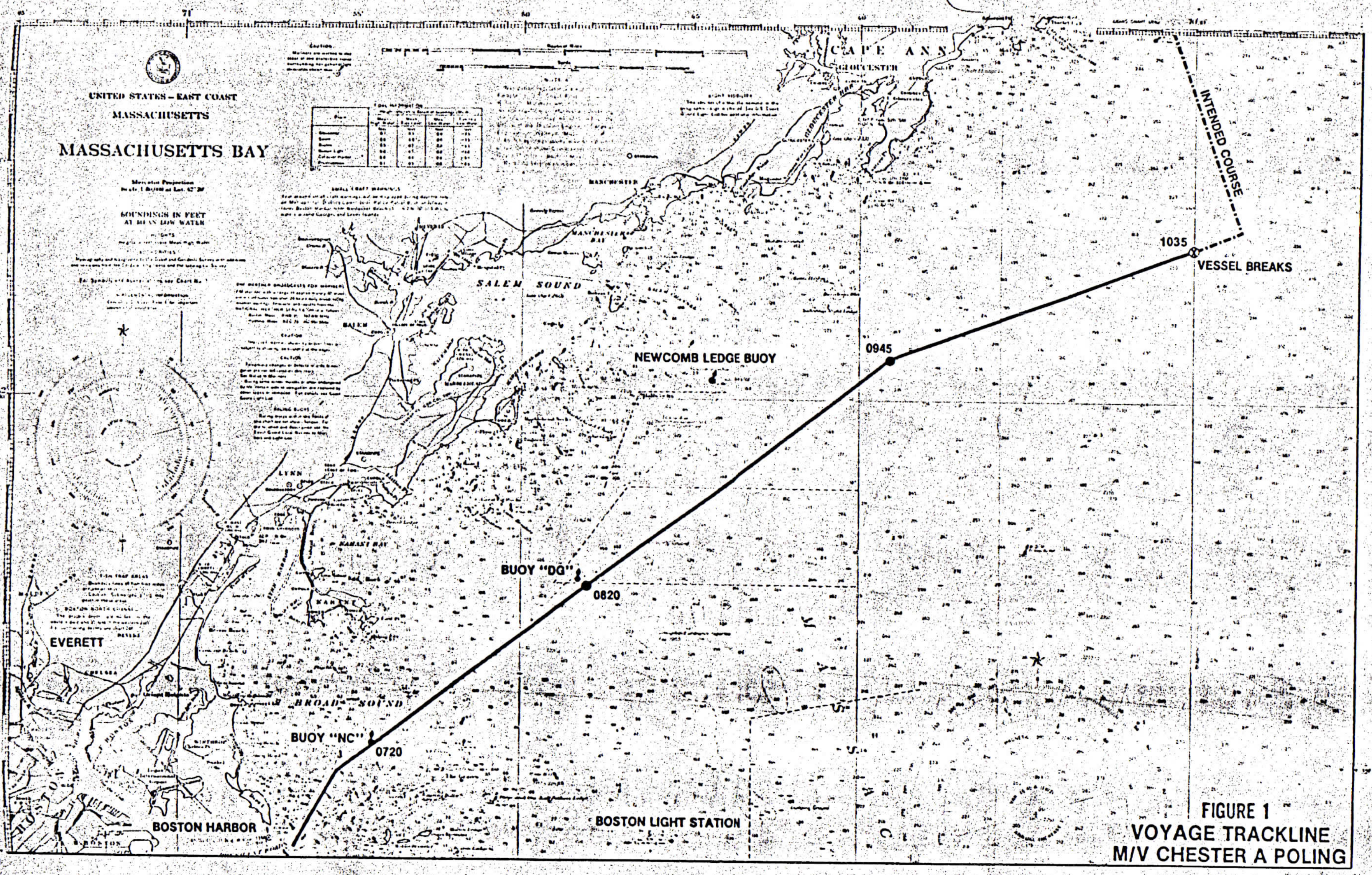

FIGURE 1
VOYAGE TRACKLINE
M/V CHESTER A POLING

The master testified that on a normal ballast voyage tanks Nos. 3 and 5 were filled for calm weather and sea conditions. If the seas increased slightly, ballast would be added to the No. 4 tanks, and for more severe seas the No. 2 tanks also would be filled. Tanks Nos. 1 and 6 were seldom used for ballast.

As the POLING proceeded on course, it pounded occasionally and the master varied the speed from about 2 to 8 kns to minimize the pounding. About 0940, when the POLING was approximately 4 nmi east of the Newcomb Ledge buoy, the master again briefly turned to a heading of 341° to determine the vessel's response to the sea on that heading. He concluded that the vessel handled satisfactorily. The master also again considered seeking shelter from the storm. He testified that he decided if he were going to seek shelter from the storm, he would return to Boston Harbor, because the anchorage in Gloucester Harbor would not be "too good" and a southeast wind "goes right in there." The testimony does not indicate the master's reasons for rejecting Salem Harbor. (See figure 1.) Also, he had successfully piloted the POLING during more severe weather and sea conditions. The master realized that the weather was becoming worse than the NWS had forecasted, but he believed that the POLING would round Cape Ann before it "really picked up."

Twice during the previous winter, the master had returned the POLING to harbor because of severe weather and sea conditions. He testified that he would have returned to Boston on this voyage if his final destination had been Portland, Maine, rather than Newington. Considering the weather and his several options, he decided that his best course of action would be to make the course change for the final leg of the voyage as soon as possible, and about 0945 he altered course to 080° to bring the POLING into position to make the course change to 341° to round Cape Ann and proceed to Newington.

The wind and seas continued to increase. About 20- to 25-ft seas normally were encountered from about 080° to 090°. The distance between the wave crests was about 150 ft. The master continued to vary the POLING's speed, but now from about 2 to 6 kns, to diminish the increased pounding.

About 1015, the master and seaman on watch heard a banging noise. As the master reduced speed, the seaman went out on deck to investigate, but he did not see anything adrift and could not determine the cause of the noise. The master believed that a wooden fender under the wheelhouse was banging as it had on previous trips. After the seaman returned to the wheelhouse, the master increased speed slightly and then determined the position of the POLING by radar and LORAN 3/ about 1020.

3/ LORAN is an electronic navigation system that uses synchronized pulse signals to determine hyperbolic lines of positions.

About 1035, the POLING encountered an unusually large wave, estimated by the seaman on wheelhouse lookout to be about 45-ft high. As the bow rose on the wave, another large bang was heard and the vessel lurched. The hull split about 27 ft forward of amidships. The deck remained intact, but the bottom and sides split completely. The bow and the stern began to rise as the midsection of the vessel settled deeper into the water with the intact deck acting as a hinge. The starboard main propulsion engine, generator, and steering system immediately stopped operating. The engineer later shut down the port main propulsion engine and the heating plant. The emergency lighting system activated properly, and the battery-powered VHF radio remained operational.

The seaman on watch activated the general alarm, which operated properly and alerted the crew in the after deckhouse. The chief engineer was alerted by the starboard engine's stopping, and the chief mate heard several thumps just before the general alarm sounded. The master broadcast a Mayday message on VHF Channel 13, which was received by the 95-ft Coast Guard cutter CAPE GEORGE in Gloucester Harbor. The CAPE GEORGE was underway at 1045, and the 95-ft Coast Guard cutter CAPE CROSS, which had been undergoing repairs, was underway at 1115.

Upon hearing the general alarm, the crewmembers on the stern of the POLING immediately donned personal flotation devices (PFD) and assembled on the afterdeck. The master and the seaman on watch were effectively isolated on the forward part of the vessel because the entire midsection was underwater and the catwalk had been torn apart. The master's only means of communication with the crew on the afterdeck was a battery-powered megaphone, which ceased operating after the crew had been instructed to remain calm and that the Coast Guard was responding. The master estimated the expected position of the POLING at the anticipated time of arrival of the CAPE GEORGE, and radioed the information to the Coast Guard. He also requested that the crewmembers on the stern be rescued first.

The crewmembers on the stern of the POLING released the inflatable liferaft from its cradle, threw it overboard, and attempted to inflate it by pulling on the sea painter. The liferaft did not inflate, even after numerous attempts by two crewmembers. The crew then turned their attention to the lifeboat, but after several unsuccessful attempts to launch it, discontinued their efforts. The crew then assembled together inside the covered passageway on the afterdeck to await Coast Guard assistance.

About 1130, the CAPE GEORGE located the POLING. Attempts to communicate with the crew on the afterdeck were thwarted by the noise of the wind and seas. The heavy seas prevented the CAPE GEORGE from coming alongside the stern of the POLING, and two attempts to fire a line to guide a liferaft to the crew on the stern failed because of high winds and the severe rolling of the CAPE GEORGE.

About 1200, the bow and stern sections of the POLING broke completely apart after the bow swung around and hit the stern section several times. As it drifted from the stern section, the bow section listed heavily and began to sink. The wheelhouse flooded and the master and seaman, both wearing PFD's, jumped into the ocean. Scramble nets were rigged on both sides of the CAPE GEORGE. The master swam to the CAPE GEORGE, entwined his arms in the starboard scramble net, and was hauled aboard. The seaman was not able to swim because of exhaustion and cold. After several rescue attempts with ring buoys, he was hauled aboard with the scramble net. Both the master and seaman suffered from hypothermia and received appropriate treatment on board the CAPE GEORGE and later at a Gloucester hospital.

About 1300, the CAPE CROSS arrived on scene, and the Coast Guard helicopter CG1438 from Cape Cod arrived about 1315. The CAPE GEORGE departed shortly thereafter to take the master and seaman ashore for transportation to the hospital.

A rescue basket with a guide line was lowered from the helicopter to the crewmembers on the stern and landed on top of some empty oil drums. As the chief mate tended the basket, the cook entered it. As the basket was hoisted, it hit a railing and briefly touched the water, but the cook was raised to the helicopter without further problems. The basket was lowered for the next man, but was held outboard at the ship's rail by one crewmember. The next seaman attempted to enter the basket, but it began to move. As he leaned outside the rail to grab the basket, he fell into the ocean. He swam a few strokes, disappeared for a moment, and reappeared, floating motionless and face downward. Attempts by the helicopter crew to drag the basket under him were unsuccessful, and they returned their attention to evacuating the personnel still on board the stern. The CAPE CROSS immediately began searching for the seaman, but he was not found.

The three remaining crewmembers on board realized at this time that the stern section was about to capsize, so they jumped into the ocean. The chief mate could not swim, but he managed to enter the rescue basket as it was dragged under him by the helicopter. He was hoisted aboard the helicopter.

The CAPE CROSS proceeded toward the chief engineer and seaman, who quickly became helpless because of hypothermia. After several attempts, the two men managed to put their arms through a ring buoy and were pulled alongside the CAPE CROSS. The men could not climb the Jacobs ladder which had been lowered for them. They wrapped their arms around the ladder rungs and were hauled aboard with the ladder. The men received appropriate treatment on board the CAPE CROSS and later at a Gloucester hospital.

Injuries to Persons

Injuries	Crew	Coast Guard Personnel
Fatal	1	0
Nonfatal	6	4

Damage to Vessels

The POLING was a complete loss. The stern section was located in approximately 80 ft of water about 1/2 nmi southeast of Eastern Point, Massachusetts. The bow section has not been located positively, but, based on a side-scanning sonar search, is believed to be located in approximately 200 ft of water about 2 nmi southeast of Eastern Point.

Electronic equipment, deck equipment, antennae, engines, and steering mechanisms on board several Coast Guard 44-ft motor lifeboats (MLB) and 41-ft utility boats (UTB) that attempted to assist the POLING were damaged by heavy seas and immersion in saltwater. These vessels were forced to return to their stations.

Crew Information

The POLING's crew consisted of a master, a chief mate, a chief engineer, a cook, and three seamen. Each crewmember was properly licensed and documented, and had been permanently employed on the POLING for several years. The master had been a U.S. licensed deck officer since 1952. He had served as master of the POLING since 1969.

The master and chief mate maintained alternating 6-hour watches, as did two seamen who performed general maintenance, pumping operations, and wheelhouse lookout duties. The third seaman performed general maintenance during the day only. The chief engineer did not have specific duty hours, but worked as necessary to start the engines and do general engineroom maintenance and repair.

Vessel Information

The POLING was a coastal tanker, about 281 ft long, 40 ft wide, and 18 ft deep, with a cargo capacity of about 21,000 barrels. The engineroom and quarters were at the stern, and the raised pilothouse was slightly forward of amidships. The forepeak tank, chain lockers, storeroom, and an unused pumproom were located at the bow. Six pairs of cargo tanks, each 31 1/2 feet long, extended from the unused pumproom at the bow to the engineroom at the stern. The cargo and ballast pumps were located on the main deck over the No. 5 tanks. (See figure 2.) The two diesel, main propulsion engines were remotely operable from the wheelhouse. The POLING also had an automatic pilot, two radar sets, a LORAN C navigation set, a single-sideband radio, two VHF radio sets, a magnetic compass, and a gyro compass. One VHF radio set was equipped with emergency battery power.

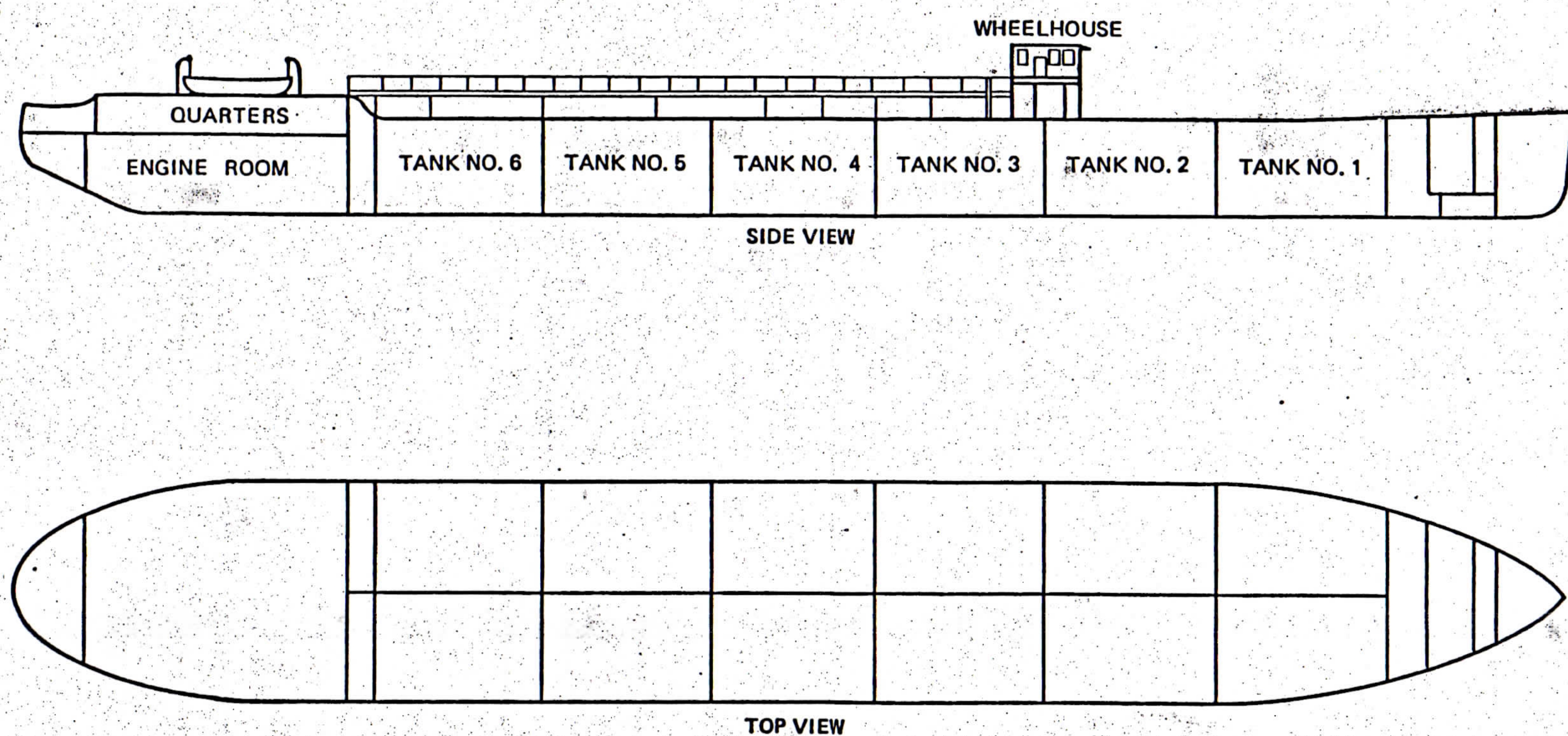

Figure 2. Vessel arrangement of the M/V CHESTER A. POLING.

The POLING was constructed in 1934 and was lengthened in 1956. The vessel, as lengthened, was designed and constructed in accordance with the American Bureau of Shipping (ABS) "Rules for Building and Classing Steel Vessels," 1955 edition, and received classification as an oil carrier for Great Lakes and Short Coastwise voyages. The ABS classification was terminated later at the owners request. The POLING also had a valid Coast Guard Certificate of Inspection and valid Load Line Certificates for Great Lakes service and Special Coastwise service. An approved Loading Manual had not been prepared for the POLING, nor was one required.

The POLING was longitudinally framed at the deck and bottom, and transversely framed at the sides. The side frames and bottom longitudinal stiffeners were 9 1/2-inch by 3 1/2-inch, serrated "L" sections cut from 15-inch by 3 1/2-inch by 40-lb/ft channels.

The ABS and the Coast Guard inspected the POLING in drydock in April 1976 for revalidation of the Load Line Certificates (ABS) and the Certificate of Inspection (USCG). Ultrasonic gaugings 4/ were taken of the deck, side, and bottom plating. Several deck plates were replaced because they had corroded beyond acceptable limits. The Coast Guard required two side plates and a section of the keel at the bow to be replaced because of visible deficiencies. Corrosion, generally within acceptable limits, was found in other areas of the sides, bottom, and deck.

The Coast Guard found the condition and operation of all piping, electrical, vessel control, and safety systems to be acceptable. Lifesaving and safety equipment operated satisfactorily, including the inflatable liferaft which had been inspected (including inflation test) at an approved facility in March 1976.

Waterway Information

When the master considered seeking shelter from the storm about 0940, the POLING was about 5 nmi from Gloucester Harbor and about 10 nmi from Salem Harbor. (See figure 1.) The entrance to Gloucester Harbor is about 1 nmi wide and is fitted with a breakwater, which leaves about a 1/2 nmi navigable entrance. The harbor entrance faces generally south, and the harbor bottom is hard. The unprotected and relatively shallow Salem Sound must be transited to enter Salem Harbor. The channels through Salem Sound are bounded by rocks, shoals, and ledges, and are about 1/4 nmi wide. The mouth of Salem Sound faces generally east.

4/ Ultrasonic gauging is a method used to determine the thickness of steel plates without drilling or cutting.

Cape Ann juts out into the Atlantic Ocean just north of Gloucester Harbor. Ipswich Bay is west of Cape Ann, and is protected from southerly through easterly winds.

Based on weather observations made by ships passing through the Massachusetts coastal area from Boston to Cape Ann during the months of January, the wind speed is normally less than about 35 kns, the wave height is normally less than about 10 ft, and the visibility is normally greater than about 2 nmi. 5/

Meteorological Information

As the POLING transited Boston Harbor about 0700 on January 10, 1977, the master estimated the visibility to be about 1/4 to 1/2 mile in snow. The Boston Light Station, about 7 nmi east of the entrance to Boston Harbor, reported southeast winds at 18 kns, gusting to 22 kns, a sea temperature of 30° F, an air temperature of 32° F, and 2-ft waves.

The weather and sea conditions steadily worsened as the POLING proceeded toward Newington. The wind increased to a steady 50 kns and the seas increased to 20 to 25 ft by 1030. The air temperature increased to near 40° F, but the visibility remained restricted because of rain. After the POLING broke, the weather conditions continued to worsen. The CAPE GEORGE's anemometer indicated 55- to 60-kn winds at about 1130. The seas increased to 25 to 30 ft and were occasionally larger, according to crewmen aboard the POLING and rescue vessels.

The NWS forecast office at Boston had issued this marine warning for the Massachusetts and Rhode Island coastal waters at 1700 on January 9, 1977: "Gale warnings issued at 5 p.m. (1700) for increasing winds late tonight and Monday. Winds veering to northeasterly late tonight, becoming east to southeast 35 to 45 knots Monday." At 0316, January 10, 1977, the following NWS forecast was issued for the coastal waters within 25 miles offshore from Block Island to the Merrimac River:

> Gale warnings in effect.
>
> A developing low pressure area along the Carolina coast will move rapidly northward into New England early tonight intensifying into a gale by this afternoon. Gale weather center will continue northward into the St. Lawrence Valley Tuesday.
>
> Northeasterly winds 10 to 20 knots veering to the east this morning and increasing to 25 to 35 knots. Southeasterly winds 35 to 45 knots and gusty this afternoon, veering to the southwest to west tonight, continuing 35 to 45 knots. Tuesday westerly winds 25 to 40 knots. Snow changing to rain

5/ United States Coast Pilot, Atlantic Coast: Eastport to Cape Cod, National Oceanic and Atmospheric Administration, 1978.

this morning continuing heavy at times before ending this evening. Partly cloudy later tonight and Tuesday. Visibility variable to below 1 mile in snow, rain, and developing fog patches today improving to over 5 miles tonight and Tuesday. Seas building to 6 to 10 ft over exposed waters by late afternoon, subsiding to 5 to 8 ft tonight and Tuesday.

Medical and Pathological Information

All rescued crewmembers of the POLING suffered from hypothermia. The master also sustained a broken finger. Four Coast Guardsmen were injured because of extreme vessel motions.

Survival Aspects

The accident was survivable. The forward and aft sections of the hull remained together and afloat for about 1 1/2 hours after the vessel broke, and the stern section remained afloat for an additional 1 1/2 hours after separating from the bow. Coast Guard rescue units responded promptly and were on scene before the POLING's crew was forced to abandon the broken vessel.

Survival time in the 30° F seawater would have been about 1/2 hour. 6/ This survival time would be reduced for persons who had lost body heat due to wet clothing before immersion. The survival time would have been increased significantly if the crewmembers had been wearing exposure suits, but none were available.

No lifeboat or liferaft was available to the two persons on the bow section of the vessel, as these primary lifesaving devices were stowed on the stern. The crewmembers on the stern section could not launch the only lifeboat because of boarding seas, which made it dangerous to work near the lifeboat's stowage position on the port side. The liferaft canister was thrown into the water, but the raft did not inflate promptly. It was later observed fully inflated and tangled in the broken catwalk on the forward part of the stern section. The chief mate tried to retrieve the liferaft, but was forced back by boarding seas

PFD's were available to all crewmembers. Each crewmember who used a PFD remained afloat after entering the water, including those who could not swim. The testimony indicates that the seaman who was lost had removed his PFD some time before falling into the ocean.

6/ R. E. DeForest and E. L. Beckman, "Some Medical Contraindications to the Use of the Standard Life Jacket for Survival," U.S. Naval Air Development Center, Johnsville, Pa., 9 August 1961, Report No. AD-263-195.

Two crewmembers were rescued by the Coast Guard's helicopter-borne rescue basket. The seaman who was lost fell into the ocean attempting to enter the basket as it was held outboard of the ship's deck railing by another crewmember. The chief mate also attempted to enter the rescue basket in this manner, but he was grabbed and held by another crewmember just as he was about to fall into the ocean. The noise level on the stern of the POLING was high because of the wind, breaking seas, and proximity of the helicopter, and the CAPE CROSS' attempts to inform the crewmembers by electric megaphone of the proper procedures for tending the rescue basket were unsuccessful. Training in the use of a helicopter-borne rescue basket is not normally provided to merchant vessel crews. The relative vertical motion between the POLING's stern section and the helicopter was about 50 ft, because of the heaving of the stern in the sea and the changing hover of the helicopter caused by wind gusts.

Tests and Research

Several small samples of bottom plating and longitudinal stiffeners were removed from the fracture area of the stern section by divers and were submitted to the Safety Board's metallurgical laboratory for examination. The fractures in the sections of steel plate were examined with a binocular microscope at magnifications from 10 to 70 times. No evidence of fatigue or progressive-type failure was found. All fractures examined were typical of overload failures. A fractured bottom longitudinal, which appeared to have been extensively battered at the fracture face, was examined with a scanning electron microscope to determine the nature of apparent damage. The examination revealed that the mechanical damage to the fracture face was consistent with damage from multiple impacts.

After these initial examinations, a section of the bottom, about 5 ft long and 24 ft wide, was removed from the fracture area of the sunken stern section. (See figure 3.) This section of plating, with some longitudinal stiffeners still attached, was examined by an independent metallurgical laboratory. 7/ The chemical composition and tensile properties of the steel were determined to be acceptable. The steel samples exhibited yield strengths of about 40 ksi and ultimate strengths of about 63 ksi. Charpy V-Notch impact tests indicated absorbed energy values of 2.5 to 5.0 ft-lbs at test temperatures from 0° to 60° F for the longitudinal stiffener tested. Examination of another longitudinal stiffener revealed a brittle fracture with chevron marks pointing toward the end of the flange. The flat keel plate was determined to have a nil-ductility transition temperature of 45° F by drop weight testing methods.

7/ R. R. Fessler and K. R. Grube, "Metallurgical Study of Samples from the Tankship CHESTER A. POLING," August 1, 1977, Battelle Columbus Laboratories, Columbus, Ohio.

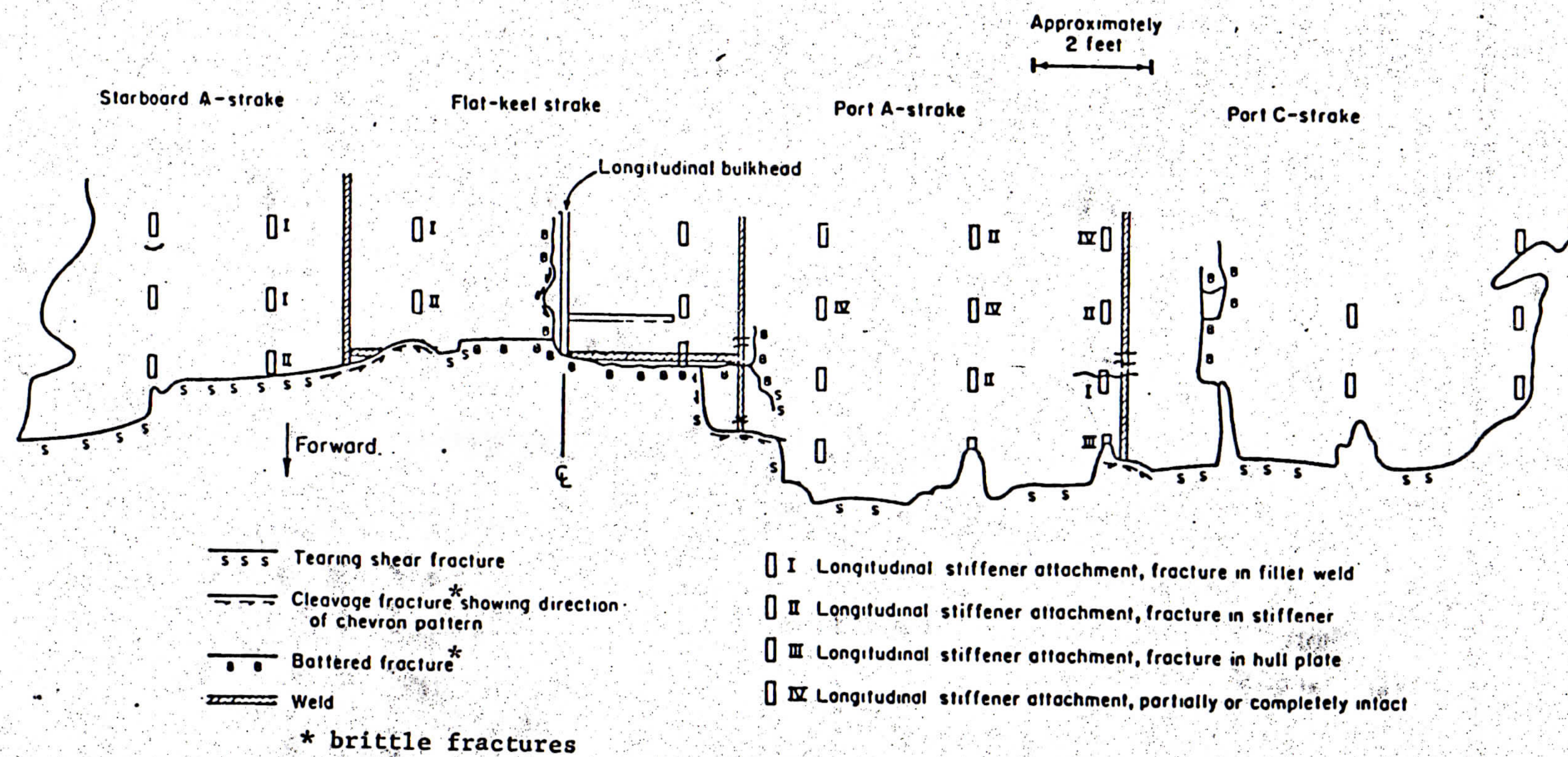

Figure 3. Diagram of fracture in the bottom hull plate of the M/V CHESTER A. POLING. (The inside surface of the plate is shown.)

Based on these tests and other independent observations and investigations, an analysis of the structural failure of the POLING was made by an independent fracture mechanics consultant. The report of the analysis 8/ concluded that the primary factor causing the structural failure of the POLING was the high stress level in the bottom plating and stiffeners that was caused by the extremely heavy seas for the particular condition of ballasting. The maximum stress in the bottom plating was estimated to be at least 25 to 30 ksi in tension during sagging and 10 ksi in compression during hogging. (A normal stress level is less than 10 ksi.) These stresses led to failure of a stiffener, subsequent buckling and brittle fracture of part of the bottom plating, separation of the bottom hull structure by tensile overloading, and finally complete separation of the ship into two sections, according to the report. Other factors, such as design, materials, and welding, were not considered to be primary causes of failure. The report also indicated that the critical buckling stress of the bottom panels was estimated to be about 31 ksi.

Calculations made by the Coast Guard's Merchant Marine Technical Division showed that the POLING's original structure was well configured to accept compressive loads up to yield stress. 9/ The calculations indicate that with the actual ballast condition and hull scantlings at the time of the casualty, the POLING probably could have survived a seaway with significant wave heights up to about 18 ft. Had the ballast been loaded in tanks Nos. 1, 3, 4 and 6, the POLING probably could have survived a seaway with significant wave heights up to about 30 ft.

Calculations performed by the Massachusetts Institute of Technology showed that an increase in speed from 0 to 6 kns would have caused an increase in hull stress of about 40 percent on the POLING. The calculations indicate that the POLING had to endure as many as 140 slams per hour when moving at about 6 kns into the seas observed at the time of the casualty.

Other Information

A tankship's loading condition has a significant effect upon the hull stress experienced by the vessel. Loading cargo or ballast in the midship tanks only or in the bow and stern tanks only will cause the hull to bend. When loaded amidships only, the resultant bending is termed "sagging," and when loaded in the bow and stern only, the resultant bending is termed "hogging."

8/ S. T. Rolfe, "Analysis of the Failure of the CHESTER A. POLING," October 7, 1977, University of Kansas, Lawrence, Kansas.

9/ Sedlak and Billingsley, "Evaluation of the Circumstances Relating to the Structural Failure of the CHESTER A. POLING," November 4, 1977, U.S. Coast Guard Headquarters, Washington, D.C.

Hull stress information based upon loading condition, sea state, and ship speed and relative heading can be presented graphically as a series of maneuvering curves. 10/ A master could use these curves to determine the relative magnitudes of bending moments experienced by his vessel at various speeds and headings in the sea state he observes. He could thereby determine the best means to reduce hull stresses in heavy weather. The technology needed to calculate reliable maneuvering curves inexpensively was not available when the POLING was lengthened, and such curves had not been prepared for the POLING.

ANALYSIS

Structural Failure

The heavy seas encountered by the POLING subjected the vessel to high stress levels, both in tension and compression, for its condition of ballasting. The estimated stress levels in the bottom structure were much higher than are normally observed in ships.

The critical buckling stress of the bottom plating panels was about 31 ksi, so the estimated stress level of about 10 ksi in the hogging condition would not have been sufficient to cause initial buckling of a complete panel. It also is unlikely that a panel failed initially because of tensile overload, because the salvaged bottom section showed buckled plating and cracks on both sides of the plate, which indicates that the plate was bent both inward and outward. Therefore, the Safety Board concludes that the initial failure did not involve a complete bottom plating panel.

If a bottom plating panel did not fail because of buckling or tensile overload, the initial failure probably occurred to one of the panel supports--a bottom longitudinal stiffener. A stiffener could have failed by brittle fracture, local buckling, or tearing away from the bottom plating. The salvaged bottom section showed evidence of each of these types of failure, and a stiffener could have failed initially in any of these three modes.

A longitudinal stiffener on the salvaged bottom section showed a completely battered fracture face. The damage to the fracture face was consistent with damage from multiple impacts. To cause this damage, both ends of the broken stiffener must have fit closely together after breaking and must have struck each other forcefully several times. If the stiffener had been initially torn away from the hull plate, or if it had failed because of local buckling, it is unlikely that the ends could have mated precisely enough to cause the observed damage. Local buckling of the stiffener also would have been unlikely because the POLING's

10/ K. Lindeman, et al., "On the Application of Hull Surveillance Systems for Increased Safety and Improved Structural Utilization in Rough Weather," The Society of Naval Architects and Marine Engineers, November 1977.

structure was well configured to accept compressive loads up to yield stress. Therefore, the Safety Board concludes that the stiffener did not fail initially by local buckling or tearing away from the bottom plating.

The stiffener steel exhibited low notch toughness at temperatures below 60° F, and the ambient seawater temperature during the POLING's last voyage was about 30° F. Stress concentrations would have existed near the cut-outs in the webs of the stiffeners. A high loading rate was probably induced by the POLING's slamming into waves. Combined with the high tensile stresses, these factors could have caused the brittle fracture of a stiffener. Chevron marks on the fracture face of a longitudinal stiffener pointed toward the end of the stiffener's flange, indicating that a brittle fracture had originated at the end of the flange. When steel fractures brittlely, a sharp cracking noise results. Crewmembers on the POLING heard similar noises before the vessel broke. Therefore, the Safety Board concludes that the initial failure was the brittle fracture of a bottom longitudinal stiffener during tensile loading.

After the stiffener failed, the critical buckling stress of the two adjacent plating panels would have been reduced to about 9 ksi. This reduction and the compressive stresses in the bottom structure when the vessel was hogging probably caused the bottom plating to buckle. The salvaged bottom plating showed evidence of buckling.

As several waves passed the POLING, the buckled plating was straightened by tensile loading and then buckled again by compressive loading several times. This caused some remaining stiffeners to be pulled away from the bottom plating, which further reduced the strength of the bottom structure. Continued reversal of loading of the buckled, unstiffened bottom plating caused multiple cracking on both the top and bottom surfaces of the bottom plating, as seen on the salvaged section. Several brittle fractures occurred in welds, extended into the plating, and then continued as shear failures under the extreme overload conditions. Thus, the remaining parts of the bottom finally failed because of tensile overload.

After the bottom failed, gross overload of the remaining effective hull girder then caused the failure to progress immediately up the sides of the vessel and stop at the main deck as the POLING settled into the water. The deck then acted as a hinge, holding the bow and stern sections of the vessel together for some time. It eventually failed, probably because of a combination of fatigue and overloading induced by the vessel's motions in the heavy seas.

Weather and Sea Conditions

On her last voyage, the POLING traversed a coastal region which was battered by a rapidly moving, intensifying winter storm. At 0700, the Boston Light Station reported 2-ft waves and 18-kn winds. By 1030, the POLING was experiencing 20- to 25-ft waves and 50-kn winds and was only about 15 nmi northeast of the Boston Light Station.

The Safety Board's analysis of the meteorological factors at the time and place of the accident indicates that the wind was from the east to southeast at sustained speeds of 35 to 45 kns with gusts to 55 kns, and the significant wave height was 18 to 22 ft. The NWS forecasted east winds at 25 to 35 kns in the morning, increasing to 35 to 45 kns, and gusty from the southeast in the afternoon with "seas building to 6 to 10 ft." By 1130, the CAPE GEORGE's anemometer was indicating sustained winds of 55 to 60 kns, and crewmen on the POLING and rescue vessels estimated wave heights of 25 to 30 ft. The Safety Board concludes that the NWS forecast was substantially in error.

When the POLING departed Boston Harbor, the existing and forecasted weather and sea conditions were acceptable for the planned voyage. As the POLING continued on course toward Cape Ann, the wind and seas increased to unpredicted levels quite rapidly, and at the same time, the POLING was moving further from acceptable harbors of refuge. If the weather forecast that the master received when he left Boston Harbor had been substantially correct, he might have discontinued the voyage while safe refuge was still available. This is further supported by the fact that the master had discontinued two voyages during the previous winter because of adverse weather and sea conditions, which indicates that he was sensitive to weather considerations.

When the master considered seeking shelter from the storm about 0940, the POLING was within about 17 nmi from three harbors. The high winds and hard bottom would have made secure anchoring difficult in Gloucester Harbor. To enter Salem Harbor, the POLING would have had to transit the unprotected and relatively shallow Salem Sound through narrow channels. The wind was blowing directly into the mouth of Salem Sound, and the ocean waves were traveling in the same direction. Combined with the shallow water effect, this probably made Salem Sound extremely rough. Since the channels through Salem Sound were bounded by rocks, shoals, and ledges, and the visibility was 1/4 nmi in heavy snow and fog, it would have been risky to attempt to navigate the POLING through Salem Sound into Salem Harbor.

The master considered returning to Boston Harbor to be a viable alternative. However, at 0940 the POLING was about 8 nmi closer to the point of course change to 341° than to Boston Harbor, and the master had determined that the vessel handled satisfactorily on the 341° heading. Once around Cape Ann, some protection from the wind and waves would have been afforded by the Cape. If necessary, the master may have been able to seek shelter in Ipswich Bay after rounding Cape Ann. The Safety Board concludes that the master's decision to continue the voyage was reasonable.

Ship Speed and Hull Stress

The primary hull stress experienced by a ship is due to longitudinal bending moments. For a ship in a seaway, the total bending moment is a combination of the still water bending moment, caused by the vessel's internal arrangement, hull form, buoyancy, and loading condition, and the dynamic bending moment caused by waves. The dynamic bending moment primarily depends on sea state, ship speed, and relative heading. Increasing the ship speed or sea state will normally increase the dynamic stress, which is often highest when heading into the waves.

The master indicated that it was necessary to vary the speed of the POLING during most of the trip to decrease the vessel's pounding. Typically, a master would slow his vessel as large waves approached, and would speed up again after they passed. An alternative would be to proceed at slow speed continually, but this would increase the length of time necessary to travel a given distance. Calculations based on the positions and times plotted on the chart the master used for navigation indicate that his speed estimates for the last voyage of the POLING are generally correct. From 0940 until the POLING broke about 1035, the vessel's average speed was about 6 kns. At this speed, the stresses experienced by the ship were calculated to be about 40 percent higher than the zero-speed stresses in the observed seaway. Had maneuvering curves been available, the master would have known the magnitude of stress increase with speed increase.

Calculations also show that the POLING was subjected to about 140 slams per hour. The stresses induced in the vessel's structure from slamming--the impact of the bow with a wave--would be added to the other hull stresses. Although difficult to quantify, slamming loads can be quite high, but these loads also can be reduced by slowing.

When the master decided to continue the voyage around Cape Ann, he was concerned about the weather, and could see that the wind and seas were continually increasing. While he had no means available to precisely determine the hull stresses created by the seas and the effect of the POLING's speed on the magnitude of the stresses, he probably was aware that higher speed created higher stresses because he reduced the vessel's speed in response to increased pounding.

The POLING probably could have survived a seaway with significant wave heights up to 18 ft, and the Safety Board's meteorological analysis shows that the significant wave height was 18 to 22 ft. The reduction in hull stresses effected by a reduction in speed might have been sufficient to enable the POLING to survive.

Although it cannot be positively determined that a speed reduction would have saved the POLING, the Safety Board does conclude that the vessel's speed was a contributing factor in the creation of high hull stresses.

Ballasting and Hull Stress

On her last voyage, the POLING carried ballast in tanks Nos. 2, 3, 4, and 5. This created a hull bending moment in the sagging condition. Had the ballast been distributed over the length of the vessel, such as by loading ballast in tanks Nos. 1, 3, 4, and 6, the bending moment could have been significantly reduced. This would have enabled the POLING to endure more severe seas than was possible in the actual loaded condition. In fact, the POLING might have been able to endure a seaway with significant wave heights up to about 30 ft. Since the ballasting equipment operated properly, and there were no operational considerations that required specific tanks to be filled in a certain order, a better ballast arrangement could have been used. The Safety Board concludes that the distribution of ballast water in the POLING was improper.

The applicable Coast Guard regulations did not require that a loading manual be prepared for the POLING. The master had no information regarding the stresses caused by various loading arrangements, and he could rely only on his experience to determine the amount and location of ballast necessary for a voyage. His ballasting procedure on the POLING's last voyage was the same procedure he had used for previous trips.

Preparation of a loading manual for a vessel with a common arrangement and operation, such as the POLING, is not difficult. The vessel's tank arrangement was not complicated, nor were varieties of cargo with significantly different specific gravities carried at the same time. For a typical voyage, a vessel in the clean product coastal trade would be fully loaded with cargo or ballasted to some degree depending on sea conditions. A loading manual could be prepared which would allow the master to determine quickly the best arrangement of cargo or ballast. Since the amount of ballast carried depends on sea conditions encountered, ballasting is often performed en route as conditions change. A ballasting procedure or sequence could be developed which would ensure that hull stresses were minimized during the entire ballasting operation.

Had a loading manual been available, a prudent master would have followed the procedures suggested. The procedures would have been thoroughly examined before inclusion in the manual, and proper ballasting arrangements would have been shown. The Safety Board considers the lack of such a manual to be a contributing cause to this casualty.

Rescue Efforts

The Coast Guard cutter CAPE GEORGE was underway from Gloucester Harbor within 5 min of receiving the POLING's distress call. While the CAPE GEORGE was en route, the POLING was drifting generally toward Gloucester Harbor. The CAPE GEORGE located the POLING in conditions of severe seas and reduced visibility within 50 min of receiving the distress call.

The quick response by the CAPE GEORGE and the proximity of the POLING to Gloucester Harbor--within about 5 nmi considering drift--are directly responsible for saving the lives of the master and seaman who were in the wheelhouse. If the master and seaman had been forced to abandon the vessel before the Coast Guard arrived, it is unlikely that they would have been rescued. No lifeboats or liferafts were stowed on the bow section, and no exposure suits were available. Considering the rough seas and restricted visibility conditions, they probably would not have been located in time.

Several 44-ft and 41-ft Coast Guard vessels that attempted to assist the POLING were forced to return to their stations. The helicopter CG1438 could not respond immediately due to icing conditions and high winds. Other occasions may arise when rescue units cannot reach an accident scene quickly. Requirements for survival equipment should consider that persons may have to endure severe environments for an extended time. The Safety Board concludes that exposure suits should be provided for each member of the crew on vessels that routinely operate in areas of cold air or sea temperatures, and at least one liferaft should be stowed near each accommodation space and working space.

The helicopter CG1438 rescued two persons, one from the stern of the POLING and one from the water, using the standard rescue basket. One person was lost attempting to enter the basket. Although the Coast Guard attempted to orally instruct the POLING's crew on the proper use of the rescue basket, the high ambient noise level precluded effective voice communication.

Training in the use of a helicopter-borne rescue basket is not normally provided to merchant vessel crews. The POLING's crew was not aware of the dangers associated with boarding the basket outboard of the vessel's deck rail. A guide line was properly attached to the basket by the helicopter crew, but the POLING's crew did not effectively use it to guide the basket to a safe location on the POLING's deck.

Had the POLING's crew been familiar with the rescue basket and trained in the proper methods to use it, it is likely that the loss of life would have been prevented. A placard of simple instructions attached to the basket would have provided some guidance. The Safety Board concludes that mariners should receive instruction in the proper handling of a rescue basket, and that the basket should be fitted with a placard of simple directions for its proper use.

The liferaft was not recovered, so the cause for its apparent malfunction could not be determined.

CONCLUSIONS

Findings

1. Improper ballasting and heavy seas caused high stresses in the POLING's bottom structure.

2. The initial failure in the bottom structure was probably the brittle fracture of a bottom longitudinal stiffener during tensile loading.

3. The loss of one bottom longitudinal stiffener significantly reduced the resistance of the adjacent plating panels to buckling.

4. Final failure of the POLING's bottom and sides resulted from tensile overload.

5. The POLING probably could have endured the heavy sea conditions if it had been properly ballasted.

6. Preparation of a loading manual for the POLING to indicate proper ballasting procedures would not have been difficult.

7. The National Weather Service weather forecasts pertinent to the time and place of this accident were substantially in error.

8. The master reasonably decided not to attempt to take the POLING into nearby harbors because of the high winds, heavy seas, and restricted visibility.

9. The Coast Guard's quick response and outstanding rescue efforts were directly responsible for saving the lives of six of the seven crewmembers.

10. Exposure suits should be provided for each crewmember on vessels that routinely operate in areas of cold air or sea temperatures.

11. A liferaft should be stowed near each accommodation and and working space on coastal tankships.

12. The POLING's crew was unaware of the proper techniques for handling the Coast Guard helicopter-borne rescue basket and handled it improperly.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the brittle fracture of a bottom longitudinal stiffener, which led to buckling of the adjacent bottom plating panels and subsequent failure of the complete bottom and sides. The bottom longitudinal stiffener failed because of the high stresses created by the improper distribution of ballast water and the heavy seas. Contributing to the accident were the lack of a loading manual to indicate proper ballasting procedures, the speed of the vessel, and the inaccuracy of the National Weather Service's weather forecasts.

Contributing to the loss of life were the lost seaman's failure to wear a personal flotation device, and the improper handling of the Coast Guard helicopter's rescue basket by the POLING's crew, which resulted from the crew's lack of training and their inability to hear Coast Guard instructions over the noise created by the helicopter, high winds, and breaking seas.

RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board made the following recommendations:

--to the U.S. Coast Guard:

. "Require that a loading manual indicating proper cargo and ballast loading arrangements and procedures be prepared for each coastal tankship. (Class II, Priority Action) (M-78-63)

"Study the feasibility of providing estimated hull stress information based on loading condition, sea state, and ship speed and relative heading in graphical form in coastal tankship loading manuals. (Class III, Longer Term Action) (M-78-64)

"Require that exposure suits be provided for each crewmember on vessels that routinely operate in areas of cold air or sea temperatures. (Class II, Priority Action) (M-78-65)

"Require that at least one inflatable liferaft be stowed near each accommodation and working space on coastal tankships. (Class II, Priority Action) (M-78-66)

"Develop an effective method to insure that each merchant seaman is instructed and trained in the proper use of helicopter-borne rescue baskets. (Class II, Priority Action) (M-78-67)

"Install a placard of simple user instructions suitable for emergency situations on each Coast Guard helicopter-borne rescue basket. (Class II, Priority Action) (M-78-68)"

--to the Maritime Administration, U.S. Department of Commerce:

"With assistance from the U.S. Coast Guard and maritime industry management and labor, develop a survival and rescue training course to provide instruction in Coast Guard sea rescue methods and in the proper actions merchant seamen should take to aid in their rescue. (Class II, Priority Action) (M-78-69)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ ELWOOD T. DRIVER
Member

September 14, 1978

APPENDIX

INVESTIGATION

This accident was investigated jointly with the U.S. Coast Guard as authorized by the Independent Safety Board Act of 1974 (49 USC 1901). The investigation included a public hearing which convened in Boston, Massachusetts, on January 14, 1977, and which heard testimony from 21 witnesses during 6 days, and accepted 48 exhibits into the record. Laboratory tests were conducted at the Safety Board's metallurgical laboratory and Battelle Columbus Laboratories, Columbus, Ohio. Calculations and analysis were made by the University of Kansas, Massachusetts Institute of Technology, the Coast Guard Headquarters Merchant Marine Technical Division, and the Safety Board's staff. The Safety Board was represented by a member of its staff in all appropriate phases of the investigation.

The National Transportation Safety Board has considered all those facts in the investigative record that are pertinent to the Safety Board's statutory responsibility to determine the cause or probable cause of the casualty and to make recommendations.