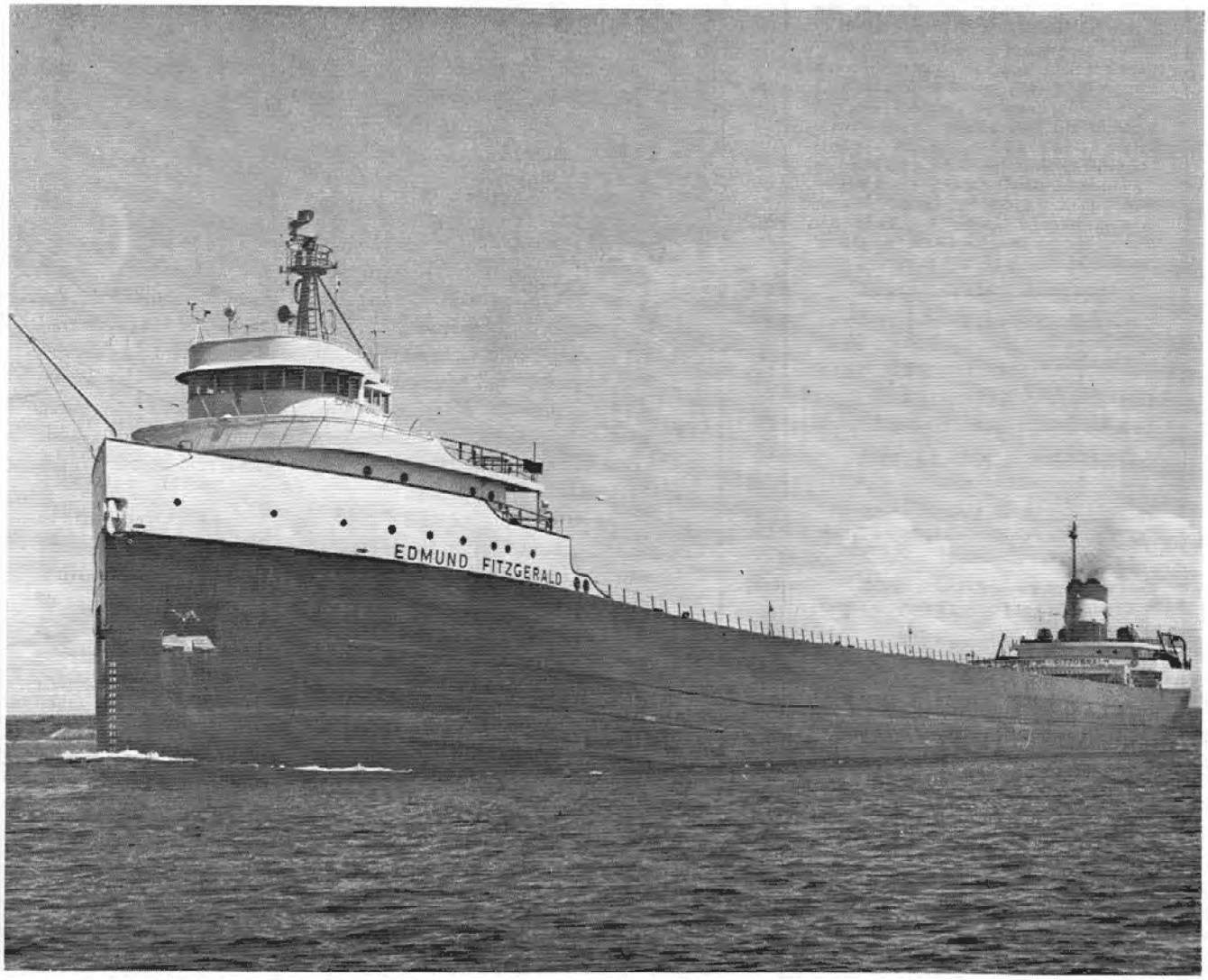
PROCEEDINGS
OF THE MARINE SAFETY COUNCIL



DEPARTMENT OF TRANSPORTATION UNITED STATES COAST GUARD

Vol. 34, Nos. 9–12 CG–129 September–December 1977

PROCEEDINGS

OF THE MARINE SAFETY COUNCIL

Published monthly by the Commandant, USCG, in the interest of safety at sea under the auspices of the Marine Safety Council. Special permission for republication, either in whole or in part, with the exception of copyrighted articles or artwork, is not required provided credit is given to the Proceedings of the Marine Safety Council. All inquiries and requests for subscriptions should be addressed to Commandant (G–CMC), U.S. Coast Guard, Washington, D.C. 20590. Use of funds for printing this publication has been approved by the Director of the Bureau of the Budget, March 12, 1974.

CONTENTS

FEATURES

DEPARTMENTS

COVER

The SS *Edmund Fitzgerald* sank during a severe storm on Lake Superior in November 1975. The *Fitzgerald* had reported minor damage sometime earlier, and was being tracked by an accompanying vessel when it disappeared from the radar scope.

The loss of the *Fitzgerald* quickly became one of the most famous—even legendary—of modern American shipwrecks. This was due in part to the tragedy of the lives lost, and in part to the mystery of how it happened.

The true story of the *Fitzgerald*'s last hours remains, in some respects, a matter for speculation. But in one of the most exhaustive investigations ever conducted by the Coast Guard, a body of evidence has been accumulated pointing to a number of specific probable causes and contributing factors. The findings of that investigation are summarized in this issue, and an article in a future issue will address the considerable and unique hazards of Great Lakes shipping.

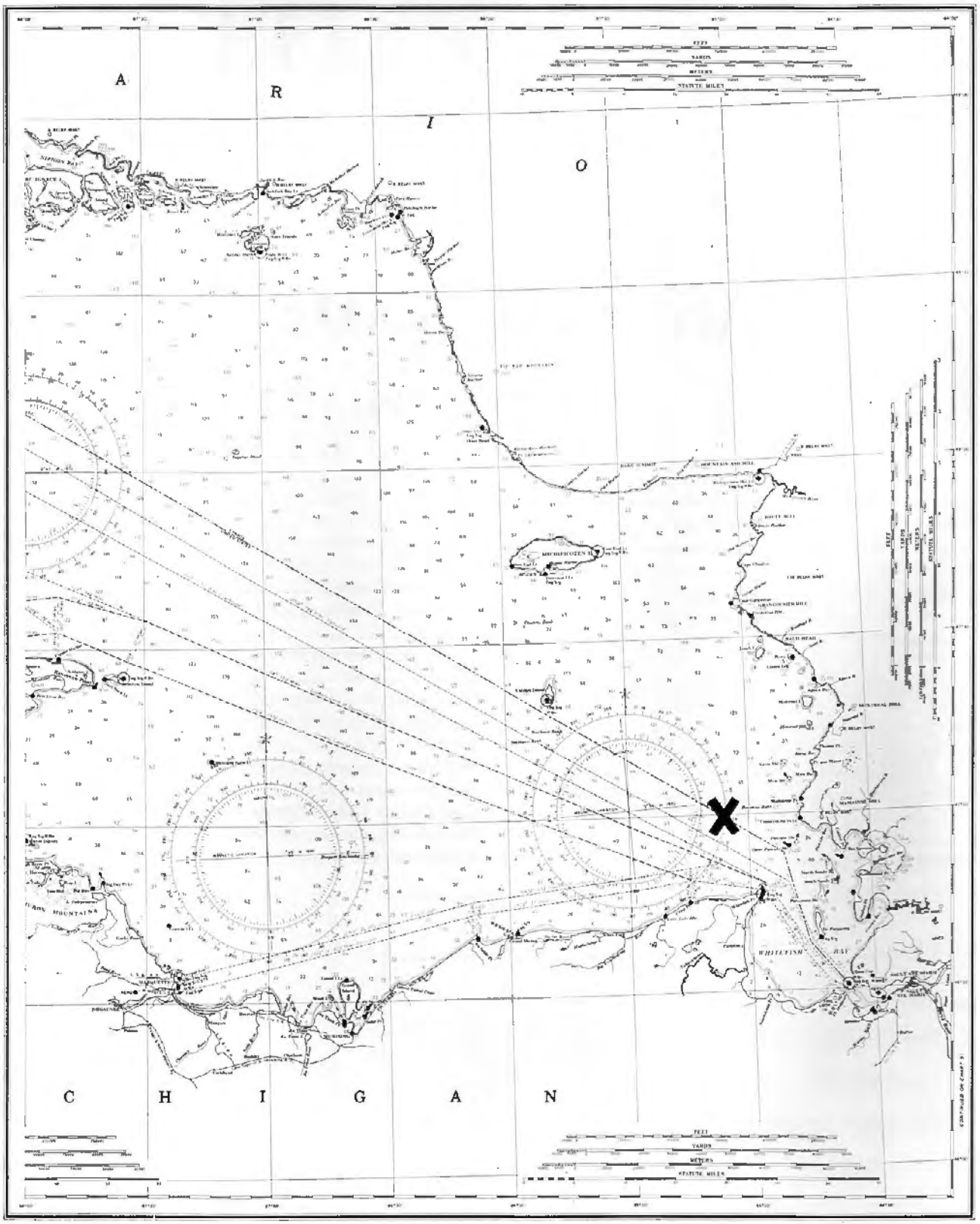
DIST. (SDL No. 106)
A: acde(2); fghklmntuv(1)
B: n(50); c(16); e(5); f(4); ghj(3); r(2); bkipq(1)
C: eglmp(1)
D: adgklm(1)
E: mn(1)
F: kp(1)
Lists TCG–06, CG–13

THIS COPY FOR NOT LESS THAN 20 READERS— PLEASE PASS IT ALONG

ANNUAL INDEX

Volume 34

253-928—78——2


A
R
I
O
C
H
I
G
A
N
WHITEFISH BAY

The Sinking of the Edmund Fitzgerald

The fully laden ore carrier SS Edmund Fitzgerald *was downbound in Lake Superior on 10 November 1975. Early in the evening, in the approximate position 46°59.9′ N, 85°06.6′ W, 17 miles from the entrance to Whitefish Bay, the* Fitzgerald *suddenly sank, taking the lives of her 29-man crew.*

A Coast Guard Marine Board of Investigation chaired by Rear Admiral Winford W. Barrow, was convened in Cleveland, Ohio, to examine the facts surrounding this casualty and to make recommendations to prevent the recurrence of similar casualties. Individual copies of the complete Marine Board report, of which the following is a summary, may be obtained by writing to: Commandant (G-MMI), U.S. Coast Guard Headquarters, Washington, D.C. 20590.

The SS *Edmund Fitzgerald* was built by the Great Lakes Engineering Works, River Rouge, Michigan, in 1959, and home ported in Milwaukee, Wisconsin. The *Fitzgerald* was a typically constructed Great Lakes "straight decker" cargo vessel, 729 feet long, 75 feet in beam, and 39 feet from spar deck to keel. The pilothouse and some accommodation spaces were located forward, and the 7,500 h.p. steam turbine powerplant, crew berthing, and messing facilities were aft. The main cargo space amidships was divided into three cargo holds by two transverse non-watertight screen bulkheads. The 21 hatch covers each measured 11 feet by 48 feet on 24-foot centers along the spar deck.

Outboard, under the forward of the cargo holds, were the ballast tanks. These were drained and filled by four electrically driven 7,000-gal/min main ballast pumps and two electrically driven 2,000-gal/min auxiliary ballast pumps. Crew access forward or aft could be accomplished topside or through tunnels located port and starboard, outboard, immediately under the spar deck.

The hatch covers were removed and replaced using an electrically powered hatch crane which straddled the hatches and traveled fore and aft on rails located outboard of the hatch coamings, port and starboard. Each hatch was secured by 68 manually positioned "Kestener clamps" arranged on approximately 2-foot centers around the coaming. These clamps are double pivoted with an adjustable tension bolt which seats on a dish "button" on the hatch cover.

At approximately 8:30 a.m. on 9 November, the *Fitzgerald* commenced loading a cargo of taconite iron ore at the Burlington Northern Railroad Dock No. 1 in Superior, Wisconsin. Taconite pellets are manufactured by a process known as "oxide pelletizing," and when finished contain 65 percent iron oxide. The bulk density of taconite is approximately 130 pounds per cubic foot and the stowage factor is 17 cubic feet per long ton. Due to the small size of the pellets, about the size of a large marble, it is easily handled by conveyor belts, in hopper type railroad cars and in chutes. When loaded, taconite is very stable and has an angle of repose between 26 and 30 degrees. It will not dissolve in water and absorbs about 7 percent moisture by weight.

As the *Fitzgerald* was loaded, the fresh water ballast in the ballast tanks was simultaneously pumped overboard. During this loading operation, the vessel was also taking on approximately 50,000 gallons of Bunker C fuel oil. By 2:15 that afternoon the loading of 26,116 long tons of taconite had been completed and preparations were made for getting underway.

At the time of the *Fitzgerald*'s sailing, the National Weather Service had been tracking "a typical November storm" which had been generated over the Oklahoma Panhandle on 8 November and was predicted to pass just south of Lake Superior by 7:00

p.m. on 10 November. By 7:00 p.m. on the 9th the storm had rapidly intensified and moved further north than had been predicted. The Weather Service issued gale warnings for Lake Superior with the winds in the eastern half of the Lake predicted to be "east to northeast, increasing to 25 to 37 knots during the night and northeasterly 28 to 38 knots, shifting to northwest to northerly 30 to 40 knots by Monday (10 November) afternoon," with waves 5 to 10 feet.

The *Edmund Fitzgerald* passed Two Harbors, Wisconsin, several hours after departure and was joined on the downbound voyage by the *Arthur M. Anderson*, an ore carrier also loaded with taconite. Sometime after 2:00 a.m. on 10 November, the masters of the *Fitzgerald* and *Anderson* discussed the deteriorating weather conditions and what course of action they should take. At that time the National Weather Service had changed their advisory from gale warnings to storm warnings, and predicted northeast winds to 50 knots. The masters agreed to depart from the normal shipping lanes along the southern shore of the Lake and to proceed on a more northeasterly course in order to be in the lee of the Canadian shore.

At approximately 3:00 a.m., the *Anderson* logged winds of 42 knots from 034°T. The *Anderson* changed course to 055°T and the *Fitzgerald* was heading approximately 060°T. Up until this time the *Fitzgerald* had been close behind the *Anderson*, but now, due to her greater speed, she began pulling slightly ahead.

Around 10:30 on the morning of the 10th, approximately 25 miles from the eastern shore, the *Anderson* changed course to 125°T, while the *Fitzgerald* was observed heading closer to shore before turning south. Because the *Anderson* was, in effect, cutting corners, it was able to keep up with the faster *Fitzgerald*.

At 11:52 a.m. the *Anderson* changed course to 149°T. The weather was now overcast with winds from 158°T at 30 knots. The barometer had dropped rapidly and was now reading 28.84, and the wave height was 10 to 12 feet. An hour later, the *Anderson* was abeam of Otter Head Light at a distance of 10.8 miles. The course was changed to 154°T at that point in order to clear Michipicoten Island West End Light by 2 to 2½ miles. The *Fitzgerald* was 7 to 8 miles ahead and slightly to the east of *Anderson*'s heading and the two vessels appeared to be on slightly converging courses.

Around 1:40 p.m. the masters of both vessels again discussed the deteriorating weather conditons. The master of the *Anderson* indicated that he expected the wind to shift to the northwest, and that he intended to change course to the west before passing Michipicoten Island in order to assure that the seas were from astern. The master of the *Fitzgerald* indicated that since he had already passed the island he would continue even though his vessel was "rolling some." After this radio exchange, at approximately 1:50 p.m., the *Anderson* changed course to 230°T. The eye of the storm must have been passing through at that time, as the weather was logged as overcast, winds 5 knots from 305°T with fair visibility.

About 2:45, the *Anderson* changed course to 130°T in order to pass clear of the 6-fathom shoal located approximately 4 miles north of Caribou Island. By the time the *Anderson* was steady on the new course, the *Fitzgerald* was observed to be approximately 16 miles ahead. The winds had increased to 42 knots from 315°T and it had started snowing. The crew of the *Anderson* lost sight of the *Fitzgerald*, and it was never to be seen again.

At 3:20 p.m. the mate on watch logged the *Anderson* abeam of Michipicoten West End Light at a distance of 7.7 miles. The seas were beginning to build rapidly from the northwest. On the 130°T course the master thought his vessel was being set down too close to Caribou Island, so the course was changed to 125°T. This new course was "shaped up" to clear the shoal and to reach a point 6 miles off the island.

After steadying on the new course, the mate observed on radar that the *Fitzgerald* was a little over 16 miles ahead of the *Anderson* and "a shade" to the right of dead ahead. The *Fitzgerald*'s position was observed to open further to the right of the *Anderson*'s radar heading flasher. Since no radar plot of the *Fitzgerald* had been maintained, the watch officers aboard the *Anderson* were unable to determine whether the change in the relative position of the *Fitzgerald* resulted from the divergent courses of the two vessels or whether the *Fitzgerald* had made a course change.

The officers onboard the *Anderson* observed that the *Fitzgerald* passed north and east of Caribou Island. The captain of the *Anderson* estimated that the *Fitzgerald* passed close to the 6-fathom shoal and he told the mate on watch that the *Fitzgerald* was closer to the shoal than he wanted the *Anderson* to be.

At 3:20 p.m. the *Anderson* recorded steady winds of 43 knots from the northwest with snow. The seas were 12 to 16 feet and the *Anderson* was shipping considerable quantities of water on deck.

Shortly after 3:30, the *Fitzgerald* called the *Anderson*. The caller, whom the *Anderson*'s bridge watch assumed was the captain of the *Fitzgerald*, reported a fence rail down, two vents lost or damaged, a list, and both pumps going. The master of the *Anderson* later testified that he had understood this to mean the loss of ballast tank vents and a small list.

The *Fitzgerald* was then approximately 17 miles ahead and 1 to 1½ points to the right of *Anderson*'s heading. The *Fitzgerald*'s master indicated that he would "check down" to allow the *Anderson* to close the distance between the two vessels, and the master of the *Anderson* agreed

to keep track of the *Fitzgerald*. None of the officers on the *Anderson* who had overheard this conservation felt that there was any real fear for the safety of the *Fitzgerald*.

Shortly after this conversation, the *Anderson* received a U.S. Coast Guard broadcast indicating that the Sault Ste. Marie locks had been closed and that all ships should seek a safe anchorage.

Sometime between 4:10 and 4:15 in the afternoon, the *Fitzgerald* called to say that their radars weren't working, and to request that the *Anderson* provide navigational assistance. The *Fitzgerald* was observed to pass approximately 3 to 5 miles east of Caribou Island sometime between 4:00 and 4:30 p.m. on its closest point of approach to the island. The *Anderson* continued to trail behind by approximately 16 miles.

During this same period, the upbound Swedish vessel *Avafors* answered a call from the *Fitzgerald* for any vessel in the vicinity of Whitefish Point. The *Fitzgerald* asked if Whitefish Point beacon or light was on. The pilot replied that he could neither see the light nor receive the beacon. Later he overheard the *Fitzgerald* call the Coast Guard at Sault Ste. Marie and then at Grande Marais, but he did not hear whether or not the Coast Guard answered.

At 4:39, the Coast Guard Station at Grande Marais, Michigan, received a call from *Fitzgerald* asking if the radiobeacon was operating. The watch stander at Grande Marais contacted Group Sault Ste. Marie and was told that Whitefish radiobeacon was not operating due to a power failure. Grande Marais called the *Fitzgerald* back immediately and relayed the information.

At 4:52 p.m., the *Anderson* changed course to 141°T and passed abeam of Caribou Island at a distance of approximately 6 miles. The winds were logged at 58 knots from 304°T, the highest recorded during the voyage. It was still snowing lightly, with limited visibility and seas 12 to 18 feet.

The mate on watch took a fix at 5:01 p.m. and noted that the *Fitzgerald* was 15 miles ahead and "just a shade" to the left of the *Anderson*'s radar heading marker. He informed the *Fitzgerald* that Whitefish Point was 35 miles ahead on a bearing of 144°T from *Fitzgerald*'s position. The *Fitzgerald* acknowledged this information and indicated that they "wanted to be 2 to 2½ miles off Whitefish Point." The mate on the *Anderson* estimated that, with the drift, *Fitzgerald* was probably headed for that position.

Sometime after 5:00 p.m., the pilot of the *Avafors* again called the *Fitzgerald* and, after confirming that he was speaking to the master, told him that Whitefish Point light was now on, but the beacon was still off. At one point in this conversation, the master of the *Fitzgerald* paused and, apparently in response to a question by someone on his ship said, "Don't allow nobody on deck," and something else about a vent which the pilot was unable to understand. He then returned to his conversation with the pilot, saying that the *Fitzgerald* had a "bad list," had lost both radars, and was taking heavy seas over the deck in one of the worst seas he had even been in.

The pilot later stated that during the time between his two conversations with the *Fitzgerald*, he overheard two other conversations between the *Fitzgerald* and the *Anderson*. He did not recall the subject of the first, but in the second one *Anderson* placed *Fitzgerald* about 20 miles above Whitefish, "as near as he could tell," and *Anderson* was "about 10 miles behind and gaining about a mile and a half an hour."

The master of the *Anderson* testified that around 6:00 p.m., when

approximately 15 miles southeast of Caribou Island and just out of its lee, the vessel encountered much heavier seas with some waves as high as 25 feet.

At 6:20 the mate on watch called the *Fitzgerald* and asked what course they were steering, because they appeared to be working to the left of *Anderson*. They replied that they were steering 141°T. Again, at 7:00 p.m., the mate informed the *Fitzgerald* that they were 10 miles ahead and 1½ to 2 miles to the left of *Anderson*'s heading flasher, and that *Fitzgerald* was thus 15 miles from the islands at Crisp Point.

Ten minutes later, the mate again called the *Fitzgerald* and told them, "There's a target 19 miles ahead of us, so it's 9 miles ahead of you."

The *Fitzgerald* responded, "Well, am I going to clear?"

"Yes, he's going to pass to the west of you."

"Well, fine."

As the mate started to sign off, he asked, "Oh, by the way, how are you making out with your problems?"

"We're holding our own."

"Okay, fine, I'll be talking to you later."

This was the last transmission heard from the *Fitzgerald*.

At 7:10 p.m., the master of the *Anderson* observed that his vessel was 25 miles north-northwest of Whitefish Point, with the radar showing *Fitzgerald* 9 miles ahead and 1 to 1½ miles to the east of the heading flasher. This was the last time that anyone on the *Anderson* observed a target on the radar that they were certain was the *Fitzgerald*.

Shortly thereafter, it stopped snowing and the visibility improved considerably. At this time the wheelsman on the *Anderson* thought he saw a red and a white light on the port bow, the white one forward of the red one. He concluded that the red light was on the shore, and then mentioned the white light to the rest of the bridge watch, but no one else was able to see it.

The mate now could see lights which he believed to be those of one of the upbound vessels 17 to 18 miles ahead. Because the *Edmund Fitzgerald* should have been closer, he was surprised that he could not see her lights. Thinking that the *Fitzgerald* might have had a blackout, the master told everyone on the bridge to look for a silhouette on the horizon.

At 7:20, after adjusting the radar, the *Anderson* had three distinct targets, but none was the *Fitzgerald*. The master tried to call the *Fitzgerald* on VHF–FM, and there was no response. The mate then attempted to call first the *Fitzgerald* and then one of the upbound vessels, but neither answered. He then called a vessel known to be anchored in Whitefish Bay, which responded and indicated that the *Anderson*'s signal was good.

The master of the *Anderson* testified that he tried to call the Coast Guard at Sault Ste. Marie on channel 16 and was told to shift to channel 12, but received no followup. He then called one of the upbound vessels near Whitefish Point and talked with the pilot, who indicated that he had no radar contacts which could be the *Fitzgerald*. Around 8:25 p.m. the master called the Coast Guard at Sault Ste. Marie, feeling that by this time it was "pretty evident that the *Fitzgerald* was gone." The *Anderson* had Whitefish Point abeam at 8:59, and at that time the winds were logged at 48 knots.

Coast Guard Group Sault Ste. Marie logged a call from the *Anderson* at 8:32 in which the master said: "I am very concerned with the welfare of the steamer *Edmund Fitzgerald*. He was right in front of us experiencing a little difficulty, taking on a small amount of water, and none of the upbound ships have passed him. I can see no lights as before and don't have him on radar. I just hope he didn't take a nosedive." This was the first recorded call from the *Anderson*.

Search Efforts

Following the *Anderson*'s 8:25 p.m. call concerning the *Fitzgerald*, the Coast Guard attempted contact on VHF/FM and also requested commercial radio station WLC at Roger's City, Michigan, to try to make contact. Neither station was successful. At 8:40 the Coast Guard Station at Sault Ste. Marie informed the Coast Guard Rescue Coordination Center (RCC) in Cleveland, the coordinator of search and rescue efforts on the Great Lakes, that there was uncertainty about the *Fitzgerald*.

A few minutes after 9 p.m., the *Anderson* called Coast Guard Station Sault Ste. Marie and reported the *Fitzgerald* missing. This report was immediately relayed to RCC Cleveland, and at 9:15 the Coast Guard Air Station at Traverse City, Michigan, was directed to dispatch an aircraft. At the same time, the Canadian Rescue Center at Trenton, Ontario, was advised of the situation. Before 9:30, RCC had directed to the scene both the Coast Guard Cutters *Naugatuck*, moored at Sault Ste. Marie, and *Woodrush*, moored in Duluth, Minnesota, approximately 300 miles away.

At the time that they reported the *Fitzgerald* missing, the *Anderson*, then at the entrance to Whitefish Bay, reversed course to assist in the search. Around 10:30, Coast Guard Group Sault Ste. Marie contacted seven other U.S. and Canadian vessels in or near the Bay. Of these, only the *William Clay Ford* and the *Hilda Marjanne* responded that they would get underway. The latter, however, found the conditions too severe and returned to anchorage after about 30 minutes.

Three upbound vessels which were in or slightly beyond the search area were asked to assist, but indicated that they did not believe they could reverse course without serious hazard. One of them, the *Nanfri*, did reduce speed, change course slightly to the north, and maintain a lookout.

The first Coast Guard aircraft began searching at 10:53 p.m. At 12:05 a.m. a helicopter arrived on scene, followed at 1:00 by another, the latter fitted with a "Night Sun," a focusable, 3.8 million candlepower xenon arc search light. A Canadian C–130 fixed-wing aircraft was dispatched at 12:37 a.m.

The cutter *Woodrush* got underway at 12:08 a.m. on 11 November and arrived on scene approximately 24 hours later. A Coast Guard 40-foot patrol boat, the CG–40573, was sent out from Sault Ste. Marie on the morning of the 11th and searched until late that afternoon.

The Coast Guard Cutter *Naugatuck* is restricted from operating in open water when winds exceed 60 knots, and because of the severe weather and sea conditions in eastern Lake Superior on the evening of 10 November when the *Naugatuck* was directed to get underway, it was also directed not to proceed beyond the entrance to Whitefish Bay. The *Naugatuck* suffered a failure of a lube oil line after being ordered to get underway. By the next morning, repairs had been completed and the weather had moderated. The *Naugatuck* got underway at approximately 9:00 a.m. and was on scene at 12:45 p.m.

There were no other Coast Guard search and rescue vessels available nearby that were considered capable of responding in the weather conditions which existed. The Canadian Coast Guard vessel, *Verendrye,* was made available nn the 12th and 13th of November and searched the area along the Canadian shore.

Coast Guard Station Sault Ste. Marie made urgent broadcasts for the *Fitzgerald* at 9:45 p.m. and at 10:00 p.m. An urgent broadcast was initiated hy the Ninth Coast Guard District at 10:38 p.m. and was rebroadcast regularly until 11:27 p.m. on 13 November.

In addition to the commercial vessels *Arthur M. Anderson, William Clay Ford,* and *Hilda Marjanne* which undertook the search on the night of the 10th, the following vessels responded to the urgent broadcast and assisted in the search: the *Armco, Roger Blough, Reserve, Wilfred Sykes,* and *William R. Roesch.* The Canadian vessels *Frontenac, Joan O. McKellar, Murray Bay,* and the fishing vessel *James D.* were also involved in the search. Throughout the night on the 10th, the fixed-wing aircraft, the helicopters, and the vessels *Anderson* and *Ford* searched the area using lights and flares.

The search area during the 11th, 12th, and 13th encompassed an area on the eastern end of Lake Superior from the eastern shore westward to a north–south line approximately 15 miles west of Crisp Point, and from the southern shore northward to an east–west line approximately at Caribou Island.

The coordinated air/sea search which began at daylight on the 11th utilized Coast Guard aircraft from Traverse City, Air Station Elizabeth City, N.C., and the Michigan Air National Guard, as well as a Canadian C–130 aircraft. The Coast Guard Cutters *Naugatuck* and *Woodrush* conducted various surface search patterns coordinated with the aircraft. At 10:12 p.m. on November 13th, the active search was suspended. Coast Guard Air Station Traverse City was directed to make daily flights over the area for about a week, and, after that, weekly flights were conducted until the end of the year.

The Ontario Provincial Police conducted numerous shoreline searches during the active search period and helicopters from Coast Guard Air Station Traverse City searched the Michigan and Canadian shorelines. Despite the intensive search efforts, no survivors were found, nor were any hodies recovered. The only things found were one lifeboat and half of another, two inflatable liferafts, 21 life preservers or life preserver pieces, and some miscellaneous flotsam identified as being from the *Fitzgerald.*

On the morning of 11 November 1975, it became apparent that there was some discharge of oil in the area where the *Fitzgerald* was lost. The U.S.–Canadian Joint Response Team was called in and remained on scene in an observer/advisory capacity until Friday, 14 November. At that time, it was concluded that the diesel how thruster fuel on board the vessel had vented and that the main propulsion fuel had reached a sufficiently low temperature to preclude further venting. The oil which had been observed on the surface dissipated and no cleanup effort was undertaken.

Also on the 14th, a Navy aircraft equipped with Magnetic Anomaly Detection (MAD) equipment located a strong single magnetic contact in the position 47°00.5′ N, 85° 06′ W. Additionally, a slight oil slick was noted at the site. This contact was later determined to be the sunken wreckage of the *Edmund Fitzgerald.*

Underwater Search and Survey

During the next 6 months, an extensive sequence of underwater search and survey activities was undertaken to locate the wreckage of the *Fitzgerald.* The first of these, a side-scan sonar search using the cutter *Woodrush* and equipment and personnel from the U.S. Coast Guard Research and Development Center, was conducted from 14 through 16 November 1975. During the first half day of the search, wreckage was located which was later positively identified as the *Fitzgerald.* The position of this wreckage, 46°59.8′ N, 85° 0.67′ W, was established by using highly sophisticated Coast Guard navigation equipment.

Further study disclosed two large objects lying close together on the lake floor in approximately 530 feet of water. Although the sonar trace quality was poor due to the continued bad weather in the area, preliminary calculations showed that each of the

objects was about 300 feet long. Additionally, a "sonically rough" area near these objects was detected and tentatively identified as spilled cargo.

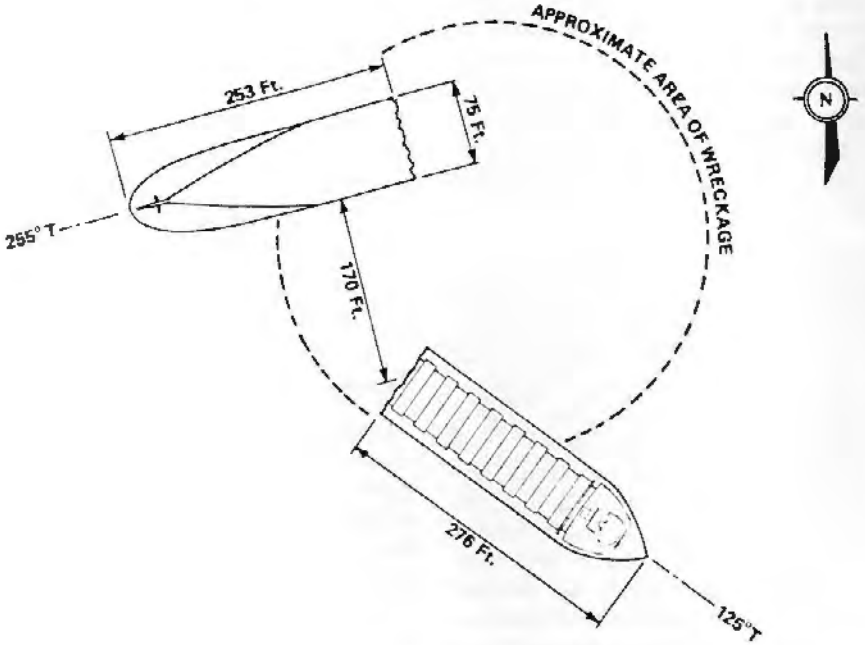
Because this first side-scan sonar search was conducted under conditions of adverse weather and the equipment used was not fully adapted to the water in which the wreckage was found, the Marine Board of Investigation recommended a second, more detailed side-scan sonar search. This second search was conducted during the period 22–25 November by a commercial contractor, again using the *Woodrush* as a platform for the survey.

The sonar operations were conducted almost continuously during the 3-day period under severe wind and sea conditions. A total of 80 sonar traces were made, along with nearly 300 navigational fixes to accurately determine the location of each trace. Based on the analysis of this survey, the Marine Board determined that the wreckage was very probably that of the *Fitzgerald;* still, positive identification was necessary. It was felt that the configuration and arrangement of the wreckage and the bottom conditions were such that a detailed *visual* survey was both feasible and necessary.

Early in the following spring, from the 12th through the 16th of May 1976, another sonar survey was made. This third survey was conducted in order to reestablish the exact position of the wreckage for the photographic survey and to ensure that the moorings for the survey platform were kept clear of the wreck.

On 20 May, a visual survey of the wreckage was begun using the U.S. Navy CURV III system. The CURV III system is composed of an unmanned underwater vehicle, an umbilical control and power cable, and surface equipment operated from any suitable support vessel. The vehicle is capable of making visual observations, recovering small objects, and performing other light work at depths to 7,000 feet. Mounted on board the search vehicle were one 35 mm still camera and two black and white TV cameras, lights, a manipulator arm, and other machinery.

Between the 20th and 28th of May, CURV III made a total of 12 dives, logging more than 56 hours of "bottom time" and recording 43,255 feet of videotape and 895 color photographs. Unfortunately, the visual survey was considerably hampered by mud which covered the wreckage and which was stirred up by the passage of the CURV III vehicle, greatly reducing the visibility. Consequently all the photographs were taken at a very close range showing only small details. However, the name of the vessel was clearly visible on both the stern and bow sections, and the identity of this wreckage was positively confirmed.



The results of the three side-scan sonar surveys and of the CURV III videotape and photographic survey were assembled and reviewed by an independent contractor, who prepared a diagram of the wreckage and artist's conceptions of the remains from several different viewpoints.

The wreckage of the *Edmund Fitzgerald* consists of an upright bow section approximately 276 feet long and lying on a heading of 125°T, an inverted stern section approximately 253 feet long lying on a heading of 075°T, and debris between. The two sections lie about 170 feet apart. All of the wreckage appeared to be settled into the bottom mud, and a great deal of mud covered the spar deck of the bow section. The bottom appeared to be plowed up around both the bow and stern sections.

Conclusions

The Marine Board of Investigation concluded that, lacking more definite information and in the absence of any survivors or witnesses, the proximate cause of the loss of the *Edmund Fitzgerald* could not be determined.

The most probable cause for the sinking of the vessel was the loss of buoyancy and stability resulting from massive flooding of the cargo hold. This flooding most likely took place through ineffective hatch closures as boarding seas rolled along the spar deck. Beginning early on 10 November, and progressing during the worsening weather and sea condi-

tions, the flooding increased in volume as the vessel lost effective freeboard, until finally the vessel plunged in the heavy seas.

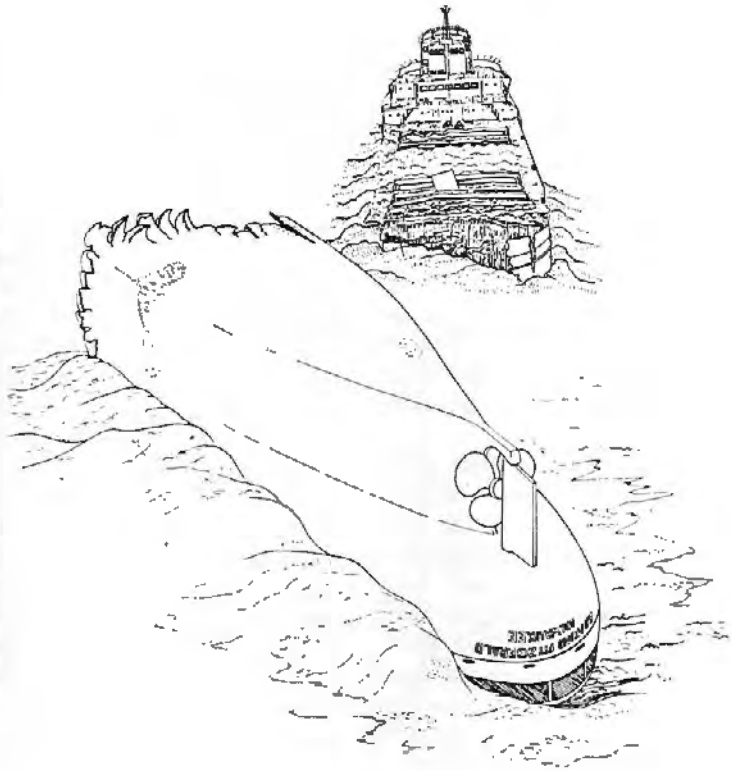
Contributing to this was the fact that the load line regulations in effect at the time allowed 3 feet 3¼ inches less freeboard than had been required when the vessel was built. The reduction in minimum required freeboard significantly reduced the vessel's buoyancy and also resulted in a significantly increased frequency and force of boarding seas in the storm the *Fitzgerald* encountered on the 10th. In turn, this resulted in an increased quantity of water flooding through the loosely dogged hatches and through other openings resulting from topside damage.

The system of hatch coamings, gaskets, and clamps installed on the *Fitzgerald* required continuing maintenance and repair due to both routine wear and the damages which regularly occurred during cargo transfer operations. That this required maintenance was not regularly performed was brought out by the fact that the crew of the vessel had no positive guidelines, in the form of company requirements or otherwise, concerning such maintenance. Significant repairs had been required during the previous winter layup period and more repairs of the same nature were expected during the next layup, indicating that the repairs were not regularly performed as damage occurred.

It was concluded by the Board that the system of cargo hatch coamings, gaskets, covers, and clamps which were installed on the *Fitzgerald* and the manner in which the system was maintained did not provide an effective means of preventing the penetration of water into the ship in any sea condition as required by Coast Guard regulations.

If the clamps had been properly fastened, any damage, disruption, or dislocation of the hatch covers would have resulted in damage to the Kestener-type hatch cover clamps. But the underwater survey showed that only a few of the clamps were damaged. It was concluded that there were too few properly fastened clamps to provide an effective closure of the hatches.

The cargo hold of the *Fitzgerald* was not fitted with a system of sounding tubes or other devices to detect the presence of flooding water. Had the water in the cargo hold reached a height to be seen, it is inconceivable that a seasoned master would not have taken more positive steps for vessel and crew safety than were reported. Therefore, it was concluded that the flooding of the cargo hold was not detected.



The hold was not fitted with transverse watertight bulkheads. As a result, the flooding water which entered could migrate throughout the hold, extending the effect of the flooding, and aggravating any trim which existed.

At some time prior to 3:30 p.m. on 10 November, the *Fitzgerald* sustained damage of sufficient magnitude to cause the master to report topside damage and a list. Significantly, he reported the damage rather than the incident which had caused it. It was concluded by the Board that the incident, while possibly of a serious nature, was not of such extent as to have caused, by itself, the loss of the vessel, and further that the full extent of the incident was not perceived by the vessel's personnel. The master noted the list and topside damage and incorrectly concluded that the topside damage was the only source of flooding. Based on this conclusion he began what he believed were adequate corrective measures — pumping the spaces which could receive flooding from damaged vents—and thus felt that the problems were under control.

The topside damage referred to by the master could have been caused by the striking of a floating object which was brought aboard in the

heavy seas. This also could have resulted in undetected damage to the hull plating above or below the waterline and additional unreported damage to topside fittings, including hatch covers and clamps. The intake of water into the tunnel or into one or more ballast tanks through the damaged vents and opened hull would have produced the reported list and increased the rate of cargo hold flooding. The most likely area of damage would have been in the forward part of the ship.

The vessel had entered a snowstorm about a half hour before the topside damage was reported. In addition, the *Fitzgerald's* radars were reported inoperative shortly after the damage was reported, and may have been malfunctioning for some period before the report. Both the reduced visibility and the radar malfunction would, in the opinion of the Board, have reduced the likelihood that the crew could have detected the object in sufficient time to take avoidance action.

The topside damage also could have been caused by some unidentified object on board breaking away in the heavy seas. The only items on deck which had enough mass to do sufficient damage to the hull to cause a sustained list were a hatch cover, the hatch cover crane, or the spare propeller blade. If such extensive damage had occurred, a seasoned master would have reported it immediately; such a report was not received from the *Fitzgerald*.

It is considered possible that a light grounding or near grounding on the shoals just north of Caribou Island could have occurred. The vessel could have been damaged from the grounding, from the effect of the violent seas which would be expected near the shoals, or from the suddering that the vessel would have experienced as it passed near the shoals. The damage could have been on deck, below the waterline, or both, leading to the reported topside damage and list. The Board concluded that a delay in making a course change after passing Michipicoten Island could have caused the *Fitzgerald* to pass close to the shoals. However, the distance between Michipicoten Island and the shoals is such that a delay of upwards of an hour would have been required for the *Fitzgerald* to actually reach the shoals.

Finally, the list could have been caused by a localized hull structural failure, resulting in the flooding of a ballast tank or tanks. The underwater survey of those parts of the wreckage which could be seen showed no evidence of brittle fracture which would indicate hull structural failure.

In the final analysis, the Marine Board concluded that the exact cause of the damage reported cannot be determined, but that the most likely cause was the striking of a floating object. It was concluded that the flooding from the reported damage, and from other damage which was not detected, most likely occurred in the forward part of the vessel, resulting in trim down by the bow. By the time the damage was reported, the flooding of the cargo hold had reached such an extent that the cargo was saturated and loose water existed in the hold. Because of the trim by the bow, this water migrated forward through the non-watertight screen bulkheads which separated the cargo holds, further aggravating the trim and increasing the rate of flooding.

Because there were neither witnesses nor survivors, and because of the complexity of the hull wreckage, the actual final sequence of events culminating in the sinking could not be determined. Whatever the sequence, however, it is evident that the end was so rapid and catastrophic that there was no time to warn the crew, attempt to launch lifeboats or liferafts, don life preservers, or even make a distress call.

The testimony of witnesses indicated a conflict as to the time the Coast Guard was first notified of the problems with the *Fitzgerald*. The Board concluded that the first notification came from the master of the *Anderson* at approximately 8:25 p.m. on 10 November. At the time of this call, the actual loss of the *Fitzgerald* was neither comprehended by the master nor conveyed to the Coast Guard. A second call at approximately 9:00 p.m. on the 10th did express grave concern that the *Fitzgerald* may have sunk, and rescue efforts were immediately initiated.

The time period which elapsed in evaluating and reporting the loss of the *Fitzgerald* did not contribute to the casualty or high loss of life, because the *Fitzgerald* sank suddenly, with all hands trapped on board.

The Marine Board of Investigation noted with a deep sense of gratitude the response by the merchant vessels in the area to the Coast Guard's request for assistance in searching—response which was "in keeping with the finest traditions of mariners." The actions of the vessels *Arthur M. Anderson* and *William Clay Ford* are considered exemplary and worthy of special notice. These vessels proceeded to the scene and searched under conditions of extreme weather and sea. The response of the Canadian vessel *Hilda Marjanne,* which got underway but was forced back by weather, was also worthy of note.

The Marine Board noted that the response by Coast Guard aircraft from Air Station Traverse City was timely. The first aircraft was not launched until 51 minutes after it had been ordered because of the time necessary to load flares for a night search. The launching of three aircraft within 1 hour and 35 minutes is within prescribed response requirements. The request for and dispatch of additional SAR aircraft from Coast Guard Air Station Elizabeth City, from the U.S. Navy, from the Michigan Air National Guard, and from Canadian SAR forces was also timely.

The Coast Guard buoy tender *Woodrush* was the only surface unit

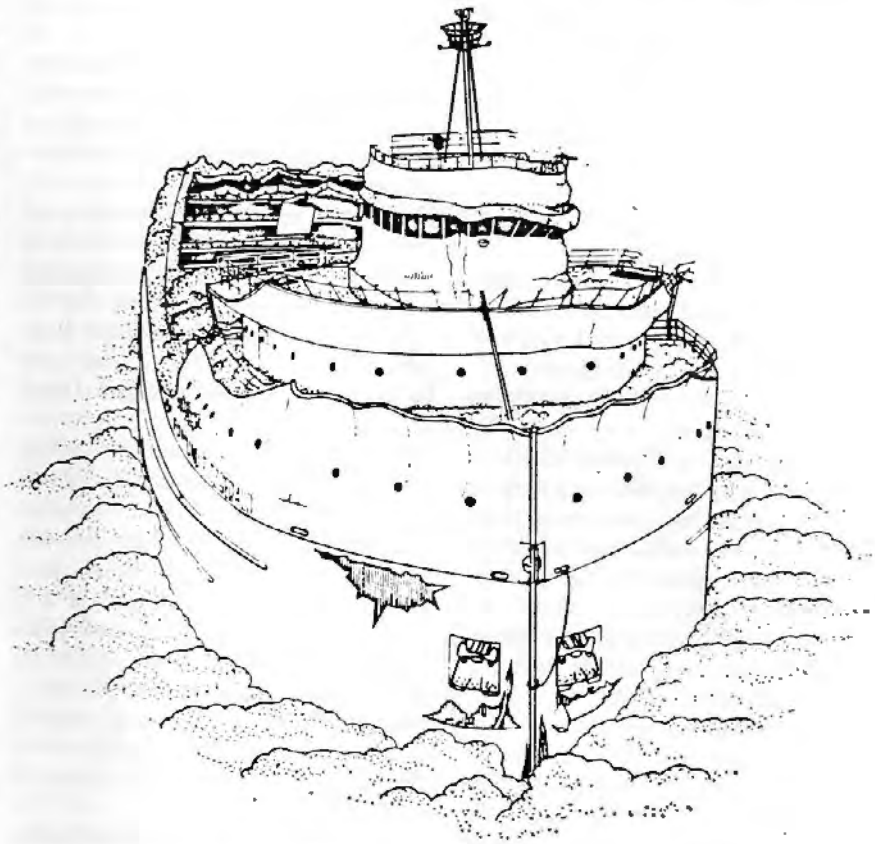
in a SAR standby status which was close enough to respond within a reasonable time and large enough to cope with the adverse weather and sea conditions. The *Woodrush* was moored at its home port in Duluth, Minnesota, on 6-hour standby status at the time of the casualty, but got underway within 2½ hours. The wind and sea conditions precluded the use of the harbor tug *Naugatuck* stationed at Sault Ste. Marie, and the small craft designed for coastal operations which were available on Lake Superior also were unsuitable for search 15 miles offshore in the high sea state that existed.

The Board noted that the progress of the severe storm which crossed Lake Superior on the 9th and 10th of November was adequately tracked by the National Weather Service, and the weather reports and forecasts reflected its path and severity. Forecasts were upgraded in a timely manner and a special warning was issued.

Estimates of wind velocity by persons on vessels in the storm were higher than those forecast and also higher than those reported by shore stations. Still, the overall severity of the storm was generally as forecast and reported and the Board concluded that mariners on Lake Superior on 10 November were adequately warned of the severe weather and the master of the *Fitzgerald* was aware of the severity and location of the storm.

The nature of Great Lakes shipping, with short voyages, much of the time in well protected waters, frequently with the same routine from trip to trip, leads to complacency and an overly optimistic attitude concerning the extreme weather hazards which can and do exist. The Marine Board felt that this attitude reflects itself at times in deferral of maintenance and repairs, in failure to prepare properly for heavy weather, and in the conviction that since refuges are near, safety is possible by "running for it."

While it is true that sailing conditions are good during the summer season, changes can occur abruptly with severe storms and extreme weather and sea conditions arising rapidly. This tragic accident points out the need for all persons involved in Great Lakes shipping to foster increased awareness of the hazards which exist.



Recommendations and Commandant's Action

Load lines; weathertight integrity

The Marine Board of Investigation made four recommendations directly related to load line regulations and weathertight integrity.

1. That Part 45 of Title 46 of the Code of Federal Regulations (Great Lakes Load Lines) be amended immediatly to rescind the reduction in minimum freeboard brought about by the 1959, 1971, and 1973 changes to the load line regulations. [*Recommendation 1*]

2. That the owners and operators of Great Lakes ore carrying vessels undertake a positive and continuing program of repair and maintenance to insure that all closures for openings above the freeboard deck are weathertight, that is, capable of preventing the penetration of water into the ship in any sea condition. This program should include frequent adjustment of hatch clamping devices and vent closures and prompt repair of all hatches, coamings, covers, and clamping devices found damaged or deteriorated. [*Recommendation 3*]

3. That Part 45 of Title 46 of the Code of Federal Regulations be amended to require closing and securing of hatches when underway in open waters and closing of vent caps when underway in a loaded condition. A visual inspection of the closure of hatch covers and vent caps should be conducted and logged by a licensed officer prior to sailing in a

loaded condition [*Recommendation 4*]

4. That the Coast Guard undertake a program to evaluate hatch closures presently used on Great Lakes ore carriers with a view toward requiring a more effective means of closure of such deck fittings. [*Recommendation 5*]

In response to these recommendations, the Commandant stated that the assignment of freeboard is based upon, among other things, a presumption of the ability to achieve sufficient weathertight integrity to prevent significant flooding. The mutually dependent areas of safety which are an integral part of all load line regulations are:

(1) that the hull is strong enough for all anticipated seaways;

(2) that the ship is designed and operated with proper stability;

(3) that the hull is watertight to the freeboard deck;

(4) that the hull has sufficient reserve buoyancy for seaworthiness;

(5) that the topside area is properly fitted so as to be capable of being made weathertight for all anticipated seaways; and,

(6) that protection for the movement of the crew on the weather decks at sea is provided.

None of these basic safety areas can be eliminated by additions to freeboard within practical limits. Freeboard, or its increase, is not by itself an adequate substitute for properly designed, maintained, and operated hatches, coamings, gaskets, and securing attachments. Such a substitution would unduly penalize good design, maintenance, and vessel operations.

The Coast Guard has been conducting a Great Lakes ship-rider program since the fall season of 1976 to evaluate the overall effectiveness of the combination of freeboard, hatch closure, and ventilator closure during the Intermediate (October 1–31) and Winter (November 1–March 31) freeboard seasons. The evidence found by the Board of Investigation, indicating that it was not a singular occurrence that the hatch covers on the *Edmund Fitzgerald* may not have been properly secured, has been confirmed by this program. Several ships were found to suffer in varying degrees from a lack of weathertight integrity due to the inability to make hatch covers weathertight and due to the inattention to ventilater covers prior to a winter season voyage.

The Commandant has initiated action to continue the ship-rider program in 1977, and in succeeding years as necessary, in order to either prevent from sailing or to severely restrict the voyage weather limits of any ship found to lack sufficient weathertight integrity. Extra seasonal freeboard requirements may also be assigned to supplement weather limitations on an individual vessel basis by the Commander, Ninth Coast Guard District.

The Commandant stated that the owners and operators of vessels should be aware of the fact that weathertight closures which are not effective when battened down void both the Load Line Certificate and the Certificate of Inspection. Additionally, ships' masters are reminded of their responsibilities for weathertight integrity before and during weather conditions as outlined in the operational regulations contained in 46 CFR, Part 97.

The Coast Guard will immediately undertake a critical evaluation of the hatch closures presently in use on Great Lakes bulk carriers. Should this evaluation show the present design either to be ineffective or to require such maintenance as to be difficult to assure weathertight integrity, regulatory notices will be published stating the design or maintenance shortcomings and requiring that ships modify or change hatch covers to correct these deficiencies. The Coast Guard will also reassess the existing Intermediate and Winter Season freeboard corrections, utilizing wave analysis information on Great Lakes wave spectra, gathered during an ongoing research program scheduled from 1977–1979.

Watertight subdivision

The Board recommended that any subsequent amendments to the Great Lakes Load Line Regulations, as they apply to ore carriers such as the *Edmund Fitzgerald,* should reflect full consideration of the necessity for a means of detecting and removing flooding water from the cargo hold and for watertight subdivision of the cargo hold spaces. Such an appraisal should take into account the severe weather and sea conditions encountered by these vessels and the resultant high degree of deck wetness, and also the inherent difficulty in meeting and maintaining a weathertight standard with the system of hatches, coamings, covers, gaskets, and clamps used on the *Fitzgerald* and many other Great Lakes vessels. [*Recommendation 2*]

In response to that recommendation, the Commandant intends to develop a federal regulation establishing a minimum level of subdivision for inspected Great Lakes cargo ships for two reasons directly related to this casualty. First, the sudden catastrophic foundering of the vessel apparently allowed no time for radio messages or for individual survival measures. Second, the *SS Edmund Fitzgerald* survived for several hours after indicating by radio message that some damage had occurred and that the ship was about one hour from a safe harbor of refuge when it sank.

It is possible that even a minimum degree of watertight subdivision within the cargo holds could have effected a great change on the ultimate fate of both the ship and her crew. It is possible that the flooding, which is presumed to have occurred through ineffective hatch covers, might have occurred through only one or two hatches, but the subsequent flooding was able to penetrate the entire cargo hold.

Subdivision bulkheads in the cargo space would have limited this flood-

ing, possibly enough to enable this ship to make it to safe harbor. Had they realized the extent of the damage, the provision of subdivision calculations and damage control instructions might have at least allowed the crew more time to escape prior to the sinking.

An additional concern is raised by the report of minor side damage incidents. Bulk carriers are now being built which do not have the crew passage/ballast tank combination at the sides which provided some protection in cases of minor penetration. The arrangements on these new vessels are such that a penetration of the hull near the waterline might cause flooding over 90 percent of the ship's length. An incident could occur such that little chance of preventing the sinking of the vessel would exist, and the crew might have a very short time to escape. Subdivision standards will be directed toward this type of casualty. As the benefits of subdivision apply also to oceangoing cargo ships, international discussions toward an increase of subdivision safety for all cargo ships will be further pursued.

Lifesaving equipment; training

The Board made six recommendations concerning lifesaving equipment and crew training. These recommendations are:

1. That the owners and operators of Great Lakes vessels, in cooperation with the maritime unions and training schools, undertake a program to improve the level of crew training in the use of lifesaving equipment installed on board the vessels, and in other emergency procedures. This program should specifically include training in the use of inflatable liferafts and should afford crews of vessels the opportunity to see a raft inflated. [*Recommendation 6*]

2. That Part 97 of Title 46 of the Code of Federal Regulations be amended to require crew training in launching, inflation, and operation of inflatable liferafts. [*Recommendation 7*]

3. That the Coast Guard institute a continuing program of inspections and drills for Great Lakes vessels prior to each severe weather season. The severe weather season should correspond to the Winter Load Line season (1 November through 31 March). Under this program, just before the severe weather season began there would be an inspection to verify that the crew had been trained in the use of lifesaving equipment, and drills would be conducted with the crew then on board the vessel.

There would be a physical inspection of the spar deck and all critical structural and nonstructural members exposed to damage from cargo loading and off-loading equipment including, but not limited to, hatch coamings, hatch covers, vent covers, tank tops, side slopes, hatch-end girders, arches, spar deck stringers, and spar deck plating. Additionally, all emergency drills would be witnessed, and alarms, watertight closures, navigation equipment, and required logs would be inspected. [*Recommendation 8*]

4. That the Coast Guard complete, as soon as possible, the studies currently underway which concern primary lifesaving equipment, its launching, and disembarkation from stricken vessels. And, that the measure be implemented promptly to improve the entire abandon ship system, including equipping and training personnel, automatic launching of equipment, and alerting rescue forces. [*Recommendation 10*]

5. That the Coast Guard promulgate regulations which require vessels operating on the Great Lakes during the severe weather season to have, for each person on board, a suit designed to protect the wearer from exposure and hypothermia. [*Recommendation 13*]

6. That the Coast Guard foster and support programs dedicated to increasing awareness, on the part of all concerned with vessel operations, inspection, and maintenance, of the hazards faced by vessels in Great Lakes service, particularly during the severe weather season. The program should make maximum use of company safety programs, safety bulletins, publications, and trade journals. [*Recommendation 15*]

The Commandant concurred with the intent of these recommendations and with the need for improved and periodic meaningful training in the use of lifesaving equipment and for a vessel readiness inspection program prior to severe weather sailing.

In October 1976, the Coast Guard instituted a continuing program of inspections and drills for Great Lakes vessels prior to the severe weather season. The scope of this program includes the specific items listed in Recommendation 8 and are conducted while the vessels are underway and under actual operational conditions. The requirements for conducting emergency drills and crew training are contained in 46 CFR, Parts 97.15–35 and 97.13–20. It is the master's responsibility to make sure that emergency fire and boat drills are conducted at least once every week.

Assuring that adequate drills are conducted on a weekly basis is not a problem unique only to Great Lakes vessels; therefore the operations sections of 46 CFR, Parts 35, 78, 167, 168, and 185 will be amended to incorporate crew training in the launching, inflation, and operation of inflatable liferafts. The Coast Guard recognizes this lack of training as one of international magnitude, and is working within the Intergovernmental Maritime Consultative Organization (IMCO) in the preliminary stages of such a program.

Owners, operators, labor organizations, and training schools will be encouraged to develop a training program of the type outlined by the Board in Recommendation 6. In support of this effort, the Coast Guard will set qualification standards, requiring all licensed officers and able seamen be trained in the operation of inflatable liferafts as well as other lifesaving equipment. Input from the

owners and operators of Great Lakes vessels, along with their crews' labor organizations and training schools, will be solicited.

The Coast Guard is continually expanding its public awareness programs to provide useful information to seamen and aid operators and unions in the conduct of their training programs. In September 1975, a pamphlet on hypothermia, CG–473, was published and distributed on the Great Lakes and other areas where cold weather survival could be a problem.

A proposed program is being developed whereby the public, specifically those on board commercial vessels, will be made aware of various safety factors, regulations, and safe operating procedures that apply to their particular commercial operation. Great Lakes vessels would be an appropriate area for such a public awareness program.

On 7 June 1976, an Advance Notice of Proposed Rulemaking was published in the Federal Register for Great Lakes cargo, tank, and passenger vessels which proposed that:

(1) All lifeboats on vessels be totally enclosed to provide protection from exposure and to lessen the danger of swamping and subsequent capsizing.

(2) All lifeboats be diesel engine driven with the ability to start the engine in temperatures as low as −22°F.

(3) Sufficient lifeboats be provided to accommodate 100 percent of the persons on board the ship with additional lifeboats and life rafts provided and located so as to provide accommodation for an additional 100 percent in the event that a casualty renders the other lifeboats unusable.

(4) All survival craft he provided with launching devices which will be launched from their stowed positions with all persons on board, eliminating the need for lengthy pre-launch preparation, a deck crew to stay aboard to control the launch, and in the case of life rafts, the need to enter the water before boarding.

(5) Automatic float-free launching be required for life rafts.

(6) An exposure suit be required for each person on board that will protect the wearer from exposure and hypothermia.

One lifeboat manufacturer is developing a float-free launching system for lifeboats which are also launched conventionally. This concept will be given further consideration as a requirement upon completion of a prototype system and an evaluation of its feasibility.

Loading and ballasting

The Marine Board's Recommendation 9 urged, "that the Coast Guard take positive steps to insure that the masters of Great Lakes vessels are provided with information, as is required by the regulations, concerning loading and ballasting of Great Lakes vessels, and that the information provided include not only normal loaded and ballasted conditions, but also details on the sequences of loading, unloading, ballasting, deballasting, and intermediate stages thereof, as well as information on the effect upon the vessel of accidental flooding from damage of other sources."

In response to this recommendation, the Coast Guard will develop performance criteria for loading manuals which will cover all the items in this recommendation except flooding conditions. Flooding conditions will be addressed in conjunction with the casualty control efforts discussed earlier in response to the Board's Recommendation 2.

SAR capability

Recommendation 11: "That the Coast Guard schedule maintenance status for buoy tenders and icebreakers located in the Great Lakes so as to maximize surface search and rescue capability during the severe weather season, consistent with their primary missions."

This recommendation has already been implemented by the issuance of a directive, on 9 September 1976, by the Commander, Ninth Coast Guard District, containing the requirements and guidelines for scheduling maintenance and underway periods on Coast Guard vessels on the Great Lakes.

EPIRB

Recommendation 12: "That Subpart 94.60 of Title 46 of the Code of Federal Regulations, which requires emergency position indicating radio beacons (EPIRB), be amended to include requirements for such beacons on vessels operating on the Great Lakes during the severe weather season."

In response to this recommendation, the Commandant stated that action is already being taken to require an EPIRB on the VHF–FM marine band. At present there is virtually complete shore station coverage of the Great Lakes on this band and constant monitoring of Channel 16 by stations in both the United States and Canada. A prototype EPIRB for test is now being assembled and, as soon as the VHF–FM EPIRB's become available, regulations will be proposed requiring that they be installed aboard inspected Great Lakes vessels during all operating seasons.

Chart correction

Recommendation 14: "That navigation charts, showing the area immediately north of Caribou Island, be modified to show the extent of the shoals north of the island and that this modification be given the widest possible dissemination, including Notices to Mariners."

The United States Department of Commerce, National Oceanic and Atmospheric Administration, will be forwarded a completed copy of the Marine Board report, with a request that they coordinate the correction of the applicable charts with their counterparts in the Canadian Government.

Marine Safety Council Membership

The new Chief of the Office of Engineering is Rear Admiral Benedict L. Stabile.

After graduating from Brooklyn Technical High School in 1946, Stabile was appointed a Cadet at the U.S. Coast Guard Academy, New London, Conn. He was graduated with a Bachelor of Science degree in Marine Engineering and commissioned an Ensign on June 2, 1950.

During his first 2 years of duty, Stabile served in USCGC *Unimak* and USCGC *Castle Rock* out of Boston, Mass. He spent considerable time on ocean station patrols and search and rescue missions in the North Atlantic. While serving in ocean station vessels during that period Stabile was assigned temporary duty at the Atomic Defense School, Ft. McClellan, Ala.

From June 1953 to June 1956, he was assigned postgraduate training, earning a degree in Naval Construction and Engineering at the Massachusetts Institute of Technology in Cambridge, Mass.

Following school he was assigned as Assistant to the Electronics Planning Officer at the Coast Guard Yard, Curtis Bay, Md. Returning to Boston in May 1957, he reported to the USCGC *Eastwind* where he served as Assistant Engineer Officer and Engineer Officer until May 1959. This duty included several trips to the Arctic for resupplying northern weather stations and bases and in sealift operations for DEW (Distant Early Warning) Line stations.

His next tour of duty was spent at the Eighth Coast Guard District Headquarters, New Orleans, where he was assistant branch chief on the Engineering Staff for a year. Stabile was then appointed branch chief for the remaining 3 years of that tour.

From New Orleans, Stabile was transferred to the office of the Coast Guard Resident Inspector at Todd Shipyard located in Houston, Tex., where he served as inspector in connection with the construction of the new 210-foot class medium endurance cutters. Stabile then served as Executive Officer aboard the first cutter completed, USCGC *Reliance* (WMEC–615), which was commissioned on March 15, 1964, and based at Corpus Christi, Tex.

Between August 1965 and August 1968, he served as Chief, Naval Engineering Branch, Fifth Coast Guard District, Portsmouth, Va. This was followed by a year as Chief, Boating Safety Branch, also at Portsmouth.

Stabile spent the next 3 years at Coast Guard Headquarters, Washington, D.C. He was the Senior Staff Assistant, Office of Engineering, from June 1970 to June 1971. From June 1971 to June 1973 he was Chief, Ocean Engineering Division, an assignment from which he received the Meritorious Service Medal.

In 1973–75 he commanded the USCGC *Mellon*, a high endurance cutter home ported at Honolulu. For that tour of duty he was awarded the Coast Guard Commendation Medal.

In July 1975, he was assigned as Commanding Officer of the Coast Guard Yard at Curtis Bay, Md., where he remained for 2 years.

By nomination of the President and approval of the Senate, Stabile was appointed rear admiral effective July 1, 1977. Subsequently, he was named to assume the post of Chief, Office of Engineering, at Headquarters in June 1977.

Admiral Stabile's wife is the former Barbara Adele Thompson of Flushing, L. I., N.Y. a graduate of Connecticut College for Women. They have four children, Janet, Bennett, Gale, and Roderick. ⚓

Nautical Queries

The following items are examples of questions included in the Chief Mate and Master examinations and Third Assistant and Chief Engineer examinations.

Deck

1. A 250 meter vessel being towed in International waters shall carry
   - A. sidelights, sternlight, and towing light at night and a black ball during daylight.
   - B. sidelights, sternlight, and towing light at night and a black diamond during daylight.
   - C. sidelights and an all-round light at night and a black diamond during daylight.
   - D. sidelights and sternlight at night and a black diamond shape during daylight.

2. For determining a safe speed, all the following factors are mentioned by the rules EXCEPT
   - A. the presence of background light at night.
   - B. the draft, in relation to the available depth of water.
   - C. the competency of the crew.
   - D. constraints imposed by the radar range scale in use.

3. A vessel not under command, a towing vessel, and a sailing vessel all
   - A. are considered "restricted in their ability to maneuver."
   - B. have the right of way over a fishing vessel.
   - C. shall avoid impeding the safe passage of a vessel constrained by her draft.
   - D. sound the same fog signal.

4. You are in charge of a vessel underway in fog. You hear a fog signal of two prolonged blasts on the starboard quarter. You should
   - A. stop your engines.
   - B. reduce speed to bare steerageway.
   - C. hold course and speed.
   - D. sound the danger signal.

5. A lantern combining the two sidelights of a vessel's running lights may be shown on a
   - A. sailing vessel of less than 12 meters in length.
   - B. 40 meter barge.
   - C. 25 meter tug.
   - D. 15 meter vessel engaged in fishing and not making way.

Engineers

1. If a hydraulic pump and motor suffer an immediate loss of pressure with a loss of hydraulic control, the probable cause is
   - A. external leakage from the high pressure relief valve.
   - B. an internal failure in the hydraulic pump.
   - C. internal leakage through the pressure relief valve.
   - D. an internal failure in the hydraulic motor.

2. Cyclic speed variations occur in a diesel engine operating under a constant load because the engine
   - A. pistons tend to increase engine speed on the power strokes and reduce it on compression strokes.
   - B. cylinders do not all develop the same power.
   - C. load limiting governor has allowed excessive load to be placed on the engine.
   - D. speed limiting governor is failing to control engine speed.

3. The longer the ignition delay period in a diesel engine, the
   - A. more rapidly combustion pressure will rise.
   - B. less fuel will enter the cylinder.
   - C. lower cylinder combustion temperature will be.
   - D. more complete fuel combustion will be.

4. A sudden power loss in a turbocharged and aftercooled diesel engine is an indication of a (an)
   - A. seized piston in one cylinder.
   - B. overload on the intercooler.
   - C. obstruction in the engine cylinders.
   - D. turbocharger failure or malfunction.

5. Coast Guard regulations state that an audible alarm device shall be provided on emergency diesel-engine-driven generator sets to sound on
   - A. dangerous overspeeding.
   - B. high exhaust temperature.
   - C. low lube oil pressure.
   - D. low cooling water temperature.

Answers

Deck

1.D 2.C 3.D 4.C 5.A

Engineers

1.B 2.A 3.A 4.D 5.C

MERCHANT MARINE SAFETY PUBLICATIONS

The following publications of marine safety rules and regulations may be obtained from the nearest marine inspection office of the U.S. Coast Guard.* Because changes to the rules and regulations are made from time to time, these publications, between revisions, must be kept current by the individual consulting the latest applicable Federal Register. (Official changes to all Federal rules and regulations are published in the Federal Register, printed daily except Saturday, Sunday, and holidays.) The date of each Coast Guard publication in the table below is indicated in parentheses following its title. The dates of the Federal Registers affecting each publication are noted after the date of each edition.

The Federal Register will be furnished by mail to subscribers, free of postage, for $5.00 per month or $50 per year, payable in advance. The charge for individual copies is 75 cents for each issue, or 75 cents for each group of pages as actually bound. Remit check or money order, made payable to the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

CG No.	TITLE OF PUBLICATION
101–1	Specimen Examinations for Merchant Marine Deck Officers (2d and 3d Mate) (4–1–77).
101–2	Specimen Examinations for Merchant Marine Deck Officers (Master and Chief Mate) (4–1–76).
108	Rules and Regulations for Military Explosives and Hazardous Munitions (4–1–72). F.R. 7–21–72, 12–1–72, 6–18–75.
*115	Marine Engineering Regulations (6–1–73). F.R. 6–29–73, 3–8–74, 5–30–74, 6–25–74, 8–26–74, 11–14–74, 6–30–75, 9–2–75, 9–13–76, 9–26–77.
123	Rules and Regulations for Tank Vessels (8–1–77). F.R. 8–17–77, 9–12–77.
169	Navigation Rules—International—Inland (5–1–77). F.R. 7–11–77, 7–14–77, 9–26–77, 10–12–77, 11–3–77.
*172	Rules of the Road—Great Lakes (7–1–72). F.R. 10–6–72, 11–4–72, 1–16–73, 1–29–73, 5–8–73, 3–29–74, 6–3–74, 11–27–74, 4–16–75, 4–28–75, 10–22–75, 2–5–76, 1–13–77.
174	A Manual for the Safe Handling of Flammable and Combustible Liquids and Other Hazardous Products (9–1–76).
176	Load Line Regulations (2–1–71). F.R. 10–1–71, 5–10–73, 7–10–74, 10–14–75, 12–8–75, 1–8–76.
182–1	Specimen Examinations for Merchant Marine Engineer Licenses (2d and 3d Assistant) (4–1–75).
182–2	Specimen Examinations for Merchant Marine Engineer Licenses (First Assistant) (4–1–76).
182–3	Specimen Examinations for Merchant Marine Engineer Licenses (Chief Engineer) (4–1–76).
184	Rules of the Road—Western Rivers (8–1–72). F.R. 9–12–72, 12–28–72, 3–8–74, 3–29–74, 6–3–74, 11–27–74, 4–16–75, 4–28–75, 10–22–75, 2–5–76, 3–1–76, 6–10–76.
*190	Equipment Lists (5–1–75). F.R. 5–7–75, 6–2–75, 6–25–75, 7–22–75, 7–24–75, 8–1–75, 8–20–75, 9–23–75, 10–8–75, 11–21–75, 12–11–75, 12–15–75, 2–5–76, 2–23–76, 3–18–76, 4–5–76, 5–6–76, 6–10–76, 6–21–76, 6–24–76, 9–2–76, 9–13–76, 9–16–76, 10–12–76, 11–1–76, 11–4–76, 11–11–76, 12–2–76, 12–23–76, 4–4–77, 4–11–77, 4–21–77, 5–19–77, 5–26–77, 6–9–77.
191	Rules and Regulations for Licensing and Certification of Merchant Marine Personnel (11–1–76). F.R. 3–3–77, 8–8–77.
227	Laws Governing Marine Inspection (7–1–75).
239	Security of Vessels and Waterfront Facilities (5–1–74). F.R. 5–15–74, 5–24–74, 8–15–74, 9–5–74, 9–9–74, 12–3–74, 1–6–75, 1–29–75, 4–22–75, 7–2–75, 7–7–75, 7–24–75, 10–1–75, 10–8–75, 6–3–76, 9–27–76, 2–3–77, 3–31–77.
257	Rules and Regulations for Cargo and Miscellaneous Vessels (9–1–77). F.R. 9–26–77, 9–29–77.
*258	Rules and Regulations for Uninspected Vessels (4–1–77). F.R. 9–26–77.
*259	Electrical Engineering Regulations (7–1–77). F.R. 9–26–77.
268	Rules and Regulations for Manning of Vessels (7–1–77).
293	Miscellaneous Electrical Equipment List (7–2–73).
*320	Rules and Regulations for Artificial Islands and Fixed Structures on the Outer Continental Shelf (7–1–72). F.R. 7–8–72.
323	Rules and Regulations for Small Passenger Vessels (Under 100 Gross Tons) (7–1–77). F.R. 9–26–77.
329	Fire Fighting Manual for Tank Vesels (1–1–74).
439	Bridge-to-Bridge Radiotelephone Communications (12–1–72). F.R. 12–28–72, 3–8–74, 5–5–75.
467	Specimen Examinations for Uninspected Towing Vessel Operators (10–1–74).
497	Rules and Regulations for Recreational Boating (7–1–77). F.R. 7–14–77, 8–18–77.

CHANGES PUBLISHED DURING JULY–NOVEMBER

CG–115, 259 & 323, Federal Register of September 26.
CG–123, Federal Registers of August 18 & September 12.
CG–191, Federal Register of August 8.
CG–169, Federal Registers of July 11 & 14, September 26, October 12, & November 3.
CG–257, Federal Registers of September 26 & 29.

*Due to budget constraints or major revision projects, publications marked with an asterisk are out of print. Most of these pamphlets reprint portions of Titles 33 and 46, Code of Federal Regulations, which are available from the Superintendent of Documents. Consult your local Marine Inspection Office for information on availability and prices.

DEPARTMENT OF TRANSPORTATION
U. S. COAST GUARD
WASHINGTON, D. C. 20590

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U. S. COAST GUARD
DOT-514