Adopted: August 23, 2022 MIR-22/21

Sinking of Commercial Fishing Vessel *Emmy Rose*

Atlantic Ocean

About 27 miles off the coast of Provincetown, Massachusetts

November 23, 2020

Abstract: This report discusses the November 23, 2020, sinking of the commercial fishing vessel *Emmy Rose* in the Atlantic Ocean about 27 miles off the coast of Provincetown, Massachusetts. None of the vessel's four crewmembers survived the sinking. The *Emmy Rose* sank in about 800 feet of water and was not recovered. The vessel, valued at $325,000, was declared a constructive total loss. Safety issues identified in this report include the vessel's lack of sufficient stability to meet regulatory criteria, ineffective freeing port cover design, the lack of securing mechanisms for deck hatches to maintain the vessel's watertight integrity, and the need for personal locator beacons to enhance search and rescue efforts. As part of its investigation, the National Transportation Safety Board makes two new safety recommendations to the United States Coast Guard. We also reiterate one safety recommendation to the Coast Guard.

NOTE: This report was reissued September 14, 2021, with corrections to the casualty date on pages ix and 36.

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Acronyms and Abbreviations

AIS	automatic identification system
CFR	*Code of Federal Regulations*
EPIRB	emergency position indicating radio beacon
kHz	kilohertz
kW	kilowatt
MHz	megahertz
MSC	Marine Safety Center
NOAA	National Oceanic and Atmospheric Administration
NTSB	National Transportation Safety Board
PLB	personal locator beacon
ROV	remotely operated vehicle
SAR	search and rescue
VHF	very high frequency
VMS	vessel monitoring system
WHOI	Woods Hole Oceanographic Institute

Glossary

Bulwark: Vertical plating that forms an extension of a vessel's side above its weather decks (exposed decks). Strengthened by stanchions, a bulwark serves as a protection from seas for personnel and deck cargo where a vessel's freeboard is small.

Downflooding: The entry of seawater through any opening, such as a vent, door, or hatch, into the hull or superstructure of an undamaged vessel due to heel, trim, or submergence of the vessel.

Downflooding point: Downflooding points allow water to enter the buoyant volume of the vessel when they are submerged below the waterline. They are typically identified during a vessel's stability test and described in the field notes or analysis along with their location(s) and watertight integrity properties.

Freeboard: The vertical distance between the waterline and the highest watertight deck.

Freeing port: An opening in the bulwark or rail, often covered by a hinged plate, to allow large quantities of deck water to run overboard.

Hatch coaming: A vertical plated structure built around a hatchway to prevent water from entering the hold, and to serve as a framework for the hatch cover(s).

Lazarette: The aftmost compartment below the main deck, typically accessed by a deck hatch.

Lightweight displacement: The weight of a vessel ready for sea with no cargo, fuel, water ballast, stores, provisions, passengers, or crew on board.

Load line: Documentation confirming that a vessel meets specific structural design, construction, and maintenance criteria.

Major conversion: A conversion of a vessel that, as determined by the Commandant of the US Coast Guard, substantially changes the dimensions or carrying capacity of the vessel; changes the type of vessel; substantially prolongs the life of the vessel; or otherwise changes the vessel such that it is essentially a new vessel.

Remotely operated vehicle: A maneuverable unoccupied underwater machine, connected by a tether or cable to a vessel on the surface and typically equipped with cameras, used to explore ocean depths while being operated from the surface vessel.

Sheer: A measure of longitudinal curvature of a vessel's main deck.

Side scan sonar: Used to detect and image objects on the seafloor. A sonar device emits fan-shaped acoustic pulses down toward the seafloor across a wide angle perpendicular to the path of the sensor through the water, which may be towed from a surface vessel or submarine or mounted on a vessel or submersible's hull. Sound frequencies used in side scan sonar usually range from 100 to 500 kilohertz.

Substantial alteration: When a vessel is physically altered in a manner that affects its stability and includes alterations that: result in a change of the vessel's lightweight vertical center of gravity of more than 2 inches, a change in the vessel's lightweight displacement of more than 3%, or an increase of more than 5% in the vessel's projected lateral area, as determined by tests or calculations; change the vessel's underwater shape; change a vessel's angle of downflooding; and change a vessel's buoyant volume.

Vessel monitoring system: A satellite surveillance system primarily used by the National Oceanic and Atmospheric Administration to monitor the location and movement of commercial fishing vessels within US jurisdiction and treaty areas. The system uses satellite and cellular-based communications from onboard transceiver units, which certain vessels are required to carry. The transceiver units send position reports that include vessel identification, time, date, and location, and are mapped and displayed on the end user's computer screen.

Executive Summary

What Happened

On November 17, 2020, after departing Portland, Maine, the four crewmembers aboard the 82-foot-long commercial fishing vessel *Emmy Rose* fished for 5 days in the Gulf of Maine. On November 22, the captain notified a seafood distribution facility in Gloucester, Massachusetts, that they had about 45,000 pounds of assorted fish to offload and expected to arrive at 0600 the following morning. The crew fished for another 4 hours, departing about 1830 for Gloucester.

At 0129 on November 23, the US Coast Guard in Boston, Massachusetts, received a distress signal from the emergency position indicating radio beacon (EPIRB) registered to the *Emmy Rose*. There were no distress calls from the vessel before the EPIRB signal. The vessel had traveled about 45 miles to the west over the 7 hours since departing the fishing grounds. Weather conditions recorded by a nearby buoy (about 21 miles from the sinking site) at the time of the EPIRB signal were winds from the east-southeast at 17 knots, gusting to 21 knots, and the sea state was 5.6 feet observed with an easterly sea swell of 5-6 feet.

Coast Guard search and rescue assets were deployed to the area of the EPIRB signal, about 27 miles from Provincetown, Massachusetts. Search and rescue efforts continued for 38 hours and covered over 2,200 square miles. During the search, Coast Guard personnel recovered the EPIRB, the liferaft, one life ring, and two wooden fish hold hatch covers from the *Emmy Rose*. None of the crewmembers were located as of the date of this report, and they are presumed dead. The vessel sank in 794 feet of water and was not recovered. Its estimated value was $325,000.

What We Found

At the time of the sinking, the *Emmy Rose* likely did not meet regulatory stability criteria, which meant that the vessel had a smaller margin of safety than intended by regulations and was more susceptible to capsizing. The vessel's return course to Gloucester placed the vessel in quartering and following seas that likely allowed seawater to accumulate on the aft working deck. The vessel's freeing ports did not meet regulatory requirements for freeing port area and freeing port cover design, thus making the vessel more susceptible to accumulating water on deck. The combined effects of the weather conditions acting on the vessel and accumulating water on the starboard side caused the vessel to list to starboard and reduced the vessel's stability.

The vessel's lazarette hatch had a nonwatertight cover that had no securing mechanism, which meant the *Emmy Rose* was not being operated in accordance with its stability instructions and fishing vessel regulations, and water likely began flooding the vessel through the hatch that was likely opened by the sloshing seawater on the stern.

Because of the water on deck and downflooding through the lazarette and fish hold hatches, the vessel likely experienced a sudden capsizing.

Commercial fishing vessel safety examinations focus on safety equipment and systems on board. We found that the inclusion of an examination of freeing port covers during these safety examinations would increase the safety of commercial fishing vessels by identifying when the covers do not meet the regulations. Similarly, we found that the inclusion of an examination of hatch securing mechanisms during safety examinations would increase the safety of commercial fishing vessels by ensuring that a vessel maintains watertight integrity and is able to comply with its stability instructions.

The investigation showed that if any crewmembers had been able to evacuate the vessel after it capsized, they would have been able to survive up to 22.5 hours in the water with an immersion suit. Further, had any crewmember been able to evacuate with and activate a personal locator beacon, search and rescue crews would have had continuously updated coordinates of their locations, enhancing the crewmembers' chances of survival.

We determined that the probable cause of the sinking of the fishing vessel *Emmy Rose* was a sudden loss of stability (capsizing) caused by water collecting on the aft deck and subsequently flooding the vessel through deck hatches, which had covers that could not be secured, contrary to the vessel's stability instructions and commercial fishing vessel regulations.

What We Recommended

As a result of this investigation, we recommended that the Coast Guard increase the scope of commercial fishing vessel safety examinations to include inspections of freeing port covers and hatch covers. Additionally, we reiterated Safety Recommendation M-17-45 to the Coast Guard to require personal locator beacons for personnel employed on vessels in coastal, Great Lakes, and ocean service to enhance their chances of survival.

1. Factual Information

1.1 Event Sequence

1.1.1 Synopsis

On November 23, 2020, at 0129 local time, the US Coast Guard in Boston, Massachusetts, received a distress signal from the 82-foot-long, 116-gross-ton commercial fishing vessel *Emmy Rose* (shown below in figure 1).[1] The vessel had been under way with four crewmembers on board after fishing for 5 days. A search was initiated, and the vessel was not located. About 6,000 gallons of diesel fuel were on board, and sheening was observed during search missions; none of the crewmembers were located, and they are presumed dead. On May 19, 2021, side scan sonar was used to identify the sinking location and wreckage of *Emmy Rose*, which was about 27 miles northeast of Provincetown, Massachusetts (see figure 2). Its estimated value was $325,000.

Figure 1. *Emmy Rose* under way on an unknown date before the casualty. (Source: Coast Guard)

[1] (a) All times in this report are eastern standard time. (b) All miles in this report are nautical miles (1.15 statute miles). (c) Visit ntsb.gov to find additional information in the public docket for this NTSB investigation (case number DCA21FM007). Use the CAROL Query to search investigations.

Figure 2. *Emmy Rose* sinking site (marked with a red *X*). (Background source: Google Maps)

1.1.2 Casualty Events

About 1603 on November 17, 2020, after loading supplies and 34,000 pounds of ice, the *Emmy Rose* departed Portland, Maine, with a captain and three deckhands on board. Over the next 5 days, the crew fished at several locations in the Gulf of Maine. While under way, the crew of the *Emmy Rose* typically navigated the vessel using the autopilot system, which maintained the vessel's heading. While fishing, the captain was typically at the wheelhouse helm; he transferred vessel propulsion control to the aft control station when deploying and hauling back the nets. The vessel would drag for about 3-4 hours, and after each haul back, the crew processed the catch on deck. After cleaning the fish, they would be lowered into the fish hold, sorted by species, and segregated in pens. Once clear of fish, the nets would be redeployed over the stern ramps.

On November 21, the captain emailed the vessel manager, reported that fishing was "slow" and that he was hoping for a "big last day," and continued fishing. On November 21 at 2248, the captain of the *Emmy Rose* called the captain of the fishing vessel *3 Girls*, which was under way in the Gulf of Maine, stated that fishing had been

decent, and mentioned that he was welding on the trawl door.[2] (Depending on fishing conditions and seafloor characteristics, trawl doors may require the worn shoes [welded or bolted protective pieces fitted on the bottom of the trawl door to prevent wear while being dragged on the seafloor] of the doors to be repaired by welding).

At 1428 on November 22, the captain contacted a seafood distribution facility in Gloucester, Massachusetts, via satellite phone to schedule the *Emmy Rose*'s arrival and make offloading arrangements. He reported that the *Emmy Rose* would arrive at the facility at 0600 on November 23 to offload about 45,000 pounds of fish. According to the vessel monitoring system (VMS), after the phone call, the crew of the *Emmy Rose* continued to fish for about 4 hours before starting the transit to Gloucester.[3] It is unknown how much additional fish was caught during these final hours. The captain and crew planned to offload the catch in Gloucester and head back out to resume fishing operations, a process that they referred to as a "turn and burn."

About 1830 on November 22, the *Emmy Rose* departed the fishing grounds and headed for Gloucester at a speed of about 7 knots, which was a typical transit speed. The forecast from the National Weather Service for that evening called for southeast winds at 15–20 knots with gusts up to 25 knots. The seas were predicted to be about 5–8 feet high. The forecast called for patchy fog and a chance of showers after midnight.

Throughout the evening, crewmembers used the vessel's satellite phone to communicate with shoreside contacts. At 1848, one of the deckhands called his girlfriend and told her they completed fishing and were headed to Gloucester to unload the catch. He said he was at the helm but was being relieved to go to sleep. The girlfriend told investigators that the deckhand said, "it was the biggest catch they had ever had," and she heard other crewmembers in the background "laughing, giggling, and so excited to be coming home."[4] At 2101, a call was made from an unknown landline to the *Emmy Rose* satellite phone. The phone call lasted about 5 minutes. After this call, no other calls were made to or from the *Emmy Rose*.

About 2300, the *Emmy Rose* passed within 1.3 miles of the fishing vessel *Blue Canyon* (see figure 3). The *Emmy Rose* maneuvered away from the *Blue Canyon* and continued on its course for Gloucester at 7 knots. The captain of the *Blue Canyon* stated

[2] On the seafloor, trawl doors act as wings, using a hydrodynamic shape to provide a horizontal spread of the net as the vessel moves ahead. When the vessel is not fishing and the net is on board, the two trawl doors are typically stored on the port and starboard sides of the aft deck near the stern.

[3] Positions for the *Emmy Rose* were transmitted every 30 minutes.

[4] The NTSB and Coast Guard worked jointly to investigate this casualty; throughout this report, "investigators" refers to both NTSB and Coast Guard investigators.

that he did not communicate with the crew of the *Emmy Rose* and that he believed he saw crewmembers moving about the aft deck amid the illuminated deck lights.

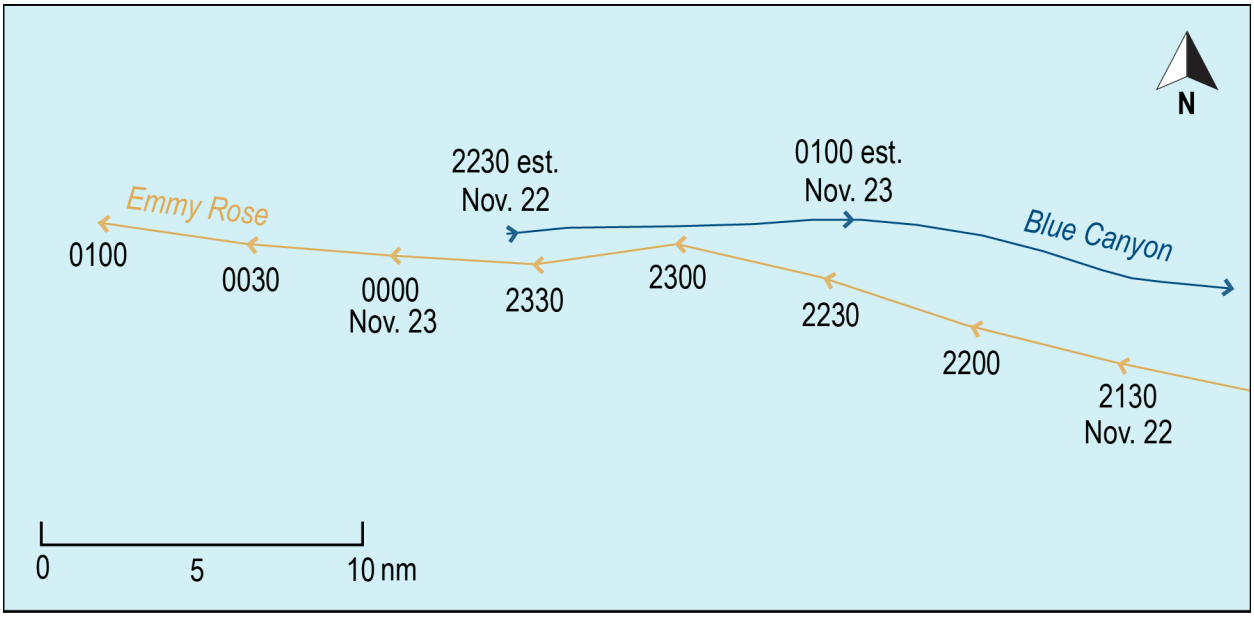

Figure 3. Location of *Emmy Rose* and *Blue Canyon* at their closest point of approach, about 2300 on November 22, based on VMS data.

At 0100 on November 23, the *Emmy Rose* was identified on the VMS to be 27 miles northeast of Provincetown, Massachusetts, on a course of 277° at 7 knots. This was the last VMS position transmitted by the *Emmy Rose*.

At 0129 on November 23, 2020, the Coast Guard Rescue Coordination Center in Boston received an alert from the 406-megahertz (MHz) non-GPS-enabled emergency position indicating radio beacon (EPIRB) registered to the *Emmy Rose*. This initial "unlocated first alert" position was about 2.4 miles southwest from the 0100 VMS position of the *Emmy Rose* (see figure 4).[5]

[5] Newer GPS-enabled EPIRBs provide instant positioning information when the unit is activated. Traditional non-GPS-enabled EPIRBs, such as the one on board the *Emmy Rose*, rely on satellites. When an EPIRB signal is first detected by an orbiting satellite, there is no comparative position information available, and the alert is referred to as "unlocated." Afterward, a "position unconfirmed" message may be sent when the EPIRB's location is available but ambiguous. The corresponding satellite must pass over the location twice before the EPIRB's position can be confirmed; this process can take anywhere from 90 minutes to 5 hours because satellites do not follow the same path every time they move.

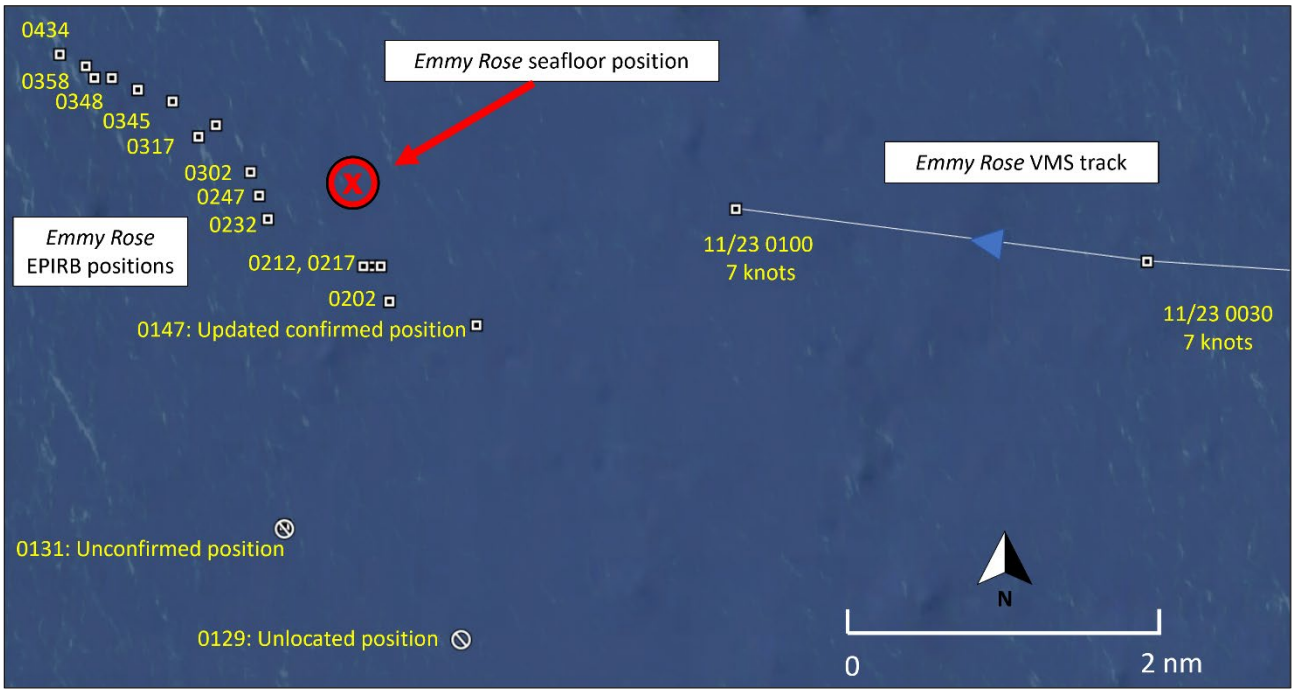

Figure 4. Emmy *Rose* final VMS track and EPIRB positions. The red *X* indicates the sinking site. (Background source: Google Earth)

At 0130, Coast Guard watchstanders notified the vessel's shoreside manager, and he attempted several times to contact the crew of the *Emmy Rose* on the satellite phone and via email, but there was no response. At 0131, a second EPIRB alert was received with an unconfirmed position, and at 0147, a confirmed alert with an updated position was received (see figure 5). Over the next 3 hours, over a dozen subsequent signals were transmitted as the EPIRB drifted toward the northwest until it was recovered by the Coast Guard. There were no very high frequency (VHF) radio transmissions received from the *Emmy Rose*.

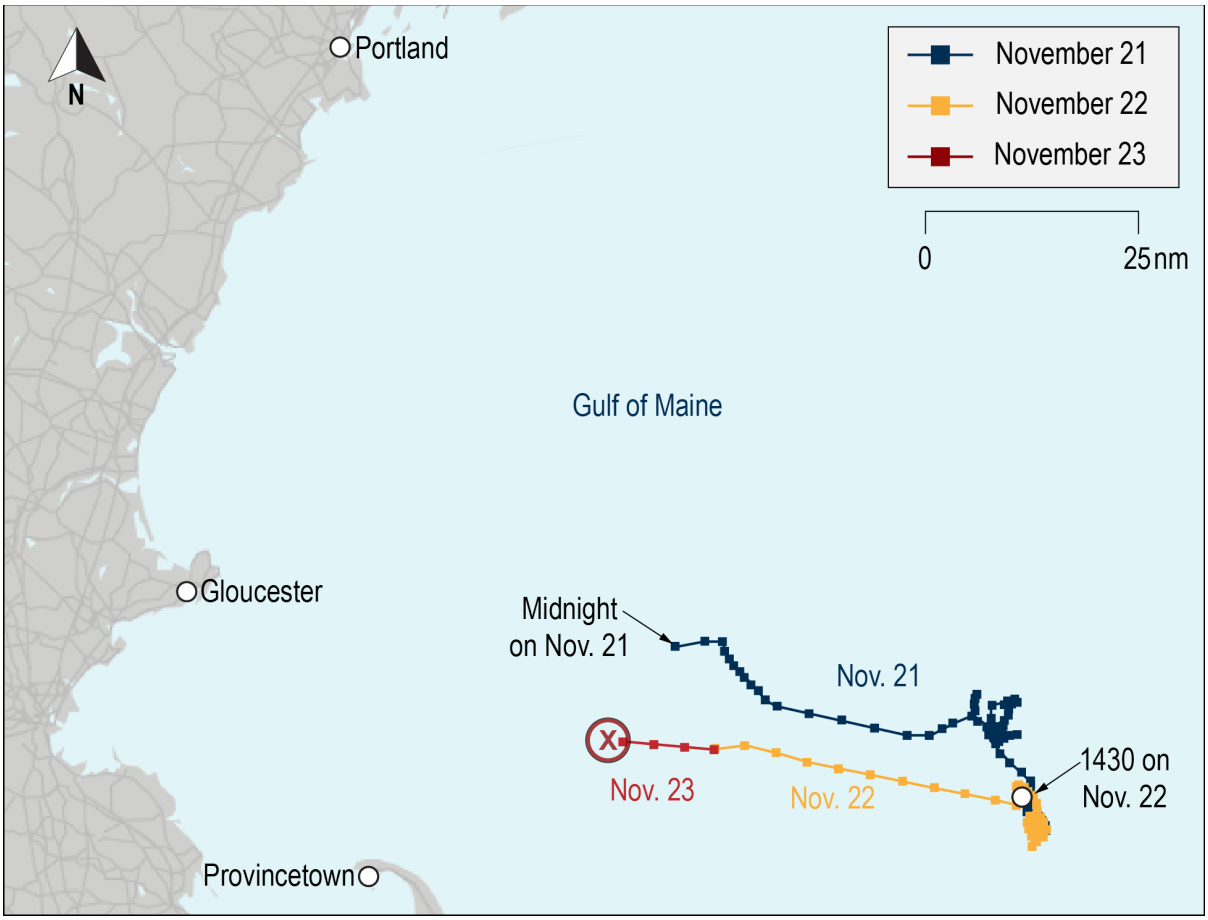

Figure 5. *Emmy Rose* trackline from November 21 to 23. A red *X* indicates the location of the confirmed EPIRB signal on November 23. (Background source: Google Maps)

1.2 Emergency Response

At 0154, the 210-foot-long Coast Guard cutter *Vigorous* was diverted from its location about 12 miles from the last known position of the *Emmy Rose* (based on the EPIRB signal) to assist with search and rescue (SAR) efforts. At 0228, the Coast Guard launched an MH-60T helicopter from Cape Cod, Massachusetts. The cutter and helicopter arrived at the *Emmy Rose*'s EPIRB position and began searching about 0300.

At 0307, the helicopter crew located an inflated liferaft and notified the cutter crew of its position. The cutter crew launched a rescue boat crew and found no crewmembers in the liferaft. They reported a "strong scent of diesel" in the area. At 0326, the helicopter crew located the *Emmy Rose*'s EPIRB about 500 yards (0.25 miles) from the liferaft in a debris field containing a fish tote and other small objects. Throughout the early morning hours, the Coast Guard deployed additional assets including a 47-foot-long motor lifeboat and a fixed wing aircraft to the area to search for survivors.

About 0640, SAR crews spotted an estimated 600-foot oil sheen. Later that morning, the EPIRB, liferaft, one life ring, and two wooden fish hold hatch covers from the *Emmy Rose* were recovered by SAR crews. On November 24 at 1722, after searching over 2,200 square miles over a 38-hour period, the Coast Guard suspended SAR efforts.

In May 2021, side scan sonar and a remotely operated vehicle (ROV) were used to locate and survey the sunken vessel (see section 1.7.1 Side Scan Sonar for additional information on this effort).

1.3 Injuries

Table 1. Injuries sustained in the *Emmy Rose* sinking.[6]

Type of Injury	Crew
Fatal	4
Serious	0
Minor	0
None	0

1.4 Damage

The *Emmy Rose* sank in 794 feet of water and was not recovered. The vessel, valued at $325,000, was declared a constructive total loss.

1.5 Vessel Information

1.5.1 General

The *Emmy Rose* was a steel-hulled, single-propeller fishing vessel built as the *Miss Elizabeth III* in 1987 at the Tommy Nguyen shipyard in New Iberia, Louisiana. The Gulf shrimp-style fishing vessel was subsequently renamed *Miss Monica* (1994-1995), *Virgin Steel* (1995-1997), and *Miss Elizabeth III* (1997-2001). In January 2001, the vessel

[6] The National Transportation Safety Board uses the International Civil Aviation Organization injury criteria in all of its accident reports, regardless of transportation mode. A serious injury is a nonfatal injury that requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; results in a fracture of any bone; causes severe hemorrhages, nerve, muscle, or tendon damage; involves any internal organ; or involves second- or third-degree burns, or any burn affecting more than 5% of the body surface.

was sold to Sasha Lee Inc. Its homeport was changed to New Bedford, Massachusetts, and the vessel was renamed *Sasha Lee*.

Gulf shrimp-style vessels are typically side trawlers and are designed with a raised bow and stern to handle the majority of the cargo weight midships as the nets are deployed over the sides of the vessel with the outriggers, as opposed to over the stern, as is done in the northeast groundfishing fleet.[7] The vessel (*Sasha Lee*) was designed with sheer and described as having a "banana" shape in which the main deck about midships was lower than the bow and the stern.

With the change in location and fishery, the *Sasha Lee* was modified to a stern trawling vessel to accommodate the regional fishery. Two 7-foot-diameter steel net drums and mounting frames were added to the stern of the vessel (drums shown in figure 6). The port and starboard walkways were closed off and the bulwarks were extended to provide the crew with protection from the elements on the aft deck. Over the next several years, other changes were made to the vessel: the diameter of the net reels was increased to allow for larger nets, an additional cargo boom was added, two storage bins filled with fishing gear were added on the top deck, and additional fishing and rigging gear was stored aboard the vessel on the working deck. There were no records of whether any of the changes altered the vessel's lightweight displacement or the position of its vertical center of gravity (see Appendix C for principles of stability).

Figure 6. *Sasha Lee* net reels in 2001 (*left*) and 2019 (*right*). (Background sources: Farrell and Norton Naval Architects [*left*] and Blue Harvest Fisheries [*right*])

On May 6, 2020, the *Sasha Lee* was purchased by Boat Aaron & Melissa, renamed *Emmy Rose*, and its homeport was changed to Portland, Maine.

[7] *Groundfishing*, or bottom trawling, is a fishing practice involving herding and capturing target species, including groundfish, which generally feed and dwell near the bottom of the sea (e.g. cod, haddock, or pollock) by towing a net along the ocean floor.

The *Emmy Rose* was licensed by the National Oceanic and Atmospheric Administration (NOAA) to engage in the New England multi-species fisheries trade and was used exclusively for groundfishing. Vessel particulars for the *Emmy Rose* are shown in Table 2.

Table 2. Vessel Particulars

Vessel	***Emmy Rose***
Type	Fishing (Fishing vessel)
Flag	United States
Port of registry	Portland, Maine
Year built	1987
Official number (US)	909149
IMO number	N/A
Classification society	N/A
Length	82.0 ft (25.0 m)
Beam	22.9 ft (7.0 m)
Draft (casualty)	9.1 ft (2.8 m) est.
Tonnage	116 GRT
Engine power; manufacturer	1 x 630 hp (469.8 kW); Caterpillar 3412 diesel engine
Persons on board	4

1.5.2 Layout

The *Emmy Rose* had three decks: the top deck, the main deck, and the lower level (see figure 7 and figure 8). The vessel's hydraulic port and starboard cargo booms and winches were located on the top deck, which also housed a steel mast with a crosstree with cradles for storing the port and starboard outriggers when stowed. At sea, the crew typically deployed the outriggers and lowered the paravanes, or "birds," into the water after departing the harbor to slow the roll of the vessel to make it more comfortable and more workable. The vessel manager estimated that each paravane weighed 100 pounds, and, when fully deployed to their stops, the paravanes extended into the water about 30 feet.

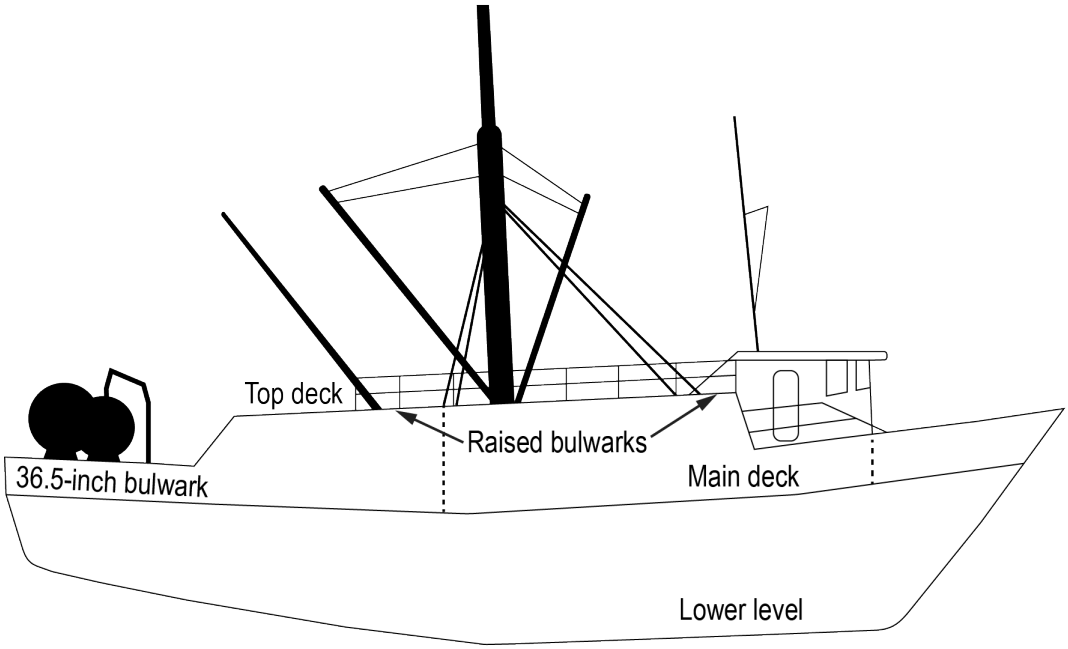

Figure 7. Simplified profile view of *Emmy Rose*.

The main deck consisted of the wheelhouse, which was elevated over the main deck, accommodation spaces, and the working deck. The wheelhouse could be accessed through two watertight doors (one on the port side and one on the starboard side), each with four dogs (securing mechanisms that hold a door or hatch closed), or through the accommodation space. Accommodation spaces for the crew were located on the main deck a few steps below the wheelhouse. Accommodations consisted of two bunkrooms, a lavatory, and a galley. A two-dog watertight door to the engine room and accommodation spaces was located on the port side of the forward bulkhead of the aft deck.

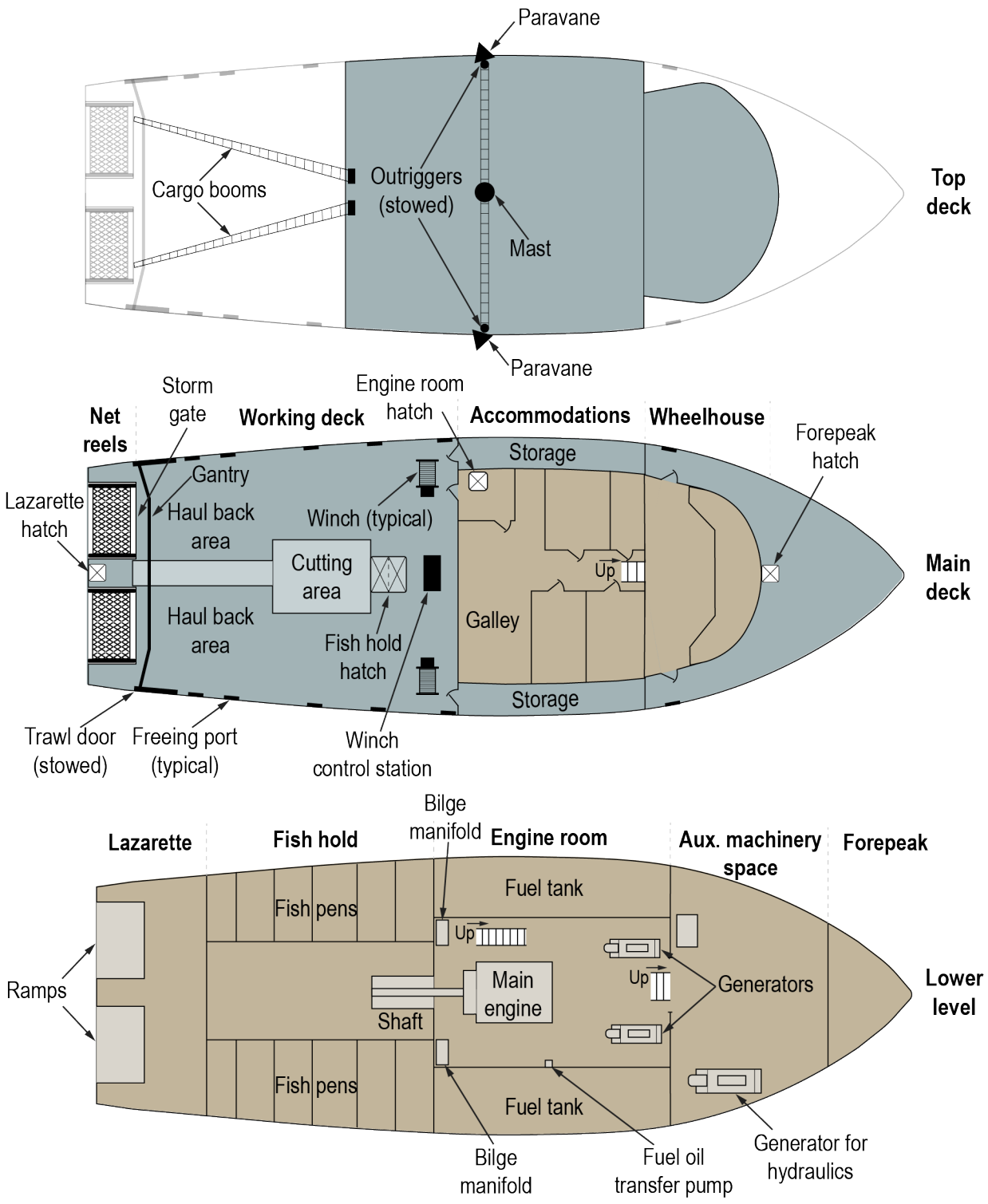

Figure 8. Plan view of *Emmy Rose* decks.

The forward part of the working deck was equipped with two hydraulic winches for operating trawling machinery sheltered by an extended deck level above. The winches were controlled from a station between them.

The aft portion of the working deck had 36.5-inch-high steel bulwarks. On each side of the vessel, the bulwarks were fitted with five freeing ports, each measuring 10 inches by 20 inches. A freeing port is any direct opening through a vessel's bulwarks or hull designed to quickly drain water that has accumulated on exposed decks overboard. Each freeing port had a restrictor plate that was held up in the open position by a chain. The restrictor plate could be lowered to block off the opening to prevent catch from going over the side of the vessel during landing and loading. Each restrictor plate contained three half-circle cutouts to allow limited water to drain when in the closed position (see figure 9). There were two freeing ports in the forward portion of the vessel, one on each side below the wheelhouse doors.

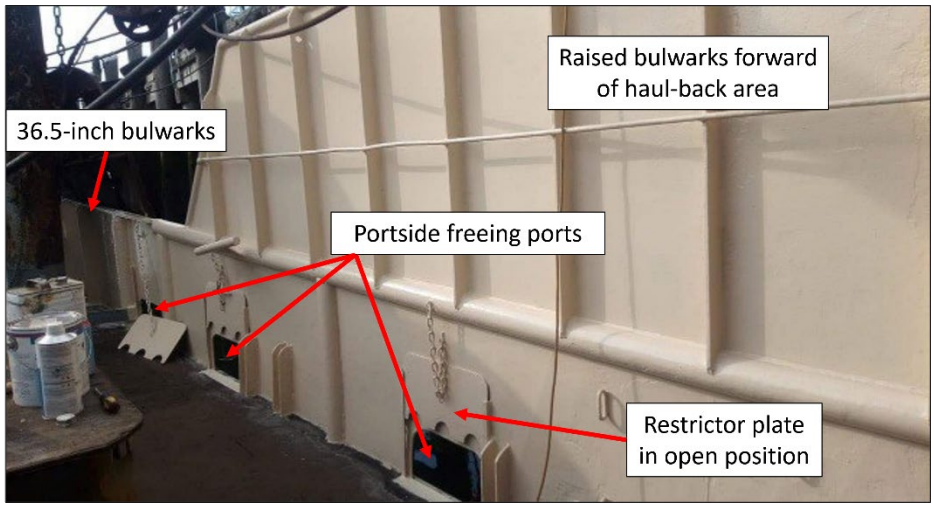

Figure 9. Freeing ports on portside bulwarks. (Background source: Boat Aaron & Melissa)

Forward of the haul-back area (where the catch was landed), the bulwarks rose to meet the main deck level, shielding the forward part of the working deck area on both sides from the elements and creating storage areas outboard of the accommodation space. Two hydraulically operated, chain-driven net reels were mounted over the port and starboard net ramps above the vessel's transom. Below each net reel there was a hinged storm gate, about 6 feet wide and 2 feet high, which could be raised to a vertical position and pinned from each side to limit seawater from entering the working deck over the stern ramps. The aft working deck is shown in Figure 10.

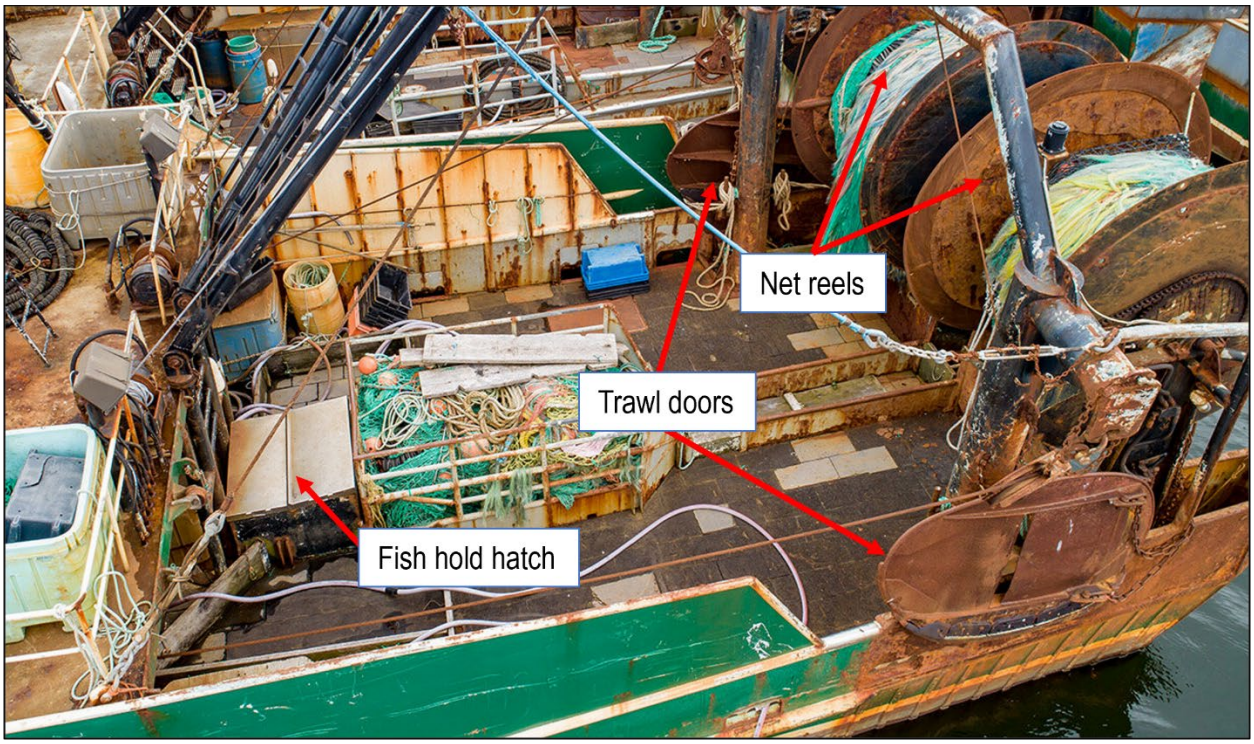

Figure 10. Aft working deck of *Sasha Lee* in 2019 before its purchase by Boat Aaron & Melissa. The storm gates are beneath the net reels and cannot be seen in the photo. (Background source: Blue Harvest Fisheries)

On the lower level, areas from forward to aft were divided into a forepeak, an engine room, a fish hold, and a lazarette. The engine room, fish hold, and lazarette could each be accessed through hatches located on the aft working deck.

The fish hold, located aft of the engine room, was accessed through a centerline hatch that measured 46 inches by 48 inches. The hatch had a 32-inch raised steel coaming (structure supporting the hatch) and was secured with a nonwatertight, two-piece wooden cover, which was topped with a two-piece center-hinged stainless-steel cover. The fish hold was subdivided into 12 individual pens, and wooden boards were used to contain fish in each pen. The stuffing box for the propeller shaft through-hull penetration was housed in the bilge of the fish hold. This area was fitted with a high-water alarm and bilge suctions from the engine room pumping system.

The lazarette was the farthest aft compartment and contained the rudder post and steering rams, a high-water bilge alarm, and a bilge suction. The lazarette was accessed through a 24-inch-by-24-inch hatch (see figure 11). The hatch had a 6-inch raised steel coaming and a nonwatertight steel cover, which, according to the vessel manager, did not have dogs or latches to secure it.

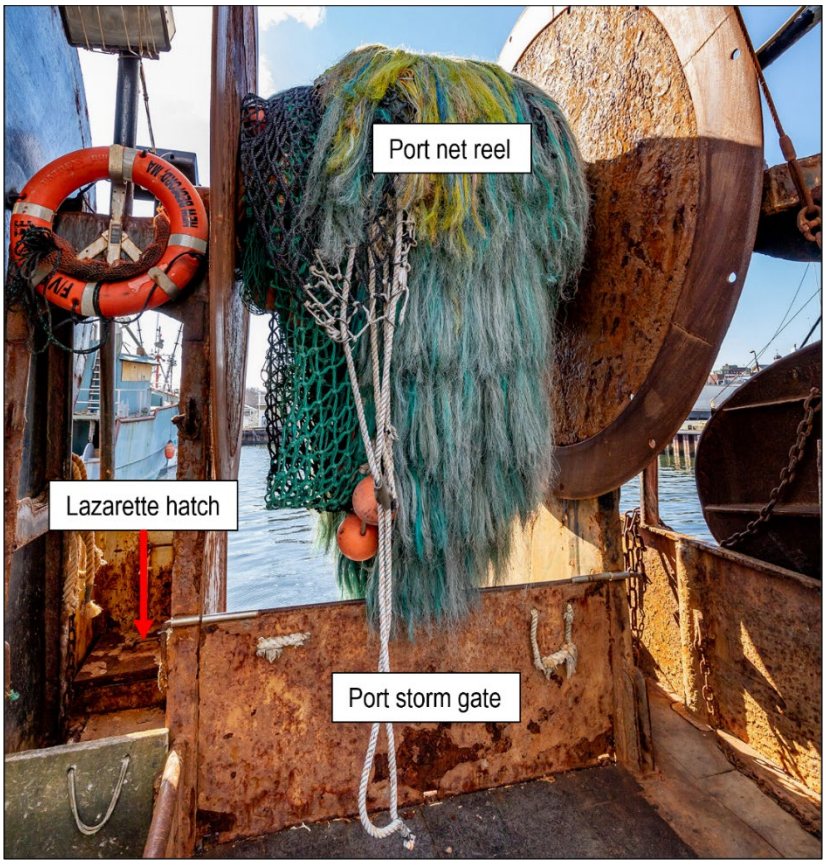

Figure 11. Port net reel, storm gate, and lazarette hatch of *Sasha Lee* in 2019 before its purchase by Boat Aaron & Melissa. (Background source: Blue Harvest Fisheries)

1.5.3 Propulsion and Machinery Systems

Propulsion for the *Emmy Rose* was provided by a 12-cylinder, keel-cooled diesel engine rated at 630 hp. The engine was coupled to a four-bladed propeller set in a nonrotating nozzle on a 6-inch shaft. Engine speed could be controlled from a throttle in the wheelhouse as well as from the aft control station on the working deck.
A semi-balanced steel rudder was hung from the skeg and supported from below (see figure 12). The rudder could be controlled from the helm in the wheelhouse or by the autopilot system.

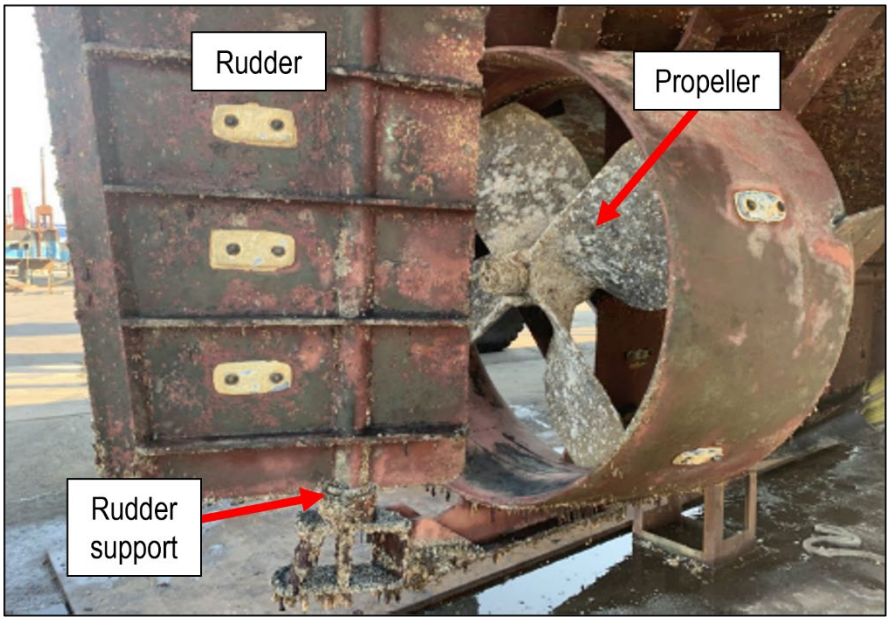

Figure 12. Propeller and rudder arrangement of *Sasha Lee* before its purchase by Boat Aaron & Melissa. (Source: Marine Safety Consultants)

Electrical power for the *Emmy Rose* was provided by two 220-volt diesel generators: a four-cylinder diesel generator rated for 65 kilowatt (kW) and a smaller 20 kW unit. The deck hydraulic systems were powered by a six-cylinder diesel engine located in the auxiliary machinery room forward of the engine room (there was no door between the spaces).

1.5.4 Fuel Capacity and Burn

The *Emmy Rose* had a fuel capacity of 14,200 gallons in two 7,100-gallon fuel tanks located outboard of the engine room. A fuel oil transfer pump with an estimated capacity of 26 gallons per minute was used to transfer diesel fuel between the port and starboard tanks for fuel service and to control any list that might develop as a result of regular operations. According to the vessel manager, the fuel transfer valves were labeled in paint on the tank bulkhead, but there were no written procedures for fuel transfer aboard the *Emmy Rose*.

According to the manager and previous crewmembers, fuel for the main engine could be supplied from either the port or starboard tank. The unburned, excess fuel returns could be directed to either tank. The *Emmy Rose* typically burned about 550 gallons of fuel per day while under way.

The precise amount of fuel aboard the *Emmy Rose* at the time of the sinking is unknown. Typically, the crew filled the fuel tanks to about 75% capacity (11,250 gallons) when taking on fuel. On November 12, 2020, the crew loaded 4,297 gallons of fuel and

then spent 7 days under way before the casualty. (After the casualty, investigators estimated that there were 6,000 gallons remaining on board the vessel.)

The vessel's bilge pumping and deck washdown operations were provided by four electrically driven, self-priming centrifugal pumps in the engine room (see figure 13). Two independent manifolds were piped to sea chests for seawater priming and supply. Both manifolds included suction piping from the engine room, fish hold, and lazarette. All pumps discharged to a manifold on the aft working deck where water could be discharged overboard or directed over the working deck through flexible hoses for washdown. The engine room, fish hold, and lazarette were equipped with high-water bilge alarms with audible and visual alarms in the wheelhouse, which had been all successfully tested in July 2020 during a safety examination.

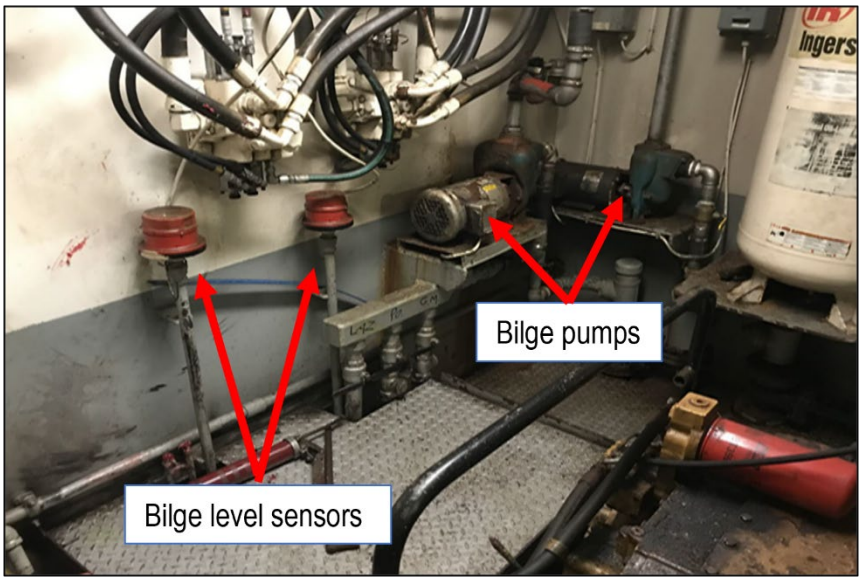

Figure 13. Bilge pumps and level sensors in the engine room of the *Sasha Lee* before its purchase by Boat Aaron & Melissa. (Source: Marine Safety Consultants)

1.5.5 Navigation and Communication Equipment

For navigation and communication, the *Emmy Rose* was equipped with two radars, two GPS navigation systems, three VHF radios, one single side band radio, an automatic identification system (AIS), one autopilot, a compass, three computers, and a satellite telephone. The vessel was also equipped with a video camera system for the crew to monitor the aft deck and engine room, but it was not designed to record.

1.5.6 Maintenance

Between trips, a shore engineer conducted maintenance on the *Emmy Rose* based on work lists left by the captain that identified what tasks needed to be

completed. The shore engineer had about 35 years' experience in the commercial fishing industry and had worked aboard several boats in New England. He welded and performed engine maintenance and other mechanical repairs aboard the *Emmy Rose*.

On September 11, 2020, the *Emmy Rose* was hauled out of the water to have the propeller resized after the captain reported the engine was running "a little bit warm and the rpms aren't there." The manager contacted a propeller company, and a reconditioned, smaller propeller was installed to replace the original propeller. The manager and shore engineer reported that engine operations improved after the replacement.

On November 11, 2020, the trawl doors were replaced with a different style of doors. The vessel manager stated that this was common based on wear and operations. According to the manager and crane operator who loaded the doors, the new doors were about the same weight as the doors they replaced.

1.5.7 Surveys and Examinations

The *Emmy Rose* was classified by the Coast Guard as an uninspected fishing vessel and was subject to the federal regulations under Title 46 *Code of Federal Regulations* (*CFR*) Subchapter C, part 28. Regulations in this subchapter included provisions for lifesaving, firefighting, navigation, communication, dewatering systems, and emergency instructions and drills. Because the *Emmy Rose* was less than 200 domestic gross tons, the vessel was not subject to Coast Guard inspection and certification or manning and licensing requirements.

In August 2019, in-water and out-of-water surveys of the vessel (then named *Sasha Lee*) were conducted in preparation for its sale. Using an ultrasonic thickness gauge, about 80 spot measurements of the underwater hull plating were taken. Readings showed "very little overall wastage around 10%." The lowest readings were along the port and starboard garboard plates (plates adjacent to the keel) as well as on the transom where there was a low reading (0.263 inches) with multiple other similar low readings taken below the net drum ramps. The report indicated that the as-built plate thickness was unknown, and, based on the readings, the bottom plate appeared to be 3/8 (0.375) inches thick. The general overall condition vessel was found to be "very good" and considered "fit for service as an offshore ground fish vessel."

Under the Coast Guard Authorization Act of 2010, commercial fishing vessel safety examinations are required once every 5 years for fishing vessels that operate 3 miles beyond shore. These safety examinations help ensure that all the required safety equipment and systems on board are in serviceable condition; examinations do not include the hull or machinery as required for Coast Guard-inspected vessels. Regulations

and Coast Guard policies authorize designated third-party examiners to conduct these safety examinations upon the request of vessel owners.

On July 21, 2020, a designated third-party commercial fishing vessel examiner conducted a safety examination. The examiner completed the safety examination checklist and indicated that the vessel had not had a major conversion or alteration to the fishing equipment (for the purpose of catching, landing, or processing fish in a manner different than has previously been accomplished on the vessel) after September 1991. The examiner identified two deficiencies while aboard the *Emmy Rose*: the EPIRB battery was expired, and the vessel did not have a waste management plan. During the examination, the examiner was provided with a safety orientation but did not observe an emergency drill. The deficiencies were corrected, and a Commercial Fishing Vessel Decal was issued on July 22, 2020.

1.6 Survival Factors

Lifesaving equipment aboard the *Emmy Rose* consisted of five immersion suits, three life ring buoys, one liferaft, and an EPIRB. The inflatable six-person liferaft, manufactured in 2009, was stored in a cradle aft of the wheelhouse on the starboard side. The liferaft was equipped with a hydrostatic release that was designed to deploy and inflate the raft when submerged. The raft was last inspected in May 2020.

A 406-MHz category 1 (automatic deployment) EPIRB was mounted in a bracket aft of the wheelhouse on the port side. The EPIRB was a non-GPS-enabled beacon. The battery had been replaced in July 2020 and had an expiration date of June 2026. The EPIRB was equipped with a hydrostatic release that would deploy when submerged. A postcasualty inspection of the EPIRB showed that its activation tab was in the armed position; it had not been manually switched to the activated position.

The vessel manager was unaware of whether any of the crewmembers had personal locator beacons (PLB) while aboard the *Emmy Rose*. No PLBs were recovered by SAR crews.

According to the Coast Guard, in the weather and sea conditions at the time of the search and rescue (see section 1.8 Environmental Conditions) a person in the 52°F water in the area of the sinking location without an immersion suit could function for a maximum estimated 10 hours and could survive for up to 13 hours. A person in the water wearing an immersion suit could function for a maximum estimated 18.4 hours and could survive for up to 22.5 hours.

1.7 Wreckage

After the sinking of the *Emmy Rose*, the Coast Guard Navigation Center performed a search for vessels that were in the vicinity of the *Emmy Rose*'s EPIRB position from 2300 on November 22 to 0300 on November 23 to explore the possibility of an unreported collision. The fishing vessel *Blue Canyon* and the Coast Guard cutter *Vigorous* were detected but were not within several miles of the sinking site (see figure 14). No other vessels were located near the *Emmy Rose* in the 2.5 hours before the sinking.

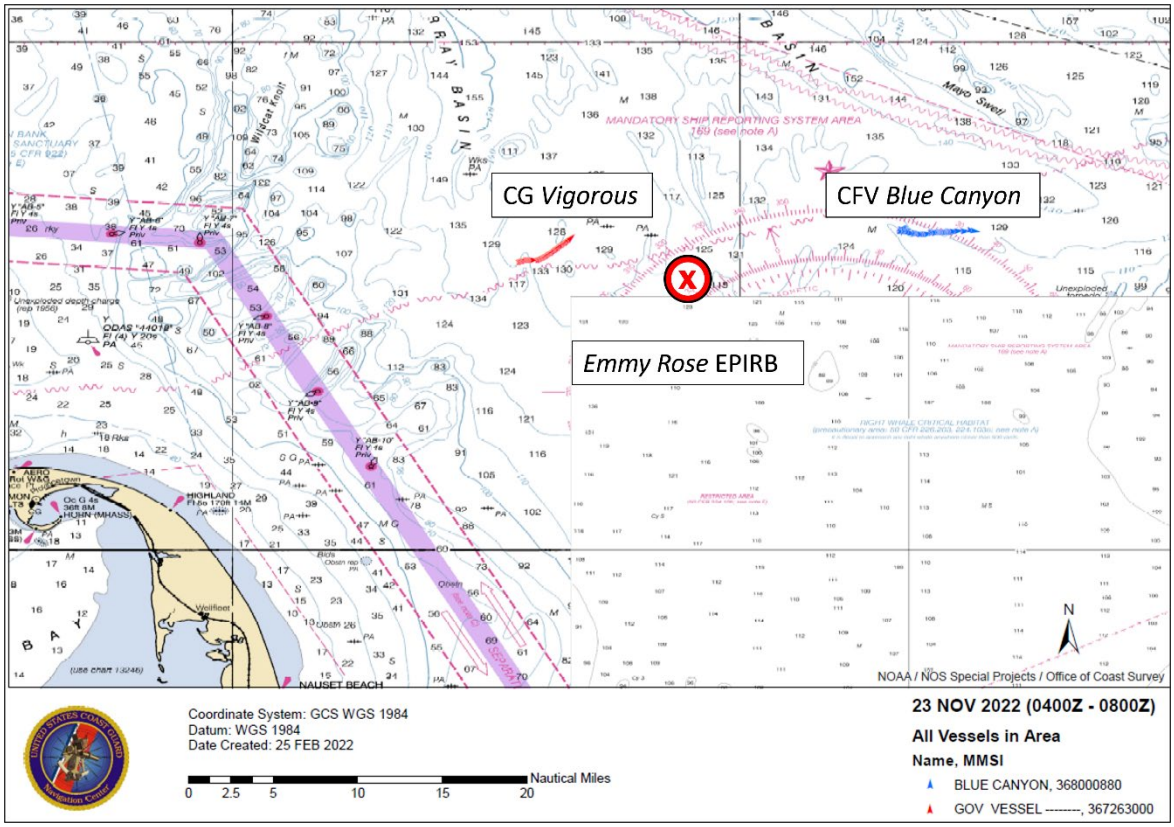

Figure 14. Search for vessels near the *Emmy Rose* from November 22 at 2300 to November 23 at 0300. A red *X* marks the location of the *Emmy Rose* based on the EPIRB signal. (Source: Coast Guard Navigation Center)

Additionally, after the casualty, the National Transportation Safety Board (NTSB) examined the *Emmy Rose*'s positions, headings, and speed in the hours leading up to the sinking (as recorded by VMS). The wreckage of the *Emmy Rose* was located on the same track and about the same distance that would have been expected if the vessel had maintained its average 7-knot transit speed and heading after the last VMS transmission at 0100.

1.7.1 Side Scan Sonar Search

In May 2021, investigators contacted MIND Technology to conduct a side scan sonar search to locate the sunken *Emmy Rose* on the seafloor and assess its condition. Two side scan sonars—a Klein 4000 (100 kilohertz [kHz]/400 kHz) and a prototype Klein 4K-SVY (300 kHz/600 kHz)—were mobilized onto the NOAA research vessel *Auk* for the search. The Klein 4000 was used as the primary search sonar; its lower frequency pairs were better suited to longer scan ranges. The prototype Klein 4K-SVY's 600-kHz frequency was used to obtain higher resolution data over the wreck site to assess the condition of the *Emmy Rose* on the seafloor. The NOAA vessel departed Scituate, Massachusetts, on May 18 and began following a search pattern the following day that was developed based on weather and sea conditions at the time of the sinking and based on the vessel's position data according to VMS.

On May 19 at 1415, after 6.5 hours of searching, the *Emmy Rose* was located about 3.5 miles west of the last VMS position at a depth of 794 feet. Several side scan images were taken with different frequencies and at different heights above the seafloor. The images were interpreted by specialists from MIND Technologies, and a side scan survey report was provided to investigators.

The survey report stated that the *Emmy Rose* was found "sitting upright on the seafloor with the bow oriented at 135° (southeast direction) and both outriggers fully deployed" (see figure 15). The side scan images did not detect any debris field on the seafloor near the sunken vessel. Additionally, the report stated that there was "no visible damage to *Emmy Rose* evident as the mast, wire rigging, and superstructure features all appeared to be intact. The ladders on both port and starboard outriggers were visible in the sonar imagery." Sonar images indicated that both paravanes were deployed from the outriggers. Based on interpretation of imagery, MIND Technologies specialists believed that about 203 feet of cable had been deployed from the port outrigger, and the paravane was that distance ahead of the vessel. The position of both paravanes leading forward of the vessel indicated to the specialists that "the stern sunk to the seafloor before the bow at least just before the vessel made contact with the seafloor."

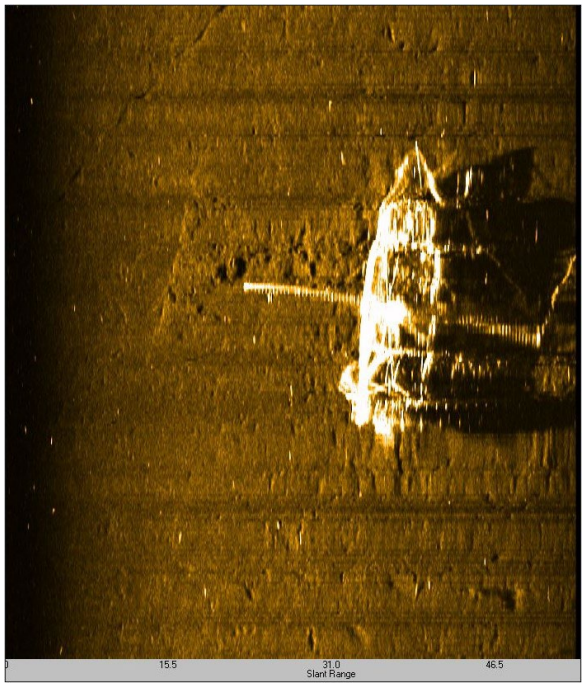

Figure 15. Side scan sonar image of *Emmy Rose* from 246 feet above at 600 kilohertz. (Source: MIND Technologies)

1.7.2 Remotely Operated Vehicle Survey

With the position of the *Emmy Rose* on the seafloor identified by the side scan sonar operation, the Coast Guard and the NTSB had the opportunity to survey the *Emmy Rose* with a remotely operated vehicle (ROV). The Coast Guard and the NTSB requested the Woods Hole Oceanographic Institute (WHOI) conduct an ROV survey of the *Emmy Rose* and provided the WHOI with the location, depth of the vessel, and high-resolution imagery from the side scan survey to support planning. On September 21, an ROV and associated equipment were loaded aboard the Coast Guard cutter *Sycamore* in Newport, Rhode Island. The *Sycamore* departed that evening for the sinking site of the *Emmy Rose* and arrived the following morning. The ROV survey results found the vessel to be in the same position and orientation as the side scan survey indicated. There was no visible damage to the vessel in the areas that the ROV was able to inspect on both sides of the bow, the port and starboard sides, the stern, and the wheelhouse.

Due to the risk of entanglement from vessel lines and maneuvering in the currents, the hull under the outriggers, aft working deck, starboard outrigger, stern ramps, and stern deck hatches could not be accessed with the ROV. The undersea currents had caused sediment to build up on the starboard side and at the stern of the vessel and prevented a hull inspection below the rub rail. The vessel's position on the seafloor and the sediment buildup also prevented an inspection of the vessel's rudder and propeller. The two fishing nets were found stowed on the net reels and covered the

storm gates, preventing the ROV from viewing the position of the gates. On the port side of the vessel's aft working deck, the trawl door was not in the typical stowage position above the bulwarks. The trawl door was positioned perpendicular to the length of the vessel, and its leading edge extended over the bulwarks, instead of being stowed inboard of the bulwarks. The starboard trawl door was stowed inside the bulwarks.

The ROV inspected the condition of the freeing ports on either side of the *Emmy Rose*. On the port side of the vessel, the aftmost freeing port was open. The next freeing port forward was closed. The next freeing port forward was partially open and had its plate hanging through the port. The remaining freeing ports on the port side were open. On the starboard side, the two aftmost freeing ports were closed. The next two freeing ports forward were open, and both had chain and lines hanging out of the ports (see figure 16). The starboard freeing port under the wheelhouse was open. The freeing ports under the outriggers were not able to be accessed by the ROV for inspection.

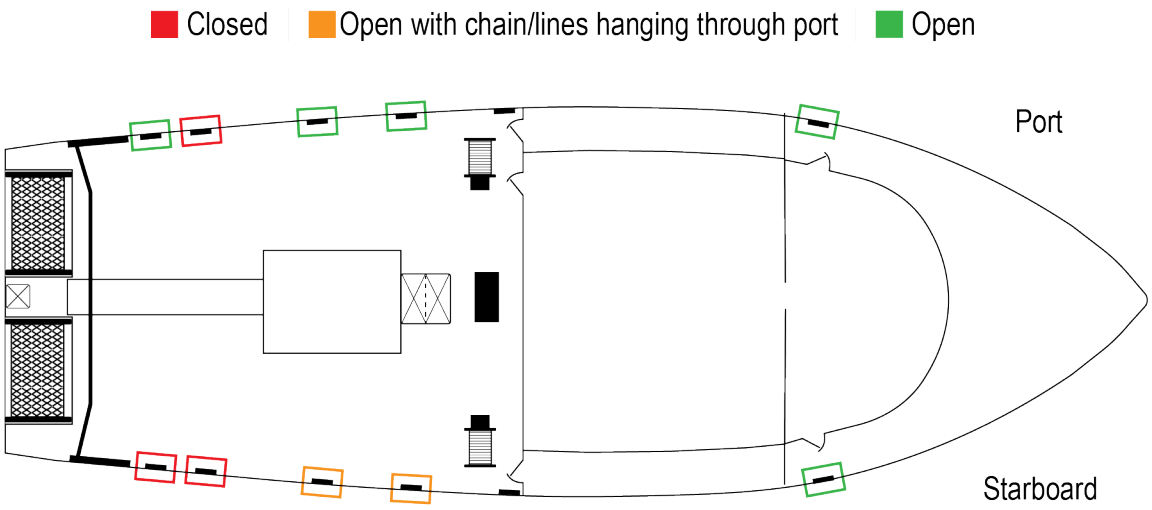

Figure 16. Status of *Emmy Rose* freeing ports during ROV survey.

On the bow, the forepeak space hatch cover was found in the closed position, and the forward-facing wheelhouse windows were intact.

Based on the findings from the May 2021 side scan sonar report, an ROV video inspection was completed on the portside outrigger and its associated rigging. Investigators aboard the *Sycamore* observed the video feed and the outrigger appeared to be free of damage. The chain for the port paravane led down to the seafloor. A line or cable leading forward off the top of the outrigger was not observed (as had been interpreted by MIND Technology's May 2021 side scan sonar report).

1.8 Environmental Conditions

At 2140 on Sunday, November 22, the National Weather Service Ocean Prediction Center released an Offshore Waters Forecast for November 23. The overall synopsis for New England stated:

> A high pressure currently north of the area will shift N[orth]E[ast] of the region tonight into Mon as a strengthening warm front gradually moves N[orth]E[ast] across the waters. Developing low pressure will track N[orth]E[ast] and pass N[orth] of the region Mon and Mon night while pulling a strong cold front E[ast] across the waters. Predicted winds and seas were S[outh]E[ast] winds 20-30 knots and seas 5 to 8 feet for the evening of the 22nd of November. Monday the 23rd called for S[outh] to S[outh]E[ast] winds 25-35 knots becoming 20 to 30 knots with seas 8-14 [feet] with a chance of rain.

The *Emmy Rose* email account received the Offshore Waters Forecast notification email from the National Weather Service at 2210 on November 22. In addition to the synopsis, the message listed weather forecasts for the next few days for the area of the New England continental shelf and slope waters from 25 miles offshore to the Hague Line, except to 1,000 fathoms south of New England. The message stated:

> GALE WARNING
>
> TONIGHT...S[outh]E[ast] winds 20 to 30 [knots]. Seas 5 to 8 [feet]. Scattered showers.
>
> MON[DAY]…S[outh] winds 20 to 30 [knots]. Seas 7 to 9 [feet]. Chance of rain early, then scattered showers and [thunderstorms].
>
> MON[DAY] NIGHT...N[orth]W[est] winds 30 to 40 [knots]. Seas 9 to 13 [feet]. Chance of rain.
>
> TUE[SDAY]...N[orth]W[est] winds 25 to 35 [knots], diminishing to 20 to 30 [knots]. Seas 7 to 13 [feet].

A weather buoy located about 9 miles north of Provincetown and about 21 miles west of the *Emmy Rose*'s last known position recorded weather conditions at 0130 on November 23. The air temperature was 51°F, dewpoint 49°F, and seawater temperature 50.5°F. The winds were from the east-southeast at 17 knots, gusting to 21 knots, and the sea state was 5.6 feet observed with an easterly sea swell of 5-6 feet and a period of 6 seconds.

Responding Coast Guard SAR crews also provided weather observations near the last known position of the *Emmy Rose*. At 0300, the cutter crew reported the weather as seas of 2-4 feet at 105° (east-southeast) with winds at 18 knots from the east-southeast

(130°), overcast skies, and 10-mile visibility. They reported the air temperature as 53°F and the sea temperature as 52°F.

The fishing vessel *Blue Canyon* had been fishing near the *Emmy Rose*, and its captain estimated that weather was "nothing that the *Emmy Rose* couldn't easily handle." He described the seas as "sloppy" but no bigger than 5–8-foot swells with a wind speed about 20-30 knots.

Several underwater acoustic recording devices that provided weather information and monitored whale activity off the coast of Massachusetts were recovered from the general area of the *Emmy Rose* sinking site. Recorded data from the devices was analyzed, but no acoustic information associated with the *Emmy Rose's* characteristics was recorded around the time of the sinking.

1.9 Stability

A vessel that is floating upright in still water will list, or heel over to an angle, when an off-center force is applied. Stability is the vessel's tendency to return to its original upright position when the force is removed. See Appendix C, "Principles of Stability," for more information regarding aspects of vessel stability discussed in this report.

1.9.1 Stability Requirements

The regulations in 46 *CFR* Part 28 outline stability requirements that are applicable to commercial fishing vessels constructed or substantially altered on or after September 15, 1991, that are 79 feet or more in length (except those required to be issued a load line under Subchapter E).[8] According to the Coast Guard, despite the vessel being constructed in 1987, the regulations were applicable to the 82-foot-long *Emmy Rose* because the vessel had undergone alterations to "the fishing or processing equipment for the purpose of catching fish in a manner different than previously accomplished." When a vessel undergoes alterations to its fishing equipment or major modifications to the vessel itself, the Coast Guard considers it to have been substantially altered; the vessel is then required meet the regulations in place at the time of the modifications, rather than the original construction date.

[8] Newer US fishing vessels (built on/after July 1, 2013) that are 79 feet or longer and that operate outside the Boundary Line are required to have a load line. A load line certificate is documentation confirming that a vessel meets specific structural design, construction, and maintenance criteria. Classification societies such as the American Bureau of Shipping review vessel stability instructions and issue load line certificates on behalf of the Coast Guard, and the Coast Guard periodically audits the classification society's load line and stability oversight program to ensure compliance with regulations.

The regulations in 46 *CFR* 28.570 and 28.575 provide guidelines for intact righting energy (the amount of energy that a vessel can absorb from external heeling forces [winds, waves, weight shifts, etc.] before it capsizes) and severe wind and roll (the ability of a ship to withstand the combined effects of beam wind and rolling). Additionally, the regulations in 46 *CFR* 28.555 require that all freeing ports must be located "to allow the rapid clearing of water in all probable conditions of list and trim." The regulations further specify the aggregate clear area of freeing ports on each side of the vessel based on the height of the vessel's bulwarks. The regulations permit freeing port covers provided that the freeing port area required is not diminished and the covers are constructed and fitted so that water readily flows outboard but not inboard.

Regulations in 46 *CFR* 28.560 require that each opening in a deck or bulkhead that is exposed to weather "be fitted with a weathertight or a watertight closure device." Additionally, the regulations state that such watertight openings for vessels 79 feet or more in length must be fitted with a coaming at least 24 inches in height.

Because the vessel had bulwarks, the *Emmy Rose* was also subject to the regulations in 46 *CFR* 28.565 for water on deck, which require the residual righting energy—that is, the difference between heeling and righting energy—to be greater than the heeling energy of the water on deck at the downflooding angle or 40° (whichever is least).

1.9.2 Vessel Stability Instructions

In March 2002, the *Emmy Rose* (then named *Sasha Lee*) underwent an inclining experiment and a stability analysis to account for the modifications performed when the vessel was converted from a Gulf shrimp side trawler to a stern trawler in 2001. At the time of the analysis, the modification was near completion, but about 11 tons (24,640 pounds) of fishing gear and other supplies were not aboard the vessel. The results of the analysis, which accounted for the 11 tons of absent fishing gear and supplies, indicated that the *Sasha Lee* met the minimum required stability characteristics 46 *CFR* Part 28 in all intact stability conditions. As required by regulations, after the vessel underwent alterations to the fishing equipment, a qualified individual (as defined in 46 *CFR* Part 28) developed stability instructions for the *Emmy Rose*; the stability instruction booklet contained operating instructions, intact stability conditions, hydrostatic properties, tank capacity plans, and tables.[9] The vessel's stability instructions stated that "no weights shall be added, removed, or relocated without determining the effect of stability of the vessel." Additionally, the instructions stated, "Deck hatches and weathertight doors to the deck house, side storerooms, and machinery spaces shall be

[9] A *qualified individual* is an individual or an organization, most often a practicing naval architect, with formal training and experience in matters dealing with naval architecture calculations.

kept closed and fully secured at all times when under way, except when actually used for transit under safe conditions." The stability instructions identified the engine room vent located forward of the wheelhouse as the vessel's downflooding point—that is, the first unsecurable (not weathertight or watertight) opening to begin downflooding as the vessel heels to port or starboard. (The inclination [heel] angle at which the point begins downflooding is the downflooding angle for the purpose of intact stability analysis.)

The vessel's manager stated that he received the stability booklet when he purchased the vessel and believed that it was kept aboard the vessel, and that it was mandatory for the captain to "know what his stability stuff is." The manager stated that there had not been any modifications that added weight to the vessel since he purchased it (in 2020).

In 2017, the Coast Guard published a "Voluntary Safety Initiatives and Good Marine Practices for Commercial Fishing Vessels" document to improve fishing vessel safety. The document recommended that commercial fishing vessels have their stability instructions "reviewed by a qualified individual every five years, or after a vessel had been modified or altered in any way that affects its stability or handling characteristics."

In October 2017, the Coast Guard released Marine Safety Alert 11-17, "Remain Upright by Fully Understanding Vessel Stability," which addressed concerns related to vessel stability and watertight integrity after the loss of a fishing vessel in the Bering Sea with multiple fatalities. Three years later, in January 2021, as a result of the sinking of other commercial fishing vessels, the Coast Guard released Marine Safety Information Bulletin (MSIB) 01-21, "Improving Fishing Vessel Stability" to "assist mariners in identifying ways to improve their stability awareness." The alert provided guidance to encourage mariners to review the vessel's stability instructions periodically, to be aware of the assumptions and conditions outlined in the instructions, and to review changes to the stability instructions following any maintenance period. The MSIB also alerted mariners to be aware of blockages of freeing ports.

1.9.3 Marine Safety Center Stability Analysis

The Coast Guard Marine Safety Center (MSC) conducted a stability analysis of the *Emmy Rose* to determine possible causes of the sinking. Neither the original build plans for the vessel nor computer models from past stability analyses were available, so the MSC used the stability analysis and lines plan created from the vessel's most recent (2002) stability test. Because the watertight integrity of the superstructure at the time of the casualty was unknown, the MSC modeled the vessel using only the buoyant volume of the hull and accounted for the sheer of the main deck. Once the model was completed, the MSC validated it by comparing hydrostatics to the data listed in the 2002

stability analysis; when compared to the vessel's draft at the time of the casualty (estimated 9.1 feet), the model's displacement was within 2% of the stability analysis.

At the time of the sinking, based on the captain's satellite call to the seafood distribution facility, the quantity of fish aboard was estimated to be 45,000 pounds, but it is unknown if the catch had been equally distributed in the fish hold. The vessel departed with about 34,000 pounds of ice; the exact remaining quantity of ice (or meltwater from it) in the fish hold was unknown but was estimated by the MSC to be 24,000 pounds, since the crew typically pumped out water from melting ice. The exact amount of fuel remaining was also unknown but estimated to be about 6,000 gallons (40% capacity); however, it was unknown if the quantity of fuel in the port and starboard tanks outboard of the engine room was equal. The MSC used the vessel's stability instructions created in 2002 as well as its estimated loading condition at the time of the sinking to establish 12 sample loading conditions covering the range of loads the vessel would encounter during routine operations and compare them with regulatory stability criteria found in 46 *CFR* Part 28.

The first seven loading conditions covered departure, mid-voyage with different cargo loads, and arrival with different cargo loads, all of which were created to match those in the 2002 stability analysis. Loading condition 8 examined the vessel's condition when arriving in port with no catch. The remaining four (9–12) loading conditions represented estimated conditions at the time of the sinking (condition 9), the vessel listing due to 25% and 50% differences in fuel quantities between the port and starboard storage tanks (conditions 10 and 11), and with uneven paravane deployment (condition 12).

The MSC evaluated each of these sample loading conditions for compliance with the stability criteria for uninspected fishing vessels in 46 *CFR* Part 28. The MSC's analysis indicated that the vessel failed one or more of the stability criteria in every loading condition (see table 3). This contrasts with the 2002 stability analysis in which the vessel passed loading conditions 1 through 7. Without the model used in the 2002 stability analysis, the MSC could not account for these differences. The MSC stated that they used the most conservative vessel model, using the observed sheer of the vessel (from the lines plan) with no additional buoyant credit given to bulwarks or the superstructure, but "even with the assumptions and conservative nature of the analysis, the failure of the criteria [was] so large the vessel was determined not to be in compliance with the standards at the time of incident."

Table 3. Summary of MSC Stability Analysis for the *Emmy Rose*'s Compliance with the Stability Criteria in 46 *CFR* Part 28. (Source: Coast Guard)[10]

Loading Condition	Water on Deck (28.565)	Intact Righting Energy (28.570)	Severe Wind and Roll (28.575)
1 Departure from port	Pass	Fail	Fail
2 Arrival at fishing grounds	Pass	Fail	Fail
3 50% catch at fishing grounds	Pass	Fail	Fail
4 100% catch departing fishing grounds	Pass	Fail	Fail
5 40% catch departing fishing grounds	Pass	Fail	Pass
6 Port arrival with 100% catch	Pass	Fail	Pass
7 Port arrival with 40% catch	Pass	Fail	Pass
8 Port arrival with 0% catch, transit trip	Pass	Fail	Pass
9 Time of incident	Pass	Fail	Fail
10 Time of incident with 25% more fuel in starboard fuel oil tank	Fail	Fail	Fail
11 Time of incident with 50% more fuel in starboard fuel oil tank	Fail	Fail	Fail
12 Time of incident with uneven paravane deployment	Pass	Fail	Fail

The MSC's analysis showed that for all the loading conditions except for 10 and 11 (conditions with unequal loading of fuel), the vessel passed criteria for water on deck. For conditions 10 and 11, a large list existed due to unequal loading of the port and

[10] In this table, loading conditions 1–7 matched similar conditions found in the stability booklet for the *Emmy Rose*; loading condition 8 simulated the vessel's condition when arriving in port with no catch; and loading conditions 9–12 were estimated for the *Emmy Rose* at the time of the sinking.

starboard fuel tanks, causing the *Emmy Rose* to fail to meet the requirements for water on deck.

The vessel failed intact righting energy criteria for all loading conditions because the maximum righting arm for each condition was achieved at an angle of heel less than 25°, and the minimum righting energy and range of stability requirements were not met.

The vessel also failed severe wind and roll criteria for all loading conditions (except conditions 5-8, which were based on either a lower catch [40%] or completion of fishing and arrival in port). The righting arm curves that the MSC developed for the likely loading condition at the time of incident (condition 9) showed that the vessel had positive stability (see Appendix C, Principles of Stability) to 42° (the MSC's analysis for this loading condition assumed that the vessel had about 24,000 pounds of ice, 45,000 pounds of fish, and a draft about 9.1 feet—corresponding to about 2.2 feet of freeboard midships).The MSC's stability analysis showed that none of the loading conditions examined for the vessel met all the regulatory criteria (for water on deck, intact righting energy, and severe wind and roll), and stated that any condition that may have caused the vessel to list—such as a list resulting from a fuel transfer operation or uneven paravane deployment—degraded stability further from the even keel condition. The MSC noted that failure to meet regulatory stability standards was not an indication of capsize or sinking; however, by not meeting regulatory stability, the *Emmy Rose* had a reduced ability to withstand wind and waves. The *Emmy Rose*'s ability to withstand environmental conditions would have been further reduced by off-center weights such as fuel or uneven paravane deployment had those existed at the time.

1.9.3.1 Freeing Ports

Based on the deck drainage requirements in 46 *CFR* 28.555, the MSC calculated that 48.9 square feet of total freeing port area was required for the *Emmy Rose*. Using estimated freeing port dimensions, the MSC calculated that with all the freeing ports open and the storm gates closed, the total freeing port area aboard the *Emmy Rose* was 26.4 square feet, or about 54% of the requirements in the regulations. With all freeing port restrictor plates in place (ports closed) and storm gates closed, the freeing port area was reduced to 1.6 square feet (the combined area of the semi-circular cutouts in the restrictor plates), or about 3.2% of the requirements in the regulations.

The MSC addressed the condition of the freeing ports as found during the ROV survey of the *Emmy Rose* on the seafloor. On the starboard side of the vessel, the freeing port restrictor plates were in place on the aft two freeing ports while the middle two freeing ports had line and chain hanging out of them. On the port side of the vessel, only one aft freeing port had the restrictor plate in place and there was no debris hanging out of the other portside freeing ports. The MSC concluded that this could be indicative of a

list to starboard causing gear on deck to shift to the starboard side and wash out of the freeing ports.

1.9.3.2 Unintentional Flooding Criteria

The unintentional flooding criteria in 46 *CFR* 28.580 specifically applied only to fishing vessels built on or after September 15, 1991; thus, the *Emmy Rose* was exempt from these requirements. In its analysis, the MSC evaluated possible damage scenarios and flooding in each of the hull's four watertight compartments. The MSC's analysis indicated that the vessel failed unintentional flooding criteria for all their damage scenarios, and if either the forward combined auxiliary machinery/engine room compartment or fish hold compartment flooded, the vessel would capsize. When the aft lazarette compartment flooded, the vessel would remain afloat, although with "significant trim aft."

1.9.3.3 Flow Rate Analysis

The MSC conducted a quasi-static flow rate analysis to determine the time required to flood the compartments that could be damaged by unintentional flooding. Because the lazarette and auxiliary/engine room compartments contained the majority of the through-hull fittings (which presented the greatest risk for flooding), the MSC focused on those locations. The MSC calculated flooding rates based on different diameters of through-hull openings that could allow seawater to enter a space. In the lazarette (with an estimated volume of 1,150 cubic feet), a 1-inch hole would allow water to fill the space to equilibrium in 350 minutes; a 3-inch hole would allow water to fill the space in 38 minutes; and a 6-inch hole would allow water to fill the space in 9.5 minutes. In the combined engine room and auxiliary machinery space (with an estimated volume of 7,167 cubic feet), a 1-inch hole would allow water to fill the space in 360 minutes and result in the vessel capsizing. A 3-inch hole would capsize the vessel in 40 minutes, and a 6-inch hole would capsize the vessel in 10 minutes.

1.9.3.4 Downflooding Points

Based on photographs with estimated locations and information provided in the 2002 stability test, the MSC identified "critical points," or "downflooding points," for downflooding on the *Emmy Rose*. Downflooding occurs when an opening, such as a vent or hatch—or downflooding point—in a vessel's hull or superstructure becomes immersed as the vessel heels and allows water to flood into the vessel. The 2002 stability analysis noted the downflooding point was the engine room vent located 50 inches off the main deck forward of the wheelhouse. The MSC identified the aft lazarette hatch (considered to be watertight), located on the main deck, and the four corners of the fish

hold hatch (considered to be weathertight) as critical points. However, when evaluating intact stability compared to regulations, openings that can be made watertight and weathertight are not considered downflooding points, and therefore neither the 2002 stability analysis nor the MSC's analysis considered watertight or weathertight points as downflooding points as the vessel was heeled. The MSC noted that if the lazarette hatch was assumed to be unsecured, it would be the first opening subject to downflooding (at 55°) as the vessel heeled.

1.9.3.5 Flooding Analysis

The NTSB requested that the MSC calculate an additional stability analysis of downflooding scenarios for loading condition 9 (likely condition at time of incident) to examine the effects on the vessel's stability with water on deck with the starboard-side freeing ports blocked and the lazarette compartment simultaneously flooded. In this analysis, the lazarette hatch and fish hold hatches (which were listed in the stability booklet as securable to watertight and weathertight, respectively) were designated as downflooding points. The MSC first analyzed the effects of flooding on the lazarette in 5% increments; the flooding caused the *Emmy Rose* to be trimmed by the stern (aft). The MSC then added water on deck with the portside freeing port and the lowest point in the starboard-side bulwarks acting as spill points. The MSC found that, when accounting for water on deck and with the lazarette flooded to 25%, the *Emmy Rose* approached no righting energy. With the lazarette 30% flooded and with water on deck, the vessel capsized. In all conditions, the MSC found that the *Emmy Rose*'s range of stability was dramatically less with water on deck due to the resulting list.

1.10 Personnel Information

The 41-year-old captain of the *Emmy Rose* had about 25 years of fishing experience and had worked on the vessel since July 2020. He was the only captain that had worked aboard the *Emmy Rose* since its most recent purchase in 2020. The vessel manager stated that the captain was a hands-on captain and performed welding repairs and engine room duties on the vessel.

All three deckhands had previously worked on other fishing vessels. The vessel's manager allowed the captain to hire the vessel's crew. Deckhand no. 1, age 55, had about 35 years of experience in the fishing industry and had been working aboard the *Emmy Rose* for a month before the sinking. Deckhand no. 2, age 38, had about 20 years of experience in the fishing industry and had been working aboard the *Emmy Rose* for about 3 months. Deckhand no. 3, age 23, had about 3 years of experience in the fishing industry and had also been working aboard the *Emmy Rose* for about 3 months.

None of the crewmembers were credentialed mariners; there was no requirement for any of the *Emmy Rose* crewmembers to hold merchant mariner credentials.[11] The vessel manager and previous crewmembers stated that, aboard the *Emmy Rose*, there was no set watch rotation for the crew and the captain determined the watch schedule based upon fishing operations. It is unknown which crewmember was on watch at the time of the sinking. (At the time of the casualty, there were no regulatory requirements for watchstanding, manning, or work/rest hour restrictions applicable to the *Emmy Rose*.)

The owner of Boat Aaron & Melissa, who had been in the fishing industry for 43 years, purchased his first boat in 1986 and owned three other fishing vessels at the time of the casualty. The shoreside manager, who was an employee of Boat Aaron & Melissa, had been working on fishing vessels for about 35 years and had owned about 12 fishing vessels in his career. He was managing one other fishing vessel for another company at the time of the *Emmy Rose* sinking. As the shoreside manager of the *Emmy Rose*, he described his function as attending to "everyday activities" while the vessel was in port and working closely with the crew "as another set of hands" or a "runner." He was responsible for hiring the captain.

The manager kept in contact with the crew of the *Emmy Rose* via email and satellite phone while it was under way. No issues or problems were communicated to the manager or to any other fishing vessels during the final voyage.

1.11 Operations

1.11.1 Crew Conduct and Emergency Drills

The owner did not have a safety management system for the *Emmy Rose*, nor was one required. Each crewmember was required to sign a contract, referred to as a "fishing agreement," before joining the vessel as an independent contractor. The agreement addressed payment, fitness for duty, illness, injury, and other terms of employment. Each crewmember signed that they agreed to obey lawful commands; refrain from intoxication, use, or possession of any alcohol, drugs, or narcotics; and that there would be no sleeping on watch. The owner stated that it was up to the captain to drug-test the crew if he so desired.

According to the regulations in 46 *CFR* 28.270, the captain or individual in charge of a vessel must ensure that emergency drills are conducted and instruction is given to

[11] Vessels of less than 200 gross tons are exempt from compliance with the Officers Competency Certificates Convention, 1936, as implemented in 46 *United States Code* 8304 and Title 46 *Code of Federal Regulations* Part 15. Since the *Emmy Rose* was 116 gross tons, there was no requirement for its crewmembers to hold a valid merchant mariner license or credential.

each individual on board at least once each month. These drills addressed abandoning the vessel, fighting a fire, minimizing the effects of unintentional flooding, using lifesaving appliances, and making distress calls.

The owner and manager were not aware of any emergency drills that had been conducted aboard the vessel; the manager believed the captain was a qualified drill conductor but could not confirm. They stated that the captain would determine when drills were to be conducted. Previous crewmembers stated that new crewmembers would receive an orientation to the vessel, but no emergency drills had been conducted while they were aboard the *Emmy Rose*. There were no logs to document the testing of alarms and inspection of lifesaving appliances, nor were they required.

In early November 2020, during the trip before the sinking, an observer from NOAA joined the *Emmy Rose* for an 8-day fishing trip to collect data on fish species that were caught in each fishery area. Upon arrival, a safety checklist provided by NOAA was completed with no discrepancies. The observer recalled there were no emergency drills conducted during the voyage and that the crew fished around the clock; the time between hauls was about 5 hours, and the crew would rest between hauls. While the vessel was under way, the observer saw three crewmembers "smoking weed" as a "daily occurrence pretty much in between each haul." According to the NOAA observer, the captain was not seen smoking but had fallen asleep at the wheel "often" and had left the nets dragging longer than expected, tearing the nets and requiring the crew to repair them two or three times.

1.11.2 Previous Voyages

After being purchased and renamed in April 2020, the *Emmy Rose* completed its first voyage on July 30, 2020, and subsequently completed 12 fishing trips over 6 months. The average trip lasted between 5 and 7 days; each time, the vessel departed Portland, Maine, and fished in the Gulf of Maine. The crew offloaded their catch in Gloucester and then typically returned to Portland. During the 12 previous trips, the average catch was about 36,370 pounds of assorted groundfish. The largest offload of fish from the *Emmy Rose* was 50,150 pounds on August 15. The shoreside manager and a previous crewmember estimated that the *Emmy Rose* was able to hold over 100,000 pounds of fish in the fish hold.

A deckhand who had worked aboard *Emmy Rose* for two fishing trips in late summer 2020 reported that, on his second trip, as the vessel was transiting back to port to offload the catch, the vessel suddenly "started listing pretty bad" and there was waist-deep water on the aft working deck while the captain was transferring fuel between the two fuel tanks. He stated that the list was so severe that the water was coming over the bulwark and the aft deck was awash. According to the deckhand, the captain started

the transfer and then fell asleep in his bunk. The captain was awakened, he transferred the fuel back, and the list was corrected.

1.12 Related Casualties and NTSB Recommendations

1.12.1 *El Faro* – 2015

On October 1, 2015, the cargo vessel *El Faro* foundered and sank in the Atlantic Ocean about 40 nautical miles northeast of Acklins and Crooked Islands, Bahamas, after sailing directly into the path of a hurricane. All 33 crewmembers perished in the sinking. Three days after the sinking, on October 4, searchers spotted the remains of one *El Faro* crewmember in an immersion suit. It was not clear when the crewmember perished, or whether any other crewmembers were able to abandon ship. The NTSB concluded that "Providing all persons employed on board vessels in coastal, Great Lakes, and ocean service with personal locator beacons would enhance their chances of survival." As a result of its investigation, the NTSB issued the following Safety Recommendation to the Coast Guard:

> Require that all personnel employed on vessels in coastal, Great Lakes, and ocean service be provided with a personal locator beacon to enhance their chances of survival. (M-17-45)

This recommendation is also associated with the NTSB's 2021–2022 Most Wanted List of Transportation Safety Improvements under the issue area, "Improve Passenger and Fishing Vessel Safety." On July 17, 2018, the Coast Guard said that it was very interested in ensuring that persons in distress have the most efficient means of alerting their distress, initiating an appropriate SAR response, and providing responders with an accurate location for rescue. However, the Coast Guard did not believe that a PLB would provide the location accuracy necessary for this purpose. On April 30, 2019, the NTSB replied that it disagreed with the Coast Guard's view that PLBs did not provide the needed location accuracy. Pending a requirement that mariners use available SAR technologies, Safety Recommendation M-17-45 was classified "Open—Unacceptable Response."

1.12.2 *Scandies Rose* – 2019

On December 31, 2019, the Coast Guard received a distress call from the commercial fishing vessel *Scandies Rose*, which had been en route from Kodiak, Alaska, to fishing grounds in the Bering Sea when it capsized and sank about 2.5 miles south of Sutwik Island, Alaska. Two of the vessel's seven crewmembers were rescued by the Coast Guard several hours after the sinking; the other crewmembers were not found and were presumed dead. During SAR efforts, one Coast Guard rescue helicopter searched

an incorrect area due to "an inadvertent miscommunication of the coordinates of the search area." The NTSB concluded that "PLBs would aid in search and rescue operations by providing continuously updated and correct coordinates of crewmembers' locations." As a result of its investigation, the NTSB reiterated Safety Recommendation M-17-45.

2. Analysis

2.1 Introduction

After departing Portland, Maine, on November 17, 2020, the four crewmembers aboard the 82-foot-long commercial fishing vessel *Emmy Rose* fished for 5 days in the Gulf of Maine. On November 22, the captain notified a seafood distribution facility in Gloucester, Massachusetts, that they had about 45,000 pounds of assorted groundfish to offload and expected to arrive at 0600 the following morning. The crew fished about another 4 hours, departing the grounds about 1830 for Gloucester.

At 0129 on November 23, the Coast Guard in Boston, Massachusetts, received a distress signal from the EPIRB registered to the *Emmy Rose*. There were no distress calls from the vessel before the EPIRB signal. The vessel had traveled about 45 miles west from the fishing grounds over the 7 hours since departing. Weather conditions recorded by a nearby buoy (about 21 miles from the sinking site) at the time of the sinking reported winds from the east-southeast at 17 knots, gusting to 21 knots, and the sea state was 5.6 feet observed with an easterly sea swell of 5-6 feet.

Coast Guard SAR assets were deployed to the area of the EPIRB signal, about 27 miles from Provincetown, Massachusetts. SAR efforts continued for 38 hours and covered over 2,200 square miles. During the search, Coast Guard personnel recovered the EPIRB, the liferaft, one life ring, and two wooden fish hold hatch covers from the *Emmy Rose*. None of the crewmembers were located as of the date of this report, and they are presumed dead. The vessel sank in 794 feet of water and was not recovered. Its estimated value was $325,000.

This analysis evaluates the following safety issues:

- Lack of sufficient vessel stability to meet regulatory criteria (section 2.2),
- Ineffective freeing port cover design (section 2.3),
- Lack of securing mechanisms for deck hatches to maintain the vessel's watertight integrity (section 2.4), and
- Need for personal locator beacons to enhance search and rescue efforts (section 2.5).

Having completed a comprehensive review of the circumstances that led to the casualty, the investigation excluded the following as causal factors:

- *Fire or explosion*. The postcasualty ROV survey of the vessel did not reveal any evidence of burned, charred, or deformed sections of the vessel. There was no damage to the hull, and the paint on the hull and superstructure

was intact in all visible areas of the survey. Several acoustic listening devices near the sinking were analyzed, and no significant sounds were detected near the *Emmy Rose*'s final position before the casualty.

- *Grounding*. On the seafloor, the *Emmy Rose*'s hull was set into the sand and sediment, preventing ROV surveys of the bottom hull plating, propeller, and rudder. The NTSB reviewed the vessel's track throughout the 7-day trip from November 17 to the sinking on November 23 and determined the *Emmy Rose* did not pass over any shallow areas with depths less than 240 feet. In the last 2 days before the sinking, the crew fished and transited in areas where the water depth was greater than 450 feet.
- *Collision*. The only vessel within 10 miles of the *Emmy Rose* in the 3 hours before the sinking was the fishing vessel *Blue Harvest*; however, its trackline indicated a 1.3-mile separation about 2 hours before the *Emmy Rose*'s EPIRB alert was triggered. Side scan sonar and ROV seafloor surveys indicated that the *Emmy Rose* was sitting upright with no visible damage to the bow, hull, outriggers, or superstructure above the waterline. No calls from the *Emmy Rose* or other vessels were received broadcasting a collision. No significant sounds around the time of the sinking were detected by underwater acoustic listening devices.
- *Vessel's propulsion or steering systems*. Based on the *Emmy Rose*'s position reported by VMS and the area of its sinking, the vessel maintained an average speed of 7 knots from 2330 to about 0130, indicating that the main propulsion system was operating satisfactorily. The vessel also maintained a steady course to the west, with no noticeable change of heading, indicating that the vessel had steering ability. Further, there were no phone or radio calls from the vessel indicating any mechanical issues, which might have been expected if the vessel was experiencing a problem that could have delayed its 0600 arrival the next morning.

Thus, the NTSB concludes that none of the following were factors in this casualty: (1) fire or explosion; (2) grounding; (3) collision; or (4) the vessel's propulsion or steering systems.

The four crewmembers were not located or recovered; therefore, postcasualty tests for alcohol and other drug use could not be performed. It is unknown if alcohol or illegal drugs were being used by any crewmembers throughout the fishing trip, or if their use may have contributed to the sinking.

2.2 Stability

The 82-foot-long *Emmy Rose* did not require a load line. However, because it was over 79 feet long and underwent alterations to the fishing equipment after September 1991, it was required to meet most of the stability criteria in 46 *CFR* Part 28. Following the alterations to the vessel's fishing equipment in 2001, an inclining experiment was performed, and stability instructions were produced in 2002.

After the casualty, the MSC conducted a stability analysis of the *Emmy Rose* to determine if the vessel met applicable stability criteria. The *Emmy Rose*'s exact load conditions, such as the liquid load (amount of fuel, lube oil, potable water), ice, and catch aboard, as well as its draft, trim, and list at any time throughout the voyage were unknown. The MSC used the vessel's stability instructions created in 2002 as well as its estimated loading condition at the time of the sinking to establish 12 sample loading conditions and compare them with regulatory stability criteria found in 46 *CFR* Part 28. Seven standard loading conditions matched some of the conditions found in the 2002 stability analysis (departure, mid-voyage with different cargo loads, and arrival with different cargo loads), one condition examined the vessel's loading condition at port with no catch, and the MSC created another four possible conditions that could have specifically applied to the *Emmy Rose* at the time of the sinking.

The MSC found that for all seven sample loading conditions that matched the loading conditions in the 2002 stability instructions, the *Emmy Rose* failed one or more of the stability criteria. The vessel also failed one or more of the criteria for the four casualty estimated loading conditions that the MSC created. All of the MSC's 12 sample loading conditions failed to meet stability criteria for intact righting energy, indicating that even if the captain loaded the vessel in accordance with the stability instructions, the vessel's ability to return to an even keel when exposed to forces (such as wind or waves) that produce a heeling moment would be less than intended by applicable stability criteria, and therefore the vessel would more easily capsize than if it met the criteria. The MSC noted that they had to make assumptions in order to calculate the *Emmy Rose*'s buoyant volume, but even with their assumptions, the vessel failed the criteria by a large margin and was thus determined not to be in compliance with regulatory standards for stability at the time of the casualty.

Based on the reported catch on board the *Emmy Rose* and the typical ice and liquid load for that point in the voyage, MSC's loading condition 9, with a 9.1-foot draft, likely best represented the vessel's estimated loading condition at the time of the casualty. The *Emmy Rose* did not meet the stability criteria as calculated by MSC for this loading condition; however, the righting arm curves developed by the MSC for loading condition 9 showed the vessel had positive stability to an inclination angle of 42°. Stability criteria are generally recognized as providing an adequate level of safety for vessels that are operated prudently, which means they are not overloaded and not

operating in dangerous conditions such as violent storms. A margin of safety is built into the stability criteria that is intended to accommodate events that can happen to a vessel, such as rolling in waves, heeling due to wind, or a limited degree of listing as weight or liquids move from side to side. Because of the margin of safety in regulatory stability criteria, a vessel may be functionally stable even if it does not meet the criteria. However, by not meeting stability criteria, the *Emmy Rose* had a reduced ability to withstand wind and waves encountered on the voyage. The NTSB concludes that at the time of the sinking, the *Emmy Rose* likely did not meet regulatory stability criteria and therefore had a smaller margin of safety than intended by regulations, making it more susceptible to capsizing.

Since the stability analysis had been completed in 2002, several changes had likely been made to the vessel's configuration (including the enlarged net reels and added fishing gear); no subsequent or recent stability analysis was conducted to account for these changes. Based on the most recent photos of the vessel, the net reels were enlarged at some point after their installation in 2001 to accommodate larger nets; two storage bins were filled with fishing gear on the top deck, and additional fishing and rigging gear was stored aboard the vessel on the working deck. However, investigators were unable to ascertain if these changed the vessel's lightweight displacement or the position of its vertical center of gravity (there were no records or documentation from any modifications that were made to the vessel after the 2002 stability analysis report); therefore, investigators could not confirm if the modifications affected the vessel's stability. Weight creep—the gradual increase in the vessel's lightship weight—from these types of changes and the accumulation of extra spare parts and gear can reduce a fishing vessel's overall stability. The weight creep often occurs over long periods of time in small amounts, and therefore a reduction in stability may not be noticed by crewmembers. The MSC did not estimate or factor the weight creep in their postcasualty stability analysis.

2.3 Freeing Ports

At 0100 on November 23, 2020, the *Emmy Rose* was traveling on a course of 277° at 7 knots toward Gloucester to offload catch. A nearby buoy about 21 miles away recorded sustained winds of 17 knots with 21-knot gusts from the east-southeast. Sea conditions were estimated with 5- to 6-foot swells from the east-southeast. These conditions placed the winds and seas on the *Emmy Rose*'s port quarter (quartering winds and seas). When a fishing vessel is loaded with catch, as the *Emmy Rose* was, it operates with a deeper draft and correspondingly lower freeboard (about 2.2 feet midships), thus allowing seas to board more easily. As quartering winds and seas acted on the *Emmy Rose*, waves likely swept over the aft bulwarks and the stern ramp gates (which were lower than the 2-foot-high aft bulwarks), and through open freeing ports,

causing water to collect on the aft working deck (see figure 17). The NTSB concludes that the *Emmy Rose*'s course toward Gloucester to offload its catch subjected the vessel to quartering winds and seas that likely resulted in the accumulation of seawater on the aft working deck.

Figure 17. MSC model of *Emmy Rose*'s starboard quarter showing aft bulwarks and stern ramps (storm gates not shown). (Source: MSC)

To drain seawater that collected on deck, the *Emmy Rose* was fitted with six freeing ports on each side of the vessel. Each freeing port was equipped with a restrictor plate (cover) that was held up in the open position by a chain and could be lowered down to block the opening. Regulations did not require freeing port covers, but if a vessel did have freeing port covers, they were required to be constructed and fitted such that water could readily flow outboard but not inboard and not diminish the amount of freeing port area. However, the design of the restrictor plates used on board the *Emmy Rose* functioned primarily to prevent catch from going overboard from the working deck of the vessel, and three semi-circle cutouts within each plate allowed limited water to flow in either direction when the plates were closed.

The MSC's postcasualty analysis showed that with all freeing port covers in the open position, the calculated drainage area for the *Emmy Rose* was about 54% of the requirements in the regulations. Further, with the restrictor plates in the closed position, the *Emmy Rose*'s freeing port area was reduced from 26.3 square feet to 1.6 square feet, or about 3.2% of the requirements in the regulations. Therefore, the NTSB concludes that by not meeting the regulatory requirements for the freeing port area and design of freeing port covers, the *Emmy Rose* was more susceptible to accumulating water on deck.

As an uninspected fishing vessel less than 200 gross tons, the *Emmy Rose* was not subject to Coast Guard inspection and certification requirements. Instead, the *Emmy Rose* was subject to commercial fishing vessel safety examinations every 5 years.

Qualified third-party examiners were permitted to conduct the exams, and these exams focused on documentation, lifesaving equipment, and systems on board the vessel; they did not require an inspection of the hull, freeing ports, or watertight integrity. The *Emmy Rose* underwent its most recent safety examination on July 21, 2020, during which the only deficiencies identified included an expired EPIRB battery and lack of a waste management plan.

Commercial fishing vessel safety exams do not require an inspection of the vessel's freeing ports to ensure adequate freeing port area for the vessel's size, nor do the exams require an inspection of freeing port covers to determine whether they restrict inboard flow but allow for water to flow outboard (as is required by regulations). A vessel's freeing port area is determined by calculations outlined in 46 *CFR* Part 28. Typically, a naval architect calculates freeing port area; these calculations are not listed in a vessel's stability instructions, nor are they readily available to safety examiners. It is therefore not feasible for safety examiners to calculate freeing port area during a dockside exam.

The *Emmy Rose*'s freeing ports were fitted with restrictor plates, and as stated above, these freeing port covers allowed limited water to flow in either direction when the plates were in the closed position. In contrast, hinge-style covers or flaps would allow water to flow in only one direction (outboard); if fitted on the *Emmy Rose*, a similar style of covers may have allowed for less seawater to flow in through the freeing ports and accumulate on deck while allowing more seawater to flow out through the freeing ports. Given the importance of maintaining adequate drainage of a fishing vessel's aft working deck for vessel stability, a Coast Guard requirement to include an inspection of freeing port cover design on board vessels is warranted. A spot-check inspection of a vessel's freeing port covers could be accomplished by trained examiners. Had such an inspection been included in the safety exams, the *Emmy Rose*'s non-compliant freeing port covers would have been documented and required to be corrected by the vessel's owner. Therefore, the NTSB concludes that the inclusion of an inspection of freeing port covers during commercial fishing vessel safety examinations would increase the safety of commercial fishing vessels by identifying when the covers do not meet the regulations. As a result, the NTSB recommends that the Coast Guard increase the scope of commercial fishing vessel safety examinations to include inspection of a vessel's freeing port cover design to determine whether the covers are constructed to allow water to readily flow outboard but not inboard as required by 46 *CFR* Part 28.

During the postcasualty seafloor ROV survey, the two aftmost freeing ports on the starboard side were found with their restrictor plates closed, and one freeing port was found closed on the port side (each with an estimated 2.2-square-foot opening); the remaining seven freeing ports that were examined by the ROV were found open (two could not be accessed). The drainage area would then be 19.7 square feet, or 40% of

the regulations. Due to the wind direction on November 23, as well as the quartering wind and seas impacting the *Emmy Rose* from its port quarter, the open freeing ports on the vessel's port side would likely have allowed seawater to enter the aft working deck. Because the restrictor plates for the two starboard-side aftmost freeing ports were closed, limited water could drain through the plates' semi-circle cutouts, allowing for a pocket for seawater to collect on the starboard side of the vessel and allowing more seawater to collect as it entered the open portside freeing ports as well as over the stern ramps and bulwarks. This likely produced an initial starboard heel. The postcasualty ROV survey of the vessel showed gear (chain and lines) protruding through open starboard-side freeing ports. The gear, which was originally located on the aft working deck, likely would have shifted to the starboard side if the vessel had developed a list to starboard due to the water on deck and wind on the port side.

Operating in quartering and following seas is one of the most dangerous conditions for a stern trawler fishing vessel. The aft deck is more likely to become awash, and accumulating seawater trapped on a vessel's deck by the bulwarks can significantly reduce its overall stability because the added weight of the trapped water on deck raises the vessel's overall center of gravity. Further, the dynamic motion of the water exposes the vessel to free surface effect—the detrimental effect on a vessel's stability from partially filled (slack) tanks, shifting cargo, water in fish holds, flooded bilges, or enclosed decks. As a vessel heels, the free movement of the liquid shifts weight in the direction that the vessel is heeling. This effectively raises the vessel's center of gravity, and its overall stability is reduced. Additionally, the vessel's freeboard would also be reduced due to the added weight, allowing seawater to more readily wash over the bulwarks and collect on deck. The NTSB concludes that the combined effects of the weather conditions acting on the vessel as well as the accumulating water on the starboard side that could not drain due to the closed freeing ports caused the vessel to list to starboard and reduced the vessel's stability. This starboard list would increase the chance that the fish in the fish hold pens, fuel in storage tanks, and/or fishing gear would shift to the starboard side, causing the *Emmy Rose* to list further to starboard, and further reducing its stability and making it more susceptible to capsizing.

2.4 Sinking

There were no witnesses to the sinking of the *Emmy Rose*, nor were there any distress calls to broadcast any possible emergencies. The *Emmy Rose* was not salvaged; therefore, an in-depth postcasualty vessel examination beyond the ROV underwater survey could not be conducted to assist in determining potential sources of flooding. During the postcasualty side scan sonar search and ROV survey of the vessel, the *Emmy Rose* was found sitting on the seafloor in an upright position at a heading of 135°—nearly the reciprocal heading from its return course to Gloucester. The side scan sonar

and ROV surveys did not show any obvious external damage to the vessel that would indicate a possible source of flooding. The MSC's analysis also found that the sonar scan did not indicate any damage from collision or contacting another object. The ROV inspection of the port outrigger did not reveal any line or chain leading forward (as was previously interpreted by MIND Technology based on the postcasualty side scan sonar survey). The side scan sonar survey revealed that the vessel's starboard paravane appeared to be leading forward of the vessel from the tip of the outrigger, indicating that the vessel moved aft into its final resting place. According to the MSC's analysis, flooding of the lazarette and fish hold spaces, located aft of midships, would have caused a stern-first descent to the seafloor.

On the vessel's aft working deck was the lazarette hatch, which was located between the net reels on the stern and covered with a nonwatertight steel cover, which rested on the hatch's 6-inch-high hatch coaming. According to the vessel manager, the hatch cover could not be fastened in any way to the hatch coaming (e.g. with dogs or latches). Since the hatch lacked securing mechanisms, the force of waves over the transom or accumulating and sloshing seawater on deck from the conditions the vessel was likely experiencing could have displaced the hatch cover and allowed seawater to downflood through the hatch and quickly fill the lazarette through the 4-square-foot opening. The NTSB concludes that although a definitive source of initial flooding could not be determined, flooding of the *Emmy Rose* most likely began through the lazarette hatch's cover, which did not have securing mechanisms and therefore could not be made watertight, allowing following seas and accumulating water on deck to downflood into the lazarette.

A vessel's stability is calculated on the assumption that hatches and other openings (ventilation and doors) can be made watertight or weathertight when closed. When calculating stability, the opening that cannot be secured and is first subject to water ingress when the vessel heels is referred to as the vessel's critical downflooding point. On the *Emmy Rose*, the engine room vent located forward of the wheelhouse was the downflooding point used in calculations and identified in the vessel's stability instructions. The lazarette hatch was considered watertight, and the fish hold hatch was considered weathertight. Therefore, neither would be considered as the downflooding point in the stability analysis used to produce the 2002 stability instructions. However, the MSC noted that the if the lazarette hatch was assumed to be unsecured, it would be the first opening subject to downflooding as the vessel heeled. The accuracy of the stability instructions relies on the assumptions in the stability calculations being correct, including the naval architect's understanding that vessel owners and crew would ensure all openings would be maintained watertight and weathertight.

The *Emmy Rose*'s stability instructions explicitly stated that "deck hatches and weathertight doors to the deck house, side storerooms, and machinery spaces shall be

kept closed and fully secured at all times when under way, except when actually used for transit under safe conditions." The captain of the *Emmy Rose* was responsible for maintaining safe conditions for the crew and vessel at all times, including following the stability instructions. It is unknown if the lazarette hatch was secured in some manner by the crew (such as with straps), since the ROV was unable to access it for postcasualty inspection. However, based on the vessel manager's statement and photos of the vessel that showed the hatch cover did not have securing mechanisms, investigators determined that the hatch was likely unsecured at the time of the casualty. Additionally, the wooden fish hatch covers were recovered by SAR crews after the casualty, indicating they were most likely unsecured at the time of the sinking. With hatch covers that did not have securing mechanisms, the vessel's watertight integrity could not be assured. Secured, watertight hatch covers on the *Emmy Rose*'s lazarette and fish hold hatches would have eliminated the possibility of downflooding to these spaces, regardless of boarding seas and lower freeboard, and could have potentially prevented this casualty.

Regulations regarding deck openings, which were applicable to the *Emmy Rose*, required that all deck openings exposed to weather be fitted with a weathertight or watertight closure device. Although the lazarette and fish hold hatches had covers, they were unable to be secured because they did not have securing mechanisms and thus did not meet the regulatory requirements. Further, the lazarette hatch coaming likely was less than the 24 inches required by regulations. The top of the hatch opening was therefore closer to the deck and would have allowed water on deck to more easily spill over the hatch coaming and enter the lazarette. The NTSB concludes that the *Emmy Rose* was not being operated in accordance with its stability instructions and fishing vessel regulations requiring that deck hatches be secured to ensure they are watertight or weathertight.

Commercial fishing vessel safety exams do not include an inspection of a vessel's hatches or doors or their securing mechanisms. As stated above, the lazarette hatch on board the *Emmy Rose* had a cover that did not have securing mechanisms and therefore could not be made watertight, which likely allowed quartering seas and accumulating water on deck to flood into the vessel through the hatch. Given the importance of a vessel maintaining watertight integrity, examining the securing mechanisms for a vessel's hatches and doors is crucial to vessel safety, and a Coast Guard requirement to include an inspection of hatch cover securing mechanisms on board vessels is warranted. A spot-check inspection for dogging mechanisms and gaskets of readily apparent hatches and doors could be accomplished by trained examiners. Had such an inspection been included in the safety exams, the vessel's lack of securing mechanisms for the lazarette and fish hold hatches would have been documented and required to be corrected by the vessel's owner because they are required under 46 *CFR* Part 28. The NTSB concludes that the inclusion of an inspection of hatch cover securing mechanisms during commercial fishing vessel safety examinations would increase the safety of commercial

fishing vessels by ensuring that a vessel maintains watertight integrity when the hatches are closed and secured and is able to comply with its stability instructions. Therefore, the NTSB recommends that the Coast Guard increase the scope of commercial fishing vessel safety examinations to include inspection of a vessel's hatch covers to determine whether they are watertight and have adequate securing mechanisms as required by 46 *CFR* Part 28.

Once the vessel's lazarette began flooding, in addition to the starboard list and lower freeboard from water on deck, the freeboard at the stern would have decreased further. Seawater would have begun filling the aft working deck up to the 36.5-inch bulwarks and likely displaced the fish hold hatch's nonwatertight wooden and stainless-steel hatch covers, allowing water to enter the fish hold over its 32-inch-high hatch coaming and causing another point of downflooding. An open fish hold hatch would have allowed the fish hold to quickly be flooded through the hatch's 16-square-foot area opening.

With water on deck likely entering the lazarette and fish hold through the displaced covers, the vessel's righting energy would have rapidly decreased. The MSC's analysis indicated that, with the aft lazarette compartment flooded alone, the vessel would remain afloat, although with "significant trim aft," and not capsize (the vessel still had positive stability). However, the MSC found that when the forward auxiliary machinery space or fish hold compartments flooded, the vessel would lose positive stability and capsize. Accounting for water on deck, the MSC found that, when the lazarette was flooded to 25%, the vessel approached no righting energy. With the lazarette 30% flooded and with water on deck, the vessel capsized. The MSC noted that in all conditions, the range of stability for the *Emmy Rose* was dramatically less with water on deck.

The vessel's last VMS position was reported at 0100, at which point the vessel was transiting at a speed of 7 knots. At 0129 on November 23, 2020, the Coast Guard received an alert from the *Emmy Rose*'s EPIRB. The EPIRB was mounted on the vessel's wheelhouse and was equipped with a hydrostatic release—meaning that once submerged, it released, floated, and sent a signal identifying its location. After the sinking, investigators inspected the vessel's recovered EPIRB and found that it had deployed hydrostatically. Thus, the EPIRB (and the vessel's wheelhouse) were likely submerged at the time the EPIRB sent the alert to the Coast Guard.

The wreckage of the *Emmy Rose* was located on the same track and about the same distance that would have been expected if the vessel had maintained its average 7-knot transit speed and heading (as reported by VMS). If the vessel had substantially flooded without capsizing (foundered) and lost propulsion before the EPIRB's hydrostatic release, its speed would have reduced well below 7 knots. Therefore, at the time of the EPIRB alert, the vessel was likely still moving near its typical transit speed, and the

submersion of the EPIRB happened very suddenly. Additionally, there was no radio call from any crewmember aboard the *Emmy Rose*, as is typical during developing emergency situations, indicating the crew likely experienced a sudden event without time to radio for help. The NTSB concludes that the *Emmy Rose* experienced a sudden loss of stability (capsizing) due to water on deck and flooding in the lazarette and fish hold.

The vessel was found upright on the seafloor, and the MSC's analysis stated the *Emmy Rose* likely had sunk stern first. Although the vessel likely capsized on the surface, additional flooding (once the vessel rolled over) in the lower hull compartments would have overwhelmed the vessel's remaining buoyancy (in the upper portions of the vessel), likely righting the vessel as it descended before it contacted the seafloor in an upright orientation.

2.5 Survival Factors

The crewmembers' actions leading up to the time of the sinking are unknown. In the 3.5 hours before the sinking, there were no satellite phone calls, emails, or distress calls to give any indication of what events and circumstances the crew may have been experiencing aboard the *Emmy Rose*. Because the crew's watch schedule and hours of work and rest throughout the trip are unknown, investigators could not determine which crewmember was on watch in the wheelhouse or if the wheelhouse was occupied at any time after 2101, when the last phone call was received on the *Emmy Rose*'s satellite phone. Further, it is unknown if crewmembers were engaged in any casualty control efforts, such as bilge pumping to dewater the vessel or fuel transferring to correct a list before the Coast Guard received the EPIRB signal. The captain of *Blue Harvest* witnessed crewmembers on the working deck at 2320, but it is unknown which crewmembers he saw or what they were doing.

None of the *Emmy Rose*'s crewmembers were located after the sinking. Additionally, investigators were unable to determine where on the vessel each crewmember was at the time of the sinking. Had any of the crewmembers been able to evacuate the vessel, the SAR estimates by the Coast Guard for the weather and sea conditions predicted they would have been able to survive up to a maximum 22.5 hours in the water in one of the vessel's five immersion suits or 13 hours without an immersion suit. The Coast Guard arrived at the area where the EPIRB signal activated about 1.5 hours after the vessel likely capsized and searched for survivors over a 38-hour period. However, they were unable to find any of the crewmembers. Had any crewmember been able to evacuate with an activated PLB, the device would have provided essential information to focus rescue efforts.

Advancements in technology have resulted in affordable PLBs with GPS location functionality. These devices are meant to be carried by individuals and can provide SAR operations with an accurate, continuously updated location of each person carrying a PLB. PLBs can reduce or eliminate SAR errors by providing multiple current GPS coordinates of survivors to searchers. Because the use of PLBs can result in the faster location and rescue of survivors of marine casualties, the NTSB previously issued Safety Recommendation M-17-45, addressing PLB requirements, to the Coast Guard:

> Require that all personnel employed on vessels in coastal, Great Lakes, and ocean service be provided with a personal locator beacon to enhance their chances of survival. (M-17-45)

This recommendation is also associated with the NTSB's 2021–2022 Most Wanted List of Transportation Safety Improvements under the issue area, "Improve Passenger and Fishing Vessel Safety." On July 17, 2018, the Coast Guard told the NTSB that it was very interested in ensuring that persons in distress have the most efficient means of alerting their distress, initiating an appropriate SAR response, and providing responders with an accurate location for rescue. However, the Coast Guard did not believe that a PLB would provide the location accuracy necessary for this purpose.

On April 30, 2019, the NTSB replied that it disagreed with the Coast Guard that PLBs did not provide the needed location accuracy. Newer 406-MHz PLBs use GPS input to achieve a location accuracy of about 300 feet and nearly instant SAR notification when activated. The NTSB wrote that we continue to believe that PLBs are an available, affordable technology that ensures that mariners in distress have the most efficient means of alerting rescuers, initiating an appropriate SAR response, and providing a continuous accurate location for rescue while activated. The NTSB asked the Coast Guard to reconsider the suitability of modern 406-MHz PLBs and to take the recommended action. Pending a requirement that mariners use available SAR technologies, Safety Recommendation M-17-45 was classified "Open—Unacceptable Response."

It is unlikely that the crew had PLBs; however, the NTSB concludes that had the crewmembers of the *Emmy Rose* carried PLBs on board and had they been able to activate them and abandon the vessel, search and rescue crews would have had continuously updated and correct coordinates of individual crewmembers' locations, thus enhancing their chances of survival. Therefore, the NTSB reiterates Safety Recommendation M-17-45.

3. Conclusions

3.1 Findings

1. None of the following were factors in this casualty: (1) fire or explosion; (2) grounding; (3) collision; or (4) the vessel's propulsion or steering systems.
2. At the time of the sinking, the *Emmy Rose* likely did not meet regulatory stability criteria and therefore had a smaller margin of safety than intended by regulations, making it more susceptible to capsizing.
3. The *Emmy Rose*'s course toward Gloucester to offload its catch subjected the vessel to quartering winds and seas that likely resulted in the accumulation of seawater on the aft working deck.
4. By not meeting the regulatory requirements for the freeing port area and design of freeing port covers, the *Emmy Rose* was more susceptible to accumulating water on deck.
5. The inclusion of an inspection of freeing port covers during commercial fishing vessel safety examinations would increase the safety of commercial fishing vessels by identifying when the covers do not meet the regulations.
6. The combined effects of the weather conditions acting on the vessel as well as the accumulating water on the starboard side that could not drain due to the closed freeing ports caused the vessel to list to starboard and reduced the vessel's stability.
7. Although a definitive source of initial flooding could not be determined, flooding of the *Emmy Rose* most likely began through the lazarette hatch's cover, which did not have securing mechanisms and therefore could not be made watertight, allowing following seas and accumulating water on deck to downflood into the lazarette.
8. The *Emmy Rose* was not being operated in accordance with its stability instructions and fishing vessel regulations requiring that deck hatches be secured to ensure they are watertight or weathertight.
9. The inclusion of an inspection of hatch cover securing mechanisms during commercial fishing vessel safety examinations would increase the safety of commercial fishing vessels by ensuring that a vessel maintains watertight integrity when the hatches are closed and secured and is able to comply with its stability instructions.
10. The *Emmy Rose* experienced a sudden loss of stability (capsizing) due to water on deck and flooding in the lazarette and fish hold.

11. Had the crewmembers of the *Emmy Rose* carried personal locator beacons on board and had they been able to activate them and abandon the vessel, search and rescue crews would have had continuously updated and correct coordinates of individual crewmembers' locations, thus enhancing their chances of survival.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the sinking of the fishing vessel *Emmy Rose* was a sudden loss of stability (capsizing) caused by water collecting on the aft deck and subsequent flooding through deck hatches, which were not watertight or weathertight because they had covers that did not have securing mechanisms, contrary to the vessel's stability instructions and commercial fishing vessel regulations.

4. Recommendations

4.1 New Recommendations

As a result of this investigation, the National Transportation Safety Board makes the following new safety recommendations.

To the US Coast Guard:

1. Increase the scope of commercial fishing vessel safety examinations to include inspection of a vessel's freeing port cover design to determine whether the covers are constructed to allow water to readily flow outboard but not inboard as required by 46 *Code of Federal Regulations* Part 28. (M-22-4)
2. Increase the scope of commercial fishing vessel safety examinations to include inspection of a vessel's hatch covers to determine whether they are watertight and have adequate securing mechanisms as required by 46 *Code of Federal Regulations* Part 28. (M-22-5)

4.2 Previously Issued Recommendations Reiterated in This Report

The National Transportation Safety Board reiterates the following safety recommendations.

To the US Coast Guard:

Require that all personnel employed on vessels in coastal, Great Lakes, and ocean service be provided with a personal locator beacon to enhance their chances of survival. (M-17-45)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JENNIFER HOMENDY
Chair

MICHAEL GRAHAM
Member

BRUCE LANDSBERG
Vice Chairman

THOMAS CHAPMAN
Member

Report Date: August 23, 2022

Appendixes

Appendix A: Investigation

The US Coast Guard was the lead federal agency in this investigation. The National Transportation Safety Board (NTSB) learned of the casualty from the Coast Guard on November 23, 2020, and participated with the Coast Guard in joint interviews of former crewmembers, the vessel owner, the vessel manager, and family members of the crewmembers, as well as other individuals familiar with the vessel, its crew, or the marine industry. Boat Aaron & Melissa was a party to the investigation.

Due to the severity of the casualty, as well as the scope and complexity of the investigation, the Coast Guard convened a district level formal marine casualty investigation on December 2, 2020. The Coast Guard completed a report of investigation in June 2022.

In May 2021, MIND Technologies provided side scan sonar devices to locate the *Emmy Rose* on the seafloor and assess its condition. The vessel was located on May 19, at 1415, about 3.5 miles west of the last vessel monitoring system position at a depth of 794 feet. A remotely operated vehicle survey, conducted in September 2021 by the Woods Hole Oceanographic Institute, confirmed the location of the *Emmy Rose* wreckage and examined the vessel for visible damage.

Appendix B: Consolidated Recommendation Information

Title 49 *United States Code* 1117(b) requires the following information on the recommendations in this report.

For each recommendation—

(1) a brief summary of the Board's collection and analysis of the specific accident investigation information most relevant to the recommendation;

(2) a description of the Board's use of external information, including studies, reports, and experts, other than the findings of a specific accident investigation, if any were used to inform or support the recommendation, including a brief summary of the specific safety benefits and other effects identified by each study, report, or expert; and

(3) a brief summary of any examples of actions taken by regulated entities before the publication of the safety recommendation, to the extent such actions are known to the Board, that were consistent with the recommendation.

To the US Coast Guard

M-22-4

Increase the scope of commercial fishing vessel safety examinations to include inspection of a vessel's freeing port cover design to determine whether the covers are constructed to allow water to readily flow outboard but not inboard as required by 46 *Code of Federal Regulations* Part 28.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3 Freeing Ports. Information supporting (b)(1) can be found on pages 39–42; (b)(2) and (b)(3) are not applicable.

M-22-5

Increase the scope of commercial fishing vessel safety examinations to include inspection of a vessel's hatch covers to determine whether they are watertight and have adequate securing mechanisms as required by 46 *Code of Federal Regulations* Part 28.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4 Sinking. Information supporting (b)(1) can be found on pages 42–46; (b)(2) and (b)(3) are not applicable.

M-17-45

Require that all personnel employed on vessels in coastal, Great Lakes, and ocean service be provided with a personal locator beacon to enhance their chances of survival.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5 Survival Factors. Information supporting (b)(1) can be found on pages 46–47; (b)(2) is not applicable; and (b)(3) can be found on pages 34–35.

Appendix C: Principles of Stability

Vessel stability reflects the relationship between gravity (the force pushing the vessel into the water) and buoyancy (the force pushing on a vessel allowing it to float). Gravity acts on all parts of the vessel's structure, equipment, cargo, and personnel, while buoyancy acts on every part of the vessel below the water, including the hull, propeller, and rudder. For the purposes of calculating stability, the force of gravity can be considered to act downward through a single point, known as the ship's center of gravity (G). Similarly, the buoyant force can be considered to act upward through a single point, known as the ship's center of buoyancy (B). When a vessel is floating at an even keel or upright, the force of gravity and buoyancy are vertically aligned. The properties of stability are usually expressed as the magnitude of a heeling moment necessary to incline the vessel to a certain angle, the angle a vessel may heel to before capsizing, and other parameters that can be calculated.

Stability is the tendency of a vessel to return to its original upright position when a disturbing force (e.g., wind or wave) is removed. When a disturbing force such as wave action or wind pressure exerts an inclining moment on a vessel, the vessel's underwater volume shifts in the direction of the heel, which causes the center of buoyancy to shift in the same direction (see figure C-1). The shift does not affect the position of the vessel's center of gravity unless cargo, equipment, or water (weights) are free to move. As a result, the lines of action of the forces of buoyancy and gravity

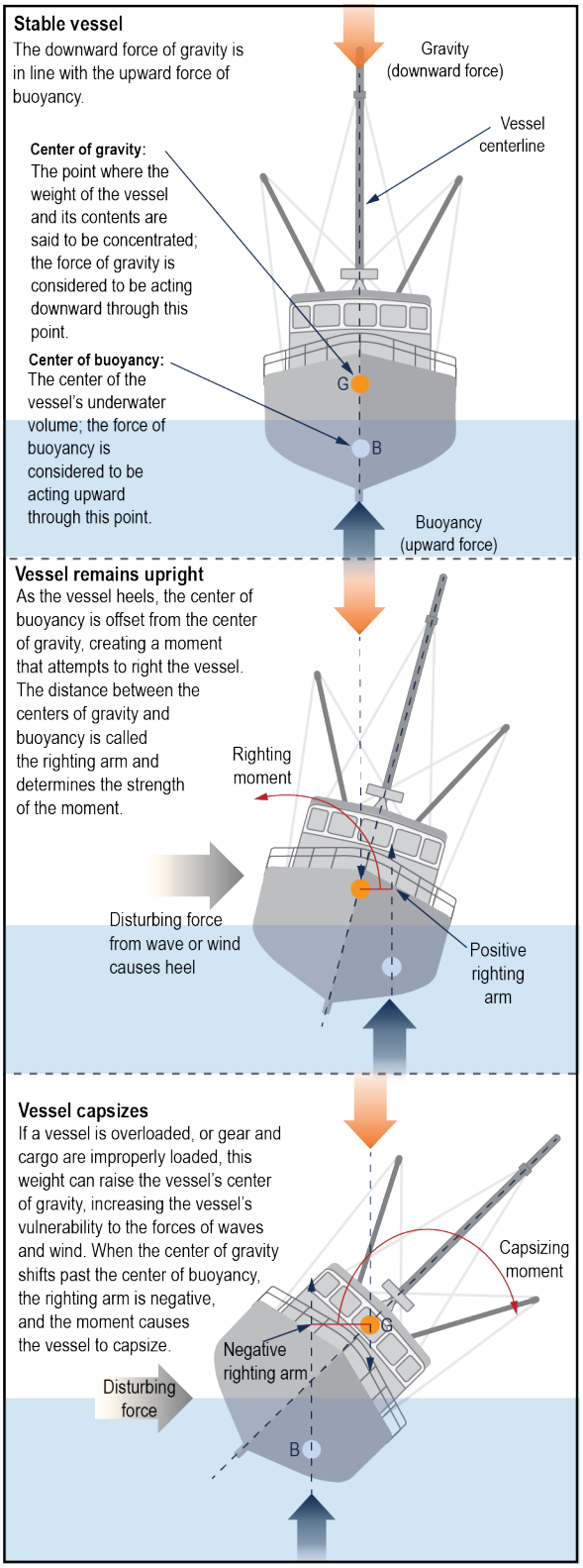

Figure C-1. Principles of stability.

separate and exert a moment on the vessel that tends to restore the vessel to an even keel. That is known as a righting moment.

The righting moment is the product of the force of buoyancy times the distance that separates the forces of buoyancy and gravity. That distance is known as the vessel's righting arm. The righting arm can be expressed as a curve plotted at successive angles of heel. The magnitude of the righting moment generally increases with the angle of heel to a maximum point, after which it decreases, reaching zero at a very large angle of heel. A reduction in the size of the righting arm usually means a decrease in stability. The angle where the righting arm crosses zero, known as the angle of vanishing stability, denotes where a vessel's stability changes from positive righting moments (positive stability) to negative capsizing moments (negative stability). The area under the righting moment curve represents the energy available to the vessel to right itself (righting energy), and in general, the more area under the curve, the larger the capsizing moments the vessel can resist. Vessels are often termed "stable" when they have enough positive stability to return to an upright position in the conditions encountered as loaded, and "unstable" when they do not, and capsize.

Intact stability refers to how an intact, or undamaged, vessel will respond when heeled over in calm conditions. The specific stability characteristics of a vessel are calculated based on the model of its hull form (hydrostatics), developed from plans and lightship characteristics stability (which are determined through an inclining experiment in which precise measurements are taken on board the vessel to determine its displacement and center of gravity). Stability analysis generally requires the services of a naval architect.

References

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Casualty Type	Capsizing/Listing
Location	Atlantic Ocean, 27 miles northeast of Provincetown, Massachusetts 42°19.1351′ N, 069°37.8461 W
Date	November 23, 2020
Time	0130 eastern standard time (coordinated universal time –5 hours)
Injuries	4 fatal
Property damage	$325,000
Environmental damage	Oil sheen with a potential of about 6,000 gallons diesel fuel

NTSB investigators worked closely with our counterparts from the **Coast Guard District 1 Formal Investigation Team** throughout this investigation.