Adopted: October 18, 2022 MIR-22/26

Capsizing of Liftboat *SEACOR Power*

Port Fourchon, Louisiana

April 13, 2021

Abstract: This report discusses the April 13, 2021, capsizing of the US-flagged liftboat *SEACOR Power* about 7 miles off the coast of Port Fourchon, Louisiana, in a severe thunderstorm with heavy rain, winds exceeding 80 knots, and 2- to 4-foot seas at the time of the capsizing. Search and rescue efforts were hampered by 30- to 40-knot winds and seas that quickly built to 10 to 12 feet and persisted throughout the evening and into the next day. Six personnel were rescued by the US Coast Guard and Good Samaritan vessels, and the bodies of six fatally injured personnel were recovered. Seven personnel were never found and are presumed dead. The vessel, valued at $25 million, was a total constructive loss. Safety issues identified in this report include gaps in forecasts and communications of weather events, the operation and stability of restricted-service liftboats in severe thunderstorms, the effectiveness of the initial response to the capsizing, and the difficulty in locating survivors in adverse weather and sea conditions. As part of its investigation, the National Transportation Safety Board makes three new recommendations and reiterates one recommendation to the United States Coast Guard. We also make one recommendation to the National Weather Service, one recommendation to the Federal Aviation Administration and the US Air Force, two recommendations to the Offshore Marine Service Association, and three recommendations to SEACOR Marine.

NOTE: This report was reissued November 16, 2022, with a corrected NTIS number on page 122.

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Acronyms and Abbreviations

AB	able seafarer
ABS	American Bureau of Shipping
AIS	automatic identification system
AIS-SART	automatic identification system search and rescue transmitter
ATC	Aviation Training Center
AVCG	allowable vertical center of gravity
CDT	central daylight time
CFD	computational fluid dynamics
CFR	*Code of Federal Regulations*
COI	certificate of inspection
SARSAT	Search And Rescue Satellite Aided Tracking
DPA	designated person ashore
EPIRB	emergency position indicating radio beacon
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
GEOSAR	geostationary search and rescue
GM	metacentric height
GMDSS	Global Maritime Distress and Safety System
GNSS	Global Navigation Satellite System
IMO	International Maritime Organization
ISM Code	IMO International Safety Management Code
MCS	mesoscale convective system

MEOSAR	medium Earth orbit search and rescue
MSC	US Coast Guard Marine Safety Center
MSI	maritime safety information
NAVTEX	navigational telex
NOAA	National Oceanic and Atmospheric Administration
NTSB	National Transportation Safety Board
NWR	NOAA Weather Radio All Hazards
NWS	National Weather Service
OMSA	Offshore Marine Service Association
OSV	offshore supply vessel
OW	offshore worker
PLB	personal locator beacon
PTO	power takeoff
RB-M	response boat-medium
RCC	Rescue Coordination Center
SAR	search and rescue
SART	search and rescue transponder
SEND	satellite emergency notification device
SMS	safety management system
SMW	Special Marine Warning
SOLAS	*International Convention for the Safety of Life at Sea*
TDWR	Terminal Doppler Weather Radar
UMIB	urgent marine information broadcast

VCG	vertical center of gravity
VHF	very high frequency
WFO	Weather Forecast Office

Glossary

Amidships: The middle of a vessel's hull, either longitudinally or laterally.

Athwartship: Across the ship from side to side.

Beam: a) The width of a ship's hull at its widest point; b) a relative direction that is toward the side of a ship (example: "The whale was sighted off the ship's port beam.").

Completion: The process of transforming a newly drilled well into an oil producing well; *recompletion* is the process of restarting or reinvigorating a producing well.

Coxswain: The person in charge of a small boat. Specific to the US Coast Guard, a small boat is less than 65 feet in length.

Draft: The vertical distance between a vessel's waterline and the bottom of its hull.

Freeboard: The vertical distance between a vessel's waterline and its highest watertight deck.

Heel: When a vessel leans temporarily due to an external force such as wind.

Lease block: A subdivision of undersea area within the US exclusive economic zone that may be leased by the federal government to private companies for oil and gas exploration and extraction.

Lightship: The weight of a ship ready for sea with no cargo, fuel, water ballast, stores, provisions, or passengers on board. Also called *lightweight*.

Load lines: Marks at the midpoint along the length of each side of a vessel's hull that establish the minimum safe freeboard.

Port and starboard: Left and right side of a vessel when facing forward (toward the bow), respectively, in nautical terminology.

Rescue boat: A powered watercraft that can be launched from a vessel to retrieve persons from the water, marshal liferafts, and tow the largest liferaft carried on the ship when loaded with its full complement of persons and equipment.

Sea clutter: False returns on a radar display created when the radar beam picks up waves from the sea surface.

Trim: The difference between the forward and aft drafts of a vessel. If the vessel's aft draft is greater than its forward draft, it is said to be "trim by the stern," and if its forward draft is greater than its aft draft, it is "trim by the head" or "trim by the bow." If the forward and aft drafts are equal, then the vessel is "on an even keel."

Watertight: Capable of preventing the passage of water in any direction under the head of water likely to occur in intact and damaged conditions.

Weathertight: When, in any sea conditions, water will not penetrate the ship.

Executive Summary

What Happened

On April 13, 2021, about 1537 local (central daylight) time, the US-flagged liftboat *SEACOR Power* capsized about 7 miles off the coast of Port Fourchon, Louisiana, in a severe thunderstorm. Eleven crew and eight offshore workers were aboard the liftboat. Vessel operators in the area reported heavy rain, winds exceeding 80 knots, and 2- to 4-foot seas at the time of the capsizing. Search and rescue efforts were hampered by 30- to 40-knot winds and seas that quickly built to 10 to 12 feet and persisted throughout the evening and into the next day. Six personnel were rescued by the US Coast Guard and Good Samaritan vessels, and the bodies of six fatally injured personnel were recovered. Seven personnel were never found and are presumed dead. The vessel, valued at $25 million, was a total constructive loss.

What We Found

We found that the captain's decision to get underway on the day of the casualty was reasonable and was not influenced by commercial pressure. However, weather information that the vessel's operator, SEACOR Marine, provided to the *SEACOR Power*'s crew was insufficient for making weather-related decisions about the liftboat's operation. Additionally, due to a Coast Guard broadcasting station outage, the *SEACOR Power* crew did not receive a National Weather Service Special Marine Warning notifying mariners of a severe thunderstorm that was approaching.

Even if the *SEACOR Power* crew had received the Special Marine Warning, data gaps, including a lack of low-altitude radar visibility over the Louisiana coastal areas, prevented the National Weather Service office that issued the Special Marine Warning from identifying and forecasting the surface wind magnitudes that impacted the *SEACOR Power.* Lowering the angle of the lowest radar beam at select coastal weather radar sites would improve low-altitude radar visibility over coastal waters.

The capsizing occurred when the *SEACOR Power* was struck by severe thunderstorm-generated winds that exceeded the vessel's operational wind speed limits, causing a loss of stability. Other operational factors may have also played a role in the capsizing, including the liftboat's trim by the stern (aft draft greater than forward draft), its turn to port and speed through the water, a cargo shift, and movement of the vessel's legs.

We found that due to the unpredictability of thunderstorm phenomena and the vulnerability of restricted-service liftboats like the *SEACOR Power*, operating restricted-service liftboats like the *SEACOR Power* in the afloat mode at any time when a Special Marine Warning has been issued for the vessel's planned route increases their risk of capsizing. Further, increasing minimum stability criteria for liftboats in restricted service would improve vessel survivability in severe thunderstorms.

The speed at which the *SEACOR Power* capsized and angle at which it came to rest made egress difficult and likely contributed to the fatalities. Following the capsizing, the Coast Guard Rescue Coordination Center did not effectively use available information to verify the validity of the location of the *SEACOR Power*'s emergency position indicating radio beacon alerts, which led to a delay in dispatching search and rescue units and notifying Good Samaritan vessels of the emergency. Additionally, SEACOR Marine did not have adequate procedures nor did it provide its staff with training for responding to the Coast Guard when contacted regarding emergency position indicating radio beacon alerts, and inaccurate information about the *SEACOR Power*'s location provided to the Coast Guard by a SEACOR Marine employee contributed to the delayed response.

High winds and heavy seas, combined with underwater and overhead obstructions, prevented both surface and air resources from getting close enough to the vessel to rescue personnel directly from the wreck, which contributed to the loss of life. In the future, a detailed procedure in Coast Guard mass rescue operations plans combined with mutual aid agreements between the Coast Guard and air rescue providers would improve and expand search and rescue capabilities.

In previous casualty investigations, we found that mariners have benefited from their vessels or employers providing personal locator beacons; had the crewmembers of the *SEACOR Power* been required to carry personal locator beacons, their chances of being rescued would have been enhanced. The search and rescue transponder held by the mate after he had been swept into the water from the wreck was not effective in signaling vessels or aircraft.

We determined that the probable cause of the capsizing of the liftboat *SEACOR Power* was a loss of stability that occurred when the vessel was struck by severe thunderstorm winds, which exceeded the vessel's operational wind speed limits. Contributing to the loss of life on the vessel were the speed at which the vessel capsized and the angle at which it came to rest, which made egress difficult, and the high winds and seas in the aftermath of the capsizing, which hampered rescue efforts.

What We Recommended

Because the localized weather could not be detected by nearby radars due to their elevation angles (antenna angles relative to the horizon), we recommended that that the National Weather Service, Federal Aviation Administration, and Air Force work together to assess coastal weather radar sites to determine if it is safe and appropriate to lower the radar angles, and then lower the angles of the lowest radar beams where appropriate.

We also recommended that the Coast Guard develop procedures to inform mariners in affected areas whenever there is an outage at a navigational telex broadcasting site; modify restricted-service liftboat stability regulations to require greater stability for newly constructed restricted-service liftboats; and develop procedures to integrate commercial, municipal, and non-profit air rescue providers into Sectors' and Districts' mass rescue operations plans, when appropriate.

We reiterated a recommendation to the Coast Guard to 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. Given the benefits of personal locator beacons, we also recommended that the Offshore Marine Service Association notify members of personal locator beacons' availability and value.

Lastly, we recommended that SEACOR Marine review its fleet to ensure its vessels are being operated strictly within the limits specified in operating manuals, stability documentation, and other required guidance, and revise its liftboat safety management system and operations manuals to include a policy requiring the vessel to remain in port or lower its legs and cease afloat operations when a Special Marine Warning has been issued for the vessel's planned route. We similarly recommended that the Offshore Marine Service Association inform their members of the circumstances of this accident and the importance of remaining in port or jacking up when a Special Marine Warning has been issued.

1. Factual Information

1.1 Casualty Narrative

On April 13, 2021, about 1537 local time (central daylight time [CDT]), the US-flagged liftboat *SEACOR Power* capsized about 7 miles off the coast of Port Fourchon, Louisiana, in a severe thunderstorm.[1] Eleven crew and eight offshore workers were aboard the liftboat. Vessel operators in the area reported heavy rain, winds exceeding 80 knots, and 2- to 4-foot seas at the time of the capsizing. Search and rescue efforts were hampered by 30- to 40-knot winds and seas that quickly built to 10 to 12 feet and persisted throughout the evening and into the next day. Six personnel were rescued by the US Coast Guard and Good Samaritan vessels, and the bodies of six fatally injured personnel were recovered. Seven personnel were never found and are presumed dead. The vessel, valued at $25 million, was a total constructive loss.

1.1.1 Liftboat Background

Liftboats are three- or four-legged self-propelled, self-elevating vessels that are typically used in the installation, maintenance, and repair of offshore facilities such as oil production platforms and wind turbines. After carrying equipment and personnel to a facility, a liftboat will elevate, or "jack up," raising its hull clear of the water to provide a stable platform for work at the site. The vessel furnishes offshore workers with accommodations, cranes, a large deck space, and, occasionally, helideck services (see Figure 1). Liftboats operate in relatively shallow water (less than 300 feet deep) along the continental shelf. In the United States, the majority of liftboats are used in the Gulf of Mexico. As of August 1, 2022, there were 77 US-flagged liftboats in active service.

[1] (a) All times in this report are central daylight time. (b) Unless otherwise specified, 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 accident investigation (case number DCA21MM024). Use the CAROL Query to search safety recommendations and investigations.

Figure 1. Precasualty photos of the *SEACOR Power* liftboat underway (*left*) and lifted, or "jacked up" (*right*). (Source: SEACOR Marine)

1.1.2 Precasualty Events

The 167-foot-long *SEACOR Power*, including its equipment and crew, had been chartered by Talos Energy LLC to support offshore work on oil producing platforms in the Gulf of Mexico. On April 10, 3 days before the capsizing, the vessel was underway returning to Port Fourchon, Louisiana, after completing a Talos assignment. During the voyage, high winds and seas made it difficult to make headway. The captain decided to stop and jack up the vessel to wait out the weather, which was the standard procedure per the vessel's Marine Operations Manual (see section 1.9.4 Marine Operations Manual for additional detail). When the winds and seas abated later that day, the *SEACOR Power* jacked down and continued on. The liftboat arrived at the Bollinger Shipyard facility in Port Fourchon later that evening.

The purpose of the port visit was to offload equipment from the previous Talos job, complete maintenance and inspections on the boat's cranes, replace a liferaft that had blown away during the return voyage, and prepare the vessel for its next assignment for Talos. The *SEACOR Power*'s crew would also change out before getting underway. A little after 0600 on April 13, the oncoming crewmembers boarded the *SEACOR Power* and relieved the offgoing crew (three of the crewmembers from the previous voyage remained aboard with the oncoming crew). The oncoming crew consisted of the captain (master), a "night captain," a mate, three able seafarers (ABs), the chief engineer, another engineer, two cooks (a day cook and a night cook), and a galleyhand.[2] Eight offshore workers (OWs), contracted by Talos to perform recompletion work at an oil producing platform, also arrived at the vessel that morning. The offshore workers were led by a well site supervisor (commonly referred to as the "company man" in the offshore oil and gas industry).

Once the oncoming and offgoing SEACOR Marine crews had turned over, the oncoming crew and the offshore workers gathered in the vessel's dining area for an orientation and safety meeting. According to survivors, the meeting was led by the captain and consisted of personnel introductions, a discussion of crane safety during the forthcoming equipment loadout (described below), instructions on where personnel were to muster in the event of an emergency, and the location of lifejackets. Attendees were informed of off-limits areas, such as the bridge and engine room, and were instructed to keep watertight doors closed and to use the vessel's internal stairway when underway.

After the meeting ended, the equipment loadout for the recompletion project began: OWs attached loads to one of the liftboat's two cranes, and then a *SEACOR Power* crewmember operated the crane to lift the equipment aboard. Another *SEACOR Power* crewmember recorded the position of each piece of equipment as it was placed on deck and each load's weight, as measured by the crane's built-in scale. The captain later entered this information into a spreadsheet to assist in calculating the vessel's stability.

At 0702, the captain received an email from a SEACOR Marine employee that provided a 7-day weather outlook. The weather information had been obtained from Buoyweather, a web-based subscription forecasting service used by SEACOR Marine. The forecast for the afternoon of April 13 predicted winds out of the southeast at 9 to 12 knots and 3-foot seas, also out of the southeast. According to the mate, he and the captain reviewed the forecast as part of a pre-underway risk assessment, and based on the predicted winds and seas, they determined that it was safe to sail when the loadout was complete about mid-day. "I was perfectly comfortable," said the mate in reference to the weather.

[2] *Night captain* was not a standard crew position on SEACOR Marine vessels. The night captain on the casualty voyage had been a master on SEACOR Marine liftboats, but due to the unavailability of vessels, the company had assigned him to the *SEACOR Power* as an additional mate.

1.1.3 Casualty Events

After the loadout was complete, the *SEACOR Power* got underway at 1218. The vessel's destination was a platform in Main Pass 138, an oil and gas lease block in the Gulf of Mexico off the Mississippi Delta, about 30 miles east of Boothville, Louisiana. The expected length of the transit from Port Fourchon to the platform was 20–22 hours. As the *SEACOR Power* transited out of the harbor, visibility was good, and the winds were light (see Figure 2). The liftboat's draft, as seen from a security camera, was about 9.3 feet amidships, with 2.5 feet of trim by the stern.

Figure 2. *SEACOR Power* outbound in Port Fourchon on the afternoon of the casualty. (Source: Port Fourchon Harbor Police)

With the mate at the helm, the liftboat cleared the Belle Pass jetties at 1413 and proceeded into the open waters of the Gulf of Mexico (see Figure 3). The *SEACOR Power* was making a speed of 3.3 knots with all four propulsion engines online, each driving their respective propellers. As the vessel proceeded on a southerly heading, it encountered 2- to 4-foot seas on the bow. About 1440, the liftboat began taking a more southeasterly heading. Its speed over the next 40 minutes ranged from 2.3 to 3.1 knots.

Figure 3. The *SEACOR Power* departed Port Fourchon en route to Main Pass 138. The location of the capsizing is indicated by a red *X*. (Background source: Google Maps)

The mate reported that, sometime after 1500, the *SEACOR Power* was overtaken by a squall from the north. He noted that the squall produced light rain that reduced visibility, but he was still able to see a platform that was nearby. The mate recalled that the sustained winds during the squall were between 30 and 40 knots, with a maximum gust of "79 mph" (69 knots). The mate told investigators that they continued, thinking that the rain might cause the seas to "lay down" (become calmer) as it often did. At 1524, the vessel's speed began to increase. By 1530, automatic identification system (AIS) data showed the vessel's speed was 5.5 knots and continuing to rise. Four minutes later, the *SEACOR Power*'s speed peaked at 8.4 knots.

The mate told National Transportation Safety Board (NTSB) and Coast Guard investigators that, 5 to 10 minutes after the first rain squall, a second squall hit the vessel with such intensity that it caused "white out" conditions. He stated that the rain was moving "almost sideways," and he could not see much farther than the bow of the *SEACOR Power*. Due to the poor visibility and because there were platforms and other vessels in the area, the mate suggested to the captain that they "soft tag" the vessel. Soft tagging is a procedure where the liftboat's legs are lowered to a point where the pads at the bases of the legs just touch the seafloor, with the hull of the vessel remaining in the water. In this way, the pads act "basically like an anchor," according to the mate. The mate told investigators that his suggestion to soft tag was based on the lack of visibility only and not the wind conditions.

The captain agreed, so the mate slowed all four engines, disengaged the two inboard propeller shafts from their engines, and engaged the inboard engines' power takeoffs (PTOs). The PTOs powered hydraulic pumps that operated the jacking gears of the three legs. Once the PTOs were engaged, the mate increased the inboard engines' speeds and began lowering the *SEACOR Power*'s legs.

While lowering the legs, the mate began turning the vessel into the wind (to port) to reduce the liftboat's speed so that the leg pads would not be damaged when they touched the seafloor. AIS data from 1535 to 1537 captured the vessel's turn as the heading changed from 143° to 099°, and the liftboat's speed slowed to 6.8 knots. The mate told investigators that, in the past when he turned the vessel with good headway on, it could heel as much as 2°. However, he believed that the liftboat was not making much headway when he initiated the turn, and thus the vessel should not have heeled much.

The mate stated that, after starting the turn, the vessel heeled to starboard about 2.5° and began rocking "a little" from side to side. He also noted that, about this time, the day cook called the bridge to report water coming into the galley (on the main deck) from one of the exterior doors. About 30 seconds to a minute after the call, the vessel heeled to 5° starboard, and the mate told the captain that he thought they were going over. The captain took the wheel and the throttles and attempted to turn the vessel back to starboard. During this attempted maneuver, the day cook again called the bridge to report water coming in a galley door. The mate did not know which door the cook was referring to, nor did he know if the door was open or closed.

The captain made an announcement over the public address system for everyone to get their lifejackets on. When the mate heard this announcement, he pressed the tilt alarm button to warn the crew. After pausing a few seconds at the 5° angle, the *SEACOR Power*'s heel to starboard increased until the vessel capsized onto its side, about 1537 local time. The vessel came to rest in 50 feet of water.

1.1.4 Post-Capsizing

With the vessel on its starboard side, the starboard exterior doors were below the water. Portside doors had to be reached by moving upwards, and port bulkheads became the overhead. Of the 19 personnel aboard the *SEACOR Power*, 9 people (the mate, the night captain, ABs 1 and 2, the night cook, the well site supervisor, and OWs 1, 2, and 3) are known to have survived the initial capsizing (see Figure 4).

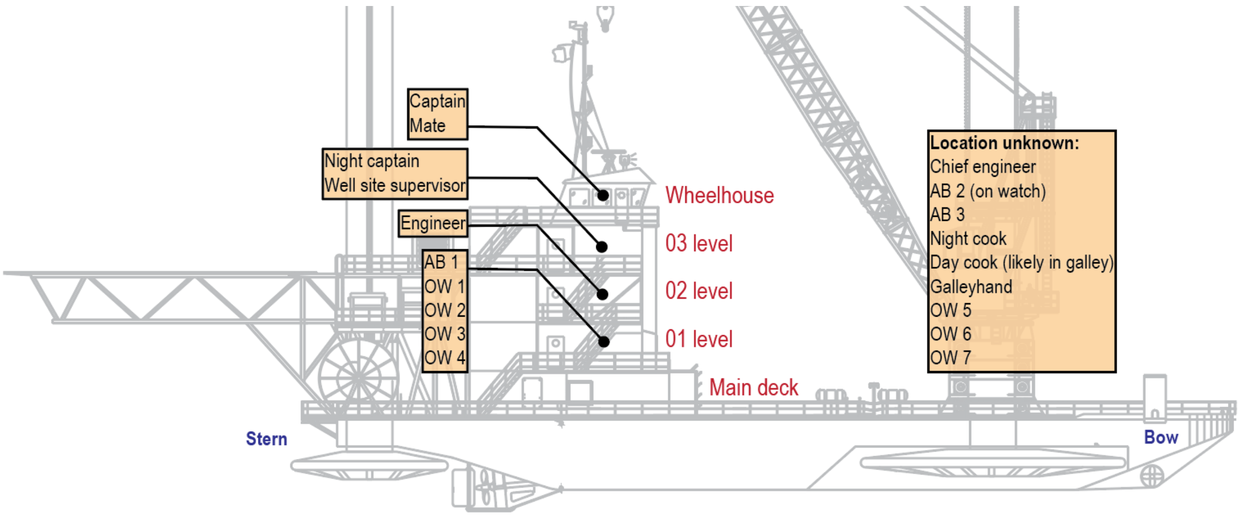

Figure 4. Known crewmember locations at the time of the capsizing.

After the vessel capsized, the mate climbed over to the Global Maritime Distress and Safety System (GMDSS) console and pressed the Inmarsat-C satellite communications system distress button. (See section 1.6.3 Global Maritime Distress and Safety System and Appendix E: Maritime Distress Communication Devices for additional information on the GMDSS and Inmarsat-C systems.) He then climbed out the port bridgewing door onto the side of the wheelhouse (see section 1.5.1.2 Construction and Arrangement for the vessel layout). He later told investigators that he did not see the captain after the vessel rolled. Once outside, he reached back inside to grab the search and rescue transponder (SART) mounted by the door.

The mate was washed off the wreck by the building seas and climbed back aboard twice. He grabbed a lifering the third time he went overboard and attempted to swim to a liferaft, but it blew away before he could reach it. He was able to don a

Type I lifejacket when a box containing extra lifejackets floated by him.[3] The mate activated the SART and recalled it was flashing, but boats that he could see in his vicinity did not move toward him. He assumed the unit was not working.

The night captain, who had been trying to sleep in his stateroom just before the capsizing, got up when the *SEACOR Power* began to heel over and was standing when the vessel capsized. After attempting to use his boots to break the window on the aft bulkhead, he went into the passageway through the door opposite the window and attempted to exit the vessel via the set of doors leading to the portside exterior. However, he could not open the first door, which was now above him. Instead, he was able to climb across the passageway, now a vertical shaft, to the well site supervisor's room. He estimated the water was 6 feet below their stateroom doors at that point.

The well site supervisor had been dozing in his stateroom when the vessel capsized. He recalled "the TV and the shelves were flying at me" and the ship's horn was sounding. After the night captain made his way into the room, they took turns beating on the window with a fire extinguisher for 5 to 8 minutes until the window shattered. The night captain donned a lifejacket and exited when the water outside was 3 to 4 feet below the window, cutting his head on the window as he passed through. The well site supervisor donned his personal lifejacket, waited until seas reached the window, and then exited. He became separated from the night captain and drifted away from the wreck.

After he egressed, the night captain hung onto a lifering rope and then a firehose, trying to stay with the vessel. He saw and heard AB 1 calling to him but eventually lost the strength to hang onto the firehose. He drifted with a debris field, grabbing onto a 5-foot board and then a mattress. He estimated he was adrift for a "couple of hours" in 12-foot seas.

AB 1, on watch at the time of the capsizing, had been on his way down from the wheelhouse to the galley via the internal companionway when the vessel rolled. He was at the 01 level, one deck above the galley, and was thrown into one of the staterooms. He then made his way up the passageway to the open portside doors and exited, assisted by AB 2. Neither had a lifejacket.

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[3] Type I lifejackets are intended for use in all waters, especially open, rough, or remote waters where rescue will be delayed. A Type I lifejacket is designed to turn an unconscious wearer face up.

OWs 1 and 2 were asleep when the vessel capsized. Lockers on the port side of the room came loose from the bulkhead and fell inboard, blocking the inward-swinging door to the passageway. OW 2 was able to push ceiling tiles aside and egress the room via the crawl space in the overhead and into the athwartship passageway, now a vertical shaft, where he saw water already halfway up the space.[4] OW 1 was unable to egress through the crawl space, so he donned a lifejacket, broke the window in the aft bulkhead of the room with an extinguisher while standing on the side of the bed, and exited (see Figure 5).

Figure 5. Stateroom with window on aft bulkhead, similar to the one OW 1 and 2 were in, aboard the *SEACOR Legacy* (a similar vessel). Note this vessel was not in service and outside equipment was stowed in rooms during an NTSB visit.

[4] This crawl space measured 10.5 inches in the same room aboard the similar vessel, *SEACOR Legacy*, excluding obstructions such as wiring and piping.

1.2 Response

The casualty occurred within the Coast Guard's Eighth District (District 8), which manages Coast Guard missions in most of the Gulf of Mexico and US inland waterways. District 8 is divided into seven Sectors; Coast Guard Sector New Orleans was responsible for the southern part of the Mississippi River and the area of Gulf of Mexico surrounding the Mississippi Delta, including the waters off Port Fourchon. The Sector had its own Command Center and acted as search mission coordinator for cases within its area, unless otherwise assumed by the District's Rescue Coordination Center (RCC).[5] The Sector was further divided into several subordinate units, with smaller cutters and small boat stations available. When larger cutters or aircraft were needed during a search and rescue (SAR) case, the Sector had to request these assets from the RCC. The Sector also maintained a radio watch on very high frequency (VHF) channels 16 and 70.[6]

The District 8 RCC received emergency position indicating radio beacon (EPIRB) alerts from several vessels during the afternoon of the casualty. The first alert was received about 1330, another about 1430, and then, with the weather event, multiple overlapping calls and alerts starting about 1530. The District 8 command duty officer stated, "it was around a 10, 15-minute span that we got five different EPIRB alerts [from different vessels]." The Sector New Orleans command duty officer noted that Sector watchstanders were "very heavily inundated with potential distress calls from both commercial and recreational vessels." The RCC was resolving seven cases before *SEACOR Power* capsized.

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[5] Command Center staffing is standardized throughout the Coast Guard. Staff include, in order of seniority, a Communications Unit handling radio and other telecommunications; a Situation Unit maintaining a common operating picture of resources, hazards, weather, and incidents; and an Operations Unit responsible for search planning, among other things. Each unit is staffed, at a minimum, by three people. The watch reports to a command duty officer who may or may not be physically working in the Command Center unless called. For search and rescue missions, overall authority rests with the search mission coordinator, a senior officer who will authorize missions and active search suspensions.

[6] For distress alerts, Sector Command Centers receive VHF distress calls, and RCCs receive Inmarsat-C and EPIRB alerts. For more information on maritime distress communication devices, see Appendix E: Maritime Distress Communication Devices.

1.2.1 Notifications

The *SEACOR Power*'s last recorded AIS transmission was at 1539:32. None of the Coast Guard units received the Inmarsat-C distress call initiated by the mate.

1.2.1.1 Emergency Position Indicating Radio Beacon

The *SEACOR Power*'s EPIRB floated free, and its signal was first detected by a geostationary search and rescue (GEOSAR) satellite at 1540 (see section 1.6.3 Global Maritime Distress and Safety System). This first alert had vessel and registration information but no position. The next alert, the first to include a position via a medium Earth orbit search and rescue (MEOSAR) satellite, was received a minute later, about 0.3 miles south-southeast of the vessel's final position. Additional alerts with position information were received at 1543, 1553, 1558, 1612, and 1621.

The NTSB reviewed phone conversations between the Coast Guard Command Centers. The first recorded mention of the *SEACOR Power* was in a 1558 phone call between the RCC and the Sector, discussing vessels involved in a different incident, when the RCC watchstander asked, "Would that happen to be the *SEACOR Power* by any chance?" The Sector had yet to hear of the capsizing and replied, "…it's the *Miss Jessica."*

At 1607, the RCC watchstander called the phone number on the *SEACOR Power* EPIRB's registration, which was the company's main phone line. A SEACOR Marine employee, working shoreside in a warehouse away from his desk, answered the call. The RCC watchstander notified the SEACOR Marine employee of the EPIRB alert from the *SEACOR Power* and asked the employee the status of the vessel. The employee responded, "I pretty much guarantee that they're not in distress… they're just sitting at the dock doing maintenance on the vessel." He told the watchstander that he would follow up with the vessel. The RCC then turned its attention to several other storm-related SAR cases including other EPIRB alerts received, many of which were false alarms.

The SEACOR Marine employee told investigators that he then drove to his office, a quarter-statute mile from the warehouse, and attempted to call the vessel unsuccessfully. The employee stated he later looked for the *SEACOR Power* using a commercial AIS reporting service and saw the liftboat was offshore.

The SEACOR Marine employee who responded to the Coast Guard call was in an entry level position at the company. His responsibilities included answering the company's main phone line, responding to emails, arranging for ground transportation for crews rotating on and off vessels, and assisting in the warehouse when needed. He told the NTSB that he was not aware of any standardized company procedures for responding to vessel emergencies, and he had received no training on EPIRBs or rescue devices for vessels. He said he did not receive notifications when vessels left port and did not see any correspondence regarding the *SEACOR Power*'s departure on the casualty day. The employee had received false EPIRB alert notifications before, and he said it was normal practice to contact the vessel to verify an emergency before calling the company's designated person ashore (DPA) and general manager.

1.2.1.2 Distress Call

The smaller liftboat *Rockfish* had gotten underway about 1330 that afternoon to move from one worksite to another worksite off the coast of Port Fourchon. The *Rockfish* captain told the NTSB that, before getting underway, he had checked the latest weather information and determined that it was "good enough to move." About 1430, the *Rockfish* arrived at its assigned worksite, about 1.1 miles northeast of the location where the *SEACOR Power* would capsize, and jacked up. The *Rockfish* survived the storm.

The *Rockfish* captain and deckhand had seen the outbound *SEACOR Power* earlier and noted that its AIS target disappeared in the weather. The captain told the NTSB, "…these AIS, when the weather gets bad, they go out; you know, they mis-signal, they go out. I thought that's what had happened." About 1625, when visibility improved after the squall had passed, the *Rockfish* crew saw the overturned *SEACOR Power*. The *Rockfish* captain radioed the *Miss Allie*, a crew boat that the *Rockfish* had been working with, for help. The captain then contacted the Coast Guard Sector New Orleans Command Center at 1628 on VHF channel 16 to report the incident. At 1640, the Sector broadcasted an urgent marine information broadcast (UMIB) requesting other vessels' assistance.[7] According to the *Rockfish* captain, 15 to 20 boats were searching in a short period of time.

[7] Other UMIB were also issued for other vessels, including one for the tug *Lily C*, whose crew were about to abandon ship, at the RCC's request.

1.2.1.3 SEACOR Marine

About 1640, the captain of the *Rockfish* called the SEACOR Marine employee to inform the company of the capsizing, and the employee transferred the call to the company's DPA. According to the DPA, after taking the call from the *Rockfish*, he called SEACOR Marine's general manager, who had already heard about the capsizing from a contact at the company that operated the *Rockfish*. At 1702, the SEACOR Marine operations manager called the District 8 RCC. The RCC watchstander told him he was unaware of the incident and answered that he would check with the Sector New Orleans Command Center. Meanwhile, the DPA called Coast Guard Marine Safety Unit Houma (Louisiana) to report the capsizing and then initiated the company's Crisis Management Team. A virtual meeting was established between the company's leadership, managers, and operations and safety personnel. The call was kept open for the next several days to facilitate information exchange and coordination.

Table 1 shows the emergency notifications chronologically.

Table 1. *SEACOR Power* notification communications.

Time	***Signal***
1540	GEOSAR EPIRB alert detected by satellite (no location data)
1541	MEOSAR EPIRB alert detected by satellite (location data)
1542	GEOSAR EPIRB alert received by RCC (no location data) MEOSAR EPIRB alert received by RCC (location data)
1544	MEOSAR EPIRB alert received by RCC (location data)
1554	MEOSAR EPIRB alert received by RCC (location data)
1558	RCC asks Sector if different incident was *SEACOR Power*
1600	MEOSAR EPIRB alert received by RCC (location data)
1607	RCC calls SEACOR Marine
1614	MEOSAR EPIRB alert received by RCC (location data)

Time	***Signal***
1625	LEOSAR (low-orbiting search and rescue) EPIRB alert received by RCC (location data)
1625	*Rockfish* sees *SEACOR Power* and calls *Miss Allie*
1628	*Rockfish* calls Sector
1640	*Rockfish* calls SEACOR Marine dispatch
1640	Sector broadcasts UMIB
1702	SEACOR Marine management calls RCC

1.2.2 Search and Rescue Resources

1.2.2.1 Coast Guard Station Grand Isle

Coast Guard Station Grand Isle, 20 miles from the site of the capsizing, was responsible for SAR in the area of the casualty. Two 45-foot response boats-medium (RB-Ms) and two 24-foot shallow watercraft were assigned to Station Grand Isle, with one RB-M always available for immediate response.

Station Grand Isle was impacted by the extreme weather affecting the region. The coxswain of the RB-M *CG-45674* (underway at 1730) stated that the station had experienced 70-knot winds with 90-knot gusts and estimated the seas offshore Grand Isle were 8 to 10 feet upon getting underway. The coxswain of the RB-M *CG-45687* requested a waiver to proceed outside of the boats' operational parameters after hearing a report of 45-knot winds on scene. The waiver request was relayed via Station Grand Isle's commanding officer and approved by the Sector Commander. The RB-M *CG-45687* was underway at 1730.

As SAR operations began, Coast Guard aircraft from Air Station New Orleans and Aviation Training Center (ATC) Mobile were grounded due to weather. With at least six SAR cases ongoing, the District 8 RCC command duty officer requested fixed wing support from Air Station Corpus Christi, Texas, which was west of and less affected by the storm. An HC-144 CASA airplane, *CG-2307*, launched about 1800 with liferafts and marker buoys for tracking currents. With a 2-hour travel time, *CG-2307* was on scene by 1944.

1.2.2.2 Cutter *Glen Harris*

The *Glen Harris* was a newly constructed 154-foot-long fast response cutter that had yet to be delivered to the Coast Guard. On the day of the casualty, the *Glen Harris* got underway about 1330 with a crew of eight Bollinger Shipyard personnel and 27 Coast Guard personnel on board for training. According to the Bollinger master, the crew reviewed weather information before getting underway and determined that they could conduct the intended training. The *Glen Harris* had passed by the *SEACOR Power* as the liftboat was transiting out of Port Fourchon; the cutter then proceeded to an area to the east. When the *Rockfish* issued the VHF radio distress call at 1628, the Bollinger crew and Coast Guard personnel heard the broadcast. The cutter proceeded to the scene of the capsizing, arriving at 1710.

1.2.2.3 Bristow Helicopters

At 1856, Bristow Helicopters, a commercial helicopter transportation and medical evacuation services company, offered assistance to the Coast Guard for SAR efforts. The Coast Guard accepted the assistance, and *Bristow 739*, an AW-139 helicopter, launched at 1934. The helicopter carried two pilots, two hoist operator/rescue specialists, a paramedic, and advanced life support equipment. While their helicopter was on scene, Bristow staff set up a triage unit at their facility with paramedics ready to receive mass casualties.

Table 2 lists a sample of the SAR assets, not including the many merchant vessels that assisted.

Table 2. Responding assets.

Response asset	*Location*	*Time underway*	*Time on scene*
CG-45674 RB-M	Station Grand Isle	1730	1847
CG-45687 RB-M	Station Grand Isle	1730	1847
CG-2307 CASA airplane	Air Station Corpus Christi, Texas	1800	1944

Response asset	***Location***	***Time underway***	***Time on scene***
Glen Harris Cutter	Open water in the Gulf of Mexico	1628	1710
Bristow 739 AW-139 helicopter	Galliano, Louisiana, facility	1934	1954

1.2.3 Rescue Operations

Six personnel were gathered on the port side of the *SEACOR Power*: OWs 1, 2, and 3; ABs 1 and 2; and the night cook. They were "pummeled by waves and rain," according to one of the survivors (see Figure 6). Four of six (OW 2, the night cook, and the two ABs) did not have lifejackets. Diesel poured from tank vents, making the structure and survivors slippery, and a loose wooden bench injured OW 1's foot. OW 2 saw the well site supervisor float by in a lifejacket but was unable to reach him. OW 1 was next swept away by the seas and drifted away from the vessel.

Figure 6. Port side of the capsized hull as seen from *Glen Harris* about 1755. Some personnel are visible. (Source: *Glen Harris*)

After arriving at the site of the capsizing, the *Glen Harris* crew reported 42-knot winds from the east and increasing sea state near the wreck. Sector New Orleans instructed the *Glen Harris* to stay with the personnel on the wreck while Good Samaritan vessels were searching for survivors downwind in the debris fields. The master estimated he could only approach to within 300 to 450 feet due to the liftboat's legs and crane boom. The *Glen Harris* launched its small boat, a 26-foot jet, but the captain recalled it. He told investigators that "it was way too much for that small boat, in that condition."

OW 1 was the first to be rescued. He estimated he had drifted for 30 to 45 minutes before being spotted by the crew boat *Arata* at 1728. The offshore supply vessel (OSV) *Elise Mary,* coordinating with *Arata,* maneuvered near OW 1 and deployed a man overboard platform. OW 1 was able to climb on board the *Elise Mary* at 1742.

The *SEACOR Power* night captain drifted 4 miles west-southwest over almost 2.5 hours while wearing a lifejacket in the 75° water. He spotted the OSV *Christian Chouest* and waved to it on each wave crest while still clinging to a mattress, until they spotted him at 1748. The OSV crew hauled the night captain aboard at 1805. The well site supervisor also drifted 4 miles west-southwest of the wreck in a lifejacket. He recalled waving to the *Christian Chouest*, when it stopped 150 feet from him to rescue the night captain, but its crew did not see him. The crew boat *Mr. Lloyd* happened upon the well site supervisor and rescued him, also at 1805 (see Figure 7).

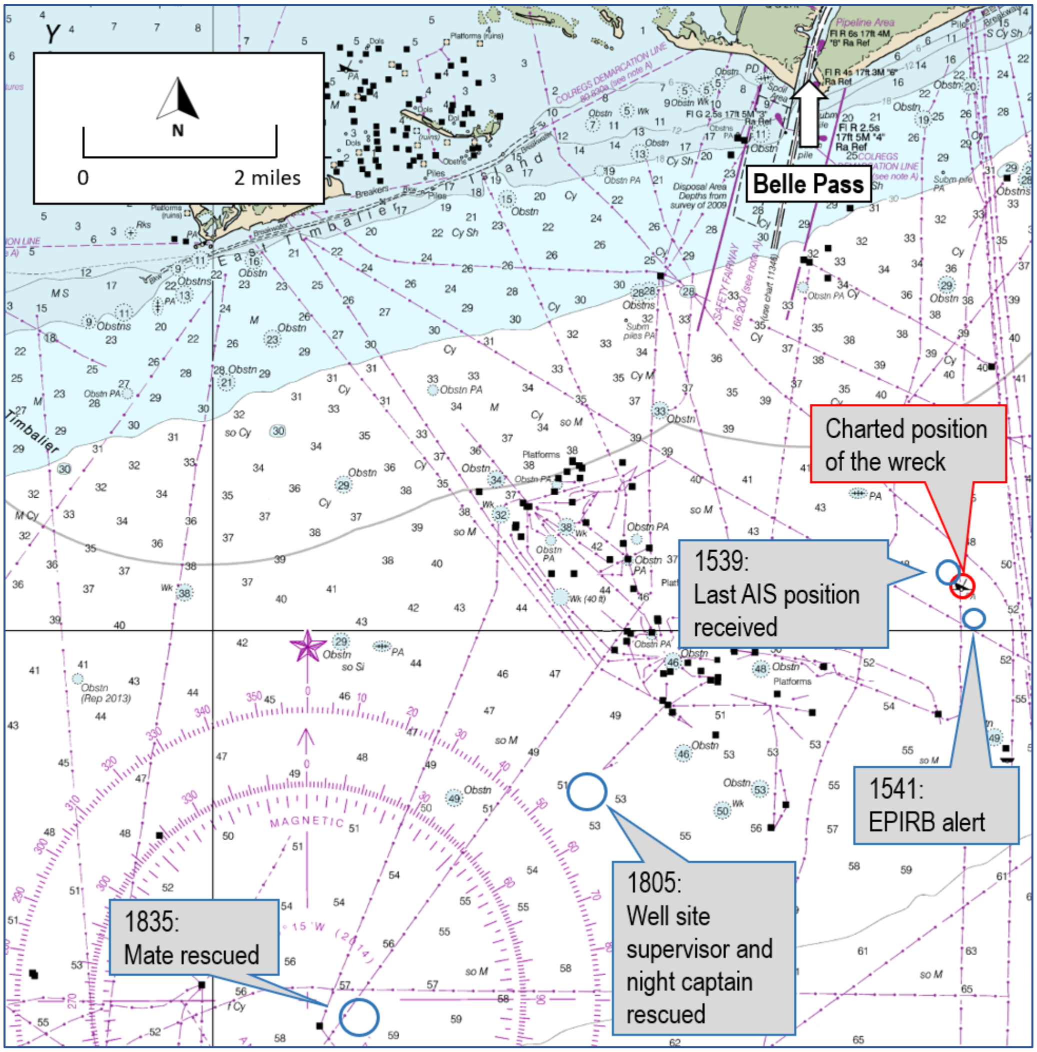

Figure 7. Extract of updated National Oceanic and Atmospheric Administration chart 11357 (annotated by NTSB), showing the locations of the Good Samaritan rescues and the actual location of the wreck. Black squares denote oil rig platforms. Depths are in feet.

On the *SEACOR Power*, OW 3, ABs 1 and 2, and the night cook climbed forward and outboard (higher on the overturned deckhouse) as the liftboat sank further. OW 2, also on the vessel, stated he couldn't climb without shoes. A wave hit OW 2 about 1809, tore his lifejacket off and swept him overboard. He swam toward the *Glen Harris*, and he was recovered from the water at 1815.

At 1835, the mate, still holding the activated SART, was rescued by the OSV *Cape Cod* about 7 miles southwest of the wreck.

The Station Grand Isle RB-Ms *CG-45674* and *CG-45687* were on scene about 1847. (See Figure 8 for a photo of an RB-M with the *SEACOR Power*.) The *CG-45674* coxswain described the seas as a "washing machine" and estimated 10- to 12-foot seas. Four people (OW 3, ABs 1 and 2, and the night cook) were still clinging to *SEACOR Power's* superstructure. Meanwhile, the *SEACOR Power* had rolled further to starboard, with the main deck at an angle of about 114° from upright. The swells were reflecting off the wreck, creating confused seas, which the *CG-45687* coxswain said made "any sort of approach nearly impossible." The RB-M crews found a large number of lifejackets and debris floating in the water.

Figure 8. *SEACOR Power* capsized on its starboard side on the evening of the casualty, with a Coast Guard RB-M in the foreground and the liftboat *Rockfish* in the background. (Source: Coast Guard)

The *CG-45687* coxswain attempted to approach the *SEACOR Power* as closely as possible. After about 20 minutes, AB 1 made his way into the water, without a lifejacket, and the crew of the *CG-45687* was able to pull him aboard at 1858. AB 1 had sustained multiple injuries, so the coxswain elected to transport him to shore about 1915. The *CG-45674* moved closer to the liftboat in case someone else fell or jumped. The three personnel remaining on the liftboat exterior had no lifejackets and no way to communicate with rescuers.

The helicopter *Bristow 739* arrived on scene at 1954, at dusk, and lowered a rescue specialist to the wreck. However, because of the orientation of the overturned vessel, the rescue specialist could not reach the three men, who were sheltering underneath handrails and the exhaust piping, without entangling the hoist cable. High winds further complicated the operation, and the helicopter, hovering 80 feet in the air, was hit with sea spray. The deployed specialist was raised back up to the helicopter cabin.

Bristow 739 lowered the rescue specialist a second time, with swimmer gear. The specialist, suspended just above the water, tried using hand signals to coax the personnel on board into the water to where he could safely retrieve them. However, they would not enter the water, and the effort was unsuccessful. The rescue specialist was recovered, and the helicopter crew then lowered lifejackets and a radio through the handrail to the remaining three men. The Coast Guard vessels were then able to communicate with the survivors. The Coast Guard crews continued to encourage the survivors to enter the water. At least one survivor stated he could not swim. *Bristow 739* eventually left the scene to refuel, while the RB-M *CG-45687* returned from Port Fourchon.

At 2119, the night cook fell overboard. The *CG-45674* located him in 2 minutes; he was unresponsive and wearing an inflated lifejacket. The boat crew was able to get the cook onto the RB-M; however, he was washed overboard in the heavy seas with the RB-M's engineer. While rescuing the engineer, the RB-M crew lost sight of the cook. The *CG-45674* searched until about 2213 when they were permitted to sail to Port Fourchon with their sick, fatigued, and wet crew.

On their second sortie, after refueling, *Bristow 739* searched for the night cook before returning to the vessel but could not find him.

The remaining two men (OW 3 and AB 2) sheltering on the liftboat's superstructure were able to communicate with the *Glen Harris* crew using the radio supplied by the Bristow helicopter. They had found relative shelter in the lee of the main deck access to the engine room. However, the wind became southerly over several hours and seas continued to build, exposing the two survivors to increasingly violent conditions. The *Glen Harris* crew observed the survivors open and enter the engine room access door about 2153 (see Figure 9).[8] The *Glen Harris* then lost radio contact with them.

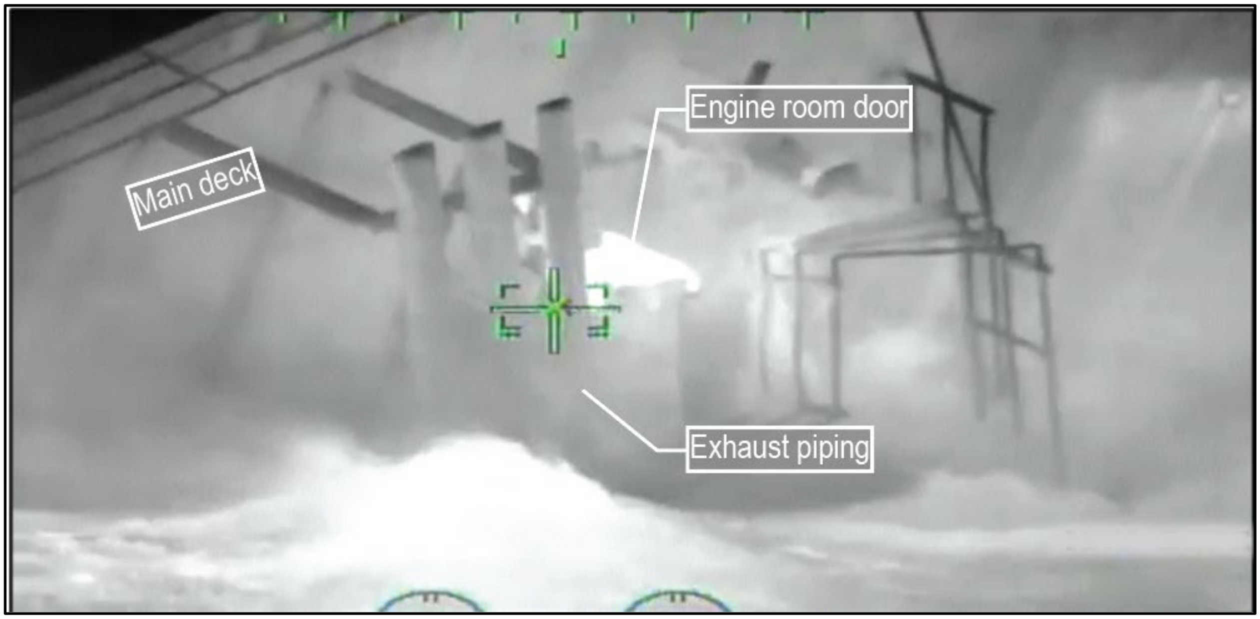

Figure 9. Door to engine room as it was opened at 2153, as seen by the *Glen Harris*. (Source: *Glen Harris*)

The cutter maintained station "a couple hundred yards" away, waiting for a Coast Guard helicopter to arrive. The *Glen Harris* had only a small shipyard crew and was not outfitted or prepared for extended operations. The Coast Guard helicopter, *CG-6506*, arrived on scene at 2315 and, having been on scene in heavy weather for 8 hours, the *Glen Harris* master decided to return to port.

As with the *Bristow 739*, the *CG-6506* crew could not rescue the survivors in the building seas, particularly given the wreck's entanglement hazards. The *CG-45687* stayed on scene until its crew was too fatigued to continue the mission, about 2315.

[8] With the vessel upright, this door would open to a landing with stairs leading down to the engine room. In its capsized position, the space became a vertical shaft with nothing to stand on, open to the engine room at the bottom, with the access door at the top.

1.2.4 Continued Search and Diving Operations

By the morning of April 14, additional Coast Guard resources were assigned to the *SEACOR Power* SAR efforts, including an Air Station Clearwater (Florida) C-130 fixed-wing aircraft, multiple ATC Mobile MH-60 helicopters, a patrol boat, and two patrol cutters. No survivors were found. Bristow Helicopters again deployed a helicopter to the scene and lowered a rescue specialist to the wreck; however, the engine room door, where the two remaining personnel had last been seen, was submerged by then.

The *SEACOR Brave*, a dynamic positioning-capable OSV, arrived at the site at 1115 on April 15 to support rescue and salvage diving operations.[9] The vessel had gotten underway at 1945 on the night of the capsizing, but had to be diverted due to high water conditions at a bridge along its initial route, which added over 100 miles to its transit.

At 1245, the vessel was ready for diving operations. The divers' initial actions were to tap on the hull of the vessel, listening for a response from any survivors within. They received no response. Diving operations ended at 1800 due to nightfall, and the *SEACOR Brave* returned to Port Fourchon. The *SEACOR Brave* and dive team returned to the wreck the next day, and over the following 6 days, divers searched the overturned vessel for survivors. Throughout the operation, divers were hampered by strong currents and poor weather conditions.

The Coast Guard cutter *Amberjack* recovered the body of the captain 0.7 miles south of the *SEACOR Power* on April 14, and a Coast Guard helicopter, *CG 6005*, discovered the body of the night cook 33 miles west of the vessel on April 15. Divers recovered the body of AB 2 from the engine room and the body of the day cook on the surface of the water near the wreck on April 16. On April 19, the engineer was recovered by divers from the 02 level. OW 7 was the last to be recovered, from the engine room, on April 20.

The Coast Guard searched for 6 days and suspended their active search on the evening of April 19. Coast Guard assets searched 9,293 square miles over 184 hours,

[9] Dynamic positioning is a vessel capability allowing it to automatically maintain position in a location using propulsion and maneuvering systems.

exceeding probability of survival calculations by 162 hours.[10] They were assisted by several other agencies including, among others, the US Customs and Border Protection, Louisiana Department of Wildlife and Fisheries, Lafourche Parish Marine Unit, and Terrebonne Water Patrol. Good Samaritans continued to search by boat, air, and shoreline for several weeks. Seven personnel were not found. See Table 3 for a complete list of survivors and fatalities by location, and Table 4 for injuries and fatalities.

[10] To estimate the likelihood of a person in the water surviving, the Coast Guard uses the Probability of Survival Decision Aid, a mathematical tool that uses inputs such as clothing, water temperature, weight, and time.

Table 3. Survivors and fatalities by location.

Status		Position	Egress after capsizing	Final location
Survived	No injuries	Mate	Overboard	Rescued 7 miles from vessel
		Well site supervisor	Overboard	Rescued 4 miles from vessel
	Minor injuries	OW 1	Portside exterior	Swept overboard and rescued
		OW 2	Portside exterior	Swept overboard and swam to RB-M
	Serious injuries	Night captain	Overboard	Rescued 4 miles from vessel
		AB 1	Portside exterior	Swam to RB-M from vessel
Deceased	Recovered	Captain	Swept overboard	Recovered 0.7 miles from vessel
		Engineer		Recovered by divers on 02 level
		AB 2	Portside exterior	Recovered by divers in engine room
		Night Cook	Portside exterior	Swept overboard Recovered 33 miles from vessel
		Day Cook	-	Recovered by divers on surface
		OW 7	-	Recovered by divers in engine room
	Missing, presumed dead	Chief engineer	-	-
		AB 3	-	-

		Galleyhand	-	-
		OW 3	Portside exterior	Last seen entering engine room to shelter
		OW 4	-	-
		OW 5	-	-
		OW 6	-	-

1.3 Injuries and Fatalities

Table 4. Injuries sustained in the *SEACOR Power* casualty.[11]

Type of Injury	Crew	Offshore workers	Total
Fatal	8	5	13
Serious	2	0	2
Minor	0	2	2
None	1	1	2
Total	11	8	19

[11] The NTSB uses the International Civil Aviation Organization injury criteria in all of its casualty reports, regardless of transportation mode. A serious injury is a non-fatal 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 percent of the body surface.

Three of the eleven crewmembers survived.[12] The night captain experienced injuries including a scalp laceration, bruises, and minor cuts. He was admitted to the hospital for 5 days to receive intravenous fluids and monitoring because of muscle tissue breakdown. The mate reported receiving a couple of scratches. AB 1 experienced blunt trauma injuries, laceration of his left abdominal wall, and multiple closed rib fractures. He was treated in the hospital and discharged after 3 days.

Five fatally injured crewmembers were recovered. With the exception of the night cook, their cause of death was drowning.[13] At the time of the release of this report, the bodies of three crewmembers (chief engineer, AB 3, and galleyhand) had not been recovered, so no additional medical information was available.

1.4 Damage

1.4.1 Salvage

The *SEACOR Power* came to rest on its starboard side post-capsizing, but the seas and currents continually acted on the vessel. The vessel later broke apart, either by wave action or during salvage operations. The forward portion of the hull, with part of the engine room, was recovered and brought ashore, along with the portions of the legs and pads, the liftboat's rescue boat, and some of the cargo. The remaining sections of the vessel, including the accommodations block, sank into the silt and could not be recovered.

1.4.2 Pollution

The *SEACOR Power* had about 28,827 gallons of diesel fuel, 5,566 gallons of hydraulic oil, and 187 gallons of waste oil aboard when it capsized, based on information entered in the vessel's HelmCONNECT reporting system. A 500-gallon diesel tote and 2,000 pounds of soda ash were on deck as well. Calculated trajectories did not indicate shoreline impact for even a worst-case discharge. Marine

[12] The vessel sailed with 19 persons. There were eight offshore workers onboard and off-duty. Of these, three survived, one was fatally injured, and four remain missing. Because the offshore workers were not involved in the operation of the vessel, the NTSB did not evaluate the offshore workers for medical conditions or drug and alcohol use.

[13] The Lafourche Parish Coroner's Office autopsy reported the cause of death of the night cook was unconsciousness due to probable hypothermia.

Safety Unit Houma liaised with the owners and/or operators of nearby pipelines in the area, neither of which reported loss of product.

1.5 Vessel Information

Table 5. Vessel Particulars.

Vessel	*SEACOR Power*
Type	Offshore (Liftboat)
Flag	United States
Port of registry	New Orleans, Louisiana
Year built	2002
Official number (US)	1115290
IMO number	8765682
Classification society	American Bureau of Shipping
Length	166.5 feet (50.7 m)
Beam	103.0 feet (31.4 m)
Draft (casualty)	9.3 feet (2.8 m)
Gross/Net tonnage	2,276 / 682 ITC
Engine power; manufacturer	4 x Caterpillar Diesel 3508B combined 3,840 hp (2,864 kW)
Persons on board	19

1.5.1 General

1.5.1.1 History

The liftboat *SEACOR Power* was built in 2002 for Superior Energy Services LLC by SEMCO LLC in Lafitte, Louisiana, and originally named the *Dixie Endeavor*. In 2012, it changed registered ownership to SEACOR LB Offshore and was renamed the

SEACOR Power. Registered ownership was transferred to Falcon Global Offshore II in 2018. The vessel was operated by SEACOR Marine LLC and, at the time of the capsizing, was chartered by Talos Energy LLC for an unspecified period of time beginning on February 20, 2021. SEACOR Marine provided the liftboat, its equipment, the vessel's crew, and the support for the vessel to remain compliant with all Coast Guard and American Bureau of Shipping (ABS) regulations and rules.

1.5.1.2 Construction and Arrangement

The hull of the *SEACOR Power* measured 167 feet long by 103 feet wide. The vessel was outfitted with two 185-ton cranes, accommodations for 50 people, and a helicopter landing pad extending out over the transom. The total length of the hull plus the helipad was 234 feet (see Figure 10).

The *SEACOR Power* had three cylindrical lifting legs that were constructed of steel, with two of the legs located on either side forward and the remaining leg located centerline aft. At construction, the legs were 250 feet tall, but they were extended to 265 feet when the vessel was acquired by SEACOR Marine in 2012. A 49-foot-long, 29-foot-wide, 5-foot-high pad was affixed to the base of each leg to distribute the weight of the vessel on the ocean floor when in the lifted position. During jacking up operations, the maximum rate of descent for the legs was about 5 feet per minute, according to the mate.

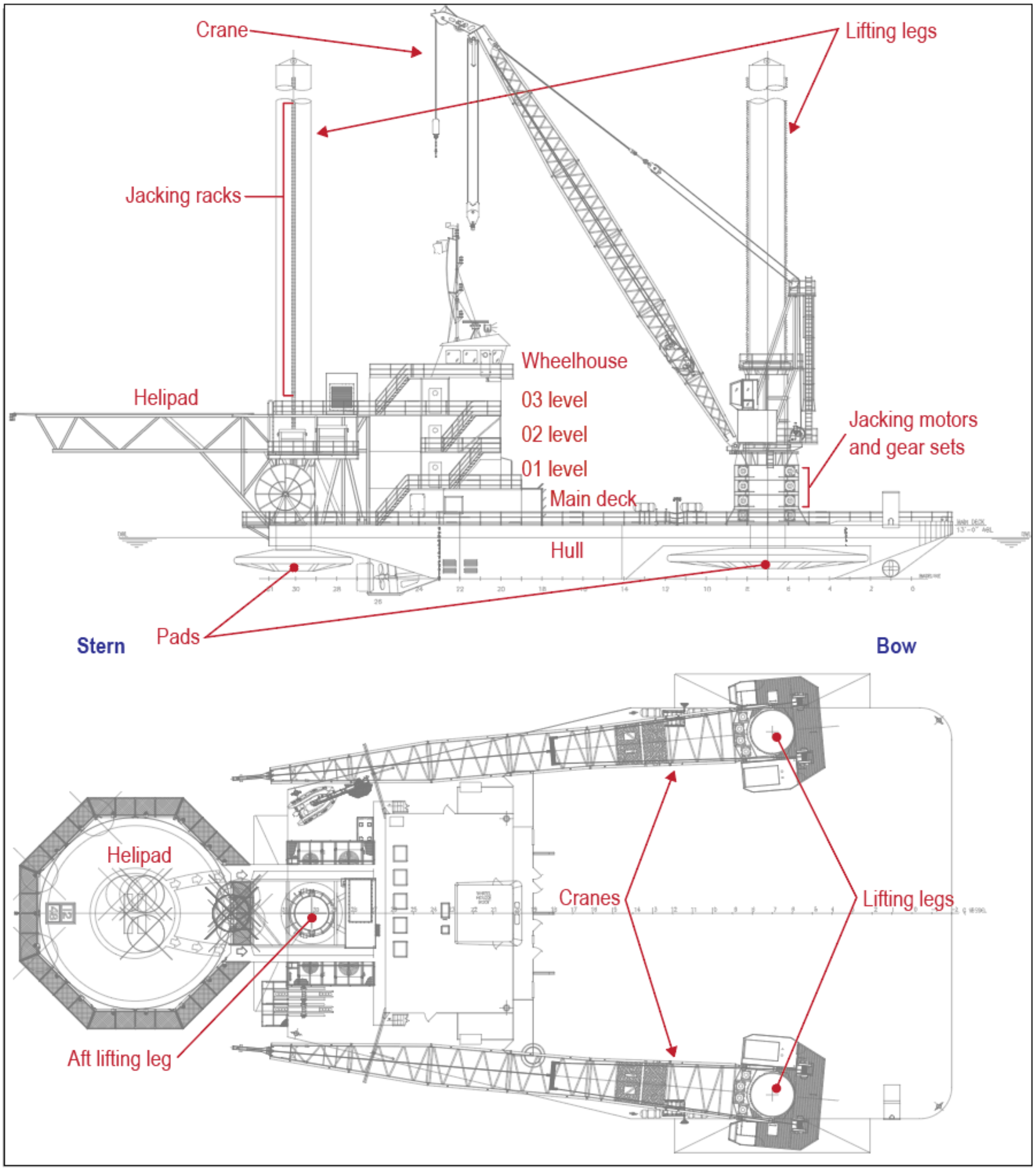

Figure 10. Profile (*upper*) and overhead (*lower*) views from the *SEACOR Power* general arrangements drawing.

The forward main deck of the vessel provided a large, open area for working and cargo stowage (see Figure 11). The deck in this area was coated with non-skid paint; investigators examined the deck on the vessel following salvage and noted no damage to the non-skid coating other than minor scrapes and gouges.

Figure 11. *SEACOR Power* main deck cargo/working area looking forward. (Source: SEACOR Marine)

The deckhouse, located aft on the vessel, included a galley and a dining area on the main deck. Access to the main deck exterior was via watertight doors (see Figure 12). The three levels above the main deck, numbered 01 to 03, comprised berthing and lounge spaces for crew and offshore workers. The wheelhouse was above the 03 level. All deckhouse levels and the wheelhouse were also accessible by external catwalks and stairways on the port and starboard sides of the vessel. Entrances to the deckhouse levels from the catwalks were via vestibules with external weathertight doors and internal non-weathertight doors.

Figure 12. Portside deckhouse and engine room accesses on similar vessel *SEACOR Legacy*.

The spaces within the hull of the *SEACOR Power* comprised port and starboard engine rooms with an equipment room in between, port and starboard steering gear rooms, fuel and potable water tanks, preload tanks (tanks filled with water during an initial vessel jack-up in a new location to test the seafloor condition), and various other tanks and voids (see Figure 13). The engineer's watch station was located in the equipment room.

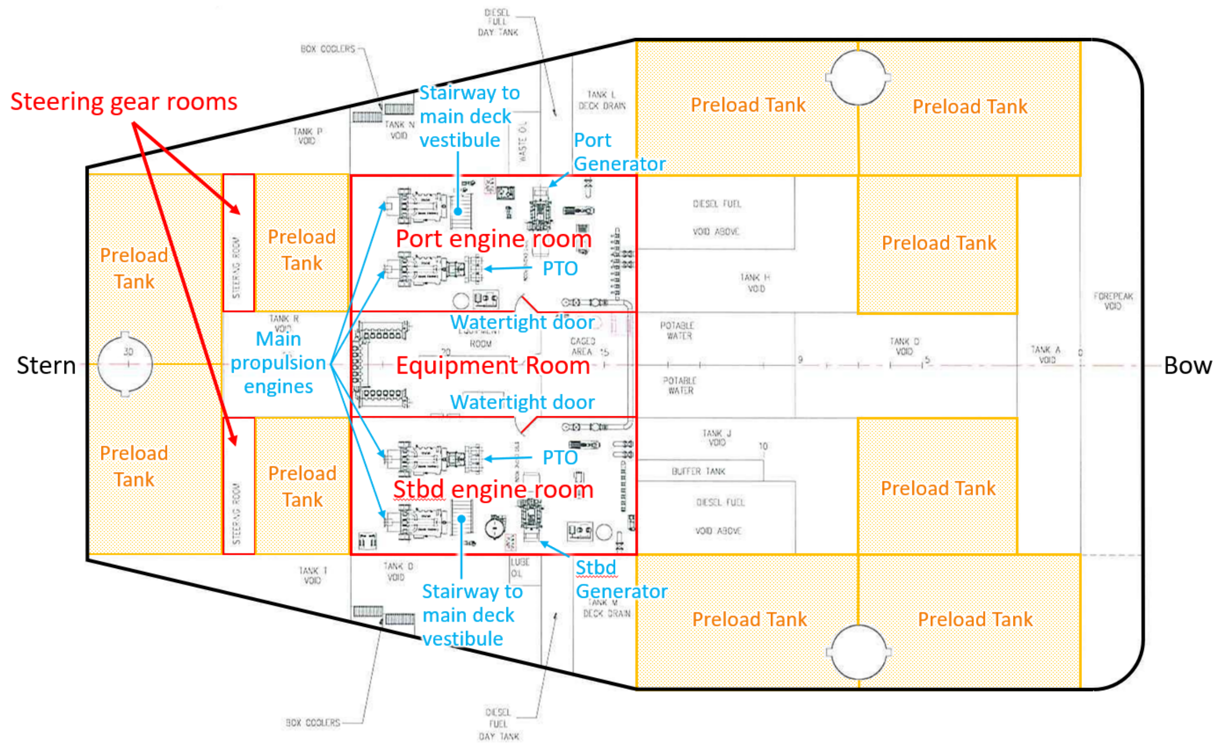

Figure 13. *SEACOR Power* hull compartments, tanks, and voids. (Background source: SEACOR Marine)

The engine rooms were accessed via companionways leading down from vestibules on the port and starboard side of the main deck. A watertight door on each of the engine room access vestibules opened to the exterior main deck (see Figure 12). Within the hull, watertight doors on the inboard side of the engine rooms allowed access to the centerline equipment room and the opposite engine room. There was no interior access to the engine rooms or equipment room from the deckhouse above.

1.5.2 Classification, Inspections, and Maintenance

1.5.2.1 Classification and Surveys

ABS, one of several nongovernmental classification societies that establish and maintain standards for the construction and operation of ships, classified the *SEACOR Power*. ABS reviewed plans and documentation before and during construction, and, throughout the build period, ABS surveyed the vessel and witnessed critical testing. Upon completion, ABS issued the *SEACOR Power* (then *Dixie Endeavor*) a certificate of classification as a liftboat. To maintain a valid certificate of classification, the

SEACOR Power was required to undergo annual surveys completed by ABS; special surveys at intervals of 5 years; drydocking surveys, held twice in a 5-year period; and surveys for damages or repairs, as needed.[14] Other surveys were also completed by ABS on behalf of the Coast Guard, including surveys verifying compliance with the International Load Line Certificate, the *International Convention for the Safety of Life at Sea* (*SOLAS*), and the *International Convention for the Prevention of Pollution from Ships*. For efficiency, several different surveys were often completed by the attending surveyors during the same visit to the vessel.

The *SEACOR Power*'s last set of surveys began on January 29, 2021. By the time the surveys were completed on February 11, 2021, ABS surveyors had documented ten findings relating to hull, machinery, safety construction, and safety equipment deficiencies, which the lead surveyor stated was about the average number for a vessel like the *SEACOR Power*. All findings were rectified, and the *SEACOR Power*'s certificate of classification was endorsed by the surveyor. The lead surveyor believed the liftboat was in satisfactory condition and "up to ABS rules and standards."

1.5.2.2 General Condition Survey

At the request of SEACOR Marine, an independent marine surveyor conducted a general condition survey of the *SEACOR Power* on February 17, 2021. The surveyor reviewed the vessel's documentation and walked each accessible space, noting the installed equipment and the condition of each area. The surveyor did not enter tanks and voids. The hull was observed from the main deck, from adjacent vessels, and from shore, and the survey report noted that the "hull plating contained no mentionable abrasions or indentations worthy of specific mention and appeared to be in very good condition." No measurements were made of the hull plate thickness. The report concluded that the *SEACOR Power* "appeared to be in good condition and well suited for its use. The vessel was well maintained with good housekeeping noted throughout." All hull and deck coatings were found to be in good order and well maintained with above average protection from the effects of saltwater service.

[14] A full listing of the required rules and surveys for a liftboat to remain in class can be found in *ABS Rules for Building and Classing Mobile Offshore Drilling Units 2001*, Part 5, "Surveys After Construction."

1.5.2.3 Regulatory Inspections

1.5.2.3.1 Certificate of Inspection

The *SEACOR Power* was registered as a US-flagged vessel and was inspected by the Coast Guard as an OSV per Title 46 *Code of Federal Regulations* (*CFR*) Subchapter L for each reissuance of a certificate of inspection (COI), which was valid for 5 years. The scope of the inspection was to ensure that the vessel was in a safe and seaworthy condition.

The *SEACOR Power* was inspected for reissuance of certification in March 2020. As part of the examination, Coast Guard marine inspectors checked lifesaving equipment, the bilge alarm system, and the watertight door alarms for the internal engine room doors. Testing of the bilge alarm system included energizing the bilge sensors so that the audible and visual alarms could be heard and seen on the bridge. Testing of the watertight door indication system included operating the hinged watertight doors in the engine room to verify that the doors' open/closed status was properly indicated (visually) on the panel on the bridge. One documentation deficiency was noted; it was corrected immediately. Following successful completion of the inspection, the vessel was issued a new COI dated March 18, 2020.

The COI listed manning requirements, permitted routes, and conditions of operations. The *SEACOR Power* COI directed that the "vessel is to proceed to a harbor of safe refuge or elevate at a location where it can survive one hundred (100) knots of wind when the twelve (12) hour weather forecast predicts sustained winds in excess of sixty (60) knots." The *SEACOR Power* COI stated that liftboat was required to be operated in accordance with its operating manual.

1.5.2.3.2 Annual Reinspections

Following issuance of a COI, the *SEACOR Power* was subject to annual reinspections by the Coast Guard. The *SEACOR Power*'s last annual inspection was conducted on February 11, 2021. Coast Guard inspectors noted three minor deficiencies, two of which were corrected during the inspection. The third deficiency was verified as corrected on February 17 (none of the deficiencies were related to the capsizing). During the inspection, Coast Guard officers observed a fire drill conducted by the crew. The inspectors noted that the "crew responded efficiently to the casualty and demonstrated excellent comm[unications]...."

1.5.2.3.3 Hull Inspections and Internal Structural Examinations

The *SEACOR Power* was also subject to drydock hull inspections and internal structural examinations twice in every 5-year period, not to exceed 3 years in between. The most recent hull and internal structural examinations for the *SEACOR Power* were conducted in tandem and commenced on February 10, 2020. The vessel was not in drydock but was jacked up, allowing Coast Guard inspectors to complete the inspection of the hull. No discrepancies were noted.

1.5.2.4 Maintenance and Repairs

Repair work was conducted any time the vessel was in port, based on the need and available time. The most recent major dockside repair period was in March 2021, during which a dent was repaired in the starboard hull plating. According to the technical superintendent, the repaired plating was surveyed by ABS following the repairs, and the repair passed leak-through and liquid penetrant tests. The superintendent stated that the gaskets on all watertight doors were checked and, as necessary, replaced.

The *SEACOR Power*'s most recent drydocking was March 2020. All of the vessel's shafts were pulled, inspected, and reinstalled. The legs and pads were checked for leaks, and non-destructive testing of the connections between the legs and pads was conducted. The testing revealed a small crack in the stern leg connection and two cracks in the port leg connection, which were repaired. According to the superintendent, there were no major modifications to the vessel during this drydocking or maintenance periods in the previous 5 years.

The off-rotation chief engineer stated that, during crew turnover on the morning of the casualty, he told the oncoming chief engineer that there were no problems with the *SEACOR Power*'s machinery or equipment, with the exception of an issue with the starboard crane motor that had been repaired while the vessel was in port. No electrical problems were reported by the off-rotation crew or the survivors. According to the mate, the vessel had no problems with machinery or equipment while underway before the capsizing.

1.6 Survival Factors

At least 9 of the 19 crew and offshore workers survived the initial capsizing. Of these, three (the mate, night captain, and well site supervisor), who were on higher levels before the incident (either the wheelhouse or the 03 level), were able to don lifejackets but were swept away by the seas soon after egressing the vessel. The remaining six made their way outside from the accommodations on lower decks (four of them did not have lifejackets). Of these six, three were later washed overboard and were successfully rescued by SAR units or a Good Samaritan vessel (two of the three had a lifejacket). The remaining three, who had lifejackets from the rescue helicopter, did not survive.

1.6.1 Means of Egress

Title 46 *CFR* Part 127 contains Coast Guard regulations regarding means of escape on US OSVs and discusses, among other things, minimum stair and door widths, ladder and stairway design, and a requirement for two egress points (excluding windows and portholes) from spaces accessible to offshore workers and "where crew may normally be employed." Spaces with an area of less than 28 square meters (302 square feet) and a maximum dimension of 6 meters (20 feet) are permitted one means of escape. Windows "must be capable of withstanding the maximum expected load from wind and waves." OSVs must also meet the construction and structural rules of the vessel's classification society.

Staterooms were located on levels 01 through 03, each measuring about 3.0 meters by 4.6 meters (10 feet by 15 feet) or 13.8 square meters (150 square feet). Each level had an athwartship passageway with the doors to the external catwalks on each end and with staterooms on either side overlooking either the stern or foredeck.

The engine rooms had two access routes, port and starboard. Stairs leading down were accessed via watertight doors on the main deck to each engine room. The equipment room, where the engineer stood watch, was between the engine rooms, separated by watertight doors. The engineer on watch would normally stay in the equipment room with the exterior and interior watertight doors closed.

1.6.2 Lifesaving Equipment

1.6.2.1 General

Title 46 *CFR* Part 133 specified minimum lifesaving equipment, some of which were also specified on the vessel's COI. *SOLAS* Chapter III contained additional lifesaving requirements for vessels of this size on this route. The Coast Guard's CG-543 Policy Letter 7-02, *Guidance on the Inspection, Maintenance, and Repair of Liftboats*, also covered liftboat-specific issues such as rescue boat requirements. The mate reported that there were no problems with safety equipment on the *SEACOR Power*.

1.6.2.2 Lifejackets

The *SEACOR Power* was certified for 50 people and could carry an additional 12 offshore workers when elevated on location. The COI required 66 adult lifejackets, including two additional lifejackets in both the engine room and wheelhouse. Type I (offshore) horsecollar-style lifejackets were stowed in every cabin and in two "big orange boxes" at the muster stations on the main deck so that personnel outside would not have to return inside in an emergency.

According to the off-rotation chief engineer, lifejackets were also stowed in the equipment room and at the top of the stairs in each engine room access vestibule. The well site supervisor stated he handed both of the vessel's lifejackets in his room to the night captain and donned his own personal Type I lifejacket before abandoning the vessel. He added that it was a good practice for contractors to have their own lifejackets.

The Bristow helicopter crew lowered aviation lifejackets—which are not designed for open or rough waters—to the personnel sheltering on the vessel.

1.6.2.3 Liferafts and Rescue Boat

Title 33 *CFR* Part 133 required, with some exceptions, enough liferafts to accommodate all persons on board on each side of an OSV longer than 279 feet. The *SEACOR Power* was outfitted with six 25-person liferafts, three on each side, with lines at each muster station to assist crew in descending to deployed liferafts. All three starboard-side liferafts deployed; all three portside liferafts stayed in their cradles above the water the first night.

The *SEACOR Power*'s rescue boat was cradled on the main deck aft on the port side. After the capsizing, OW 1 recalled seeing the boat overturned and adrift while he was hanging onto the vessel's handrails. The crew boat *Miss Allie* also reported seeing the rescue boat to the Coast Guard. It was later recovered at Isles Dernieres, Louisiana, 44 miles west of the wreck.

1.6.2.4 Other Lifesaving

Flares, handheld GMDSS VHF radios, and batteries were stowed in a ditch bag under a cabinet behind the chart table on the *SEACOR Power* bridge. The line-throwing apparatus was stowed under the console on the starboard side of the bridge.

1.6.3 Global Maritime Distress and Safety System

GMDSS is a suite of communications equipment used for sending and receiving distress alerts and maritime safety information (MSI), as well as for general communications. The type of GMDSS equipment that a vessel is required to carry is governed by *SOLAS* Chapter IV and is based on the areas in which a vessel is intended to operate. The *SEACOR Power*'s GMDSS comprised three VHF radios for short range/line of sight communications, an MF/HF radio set for medium- to long-range communications, a narrow band direct printing telex terminal, an Inmarsat-C satellite communications terminal, a nagivational telex (NAVTEX) receiver, two SARTs, and an EPIRB. The system was last surveyed and tested on February 3, 2021, and the vessel had a valid Federal Communications Commission (FCC) cargo ship safety radio certificate.

1.6.3.1 Inmarsat-C

Inmarsat-C can transmit and receive distress messages; receive MSI, including weather information and navigational warnings; and facilitate other data communications functions such as email. The mate stated that he depressed the unit's distress call transmit button for over 4 seconds immediately following the capsizing.

1.6.3.2 Navigational Telex

NAVTEX is a system for receiving urgent MSI data, including weather and navigational warnings, broadcast from coast stations. NAVTEX has a range of about 200 miles. Shipboard NAVTEX receivers automatically receive and print out NAVTEX transmissions. The *SEACOR Power*'s NAVTEX receiver was mounted on the portside of the forward console in the wheelhouse, visible to the operator at the helm. The information received via the system was displayed on a digital screen and printed out on an integrated printer. According to the mate, the *SEACOR Power*'s NAVTEX system was fully operational, but no information was received on the vessel's NAVTEX while the vessel was underway before the capsizing. See section 1.8.4.2, Navigational Telex, for more information about the broadcasting system.

1.6.3.3 Search and Rescue Transponders

SARTs are waterproof transponders for emergency use at sea. When the SART is in range of a vessel or aircraft with a 9-GHz (3-cm, X-band) surface search radar, the SART will transmit a reply signal displayed on the radar screen. The FCC's GMDSS regulations include a requirement for vessels over 500 gross tons to carry two SARTs, typically stowed for easy access inside on either side of the bridge.[15]

The SART device has a light that indicates to a survivor when it has been interrogated by a passing vessel. SARTs are also equipped with an audible indication of interrogation. Survivors, knowing there is a vessel or aircraft nearby, can then use radios or visual distress signals (flares and smoke) to request assistance. The range of the SART signal is dependent on the antenna height and line of sight. Surface ships may detect a SART at 6 to 12 miles. According to the International Maritime Organization (IMO), SARTs work best when at least 1 meter (3.3 feet) above the water (1995). As such, they are typically mounted on a pole for use in a liferaft or lifeboat or hung overhead by a lanyard. In 2007, the IMO approved the use of Automatic Identification System Search and Rescue Transmitters (AIS-SART), which transmits an AIS signal (instead of radar) visible on a vessel's AIS receiver and also on a radar and/or electronic chart display and information system (ECDIS). Coast Guard boats and fixed wing aircraft can detect AIS-SARTs, and in tests, these SARTs have been detected by Coast Guard aircraft at 50 miles.

The *SEACOR Power*'s SARTs were replaced in April 2021. The new model had a telescoping pole sold separately; crewmembers stated there were no poles stowed with the SARTs on the vessel for either the new or old models. The receipt for the purchase did not include the poles. Although the mate stated the indicator light on the SART was illuminated, none of the Coast Guard personnel or Good Samaritans on scene before the mate's rescue saw a SART signal on their radars.

[15] 47 *CFR* Part 80.

The NTSB examined the *SEACOR Power*'s SART used by the mate when he abandoned the vessel (see Figure 14). The unit was in good condition and showed evidence that it had been activated as the mate had stated. During initial postcasualty on-water testing conducted by the NTSB with the assistance of a Coast Guard response boat-small and a municipal fire boat, vessel operators did not observe the SART signal on their search radars. However, follow-on manufacturer's testing found the unit functioned properly in the laboratory and on the water. The manufacturer noted in its report that the interrogating vessel's radar settings can affect the ability to detect SART devices, and that improper settings may make detection more difficult or impossible. The manufacturer's report also noted that if the device was held by its antenna (which is the narrow part of the device and could be mistaken for a grip), the signal could be attenuated.

Figure 14. *SEACOR Power* SART following the casualty.

The NTSB tested the unit again on the water with Coast Guard boats, using updated test procedures addressing radar gain, clutter, and range settings. With some familiarization for the Coast Guard boat crews, they were able to observe the SART signal on radar. Testing of the SART with a Coast Guard HH-65 helicopter was also successful after training was conducted with the air crews.

1.6.3.4 Emergency Position Indicating Radio Beacon

The COSPAS-SARSAT system is an international distress alerting program that includes satellites and land earth stations monitoring EPIRBs and personal 406-MHz beacons (see Figure 15).[16] EPIRBs transmit a 406-MHz signal to a passing satellite when turned on manually or after floating free in the water. The distress signal includes the beacon's unique code registered to the vessel and, on newer models, a

[16] SARSAT is an acronym for Search And Rescue Satellite Aided Tracking. COSPAS is an acronym for the Russian translation.

Global Navigation Satellite System (GNSS) position.[17] In the United States, the National Oceanic and Atmospheric Administration (NOAA) receives the satellite signal and relays the information to the appropriate Coast Guard RCC.

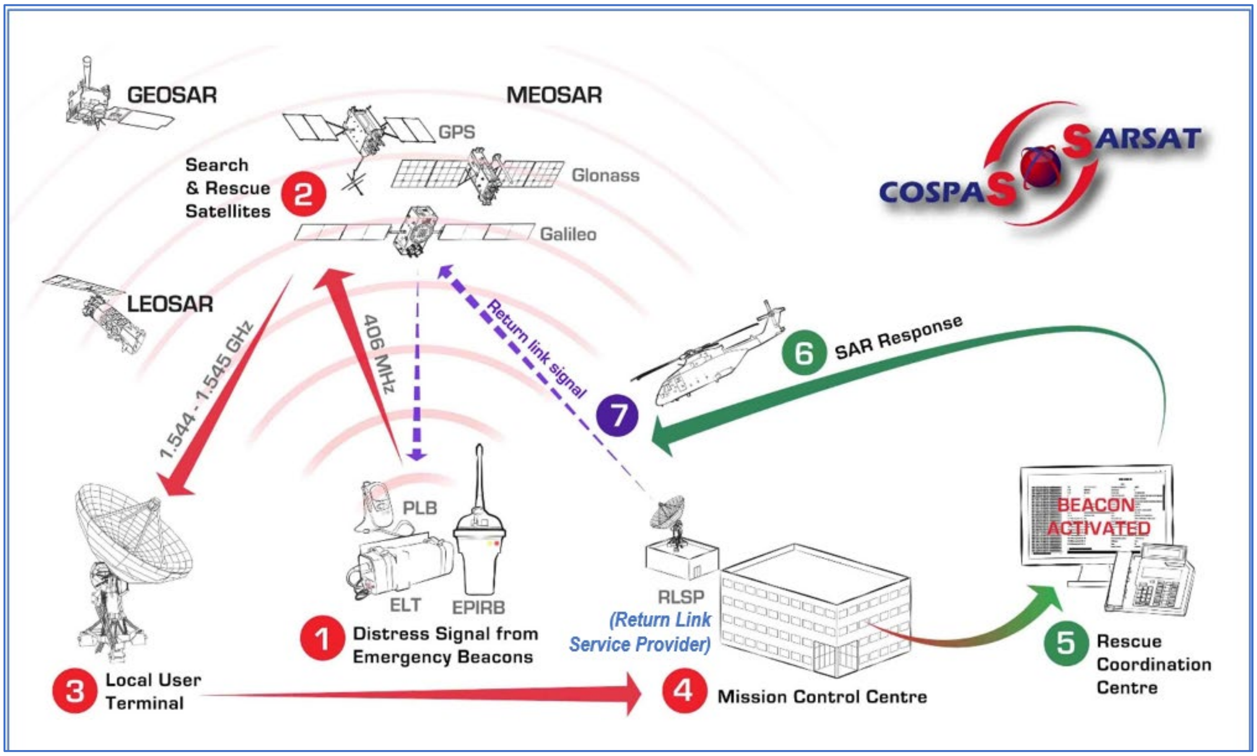

Figure 15. Overview of the COSPAS-SARSAT system, annotated by NTSB in blue. (Source: COSPAS-SARSAT)

The regulations in 46 *CFR* Part 133 required OSVs be equipped with float-free, self-activating EPIRBs that meet FCC regulations. In 2016, the FCC incorporated by reference the updated Radio Technical Commission for Maritime Services standard that requires, among other things, specific vessels (including vessels like the *SEACOR Power*) to carry GNSS-equipped EPIRBs as of January 17, 2023.[18] Similar requirements by the IMO were approved in 2019. The *SEACOR Power*'s ACR RLB-27 EPIRB, mounted outside on the port side of the wheelhouse, was not

[17] The Global Navigation Satellite System (GNSS) enables worldwide navigation positioning. GPS is the US component of the GNSS.

[18] See 47 *CFR* Part 80.1061(a).

GNSS-equipped, nor was the *SEACOR Power* required at the time of the casualty to carry a GNSS-equipped EPIRB.

Geostationary satellites equipped with SAR equipment are called GEOSAR satellites. Because geostationary satellites stay in the same position relative to the Earth's surface, they can continuously monitor a large area and may be the first to receive an EPIRB alert. However, because they are geostationary, they cannot calculate the position of the EPIRB beacon and can only transmit GNSS data if the beacon itself is GNSS-equipped. A GEOSAR satellite received the first alert from the *SEACOR Power* EPRIB at 1540. The alert was relayed to the District 8 RCC at 1542. It included registration information with description and contact information, but not a position.[19]

Some medium Earth orbit (MEOSAR) satellites have been programmed to listen for EPIRB alerts and to relay the data. MEOSAR alerts are always considered distress until downgraded. The system calculates positions using at least three satellites. At 1541, a minute after the initial GEOSAR alert, the first coordinates of the *SEACOR Power*'s EPIRB were calculated from alerts received by MEOSAR satellites, with a position 0.3 miles south-southeast of the liftboat's last AIS position. Five more MEOSAR alerts were received over the next hour, all within a 5-mile radius, with the exception of one outlier 15 miles to the east.

The RCC command duty officer told investigators that EPIRB alerts do not involve actual distress "an overwhelming majority of the time." According to NOAA, 98% of all 406-MHz emergency locator transmitter, EPIRB, and personal locator beacon (PLB) activations are false alarms. Because a high number of EPIRB alerts are false alarms due to weather or improperly disposed-of beacons, the RCC first contacts the point of contact on the EPIRB registration. Management of the SARSAT program, but not all its functions, will shift to the Coast Guard from NOAA in by 2025.

The RCC received several other EPIRB alerts the day of the capsizing, many of which were false alarms. At 1431, the RCC received an EPIRB alert from the OSV *Deep Stim*; the RCC reached the operator at 1444. The operator checked with the vessel and then confirmed with the RCC that the vessel was at the dock. In the case of the fishing vessel *Ocean Inspector,* the RCC reached the owner, who told the RCC the

[19] Mission Control Centers collect distress signals from satellites via land-based Local User Terminals, process them, and forward to the appropriate RCC.

vessel was underway and then had the vessel's master call the RCC himself and confirm he was not in danger.

RCC watchstanders learned the *SEACOR Power* EPIRB alert was, in fact, not false when SEACOR Marine management called them at 1702, 1 hour and 20 minutes after they had received the first EPIRB alert from the vessel, and 24 minutes after the Sector had received the *Rockfish* distress call.

1.6.4 Personal Locator Beacons

PLBs are personal electronic devices that are used during emergencies. Although they are not part of the GMDSS, they operate like EPIRBs, transmitting to the SARSAT system on 406 MHz. Unlike EPIRBs, PLBs must be manually activated. PLBs are registered to the owners, and contact information is available to SAR controllers. Satellite emergency notification devices (SENDs) are a commercial version of a PLB and function much the same using a commercial satellite subscription. Some SEND models include two-way texting. Newer models of PLBs and SENDs derive and transmit their own position in an emergency. According to the Coast Guard, PLBs and SENDs are becoming more commonly used amongst mariners.

None of the survivors of the *SEACOR Power* capsizing had PLBs or SENDs, nor did they know of anyone else on board who did.

1.7 Waterway Information

The *SEACOR Power*'s final position was 29°0.39′ N, 090°11.85′ W in the open waters of the Gulf of Mexico, about 7 miles from Port Fourchon, Louisiana. At that location, the water depth was about 50 feet. The area around the capsizing site is well travelled by OSVs and fishing vessels.

1.8 Environmental Information

1.8.1 Meteorological Conditions Summary

The mate on the vessel's bridge during the capsizing told investigators that they experienced two "squalls" and a maximum wind gust of 79 mph (69 knots). Vessels in the area reported heavy rain, winds exceeding 80 knots, and building seas at the time of the casualty. SAR efforts were hampered by 30- to 40-knot winds and 10- to 12-foot seas that persisted throughout the evening and into the next day.

The National Weather Service (NWS) conducted an independent analysis of the meteorological conditions at the time of the casualty and in the hours following. The resulting report noted that a "line of severe thunderstorms producing very strong winds" moved through the area at the capsizing time in what would be considered a mesoscale convective system (MCS)—a complex of thunderstorms organized on a scale larger than an individual thunderstorm and normally persisting for several hours or more. The NWS used wind observations and other data to estimate the maximum wind speed in the area (see Table 6). The report concluded that the casualty area was affected by an "unusually intense thunderstorm wind event for the region."

Table 6. Estimated maximum wind speed in knots by height and duration. (Source: National Weather Service Warning Decision Training Division)

	Height	5-second	10-second	30-second	60-second
Upper Bound	31.81 ft (10 m)	80	77	74	71
	150 ft (45.72 m)	89	86	83	80
	300 ft (91.44 m)	95	89	89	86

1.8.2Weather Radar

1.8.2.1 Radar Data

The NTSB obtained weather radar data from the NOAA National Centers for Environmental Information. There were two weather radars in the area: a WSR-88D weather radar in Slidell, Louisiana (KLIX), and a Terminal Doppler Weather Radar (TDWR) about 15 miles west of New Orleans (TMSY) (see Figure 16).

Figure 16. Map of approximate radar locations relative to capsizing site, indicated by a red *X*. (Background source: Google Earth)

KLIX was about 82 miles north-northeast of the capsizing site at an elevation about 80 feet above mean sea level (msl). At this distance, the 0.525° upward tilt of the KLIX radar would have "seen" altitudes above the capsizing location about 5,100 to 13,300 feet above msl (see Figure 17).[20]

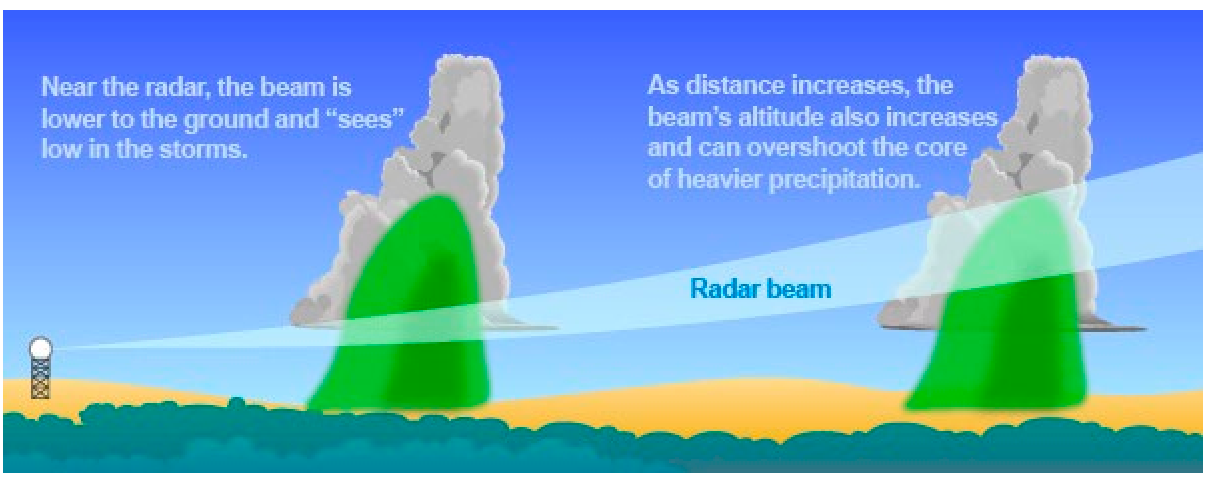

Figure 17. At increasing distance, the radar is viewing higher and higher in storms, and the beam may overshoot the most intense parts. (Source: NWS)

[20] KLIX is already approved for a lower beam angle (implementation tentatively scheduled for summer 2023) following its relocation to Hammond, Louisiana.

TMSY was about 62 miles north of the capsizing site at an elevation about 100 feet above msl. At this distance, TMSY would have “seen” altitudes above the capsizing location about 2,600 to 6,200 feet above msl. Additionally, because the TDWR wind velocity signal is only processed out to 48 miles from the radar site, the TDWR did not capture velocity information above the capsizing site.

Figure 18 presents KLIX weather radar reflectivity imagery 1) about one hour before the casualty (about 1441), 2) 30 minutes before the casualty (about 1511), 3) as light reflectivity associated with the leading edge of the MCS initially moved over the vessel (about 1532), and 4) about the time of the casualty.

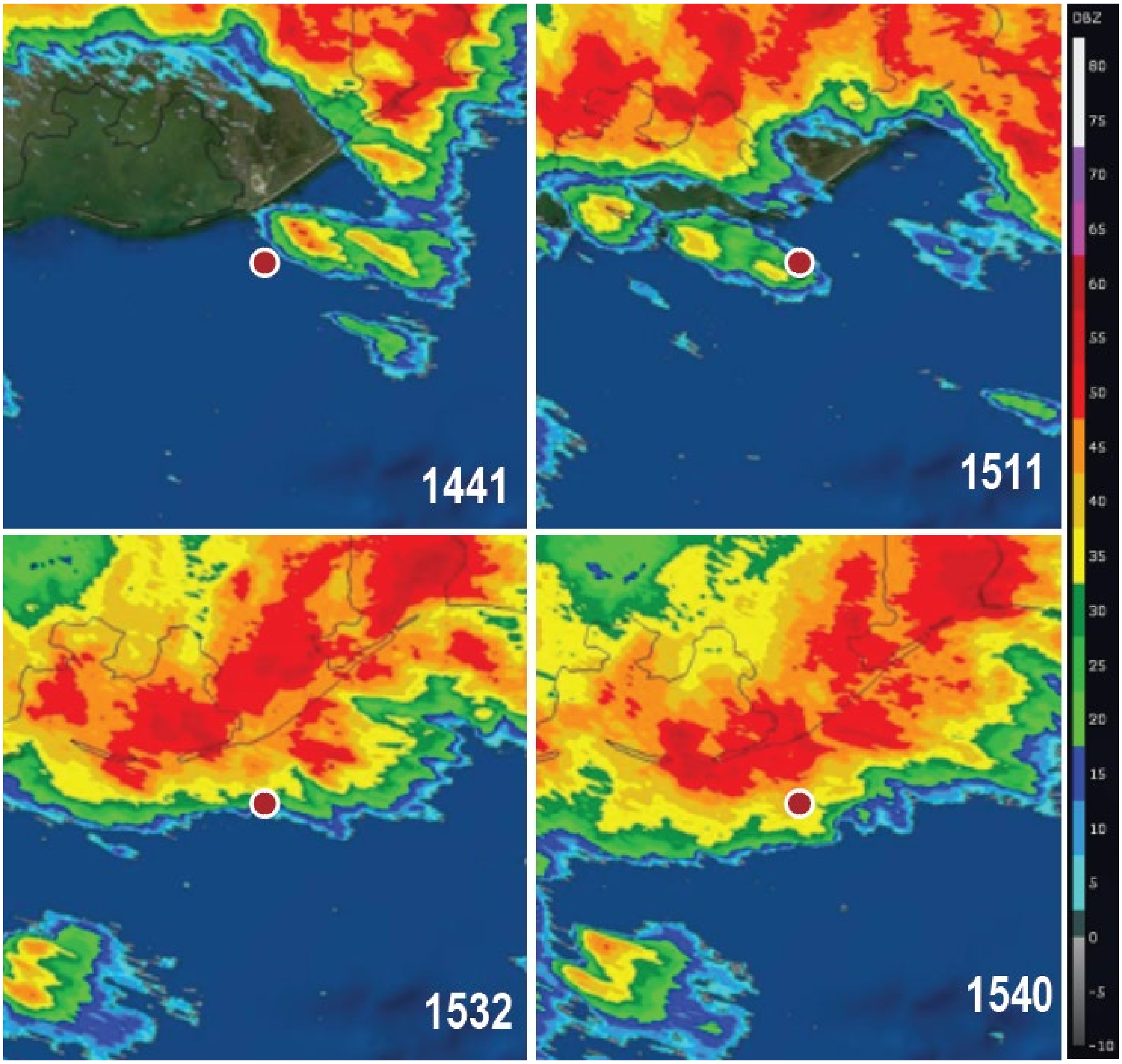

Figure 18. KLIX Level-II 0.525° base reflectivity images from sweeps initiated about 1441, 1511, 1532, and 1540. Casualty site is denoted by the red circle. The colors represent the strength of returned energy to the radar expressed in values of decibels (dBZ). The color scale is located to the right. Generally, as dBZ values increase so does the intensity of precipitation. (Source: NWS)

Doppler weather radars calculate wind speeds by measuring the movement of precipitation in the air. Figure 19 presents KLIX weather radar velocity imagery for times similar to those presented in Figure 18. The velocity imagery specifically depicts *radial* velocities, which provide the magnitude of an object's speed in the direction either directly toward the radar (negative values; more green/blue colors) or directly away from the radar (positive values; more red/yellow colors). As with the reflectivity data, KLIX's location and angle meant that the data "seen" at the capsizing location was about 5,100 to 13,300 feet above msl.

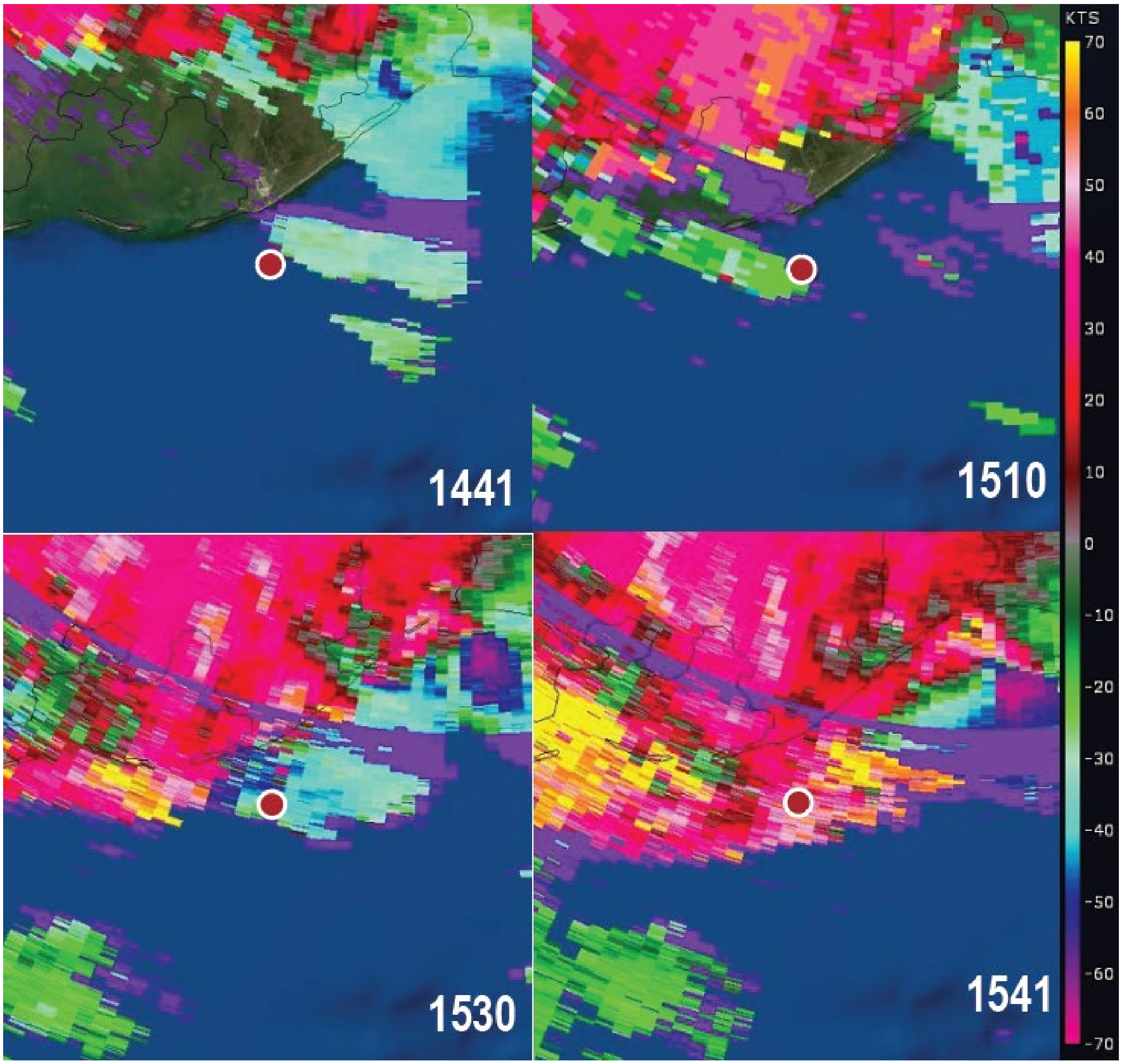

Figure 19. KLIX Level-II 0.525° base velocity images from sweeps initiated about 1441, 1510, 1530, and 1541. Casualty site is denoted by the red circle. The colors represent the calculated wind speed, in knots. (Source: NWS)

1.8.3 Surface Observations

To better understand the conditions resulting from the MCS, the NTSB retrieved weather observations from both land- and sea-based sources operational in the casualty area around the time of the capsizing (see Figure 20). Table 7 summarizes the observations from these sources.

Figure 20. Map of surface weather sources presented in this report (times indicate the position of that source at the specified time). Casualty site is denoted by the red circle.

Table 7. Summary of surface weather observations as reported.

Type	Observation Station	Distance from *SEACOR Power*	Sustained Winds (kts)	Gusts (kts)	Seas (ft)	Observations
Vessel	***Rockfish*** Liftboat	1.1 miles NE		83	10-12	Captain noted wind went from 25 to 95 mph (22 to 83 knots) "within a couple minutes," and that he had "never experienced anything like this before" in 44 years' work.
	Vanessa[1] Liftboat	4.5 miles WNW	78-87	98	12-15	Captain noted conditions "decreased dramatically and almost without warning" and that it was "one of the worst weather conditions" he'd seen.
	Glen Harris Cutter	5 miles N	43	70	-	Lieutenant noted "the weather system had come on top of us pretty quickly." And "it definitely engulfed us."
	Christian Chouest[2] OSV	5 miles W	55+	71	-	-
	Sevan Louisiana[3] Drill rig	7 miles SSE		82		Mate noted "significant winds above 50 knots and gusts above 80 knots."
	Deepwater Asgard[4] Drill ship	8 miles S		80	-	-
	Discoverer Inspiration[5] Drill ship	9 miles SSE		72	-	-
Fixed station	**LOOP**[6] Oil distribution platform	11 miles SE	23-76	27-94	-	-
	WAVCIS[7]	17 miles	47.8	62	-	-

Weather Obs Station	SW				
NOAA GISL1[8] Weather Obs Station	20 miles NE	7.8-50.1	28-65.5	-	-

[1] The *Vanessa* had one anemometer at 60 feet high.

[2] The *Christian Chouest* had three anemometers at 70-80 feet high.

[3] The *Sevan Louisiana* had four anemometers: two at 197 feet and two at 360 feet high.

[4] The *Deepwater Asgard* had three anemometers: two at 404 feet and one at 211 feet high.

[5] The *Discoverer Inspiration* had four anemometers, one at 88 feet, one at 256 feet, and two at 152 feet high.

[6] The Louisiana Offshore Oil Port (LOOP) had two anemometers, one at 133 feet and one at 190 feet high.

[7] The Louisiana State University Wave-Current-Surge Information System (WAVCIS) had one anemometer at 66 feet high.

[8] NOAA National Ocean Service Station Grand Isle (NOAA GISL1) had an anemometer at 30 feet.

1.8.4 Meteorological Communications

1.8.4.1 National Weather Service

1.8.4.1.1 Severe Thunderstorm Watch

A watch is issued when there is the potential for severe weather, but its occurrence, location, or timing is still uncertain. The NWS Storm Prediction Center issues Severe Thunderstorm Watches when severe thunderstorms are possible; the watch normally covers a broad area that can span several counties or states. Watches are usually in effect from 4 to 8 hours and are normally issued in advance of the actual thunderstorm activity.

At 1205, about 3.5 hours before the *SEACOR Power* capsized, the NWS Storm Prediction Center issued a Severe Thunderstorm Watch that was active for 16 parishes (counties) and associated coastal waters in southeastern Louisiana, including the waters around Port Fourchon. When issued, the watch was effective for 6 hours. The watch notification listed the primary threats as the possibility of "scattered damaging wind gusts to 70 mph [61 knots]" and large hail.

1.8.4.1.2 Special Marine Warning

A warning is issued when hazardous weather is occurring or imminent. Warnings generally cover smaller areas as compared to a watch and are limited in duration. According to the NWS, "a warning means weather conditions pose a threat to life or property. People in the path of the storm need to take protective action." The NWS issues Special Marine Warnings (SMWs) for severe thunderstorms affecting coastal waters. (Severe Thunderstorm Warnings are issued for thunderstorms affecting land areas.) SMWs are broadcast when the storms are predicted to produce winds of 34 knots or greater, hail 0.75 inches or more in diameter, or a waterspout. The warnings are issued for no more than 2 hours' duration, although they can be extended if conditions persist. The warning text lists the general area or areas that will be affected by the thunderstorms, as well as latitude and longitude points that define a specific area in which the activity is expected. SMWs are issued by NWS Weather Forecast Offices (WFOs); the Slidell WFO was responsible for products covering the casualty area.

On the casualty day, beginning at 0918, the Slidell WFO transmitted multiple warnings and statements relating to convective activity in southeastern Louisiana. However, most of these warnings and statements were focused on land areas north of Port Fourchon. Before the casualty, the NWS Slidell WFO issued one SMW active for an area that included the casualty vessel's route on the casualty voyage, as well as the casualty location. The warning, which was issued at 1457, advised of "wind gusts 34 knots or greater."[21]

1.8.4.1.3 NOAA Weather Radio

NWS WFO products are disseminated through "NOAA Weather Radio All Hazards" (NWR), a "nationwide network of radio stations broadcasting continuous weather information directly from the nearest NWS office." NWR is broadcast over VHF public service bands.

The *SEACOR Power* was equipped with three VHF radios capable of picking up the NWR signal (see section 1.6.3 Global Maritime Distress and Safety System). However, the radios would have to be tuned to the weather radio channels to receive

[21] WFO Slidell issued two other SMWs before the accident, at 1208 and 1427. However, the locations for these earlier warnings (as defined by the latitude and longitude points included in the warning notices) were in Barataria Bay, Louisiana, which was not along the route of the *SEACOR Power*.

the broadcast. Typically, shipboard radios are tuned to marine communications channels, such as channel 16 (“distress, safety, and calling” channel), and there is no requirement to monitor NWR broadcasts. According to the mate, there was no radio on board the casualty vessel that was dedicated to monitoring weather radio channels.

At the request of the NTSB, SEACOR Marine conducted a test of NWR reception on board its vessel *SEACOR Chief* on November 30 and December 1, 2021. During this test, the *SEACOR Chief* crew monitored channel WX3 (162.475 MHz) on its VHF radio in Port Fourchon, just outside the port, at the capsizing site, and about 22 miles southwest of the capsizing site. They were able to receive the NWR broadcast in all the locations.

1.8.4.2 Navigational Telex

The IMO has designated NAVTEX as the principal method for transmitting MSI, such as navigational and meteorological warnings and forecasts, to ships in coastal waters (1991). NAVTEX broadcasting stations in the United States are operated by the Coast Guard. In the case of an urgent weather situation, the NWS sends products for NAVTEX broadcast to the Coast Guard through the US Navy’s Fleet Weather Center.

The Coast Guard’s New Orleans NAVTEX site broadcasts weather products daily at 0000 CDT, 0800 CDT, 1200 CDT and 2000 CDT; SMWs are broadcast immediately upon receipt and are rebroadcast during the next scheduled broadcast window. However, on April 13, the day of the casualty, the New Orleans NAVTEX broadcast site logged “an equipment malfunction that precluded the 1700Z/2100Z [1200 CDT/1600 CDT] broadcasts from being sent out.” The SMWs issued by WFO Slidell between these hours were also not transmitted. According to the mate, no information was received on the vessel’s NAVTEX while underway before the capsizing.

1.8.4.3 Buoyweather

The weather report emailed to the *SEACOR Power* on the morning of the casualty had been sent to all SEACOR Marine vessels working in the region and comprised information copied and pasted from a commercial provider’s (Buoyweather’s) website. A weather report was sent daily by SEACOR Marine’s shoreside employee, and the forecasted winds, waves, and general conditions were based on a standard location (selected by the SEACOR Marine employee), which was about 17 miles southeast of Port Fourchon (12 miles southeast of the capsizing location) in the Gulf of Mexico. The SEACOR Marine employee stated that once the report was emailed to vessels each morning, he did not monitor the weather further. He said that he did not receive alerts or notifications from Buoyweather if the forecast changed or severe weather was forecasted.

1.9 Operations

1.9.1 SEACOR Marine

SEACOR Marine Holdings Inc. is a publicly traded company headquartered in Houston, Texas. The company was incorporated in 2014 as a subsidiary of SEACOR Holdings Inc. but became an independent entity in 2017. SEACOR Marine operates a fleet of OSVs, including liftboats, in the offshore energy industry.

Beginning in 2014, decreases in the prices of oil and natural gas resulted in a reduction in exploration and drilling and, in turn, negatively impacted SEACOR Marine's fleet utilization. In 2021, the company's vessel utilization rate was 66%. SEACOR Marine's general manager for the Gulf of Mexico stated that, despite the downturn, the company remained stable and company management had not been pressured by shareholders to cut costs or reduce maintenance funding for active vessels. The general manager said that, although the size of the shore-based staff had shrunk due to the reduced fleet, manning for active vessels had remained at a level capable of maintaining and operating the company's vessels.

1.9.2 Operational Demands

SEACOR Marine had proposed the timeline for the *SEACOR Power*'s precasualty port visit in Port Fourchon and departure for the next Talos assignment based on the arrival time at the port, which had been delayed when the vessel jacked up to ride out a storm, and the progress of the crane maintenance and inspections. Talos agreed to the schedule as proposed, and SEACOR Marine kept the charterer advised as the port visit progressed. According to the Talos logistics manager, there was no deadline for getting out to the next work site. The NTSB reviewed the contract between the companies and found no penalties for delays.

During postcasualty interviews, the mate, the off-rotation captain, and chief engineer all reported that they never felt pressured to perform an operation nor had they heard of any SEACOR Marine captains being pressured to conduct operations. The spouse of the casualty-voyage captain stated that her husband often felt pressure to "hurry up and get it done," but he did not tell her of any specific safety concerns.

The mate stated that the captain was "never afraid to say no. I've seen him do it before when it's not safe. …He was there for the crew, the safety of the vessel…."

1.9.3 Safety Management System

A safety management system (SMS) defines the roles and responsibilities of all personnel, including shore-based managers and vessel crews; outlines safe practices in vessel operation and navigation; and establishes safeguards against identified risks.

1.9.3.1 Verification and Certification

The IMO International Safety Management Code (ISM Code) requires that vessel operators implement an SMS (1993).[22] Per the ISM Code, the flag state—the nation where a vessel is registered—must verify and certify that a company and vessel are complying with the provisions of the code. ABS was delegated responsibility by the United States for verifying that SEACOR Marine and the *SEACOR Power* were in compliance with the ISM Code and US regulations. Between March 18 and 25, 2021, ABS conducted a renewal audit to confirm that SEACOR Marine had an SMS that met the intent of the ISM Code. The auditors did not find any nonconformities, and, on behalf of the Coast Guard, ABS issued SEACOR Marine a document of compliance with an expiration date of April 19, 2026.

On June 9, 2020, ABS conducted a safety management certificate audit for the *SEACOR Power* to confirm that the company and its shipboard management operated the vessel in accordance with the approved SMS. The auditors found that "the master, officers and crew interviewed were familiar with the vessel and conversant with the company's SMS," and ABS endorsed the safety management certificate valid until June 13, 2022.

In addition to audits by the flag state or recognized organization (such as a classification society), the ISM Code requires annual internal audits to validate compliance. The last internal audit of SEACOR Marine was conducted on January 29, 2021, with no outstanding discrepancies. The last internal audit of the *SEACOR Power* began on March 29, 2021, also with no discrepancies or non-conformities, although the mate and SEACOR Marine Quality, Health, Safety, and

[22] The ISM Code is required for US vessels through 33 *CFR* Part 96 and Title 46 *United States Code* Section 3203.

Environment superintendent told investigators that, on the day of the capsizing, supplemental documentation was still being collected.

During the internal audit, the company auditor verified that stability calculations were conducted based on a sample loading condition dated November 14, 2020. The auditor noted in the record of the audit that stability was "calculated on 'Dixie Endeavor' sheet." The company could not provide a copy of the sample calculations when requested by investigators. A report from the previous year's internal audit, conducted on April 9, 2020, also noted that stability was calculated using the "Dixie Endeavor Stability program."

1.9.3.2 SEACOR Marine Safety Management System

The SMS in use at the time of the casualty had been revised in 2017, with a new revision under review. The following topics covered in the SMS sections were relevant to the *SEACOR Power* capsizing.

1.9.3.2.1 Responsibilities and Authorities

The Fleet Operations Manual section of the SMS laid out the responsibilities and authorities of the master as well as shore-based management and staff. The SMS stated, "the master has overriding authority and responsibility to make decisions with respect to safety."

1.9.3.2.2 Voyage Planning and Risk Assessment

The Fleet Operations Manual included the company's Safe Navigation Policy and voyage planning requirements for the master. Masters were required to conduct voyage planning using a voyage passage plan form provided in the SMS, which included a field for summarizing "weather for duration of voyage." In addition to the voyage plan, masters were required to complete arrival and departure checklists that included risk assessments. Completed voyage passage plans and arrival and departure checklists were kept aboard the company's vessels.

According to the mate, the captain conducted a risk assessment with the chief engineer, engineer, and two ABs just before getting underway. The mate stated that weather was a normal part of the predeparture assessment, but it was not discussed the day of the capsizing because the captain and mate had reviewed the forecast beforehand and did not consider it a risk. Forms and checklists for the casualty voyage were not recoverable during the salvage of the *SEACOR Power*.

1.9.3.2.3 Stability

The SMS directed that all officers be thoroughly familiar with the vessel's stability documentation and fully comply with the stability documentation, and that cargo and ballast be distributed to minimize excessive trim and unfavorable list. See section 1.10.1 *SEACOR Power* Departure Condition for information on the vessel's stability during the casualty voyage.

1.9.3.2.4 Stop Work Authority

The SMS policies defined stop work authority as the "obligation to stop any situation that poses a threat to personal injury, environmental impact, and property or equipment damage." Stop work authority was a power granted to all employees of the company, and, according to the SMS, its use was supported by the company management "without repercussions." When it was invoked by an employee, the situation was to be documented by a form provided in the SMS.

On two occasions in the year before the capsizing, the captain of the *SEACOR Power* exercised his stop work authority due to weather. On May 8, 2020, the vessel was stopped in winds of 30–35 knots and seas of 5–7 feet. In the stop work authority form documenting the event, the captain described "high seas and winds hitting the vessel on the bow while travelling giving a whipping effect on the legs and the vessel." On September 18, 2020, the vessel was shut down in conditions nearly identical to those listed in the May event. Again, the captain described the winds and seas giving a whipping effect to the legs and vessels.

1.9.4 Marine Operations Manual

1.9.4.1 Coast Guard Requirements

As a liftboat, the *SEACOR Power* was also required, per 46 *CFR* Part 134, to have an operating manual approved by the Coast Guard. The *SEACOR Power* "Marine Operations Manual," dated October 14, 2014, provided information, procedures, and forms specific to the vessel. Because the manual had been produced before the implementation of the SMS, there were some overlaps in guidance between the two documents. They were largely complementary, but the SMS took precedence.

The *SEACOR Power*'s Marine Operations Manual had been reviewed by ABS for compliance with its rules, and the stability portion was approved by ABS in accordance with *Navigation and Vessel Inspection Circular No. 3-97* (NVIC 3-97), "Stability Related Review Performed by the American Bureau of Shipping for U.S. Flag Vessels." The following paragraphs provide a summary of the sections of the manual relevant to the capsizing.

1.9.4.1.1 Vessel Particulars

The operating manual contained a detailed description of the vessel, including significant dimensions, major structural components such as the legs and pads, types and numbers of engineering equipment, and the vessel construction and layout.

1.9.4.1.2 Design Operating Limits

Per the regulations, the liftboat operations manual was required to provide designed limits for each mode of operation (including draft, wave height and period, wind, and current). The Design Operating Limits section of the *SEACOR Power* manual included the lightship characteristics of the vessel, the vessel's operating limits in both afloat and elevated modes, and instructions for various conditions such as heavy weather.

This section included a table of underway operating limits that showed a maximum wind speed of 70 knots, which matched the "severe storm" wind speed used in regulatory intact-stability calculations for liftboats in restricted service (see section 1.10.2.2 for regulatory intact stability requirements). The maximum wave height was 5 feet; the NTSB could not determine the origin of this threshold.

Regarding watertight integrity, the manual directed that "all watertight doors and hatches (on and below the main deck) shall be closed and secured when not in actual use," and that the initial closing of main deck doors and hatches was to be recorded in the pre-departure checklist.

1.9.4.1.3 Loading and Securing Cargo

The manual directed the master to "take all necessary steps to ensure that deck cargo does not shift and affect stability while underway…Cargo shall be bound to securing points with chains and ratchet binders."

1.9.4.1.4 Heavy Weather

The *SEACOR Power* crew was required to monitor weather every 8 hours for normal operations and every 4 hours whenever heavy weather was predicted. The manual advised the crew to plan to suspend operations before the weather reached the vessel and to allow ample time to secure the vessel and ensure the safety of personnel. The instruction further advised that, when afloat, the crew should "jack up immediately when seas approach the vessel's maximum safe operating parameters."

1.9.4.1.5 Stability

Regulations required that the operating manual provide "stability information setting forth the maximum allowable height of the center of gravity in relation to draft data, displacement, and other applicable parameters unique to the design of the unit to determine compliance with the intact and damage stability criteria." Stability was addressed throughout the *SEACOR Power*'s operating manual. In the Design Operating Limits section, the following instructions were provided:

> The Vessel Master must, at all times, ensure the stability of his/her vessel. This means that the Master must perform the necessary stability calculations to verify that the actual KG [distance between the keel and center of gravity] falls below the allowable VCG [allowable vertical center of gravity—AVCG] curve.

In a section titled "Underway Emergency Instructions," the master was advised, "Check freeboard and trim/heel indicators. If proper balance is not possible with the available consumable liquids onboard, jack up and move the deck load." The section "Underway Precautionary Measures" directed the master to "ensure that the vessel remains in a seaworthy condition with deck cargo properly distributed (trim and heel approximately level) and secured (chained down or welded).

A dedicated stability chapter in the Marine Operations Manual directed that "the vessel will not be in open-water transit in an area where winds of more than fifty (50) knots are forecasted" and "will be operated as close to even keel (no trim or heel) as possible."

The stability chapter provided instructions for completing pre-underway stability calculations and included a worksheet to be used to tabulate cargo, liquid, and other variable loads for calculation of the vertical center of gravity (VCG), trim, and heel. Once calculated, the VCG was to be compared to the allowable VCG (AVCG) curves provided in the manual to ensure the vessel was within limits. Per the worksheet, the *SEACOR Power* was to be "as close to level heel as possible" and have "no more than 6 [inches] of trim" by the stern.

According to the mate and off-rotation captain and chief engineer, the crew did not use the form provided in the Marine Operations Manual to calculate stability, but instead used a Microsoft Excel spreadsheet. The weights and locations of loads, liquids, and personnel were input into the spreadsheet, and the application completed the calculations. The off-rotation engineer stated that, if a value computed by the stability spreadsheet was outside of allowable parameters, the cell in the spreadsheet containing the value would turn red. The off-rotation captain told investigators that the only value that was regularly out of specification was trim. He stated, "the comment that [the spreadsheet] says that you should achieve within 6 inches of trim is not reasonable. But the stability program was still accurate and would tell you that you're not within 6 inches. But that was expected."

Although the off-rotation engineer believed that the spreadsheet had been developed using the operating manual, he did not know who had created it. He told investigators, "It was on there when I got there. I just started using whatever was there that they had been using." The off-rotation captain believed that the spreadsheet had been developed by the vessel designers. He said the same spreadsheet was used by both rotational crews to calculate stability. During the Coast Guard's Postcasualty Marine Board of Investigation hearing into the *SEACOR Power* capsizing, the ABS surveyor that had conducted the most recent survey of the vessel stated that the spreadsheet had not been approved by ABS.[23] During the same hearing, an ABS auditor told investigators that a classification society approved program was not a requirement for liftboats. However, while a liftboat is not required to have an onboard stability program, the *International Convention on Load Lines* requires the stability information provided to the master be approved by the flag state or a recognized organization. The computer used to calculate stability on the day of the casualty and any paper copies of the result were not recovered during the salvage of the *SEACOR Power*.

1.9.5 Cargo and Stowage

In addition to the SMS and Marine Operations Manual, the *SEACOR Power* also had a Cargo Securing Manual approved by ABS on behalf of the Coast Guard. Per the manual, all cargo was to be "stowed and secured in such a way that the ship and persons on board are not put at risk." The manual further noted:

[23] See Appendix A: Investigation for more information on the Marine Board of Investigation.

> Decisions taken for measures of stowage and securing cargo should be based on the most severe weather conditions that may be expected by experience of the intended voyage…ship-handling decisions taken by the master, especially in bad weather conditions, should take into account the type and stowage position of the cargo and the securing arrangements.

The manual provided guidance for crews for stowing and securing different types of cargo to prevent them from sliding or toppling.

On the casualty voyage, the *SEACOR Power* was carrying various equipment and supplies for the recompletion work planned for the platform at Main Pass 138. The total weight of the cargo was about 100 long tons (224,000 pounds). According to one of the OWs who assisted with the loadout and survived the capsizing, the heaviest items—a coil tube reel, pump, console unit, and power pack—were placed centerline as far aft as possible on the main deck.

None of the equipment was lashed down to the deck after it was onloaded on the morning of the casualty. According to the mate, the *SEACOR Power* was fitted out with chains and ratchet binders for lashing, but cargo was only chained down when the vessel was in danger of leaning to one side during jacking operations. Similarly, the well site supervisor told investigators, "I've never seen cargo strapped down on a liftboat. A liftboat … is not designed to travel in rough seas. So, if there's—if they encounter rough seas they stop and jack up and get out of the water."

The mate told investigators that the cargo aboard the *SEACOR Power* did not move from its position on deck until the vessel "started going over completely."

1.10 Stability

1.10.1 *SEACOR Power* Departure Condition

Cameras throughout the harbor captured the liftboat's progress as it exited Port Fourchon on the afternoon of the casualty. Based on these videos, the vessel's departure drafts were estimated at 8 feet forward, 9 feet 3 inches at the load line mark, and 10 feet 6 inches aft (2 feet 6 inches of trim by the stern). The mate, off-rotation captain, and off-rotation chief engineer all stated that the *SEACOR Power* usually operated with stern trim, although the amount of trim varied in their testimonies. The videos did not show any appreciable list, and the vessel's port side load lines were visible above the waterline (the starboard side was not captured by any of the cameras). The off-rotation captain stated that, based on a still image from one of the harbor cameras, the vessel's draft, freeboard, and trim appeared to be normal, assuming that the liftboat had a full load of fuel and water, along with cargo on deck.

1.10.2 Intact Stability

1.10.2.1 General

A vessel that is floating upright in still water will heel, or incline, over to an angle when an off-center disturbing force, such as one created by wind or waves, is applied. Stability is the vessel's tendency to return to its original upright position when the force is removed.[24] For most vessels, the properties of intact stability are primarily concerned with heeling moments that incline a vessel transversely. However, for vessels like the *SEACOR Power* that have an unusual hull form with a much shorter length to width (beam) ratio, ship stability must also consider trimming moments that incline the vessel longitudinally (fore and aft), as well as moments that incline a vessel at varying axes between the transverse and longitudinal axes. For this reason, in this report "inclining moment" will be used in place of "heeling moment" or "trimming moment" to describe moments and their components imparted by disturbing forces.

1.10.2.2 Regulations

Stability criteria established in regulations set numeric bounds for a vessel's stability as determined through a set of calculations that account for the vessel's physical characteristics. The criteria are generally recognized as providing an adequate level of safety for vessels that are operated prudently, which means not overloaded and not operating in dangerous conditions, such as violent storms. A margin of safety is built into the stability criteria to accommodate forces that can act on a vessel, such as winds or waves.

The regulations require the designer and builder of a vessel to make calculations, conduct testing, and develop stability documentation. The stability documentation must be submitted to the Coast Guard, which reviews the vessel's stability to ensure that it complies with the regulations. (Per NVIC 3-97, the Coast Guard authorized ABS to conduct stability reviews for US-flagged vessels.) If,

[24] For more information on stability, see Appendix C: Load Lines and Principles of Stability.

following the stability review, the Coast Guard or ABS determines that the vessel meets regulatory requirements, a stability review letter will be issued by the Coast Guard or ABS attesting to the vessel's compliance.

For liftboats inspected as OSVs, the Coast Guard applies the stability requirements in 46 *CFR* Part 174 Subpart H, "Special Rules Pertaining to Liftboats."[25] Liftboat regulatory design standards are divided into unrestricted or restricted service. Liftboats in restricted service, like the *SEACOR Power*, are subject to less stringent intact stability criteria than unrestricted-service liftboats but can only work in areas that are within 12 hours of a harbor of safe refuge or in areas where they can jack up to avoid heavy weather.[26] According to Coast Guard records, 35 restricted-service liftboats were in active service as of August 1, 2022. An additional 33 active liftboats, which were constructed before liftboat stability regulations came into effect, have the same stability requirements and similar operating restrictions as restricted-service liftboats subject to Subpart H requirements.[27]

Liftboat intact stability requirements are expressed as the relationship between a vessel's righting moment (the vessel's tendency to return to equilibrium) and wind inclining moment (the sum of a given wind's forces acting on a vessel) when the vessel is inclined from upright (0°) to the angle of downflooding or the angle that the vessel capsizes. Righting moments and wind inclining moments can be plotted as curves on a graph of intact stability (see Figure 21). See Appendix C: Load Lines and Principles of Stability for additional information.

[25] Part 170 of 46 *CFR* Subchapter S provides stability requirements for "all inspected vessels," but most liftboats cannot meet the requirements in this part, and the Coast Guard has not historically applied the requirements of Part 170 to liftboats inspected as OSVs. However, liftboats are not specifically exempted from the intact stability requirements of this subchapter (unlike mobile offshore drilling units [MODUs]), and liftboats inspected under regulations for industrial vessels must meet this standard.

[26] Vessels in unrestricted service must meet the stability requirements for MODUs provided in 46 *CFR* Part 174 Subpart C.

[27] These 33 liftboats are subject to Coast Guard NVIC 8-91, which contains the same stability criteria that were incorporated into 46 *CFR* 174 Subpart H.

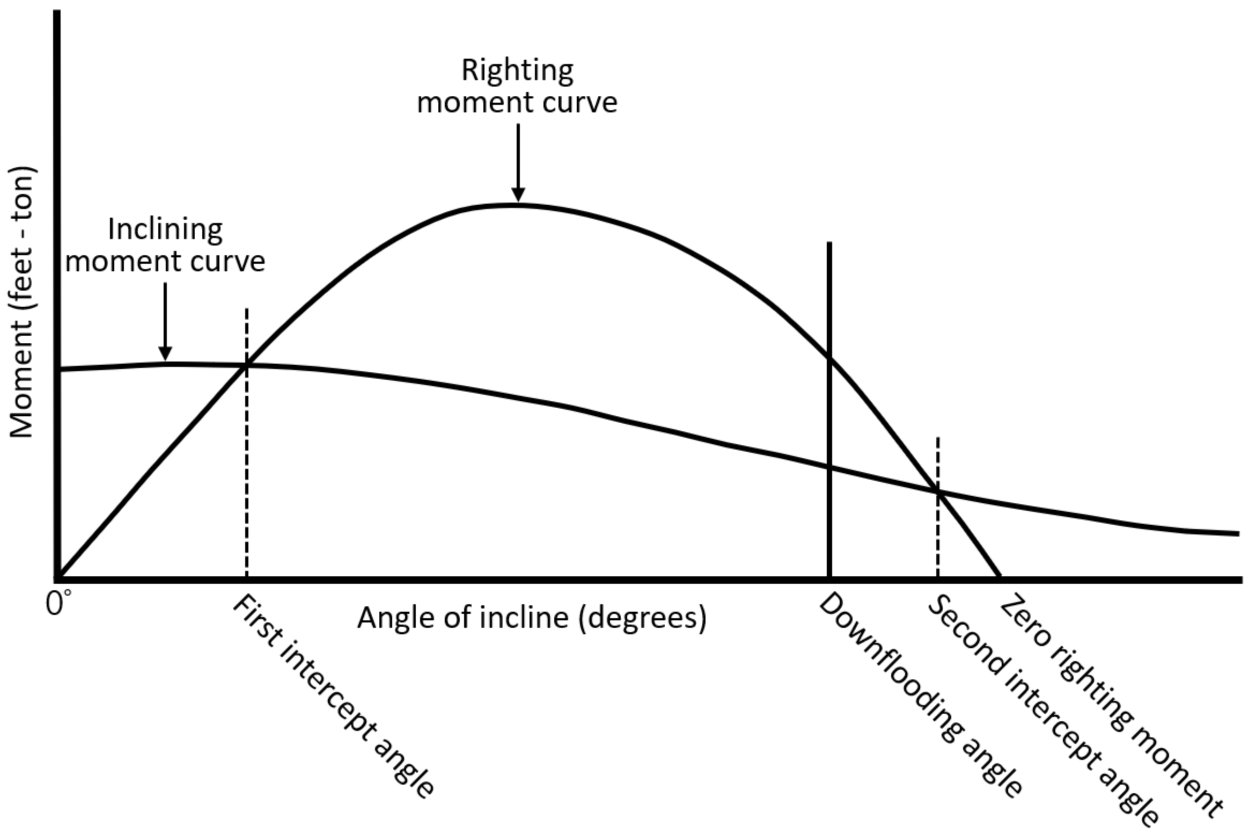

Figure 21. Righting and inclining moment curves for intact stability. The second intercept angle is the angle at which the vessel will capsize when subjected to a given wind. (Adapted from Graph 174.045, 46 *CFR* 174)

Under the regulations, wind inclining moments must be calculated for normal conditions and severe storm conditions. For a liftboat in restricted service, these conditions are defined as 60- and 70-knot winds, respectively, and stability curves must be generated for each of these conditions.[28] Based on these curves, the following stability criteria must be met for a restricted-service liftboat to comply with regulations:

- **Ratio.** The *ratio* of the area under the righting moment curve to the area under the inclining moment curve must equal 1.4 or greater. The value of the ratio provides a safety margin to account for unknown factors, including wind gustiness.

[28] For liftboats in unrestricted service, normal and severe operating conditions are defined as 70- and 100-knot winds, respectively.

- **Range.** The *range* of positive stability extending from the first intercept of the two curves to the second intercept, or the angle of downflooding, whichever is less, must be at least 10°.
- **Area.** The residual righting energy (that is, the *area* under the righting moment curve, less the area under the inclining moment curve) must be 5 foot-degrees or more.
- **Metacentric height.** The initial metacentric height (*GM*—measured as the initial slope of the righting moment curve) must be at least 1 foot.[29]

1.10.2.3 Initial Stability Analysis and Stability Review Letter

In 2002, the *SEACOR Power*'s builder, SEMCO, prepared a stability analysis package and submitted it to ABS. The package included data for the vessel as built, with 250-foot legs, as well as data for a proposed lengthening of the vessel's legs to 265 feet. ABS reviewed the package and issued a stability review letter, dated August 14, 2002.

The stability review letter included tables of AVCG for both the 250-foot and 265-foot leg configurations. The AVCG values represented the maximum height of the VCG at which the vessel could be operated, after cargo and liquid loads such as fuel and oil had been added. The AVCG varied depending on the vessel's draft, and values for drafts between 8 and 10 feet were provided in the stability review letter tables. A graph of the AVCG values for the 250-foot configuration was included in the vessel's Marine Operations Manual.

After the *SEACOR Power*'s legs were lengthened in 2012, the vessel's Marine Operations Manual was updated in 2013 to include a newly approved lightship weight, revised drawings, and updated AVCG curves. The new AVCG curves were based on the 265-foot configuration values determined in the 2002 stability review. After two additional updates were made to the operations manual in 2014, both reviewed by ABS, a revised stability review letter was issued for the *SEACOR Power* on October 21, 2014. The updated operations manual was reviewed by the Coast Guard before being placed aboard the vessel.

[29] These calculations originated in the IMO *Code for the Construction and Equipment of Mobile Offshore Drilling Units, 1979 (MODU Code 1979)* and are remain in the current MODU code, *MODU Code 2009*. For more information, see the Stability Factual.

1.10.3 Coast Guard Marine Safety Center Postcasualty Stability Analysis

After the capsizing, the Coast Guard Marine Safety Center (MSC) conducted a stability analysis of the *SEACOR Power* to determine whether the vessel met regulatory criteria for intact and damage stability 1) if it had been loaded to maximum AVCG, 2) at the time of departure from Port Fourchon, and 3) at the time of the casualty. The MSC documented the analysis and its results in a report entitled *Post-casualty Stability Analysis of Liftboat* SEACOR POWER.

1.10.3.1 Intact Stability Analysis Methods

To conduct the analysis, the MSC developed a computer model of the vessel and then analyzed the model's stability for inclining moments generated by 60- and 70-knot winds, per regulatory requirements. Although the regulations do not state what wind direction or directions must be considered in stability analyses, the MSC calculated righting and inclining moments at 15° intervals from 0 to 360° relative to the vessel (see Figure 22). The *SEACOR Power* operations manual prohibited trim by the bow and limited trim to no more than 6 inches by the stern. The MSC analyzed the model at even keel (0 trim), but, given testimony by operators that the *SEACOR Power* was regularly operated with aft trim, the MSC also analyzed the model at 0.5, 1, 2, and 3 feet of initial stern trim.[30]

[30] MSC noted in its report of the postcasualty analysis that the builder's original stability analysis and ABS's review of the analysis only considered 0 trim. In a letter to the Coast Guard commenting on the MSC report, ABS stated: "the instructions provided to ABS by the USCG MSC for the past three decades have been to provide trimmed calculations only when the trim exceeds one percent of length…The six-inch aft trim limitation proposed by the designer and included in the vessel Operations Manual was less than one percent of length. On that basis, only even keel calculations were required to be submitted and reviewed. ABS cannot perform additional calculations and approve them, as that would be performing design and/or consultation work, which would create a conflict of interest and would be well beyond the scope of 'review.' Further, the designation of operating limitations is the responsibility of the designer, not the review office."

The Coast Guard conducted two sets of analyses for each condition that it evaluated. In its first set of analyses, the model was not permitted to twist (or yaw) about its vertical axis as it was inclined, which was in keeping with the methodology used at the time of the *SEACOR Power*'s construction in 2002. With this "fixed-axis" constraint, the model had a tendency to lose stability and the righting moment curve was truncated as it was inclined towards axes just off the bow or stern, a phenomenon known as "fading stability." The MSC noted that this phenomenon was unrealistic because an actual vessel will yaw as it is inclined, rotating to the position where righting energy is weakest.

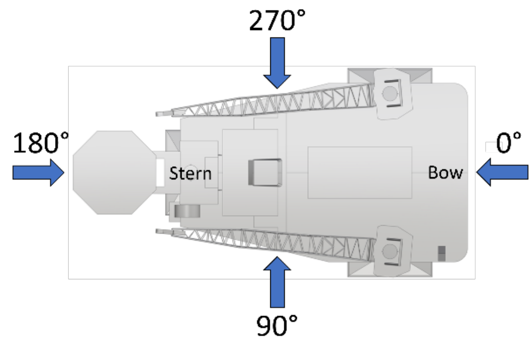

Figure 22. Diagram of a liftboat showing relative wind directions. (Background source: MSC)

To evaluate the stability of the *SEACOR Power* model without the effects of fading stability, the MSC's second set of analyses allowed the model to freely twist about the vertical axis. This "varied-axis" method was not available at the time the *SEACOR Power* was constructed.

For both the fixed-axis and varied-axis models, the MSC used the initial slope of the righting arm curve to calculate GM.

1.10.3.2 Analysis Results

1.10.3.2.1 Maximum AVCG

In the fixed-axis method of analysis for maximum AVCG in 60- and 70-knot wind conditions, the MSC found that, at zero trim (even keel), the *SEACOR Power* met the stability criteria of 46 *CFR* Part 174 Subpart H ("Special Rules Pertaining to Liftboats") for three of the four stability criteria—ratio, area, and GM—for all wind directions and all drafts. For the fourth criterion, range, the vessel passed regulatory standards for all wind directions except 15° off either side of the bow. In these two directions, the vessel passed the regulatory requirements at 8.5 feet of draft, but failed for drafts 9 feet, 9.5 feet, and 10 feet. However, the vessel failed the 10° range criterion by no more than 1.1°—at 10 feet draft, the range was 8.9°.

When the MSC analyzed the vessel by the fixed-axis method for increasing trim by the stern, the data showed that as trim increased, the instances of regulatory failures increased. The values for stability criteria (ratio, range, area, and GM) also generally decreased as trim by the stern increased. For example, for port beam winds (270° relative to the vessel), the values for range, ratio, area, and GM decreased by 17%, 7%, 26%, and 4%, respectively, as trim by the stern was increased from 0 to 2 feet.

The 2002 stability review letter for the *SEACOR Power* indicated that the vessel, with 265-foot legs, passed all the regulatory criteria for Part 174 Subpart H when the analysis was completed by ABS. In its report of its analyses, the MSC noted that:

> In 2002, ABS used a different model to analyze *SEACOR POWER*. Comparison of MSC and ABS model wind overturning moments indicated significantly different modeling treatment of the helideck. This may be the reason why the ABS model indicated that *SEACOR POWER* passed each of the regulatory criteria in 2002.

In the MSC's varied-axis method of analysis for maximum AVCG, the *SEACOR Power* met the regulatory requirements at maximum AVCG values for all wind directions and trim conditions.[31] Like the fixed-axis method, the varied-axis method showed that, in most cases, the measures of stability decreased with increasing aft trim. Table 8 provides a sample of the stability criteria as calculated by the Coast Guard for the *SEACOR Power* at a 9.5-foot draft. As trim by the stern was increased from 0 to 2 feet, ratio decreased by 21%, range decreased by 3%, and area decreased by 31%. GM initially increased as the vessel was trimmed by the stern to 0.5 feet, but then decreased again and leveled off as it was trimmed further.

Table 8. Sample results of Coast Guard varied-axis-method calculations of regulatory stability criteria for the *SEACOR Power* with a 9.5-foot draft in 60-knot winds at select wind directions, with increasing trim by the stern. Red text indicates decreasing values as trim increases; green text indicates increasing values as trim increases.

Trim (ft)	Ratio	Range (°)	Area (ft°)	GM (ft)
0	2.9	13.3	46.7	90.4
0.5	2.7	13.7	46.3	250.4

[31] For 8.5- and 9.0-foot drafts at 3-foot trim by the stern, the model did not meet the minimum ratio for righting area to inclining area (1.4); however, the margin of failure in both cases was within rounding error.

1	2.6	13.2	42.9	110.4
2	2.3	13	32.1	109.3
3	1.9	11.8	27.3	104.62

1.10.3.2.2 Departure Condition

The fixed-axis analysis of the model in the departure condition found that the model narrowly failed the range of stability requirements of 46 *CFR* Part 174 Subpart H for wind directions of 15°, 225°, and 345° with 60- and 70-knot winds. It also failed the range criterion at the 330° wind direction for 70-knot winds. The MSC noted that "in each of the failing range conditions there is a relatively high righting energy which far exceeds the requirements of the ratio criterion…and the residual righting energy [area] criterion [for the cases when the model failed the range criterion, the model passed the ratio and area criteria by wide margins]." In the varied-axis analysis of the departure condition, the *SEACOR Power* model passed all Subpart H stability criteria by wide margins. According to the MSC, "In both the 60- and 70-knot wind analyses, the weakest axis converges on wind directions just forward of the port beam at 290° to 292° relative."

1.10.3.2.3 Casualty Condition

The casualty condition was modeled with the legs lowered 10 feet and slightly less fuel on board than the departure condition. In the MSC's fixed-axis analysis of the model in the condition at the time of the capsizing, the model narrowly failed the range of stability requirements for wind directions of 0°, 15°, and 345° for 60- and 70-knot winds. The MSC noted "stability, as measured by these criteria, is improved when compared to the departure condition when the legs are fully raised." In the varied-axis analysis of the casualty condition, the model passed all regulatory criteria for intact stability by greater margins than those of the departure condition. The MSC stated, "In both the 60 and 70-knot wind analyses, the weakest axis converges on wind directions just forward of the port beam at 291° to 293° relative."

1.10.3.3 Regulatory Requirements and Operational Guidance

In the conclusions to its report, the MSC noted that the 60- and 70-knot winds used in the regulatory requirements for stability are also used "explicitly and without context within *SEACOR POWER*'s Marine Operations Manual and on the vessel's

Certificate of Inspection." The report cautions that the regulatory wind speeds are used for stability calculations that only consider static response in still water, not the actual conditions that a vessel may experience (wind and wave action). The MSC concluded that "regulatory criteria wind speeds are not appropriate for operational guidance."

1.10.4 Computational Fluid Dynamics Analysis

To better understand the forces that capsized the *SEACOR Power*, the NTSB requested that ABS conduct a computational fluid dynamics (CFD) analysis of wind load on the vessel. The NTSB and ABS collaborated to develop a plan for modeling the stability of the liftboat and evaluating potential capsizing scenarios. A Coast Guard naval architect (a member of the service's Marine Board of Investigation for the capsizing) also advised the team.

The model of the vessel used in the CFD analysis began with the model developed by the Coast Guard for the MSC analysis described above and was slightly modified for CFD. The model reflected the loading condition of the *SEACOR Power* at the time of the capsizing, with the legs lowered 10 feet, the draft at 9.25 feet at the load line marks, and the trim 2.5 feet by the stern.

The first steps of the analysis were designed to determine the computer model's most vulnerable axes of inclination: the wind directions in which the ratio of the inclining moments to righting moments were the least. The results showed that, on the port side, the vessel was most vulnerable with winds from 255° and 285° relative. The vessel's stability was then analyzed for winds along these axes using wind speeds likely experienced on the casualty day: 50-knot sustained winds and 71-, 74-, 77-, and 80-knot wind gusts (the upper bound 60-, 30-, 10-, and 5-second wind gust speeds, respectively) as measured at 10 meters (32.8 feet) height. In these steps, seas were assumed to be calm. The model did not capsize under any of these wind conditions.[32]

The next step in the analysis considered whether the *SEACOR Power*'s motion through the water, the current acting on the vessel's hull in a nearly opposite direction, and 80-knot wind gusts could have "tripped" the liftboat, causing it to

[32] Wind speeds used in the study were taken from the NWS postcasualty weather analysis (see section 1.8.1 Meteorological Conditions Summary). The NWS analysis presented a range of possible speeds for sustained winds and wind gusts; the CFD study used maximum values from this range.

capsize. Before CFD testing in this step, the vessel was analyzed to determine a steady-state orientation of the vessel when allowed to yaw in the winds, with an initial wind direction of 255° degrees relative. This process found the steady-state orientation to be with winds from 245°, and the tripping analysis was conducted assuming winds from this direction. In addition to testing the model in 80-knot winds, winds of 90, 100, and 110 knots were tested in this step to determine the model's sensitivity to wind speed. The sea state was assumed to be calm in each of the cases analyzed in this step. The CFD analysis showed that the vessel maintained stability in 80- and 90-knot winds but capsized in 100- and 110-knot winds.

The analysis then introduced sea state into the testing and evaluated the effect of swells on the *SEACOR Power*'s stability. Based on maximum forecasted seas and witness testimony of conditions just before the capsizing, the NTSB chose a wave height of 4 feet and a wave period of 4 seconds, with the swells coming from the direction of 23° relative to the vessel. Wind speeds of 70 knots (the regulatory maximum for stability in calm waters), 80 knots, and 90 knots were analyzed in this step. The analysis showed that the model maintained stability in 70- and 80-knot winds but capsized in 90-knot winds.

At the request of the NTSB, ABS added an additional step (step 8) to the CFD analysis to consider the *SEACOR Power* model's stability under three different cases involving winds and seas from different directions. In each of the cases, winds were set at 80 knots, and waves were set at 4 feet with a 4-second period. Each case also began with the model at an angle of inclination of 2°, approximating the initial inclination angle reported by the mate as he lowered the legs and began to turn the vessel into the wind. Additionally, wind loads calculated in an earlier step showed that they increased by approximately 10% when the angle of inclination changed from 0° to 10°; therefore, during this step, a 10% increase in windload was added after the model reached 10° of inclination.

- Case 1 explored whether the *SEACOR Power* maintained stability when winds came from forward of the beam, at 285° relative, with waves from 023° relative (see Figure 23). The CFD analysis showed that the vessel capsized under these conditions.
- Case 2 explored whether the model of the vessel maintained stability with co-linear winds and waves from 285°. This case was designed to simulate the effects of wind-generated waves on the *SEACOR Power* under the tested wind conditions. In this case, the vessel maintained stability.

- Case 3 explored whether the model maintained stability with co-linear winds and waves from 285° and cross waves from 023°. This case was designed to simulate the effects of both swells and wind-generated waves on the *SEACOR Power* under tested wind conditions. The CFD analysis showed that the vessel capsized under these conditions.

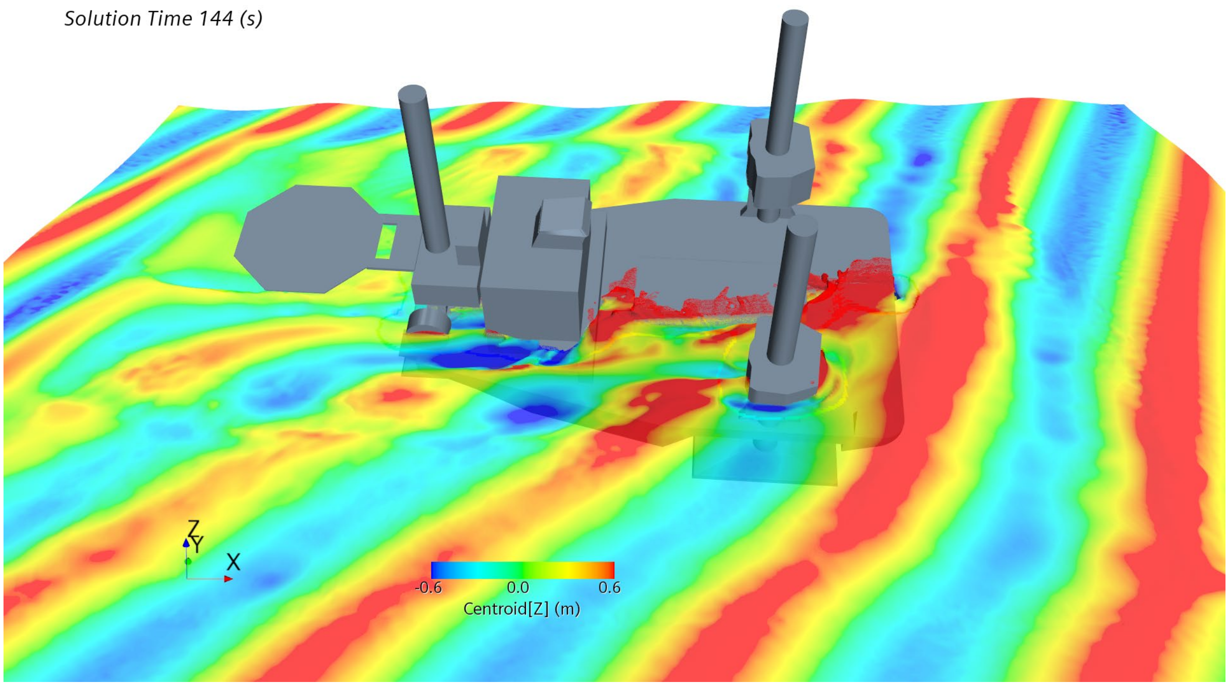

Figure 23. Illustration of the CFD analysis for step 8, case 1, simulating the effect of wind gusts with swells. Colors indicate wave height, with blues in low areas and reds in high areas. The vessel capsized in the simulation.

1.11 Key Personnel Information

1.11.1 Qualifications

The NTSB reviewed records for all eleven crewmembers and eight offshore workers aboard the *SEACOR Power* during the capsizing. All crewmembers possessed the required credentials, certifications, and/or training—including water survival training—required by regulations and commensurate with their duties. The following are summaries of the qualifications of the captain and mate on the liftboat.

The captain of the *SEACOR Power* was in the wheelhouse when the vessel capsized. He held a valid US Coast Guard credential as a master of self-propelled vessels of less than 1,600 gross register tons upon near coastal waters. The captain had worked in the offshore marine industry for over 40 years and had been employed by SEACOR Marine and its predecessor companies for about 24 years.

The mate was at the helm of the *SEACOR Power* when it began to capsize. He held a valid US Coast Guard credential as mate of self-propelled vessels of less than 1,600 gross register tons upon near coastal waters. He also held a credential as master for vessels less than 200 gross register tons in near coastal waters. He had worked for SEACOR Marine or its predecessor companies since 2004, beginning as an ordinary seaman on OSVs and working his way up to mate on liftboats; he had worked a total of 7 years on the *SEACOR Power* and had been assigned to the vessel as mate beginning in 2019. During the casualty voyage, the mate stood the day watch, assisted by the captain (the night captain was scheduled to stand the night watch). In a 2020 appraisal, the captain of the *SEACOR Power* stated that the mate was an "exceptional boat handler."

1.11.2 Work/Rest

The crew of the *SEACOR Power* worked a 14-days-on/14-days-off schedule, with the entire crew rotating on or off at the same time. When underway, watches—also known as tours—were organized in 12-hour shifts, from 0600 to 1800 and from 1800 to 0600.[33] Offshore workers did not have duties or stand watches while the vessel transited to the worksite.

The mate told investigators that he went to sleep about 2030 the night before the casualty and woke up around 0200 to travel to the vessel for the crew change. In the nights preceding the night before the casualty, he had 7–8 hours of normal sleep.

The work/rest history of the captain was not recorded.

1.11.3 Toxicological Testing

None of the three surviving crewmembers (night captain, mate, and AB 1) received postcasualty drug and alcohol testing by SEACOR Marine. AB 1's hospital

[33] In the offshore industry, including service vessels, "tour" (pronounced similarly to "tower") is a common term for a watch.

urine drug and blood ethanol screen was negative.[34] Ethanol was identified in four of the five deceased crewmembers.[35] Ethanol levels varied considerably between crewmembers and between tissue samples for each crewmember. N-propanol and n-butanol were found in two crewmembers.

Typically, after use, ethanol is distributed rapidly and uniformly throughout the body. Postmortem microbial activity may produce ethanol, which can make it difficult to determine a person's blood-alcohol concentration at the time of death (Lewis 2004). Ethanol levels from postmortem production vary considerably between body tissues. Postmortem ethanol production is more likely following extensive trauma, and ethanol generally occurs in higher concentrations in blood as more time elapses (Kugelberg 2007) (Cullen 2005). In addition to ethanol, postmortem microbial activity can also produce n-propanol and n-butanol.

1.12 Related Casualties and NTSB Recommendations

1.12.1 Liftboats

In the last 40 years, the NTSB has investigated at least eight casualties involving liftboats. However, except for the two investigations described below, the previous casualties involved unique circumstances (e.g., vessels overturning while jacked up) that are not relevant to the current investigation. Additionally, both vessels described below were constructed and capsized before 1996, when liftboat stability regulations came into effect, and were therefore not designated as either restricted- or unrestricted-service liftboats.

1.12.1.1 Liftboat *Amay S*

On October 17, 1984, the liftboat *Amay S* became disabled when it lost propulsion and electrical power while en route to Sabine Pass, Texas, from an offshore oil drilling platform in the Gulf of Mexico (NTSB 1985). The Coast Guard

[34] Ethanol is commonly referred to as alcohol when found in beer, wine, and liquor.

[35] The coroner's office provided specimens to an external lab. Testing requested was either for 17 analytes or 228 analytes; both panels included ethanol and drugs of abuse. Samples were also provided to the Federal Aviation Administration Forensic Sciences Laboratory, which tests specimens for over 1,300 compounds including toxins, prescription and over-the-counter medications and illicit drugs; information about these compounds can be found at the Drug Information Web Site (https://jag.cami.jccbi.gov/toxicology/).

Cutter *Point Hope* took the *Amay S* in tow bound for Sabine Pass, but about 15 minutes after the tow began, the *Amay S* suddenly rolled to starboard, capsized, and sank. All seven persons on board the *Amay S* were rescued by the *Point Hope*. The postcasualty stability calculations performed by the Coast Guard on the *Amay S* showed that the vessel had "limited stability." At the time of the casualty, there were no regulatory stability criteria for liftboats in the United States; thus, the NTSB issued Safety Recommendation M-85-112 to the Coast Guard to use the authority of the Outer Continental Shelf Lands Act to establish stability criteria for self-elevating liftboats that engage in outer continental shelf activities. On November 16, 1995, the Coast Guard published an interim final rule for OSVs/liftboats that became effective on March 15, 1996. The interim final rule contained the recommended stability criteria, and on November 6, 1996, the NTSB classified Safety Recommendation M-85-112 "Closed-Acceptable Action."

1.12.1.2 Liftboat *AVCO V*

On July 30, 1989, the liftboat *AVCO V* capsized and sank off the coast of Leeville, Louisiana, in severe weather associated with Hurricane Chantal (NTSB 1991). While transiting toward Leeville, rough waves impacted the starboard-side hull and caused equipment on deck to shift, imparting a list on the vessel that led to the capsizing. Ten of the fourteen persons on board died in the casualty. As a result of its investigation, the NTSB issued Safety Recommendation M-91-13 to the Coast Guard asking it to require that liftboats have on board a severe weather action plan that is tailored to the operating characteristics and limitations of the vessel. The interim final rule published by the Coast Guard on November 16, 1995, contained the recommended requirement. On November 6, 1996, the NTSB noted that 46 *CFR* 134.170(B)(6) contained a requirement that the recommended guidance be included in the liftboat operations manual. As a result, Safety Recommendation M-91-13 was classified "Closed-Acceptable Action."

The NTSB also issued Safety Recommendation M-91-19 to Chevron, the company that had chartered the *AVCO V*, to prepare and include in the company's hurricane action plan a system that considered the sea and weather operating limitations of liftboats and to use this system as guidance for evacuating personnel from such vessels or for releasing the vessels to seek shelter during predicted deteriorating weather. On April 7, 1992, Chevron replied that it instituted a review of its hurricane action plan after the findings of the NTSB's investigation were released. As a result of this review, Chevron developed and implemented a new hurricane action plan that considered the sea and weather operating limitations of liftboats and used this information for guidance on evacuating personnel from such vessels or for releasing the vessels to seek shelter. Because of the revisions that Chevron made to its hurricane action plan, on June 26, 1992, the NTSB classified Safety Recommendation M-91-19 "Closed-Acceptable Action."

1.12.2 EPIRBs and PLBs

1.12.2.1 Commercial Fishing Vessel *Lady Mary*

The NTSB's investigation of the March 24, 2009, sinking of the fishing vessel *Lady Mary*, found that the vessel's EPIRB did not transmit vessel position data and was incorrectly registered (NTSB 2011). Had the EPIRB been equipped to broadcast location, the vessel's position would have been transmitted to the Coast Guard RCC, regardless of the incorrect registration information. The investigation further found that the delay between the transmission of the *Lady Mary's* first EPIRB signal and the arrival of rescuers was 2.5 hours. Finally, the investigation found that had the rescuers arrived earlier, it was possible that the two victims found in the water wearing immersion suits would have survived.

Two months after the *Lady Mary* casualty, on July 13, 2009, the Coast Guard issued a safety alert (No. 04-09) addressing the issue of EPIRB registration. The alert urged owners and operators of EPIRBs and PLBs to confirm that their registrations were correct and to update them if necessary.

As a result of the *Lady Mary* investigation, the NTSB issued Safety Recommendation M-10-1 to the FCC to require that commercial vessels carry 406-MHz EPIRBs that broadcast vessel position data when activated. In response, on September 1, 2016, the FCC released a Report and Order, FCC 16 119, amending 47 *CFR* section 80.1061(a) to incorporate Radio Technical Commission for Maritime Services Standard 1100.3, which requires EPIRBs to broadcast position data. As a result, on October 14, 2016, Safety Recommendation M-10-1 was classified "Closed–Acceptable Action."

1.12.2.2 Cargo Vessel *El Faro*

In 2016, the FCC updated regulations to require GNSS-enabled EPIRBs on vessels. These EPIRBs transmit their positions to SAR authorities, regardless of which satellite received the position. The updated regulations prohibited the sale of non-GPS-enabled EPIRBs as of January 17, 2020, and mandated that all compulsory vessels (vessels required to be equipped with GMDSS) have GPS-enabled EPIRBs by January 31, 2023.

As a result of the NTSB's investigation of the October 1, 2015, sinking of the SS *El Faro*, which also had a non-GPS-enabled EPIRB, the NTSB issued Safety Recommendation M-17-50 to the FCC to immediately require the newer devices, rather than allowing operators to phase them in over 5 years per the updated regulations (NTSB 2017). The FCC did not respond to the recommendation until November 3, 2021, shortly after the NTSB requested that the FCC respond to the then 3.5-year-old recommendation. The FCC's initial response was submitted only 14 months before the old EPIRBs were to be phased out. In its November 3, 2021, letter, the FCC said that because vessel owners typically replaced their EPIRBs at the end of battery life, it was likely that many vessels had upgraded or were in the process of upgrading their EPIRBs to the GPS-enabled equipment. Additionally, the FCC said that the Coast Guard had conducted considerable outreach about the benefits of GPS-enabled EPIRBs. On January 25, 2022, the NTSB replied that although we agreed that there will be fewer noncompliant 406-MHz EPIRBS in service as the compliance date approaches, the intent of our recommendation was to immediately discontinue the use of EPIRBs that are not GPS enabled. Accordingly, Safety Recommendation M-17-50 was classified "Closed—Unacceptable Action."

Also as a result of the NTSB's investigation of the loss of the *El Faro*, on February 7, 2018, the NTSB issued Safety Recommendation M-17-45 to the Coast Guard to require that all personnel employed on vessels in coastal, Great Lakes, and ocean service be provided with a PLB to enhance their chances of survival. On July 17, 2018, the Coast Guard said that, at that time, a PLB did not provide the requisite location accuracy to alert SAR assets of mariners in distress and provide SAR responders with an accurate location for rescue. The Coast Guard planned to explore other technologies to provide effective distress alerting and location in a modern SAR environment.

The Save our Seas Act of 2018, Title 46 *United States Code* 3306, became law in October 2018 and requires that:

> a freight vessel inspected under this chapter be outfitted with distress signaling and location technology for the higher of— (A) the minimum complement of officers and crew specified on the certificate of inspection for such vessel; or (B) the number of persons onboard the vessel.

In the 4 years since Congress enacted the Save our Seas Act, the Coast Guard has not yet issued the needed regulation to implement this requirement.

On April 30, 2019, the NTSB replied to the Coast Guard, stating that we disagreed with the Coast Guard's assertion that, at the time, a PLB does not provide the needed location accuracy to ensure that mariners in distress have an efficient and effective means of initiating an appropriate SAR response and providing an accurate location for rescue. We pointed out that in our *El Faro* casualty report we discussed that available 406-MHz PLBs determine location accuracy within 3 miles using the 406-MHz satellite system and have a low-power homing beacon that transmits on the 121.5-MHz frequency to help locate someone in need of rescue when the SAR asset arrives. Further, as was also discussed in the report, 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 believes these devices 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 an accurate location for rescue. The NTSB asked the Coast Guard to reconsider its conclusion regarding the suitability of modern 406-MHz PLBs. Pending a requirement that mariners use available SAR technologies, Safety Recommendation M-17-45 was classified "Open—Unacceptable Response." On September 16, 2022, the Coast Guard responded that it plans to publish an Advanced Notice of Proposed Rulemaking to gather feedback and explore all available options for new requirements related to PLBs or emergency distress communications.

1.12.2.3 Fishing Vessel *Ambition*

On January 30, 2018, the NTSB issued a report on the 2016 flooding and sinking of the fishing vessel *Ambition* (NTSB 2018). The NTSB found that in that casualty, which occurred in a remote area with limited radio coverage, a SEND prompted an immediate response from a commercial response center, which relayed information to the Coast Guard about the nature of the emergency and the position of the vessel.

1.12.2.4 Fishing Vessel *Scandies Rose*

On July 13, 2021, the NTSB reiterated Safety Recommendation M-17-45 in its report about the December 31, 2019, capsizing and sinking of the fishing vessel *Scandies Rose* (NTSB 2021).

1.12.2.5 Fishing Vessel *Blue Dragon*

On August 23, 2022, the NTSB issued a report on the November 10, 2021, fire aboard the fishing vessel *Blue Dragon* (NTSB 2022). The NTSB found that in that casualty, PLBs helped validate the position of the vessel's EPIRB, and a SEND helped responders identify the nature of the emergency.

1.12.2.6 Fishing Vessel *Emmy Rose*

On August 25, 2022, the NTSB again reiterated Safety Recommendation M-17-45 in its report about the November 23, 2020, sinking of the fishing vessel *Emmy Rose* (NTSB 2022).

1.13 Postcasualty Actions

Following the capsizing of the *SEACOR Power*, SEACOR Marine revised the EPIRB registrations for its remaining vessels to include the phone numbers for the company's DPA and alternate DPA, in addition to SEACOR Marine's main line number. The main line number has also been automated, with "EMERGENCY" as number 1 so that, when selected, the caller will be forwarded to the DPA or alternate DPA to respond. Finally, SEACOR Marine has contracted a third-party service provider for real-time vessel tracking services. SEACOR Marine shoreside employees have access to the service and can view a vessel's location as required.

2. Analysis

2.1 Introduction

On April 13, 2021, about 1537 local time, the US-flagged liftboat *SEACOR Power* capsized about 7 miles off the coast of Port Fourchon, Louisiana, in a severe thunderstorm. Eleven crew and eight offshore workers were aboard the liftboat. Vessels in the area reported heavy rain, winds exceeding 80 knots, and building seas at the time of the casualty. SAR efforts were hampered by 30- to 40-knot winds and 10- to 12-foot seas that persisted throughout the evening and into the next day. Six personnel were rescued by the Coast Guard and Good Samaritan vessels, and the bodies of six fatally injured personnel were recovered. Seven personnel were never found and are presumed dead. The vessel, valued at $25 million, was a total constructive loss.

The following analysis discusses the casualty sequence and evaluates the following safety issues:

- Gaps in forecasts and communications of weather events (section 2.2.2)
- The operation and stability of restricted-service liftboats in severe thunderstorms (sections 2.2.3 and 2.2.4)
- The effectiveness of the initial response to the capsizing (section 2.3.2)
- The difficulty in locating survivors in adverse weather and sea conditions (sections 2.3.2 and 2.3.3)

Having completed a comprehensive review of the circumstances that led to the casualty, the investigation established that the following factors did not contribute to its cause:

- *Mechanical and electrical systems.* Maintenance records and inspection and survey reports for the *SEACOR Power* indicated that the vessel was well maintained. The off-rotation chief engineer and the mate told investigators that there were no major mechanical or equipment issues during turnover on the day of the capsizing. No electrical issues were reported by the off-rotation crew or the survivors.
- *Watertight integrity.* The Coast Guard inspected the vessel's hull about a year before the casualty and found no discrepancies. A general condition survey conducted on February 17, 2021, less than a month before the

casualty, reported, "all hull and deck coatings were found to be in good order and well maintained with above average protection from the effects of saltwater service." Only the forward portion of the hull was recovered, having broken apart during salvage. The recovered portion showed no sign of hull penetration, forward of the salvage damage, but the entire hull could not be effectively examined. Although a cook reported water coming into the galley, it was 30 seconds to a minute before the capsizing. Given this short amount of time and the galley's location on the main deck, it is unlikely that this event resulted in a significant amount of water entering into the vessel. Further, the mate stated that, before the capsizing, no bilge alarms sounded, indicating that the vessel did not have a substantial loss of watertight integrity leading to flooding.

- *Crew experience and qualifications*. The captain was properly credentialed and had decades of experience operating vessels in the Gulf of Mexico. He had worked for SEACOR Marine for about 24 years as a crewmember and captain on liftboats. The mate was properly credentialed and had worked for SEACOR Marine for 17 years in various deck positions, up to and including mate. All other crewmembers on the vessel were qualified for and had experience commensurate with their positions.
- *Fatigue*. The crew had changed out on the morning of the casualty. Although they had arisen early that morning, they had been off rotation for a week before the voyage and had sufficient opportunity to rest. The capsizing occurred about 3.5 hours after leaving port during the first watch; thus, the crew was not subject to chronic fatigue that can occur over time when sleep patterns are interrupted while underway.

Thus, the NTSB concludes that none of the following were safety issues for the casualty voyage: (1) mechanical and electrical systems, (2) watertight integrity, (3) crew experience and qualifications, or (4) fatigue.

Because drug and alcohol testing of the entire surviving crew was not conducted, evidence was insufficient to determine whether alcohol or other drug use played a role in this casualty. (The drug and alcohol testing that was performed on one crewmember was negative.) Ethanol in the deceased crewmembers was most likely from postmortem production.

2.2 Weather and Operations

2.2.1 Decision to Get Underway

During the previous voyage, also for charterer Talos, the *SEACOR Power* (with a different crew) had stopped and jacked up to wait out the weather, delaying its arrival in Port Fourchon. Correspondence between SEACOR Marine and Talos regarding the vessel's follow-on schedule and departure did not indicate any concern for timing or the delay caused by the stoppage, and there were no penalties in the charter contract for time delays.

When the mate was asked if he ever felt pressured to perform an operation or if he ever witnessed captains being pressured to perform, he answered no. The off-rotation captain and chief engineer responded likewise to similar questions. Although the spouse of the deceased casualty-voyage captain said that he often felt pressure to "hurry up and get it done," he did not express any specific safety concerns to her.

Since 2014, the offshore oil industry on the Gulf Coast had been in a prolonged economic downturn, resulting in many support vessels being laid up and their crews laid off. SEACOR Marine's vessel utilization rate in 2021 was just 66%. In this scarce job market, crewmembers on active vessels may feel pressure to perform and accept more risk in order to preserve employment. However, there was no evidence that such pressure affected the captain's safe operation of the vessel. On two occasions in the year before the capsizing, the captain had stopped the vessel and jacked up to avoid weather. The mate stated that the captain was "never afraid to say no. I've seen him do it before when it's not safe." The NTSB concludes that commercial pressure was not a factor in the captain's decision to get underway.

The mate stated that the weather report emailed to the vessel by a SEACOR Marine shore-based employee on the morning of the capsizing, which forecasted winds 9-12 knots and 3-foot seas in the afternoon, was the primary information source that he and the captain used to determine that it was safe to get underway. The weather report was provided to the *SEACOR Power* and other company vessels once a day and contained wind, wave, and general condition information copied from the website of the commercial weather provider Buoyweather. The forecasted conditions were based on a location in the Gulf of Mexico selected by the shore-based employee and were not specific to any vessel in the SEACOR Marine fleet. After the weather report was emailed each day, the shore-based employee did not monitor the weather for the rest of the day, and no further weather information was provided to the vessels. NWS severe weather watches and warnings were not monitored by shore employees or transmitted by the company to its vessels.

Because weather conditions can change rapidly and vary across geographic areas, vessel crews should be provided timely, accurate, and location-specific forecasts and warnings. For vessels with limited stability, like the restricted-service liftboat *SEACOR Power*, the need for accurate weather data is critical to ensuring the safe operation of the vessel. The weather report SEACOR Marine provided to the *SEACOR Power* was neither timely nor accurate and was not tailored to the vessel's transit to Main Pass 138. The report's prediction of fair conditions likely gave the captain and crew a false sense that conditions would be benign throughout the day. The NTSB concludes that the weather forecast SEACOR Marine provided to the *SEACOR Power* crew on the morning of the capsizing was insufficient for making weather-related decisions about the liftboat's operation.

Thus, the NTSB recommends that SEACOR Marine ensure its vessel crews receive timely and accurate weather forecasts tailored to each vessel's location, including applicable NWS watch and warning products when they are issued.

Beginning at 0918 and continuing throughout the day, the NWS WFO in Slidell, Louisiana, issued severe thunderstorm "warnings" for various locations in southeastern Louisiana. Severe thunderstorm warnings are issued when these storms are occurring or imminent. They are generally more limited in both time and geographic area than thunderstorm watches, and they warn those in the path of the storm to take protective action. However, severe thunderstorm warnings are only issued for land areas, and the areas covered by the morning and early afternoon warnings were to the north of the Gulf and did not include southern Lafourche Parish, where Port Fourchon is located, until 1448, after the *SEACOR Power* had gotten underway.

Severe thunderstorm "watches" are issued when severe thunderstorms are possible; watches are usually in effect for 4 to 8 hours and are normally issued in advance of the actual thunderstorm activity. At 1205, just before the *SEACOR Power* left the dock and about 3.5 hours before the capsizing, the NWS Storm Prediction Center issued a severe thunderstorm watch for an area that included the route of the *SEACOR Power*. Although the watch notification included the possibility of wind gusts up to 70 mph (61 knots), the watch area covered a very large area extending across southeastern Louisiana and its coastal waters.

At 1218, when the *SEACOR Power* left the dock and proceeded out of Port Fourchon, a thunderstorm was not in the immediate vicinity and winds were light, as evident in harbor security camera videos. Further, the captain had not received the severe thunderstorm watch information. The *SEACOR Power* was not the only liftboat in the area to get underway in the early afternoon—the *Rockfish* also got underway about 1330 to move from one worksite to another. The *Rockfish* captain stated that, before getting underway, he and his crew had assessed the latest weather information and deemed it safe to get underway. The *Rockfish* arrived at its destination and jacked up before the thunderstorm moved through the area. Additionally, the *SEACOR Power* captain, like most liftboat captains, operated under the assumption that if weather deteriorated, the vessel could jack up out of the water. (Per the *SEACOR Power*'s COI, the liftboat was required to be capable of surviving 100-knot winds when jacked up.) The NTSB concludes that, given the conditions and the marine weather information available to the captain at the time the liftboat left Port Fourchon, the captain's decision to get underway on the day of the casualty was reasonable; although the captain was not aware of the severe thunderstorm watch, it likely would not have changed his decision.

The Slidell WFO was responsible for issuing SMWs (the product available to NWS forecasters for warning the public of severe thunderstorm conditions in coastal waters) for the casualty site. Before the capsizing, the WFO issued an SMW at 1457 CDT, about 40 minutes before the casualty, active for an area that included the *SEACOR Power*'s offshore route. However, the vessel did not receive the warning.

NAVTEX is the principal method for transmitting marine safety information, such as navigational and meteorological warnings and forecasts, to ships in coastal waters. The system functions as push notifications for mariners: shipboard NAVTEX receivers automatically receive information and will print out or display the transmission, ensuring that the transmission can be seen even if the NAVTEX receiver is not continuously monitored. However, the Coast Guard's New Orleans NAVTEX broadcast site was not operational between about 1000 and 1600 CDT on the casualty day. Because the broadcast station was not operational, the SMW issued by the NWS at 1457 was not broadcast nor received by the *SEACOR Power* via NAVTEX; Although the SMW was likely broadcast on NWR, the *SEACOR Power* crew was not aware that NAVTEX was not broadcasting, and they were not monitoring the weather radio. The NTSB concludes that because the Coast Guard's New Orleans NAVTEX site was not operational on the afternoon of the capsizing, the *SEACOR Power* crew did not receive the SMW and was not aware of the severity of thunderstorms that were approaching that afternoon. Because NAVTEX is an important source of critical weather and safety information, mariners should be informed when the system is not operational so that they can seek other means of obtaining this information. Thus, the NTSB recommends that the Coast Guard develop procedures to inform mariners in affected areas whenever there is an outage at a NAVTEX broadcasting site.

2.2.2 Forecasting Data

There were no real-time standard sources of surface wind conditions within about 25 miles upstream of the casualty location.[36] Although the areas of Port Fourchon and the casualty area were covered by two weather radars, neither radar could provide low-altitude wind velocity conditions along the *SEACOR Power*'s route.[37] The WSR-88D weather radar in Slidell, Louisiana (KLIX), was about 82 miles from the capsizing site, and the TDWR located about 15 miles west of New Orleans (TMSY) was about 62 miles from the capsizing site.

This lack of surface- and low-altitude data sources meant that the NWS WFO responsible for issuing SMWs for the casualty area did not have adequate data to accurately identify and forecast the area's surface wind conditions associated with the MCS. The NTSB concludes that data gaps, including a lack of low-altitude radar visibility over the Louisiana coastal areas, prevented the NWS office that issued the SMW for the casualty site area around the casualty time from identifying and forecasting the surface wind magnitudes that impacted the *SEACOR Power*.

A lower minimum-elevation angle for the KLIX radar would have allowed forecasters to provide better analyses of convective environments and low-level wind speed assessments over the portion of the Gulf that was heavily populated by offshore oil platforms. The NWS is scheduled to lower the KLIX radar tilt when the radar is relocated from Slidell to Hammond, Louisiana, in 2023. The NWS has confirmed the radar's low-altitude coverage will improve over the Port Fourchon area when the radar moves to Hammond because of the lower elevation angle.

[36] An Automated Weather Observing System was located at South Lafourche Leonard Miller Jr. Airport in Galliano, Louisiana, which was located about 27 miles north of the casualty location at sea level.

[37] KLIX provided wind speed for the accident area; however, because of the radar's distance from the casualty region, the wind detected over the casualty site was between 5,100 and 13,300 feet above msl.

Working with the NWS, the NTSB has identified certain WSR-88D radars owned by the NWS, the Federal Aviation Administration (FAA), or the US Air Force that could provide better (lower) radar coverage over coastal waters, if adjusted. (For a full list of the identified radar sites, see Appendix D: Coastal Radar Sites.) The NTSB concludes that lowering the angle of the lowest radar beam at selected coastal weather radar sites would improve low-altitude radar visibility over coastal waters and, therefore, improve forecasters' ability to accurately monitor, forecast, and notify the public of weather conditions.

While lowering radar beams can provide better low-altitude data for marine safety, it can result in sea clutter that could be difficult to remove or suppress and may negatively affect weather data for aviation or other users. In discussions with the NTSB, the FAA has indicated that they support working with the NWS on lowering radar beams where sea clutter is not an issue or can be mitigated.

NOAA, the parent agency of the NWS, is required by the National Environmental Policy Act to analyze the potential environmental consequences of lowering a radar beam. This environmental assessment, which is the first step required to lower the radar beam, evaluates the potential benefits and environmental consequences of a lower weather radar beam, determines their significance, and develops measures to mitigate adverse impacts, if necessary. The NTSB recommends that the NWS, in collaboration with the FAA and the Air Force, determine if it is appropriate to lower the radar angle for coastal weather radar sites without compromising aviation safety or other products, and lower the radar angle at those sites where it is appropriate. Further, the NTSB recommends that the FAA and the Air Force work with the NWS to determine if it is appropriate to lower the radar angle for coastal weather radar sites without compromising aviation safety or other products, and lower the radar angle at those sites where it is appropriate.

2.2.3 Stability and Capsizing

In 2002, ABS reviewed the *SEACOR Power*'s stability for regulatory compliance, as well as for compliance with ABS rules. ABS's analysis during the review used the prescribed regulatory wind speeds for liftboats in restricted service (60 knots for normal operations and 70 knots for severe storm conditions), with the vessel in calm water, and considered the vessel in both the 250- and 265-foot configurations. ABS determined that the *SEACOR Power* met all applicable regulatory stability criteria, for both leg lengths and from all assessed wind directions, and issued the vessel a stability review letter. After the *SEACOR Power*'s legs were lengthened in 2012, ABS confirmed that stability information relevant to the 265-foot legs was included in the liftboat's operations manual. After other changes to the operations manual, a revised stability review letter was issued in 2014.

In its postcasualty analysis of the *SEACOR Power*, the Coast Guard MSC confirmed that, using the standard method of calculation used in 2002 (fixed-axis method), the liftboat met regulatory intact stability criteria for maximum AVCG for the vessel at zero trim (even keel) for three of the four stability criteria. For the fourth criterion, range of stability, the vessel passed regulatory standards for all wind directions, except for two cases with the wind 15° off either side of the bow. In these two directions, the vessel passed the regulatory requirements at 8.5 feet of draft. For drafts of 9 feet and greater, the vessel failed the regulatory minimum of 10° of range. The worst failure was at 10 feet of draft with 8.9° of range. The MSC noted that the difference in outcomes between the 2002 ABS stability review analysis (also fixed-axis), which met all conditions, and MSC's postcasualty fixed-axis analysis, which resulted in failures along two axes off the bow, may have been the result of different modeling treatments for the *SEACOR Power*'s helipad.

Using the more recently developed varied-axis method of analysis, which allowed the vessel to yaw as it inclined (more closely approximating real-world conditions), MSC found that the *SEACOR Power* met regulatory intact stability criteria for all wind directions.

The *SEACOR Power* passed all stability criteria for 22 of 24 wind direction axes evaluated in the postcasualty MSC fixed-axis analysis. In the two remaining axes, it passed 3 of 4 criteria, only narrowly failing the range criterion. For the 2002 ABS fixed-axis analysis and the postcasualty MSC varied-axis analyses, the vessel passed all criteria from all wind directions. Considering the results of all analyses, the NTSB concludes that, as designed, the *SEACOR Power* met applicable intact stability criteria.

In the minutes before the capsizing, the *SEACOR Power* was engulfed by a mesoscale thunderstorm system described by the NWS as "unusually intense." Wind speeds recorded at vessels and fixed facilities closest to the casualty were between 70 and 94 knots, at various anemometer heights, and the NWS determined that wind gusts likely reached 80 knots or greater (5-second average) at 32.8 feet (10 meters) above the water, and above 90 knots at 300 feet (91.4 meters). Seas were a maximum of 4 feet, based on predictions and survivor testimony.

The *SEACOR Power* met stability criteria when subjected to the maximum wind thresholds in the regulations (70 knots) in calm seas, but actual winds during the capsizing were above the regulatory threshold, with gusts to 80 knots. The ABS CFD analysis found that, with the *SEACOR Power* in the casualty loading condition (9 feet 3 inches load line draft with 2.5 feet of trim by the stern; legs lowered 10 feet), the vessel was vulnerable to capsizing with winds off the beam and seas at 4 feet (see Figure 24). Although the storm initially hit the *SEACOR Power* from astern, the mate turned the liftboat to port in an attempt to put the bow into the wind and slow the vessel down to soft tag the bottom. This maneuver put the winds on the vessel's port beam. The CFD model of the vessel capsized in 80-knot winds when the wind direction was just forward of the port beam (285° relative) and swells of 4 feet were coming from off the starboard bow (023° relative). The CFD model of the vessel also capsized when these wind and swell conditions were combined with wind-generated waves moving in the same direction as the winds.

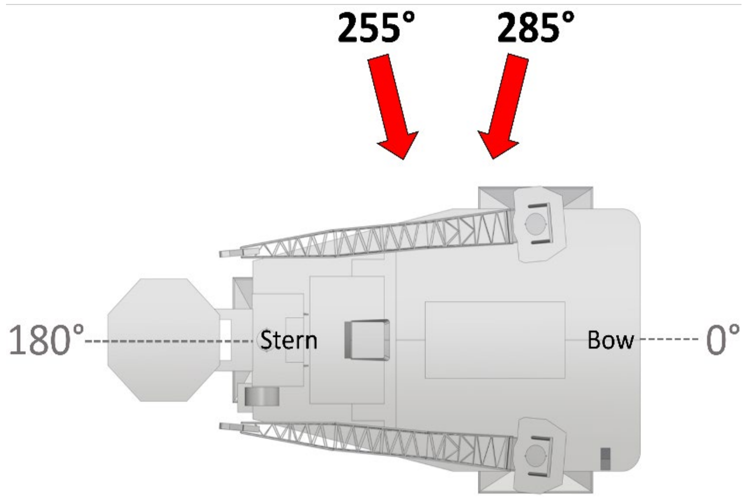

Figure 24. Most vulnerable wind direction axes for port side of the *SEACOR Power* as determined by CFD analysis.

The NTSB concludes that the *SEACOR Power* capsized when it was struck by severe thunderstorm winds that exceeded the vessel's operational wind speed limits and, when combined with sea conditions, resulted in a loss of stability.

Other operational factors may also have played a role in the capsizing. The *SEACOR Power* departed Port Fourchon with 2 feet 6 inches of trim by the stern. However, the SMS and several sections of the operations manual included guidance to the master to maintain the vessel at even trim, and the form for calculating stability provided in the operations manual advised that "the vessel afloat should have no more than 6 [inches] of trim by the stern." These instructions indicate that the vessel, as designed, was intended to be operated at or near level trim. Notably, stability calculations prepared during the construction of the vessel only included data for the vessel at even keel (even trim).

The MSC's analysis of the *SEACOR Power* at the time of the casualty (draft 9.25 feet, trim 2.5 feet by the stern, with legs down 10 feet) found that the vessel met the regulatory stability criteria. However, the MSC's analysis also showed that, with increasing aft trim, the vessel's stability criteria of ratio, range, area, and GM generally decreased. In other words, as the vessel was trimmed by the stern, the margin of positive stability decreased, most notably with winds off the beam of the vessel. Therefore, although the *SEACOR Power* met stability criteria at the time of the casualty, the vessel's trim by the stern decreased the vessel's ability to resist capsizing.

The SEACOR Marine SMS directed crews to minimize excessive trim and "fully comply with stability documentation," which would have included the stability guidance and calculations in the operations manual. As noted above, the *SEACOR Power*'s Marine Operations Manual contained several statements regarding the requirement to maintain even trim, either by cargo loading or ballasting. The stability calculation worksheet explicitly noted that the vessel should have had no more than 6 inches of trim by the stern.

However, the mate and the off-rotation captain and chief engineer indicated that the vessel was regularly operated with trim by the stern, as it was on the casualty voyage. The off-rotation captain stated that the Excel spreadsheet that was used to calculate stability would indicate that the vessel's trim exceeded the maximum trim by the stern specified in the operations manual but that this limitation was "not reasonable." He stated that the excess trim was "to be expected." The captain of the *SEACOR Power* was likely aware that the vessel was operating outside of the aft trim limitation—the stability calculation spreadsheet would have indicated so—and the testimony of the off-rotation crew indicated that the crew also was aware. Based on the statements by several of the *SEACOR Power* crewmembers, the practice of operating outside of trim limitations had been normalized.

Therefore, the NTSB concludes that operation of the *SEACOR Power* with trim by the stern that exceeded the limit specified in the operating manual, stability documentation, and other required guidance was an accepted practice by vessel crews. To ensure the remaining liftboats are not similarly affected, the NTSB recommends that SEACOR Marine conduct a comprehensive review of its active fleet to ensure its vessels are being operated strictly within the limits specified in operating manuals, stability documentation, and other required guidance.

In addition to trim by the stern, the *SEACOR Power*'s port turn and the movement of its legs may have played a role in the capsizing. On most vessels, a turn will induce a heel in the opposite direction of the turn. (For example, a port turn will induce a starboard heel.) Although crewmembers stated that the *SEACOR Power* was not prone to heeling significantly in a turn, a small amount of heel from the port turn could have contributed to the eventual loss of stability. Additionally, the vessel speed when it began the turn was about 8 knots, which was higher than the speeds that the liftboat typically operated and could have increased heel. Further, the *SEACOR Power*'s cargo had not been lashed down to the deck and could have shifted, altering the liftboat's center of gravity just before the capsizing. The mate stated that he did not see the cargo move until the vessel was already rolling, but even a small undetected shift would have affected the vessel's stability. Finally, in previous encounters with storms, the captain had noted "whipping" of the legs in high winds. If the *SEACOR Power* legs had experienced whipping in the storm that hit it on April 13, it is possible that this motion also had a negative impact on stability. The NTSB concludes that the *SEACOR Power*'s trim by the stern, its turn to port and speed through the water, a cargo shift, and movement of the vessel's legs may have contributed to the vessel's capsizing.

2.2.4 Restricted-Service Liftboat Stability

Liftboats designed for restricted service are particularly vulnerable to high winds. By the nature of their shallow hull and tall legs (when raised underway), they have a higher center of gravity than most vessels and limited stability when afloat. Although liftboats can jack up to escape dangerous conditions, the process takes several minutes to a half hour, depending on the jacking rate and water depth. In addition, restricted-service liftboats like the *SEACOR Power* may traverse waters deeper than they can jack up.

The *SEACOR Power* crew did not receive the SMW issued at 1457 for the coastal area where the *SEACOR Power* was transiting. However, if they had, it is unlikely that the captain would have stopped and jacked up the vessel before the storm approached the *SEACOR Power.* Thunderstorms are common in the Gulf Coast region, and a thunderstorm forecast alone has not traditionally precluded liftboat operations, unless strong winds and heavy seas are directly impinging on a vessel. The captain's decision to proceed with the transit while the storm approached, under the assumption that he could jack the vessel up if conditions deteriorated to near the vessel's operational limits, was consistent with normal liftboat operations.

This casualty demonstrates, however, the limitations of relying on jacking up as a safety measure, since there may not be enough time to jack up during a thunderstorm. Embedded phenomena such as downbursts can form quickly, and even generally well-identified and analyzed thunderstorms that do not initially exhibit dangerous characteristics can produce damaging winds that exceed the predicted values. The surest way that the *SEACOR Power* capsizing could have been prevented was for the captain and mate to have jacked up the vessel before the thunderstorm arrived.

To prevent a similar capsizing, restricted-service liftboat operators must take earlier action when a severe thunderstorm approaches, and the NWS SMW can provide operators with the timely notification they need. SMWs are issued for severe thunderstorms that are predicted to produce winds of 34 knots or greater, 0.75-inch or larger hail, and/or waterspouts. As noted above, storms forecasted to have winds 34 knots or greater can produce much higher winds, and high winds are often present with hail and waterspouts. An SMW is issued for a short duration, 2 hours or less, unless the dangerous conditions are still present and the warning is extended. Finally, SMWs are issued for limited geographic areas defined by specific latitude and longitude points. The NTSB concludes that, due to the unpredictability of localized thunderstorm phenomena and the vulnerability of restricted-service liftboats in these storms, operating a restricted-service liftboat in the afloat mode at any time when an SMW has been issued for the vessel's planned route increases its risk of capsizing. Thus, the NTSB recommends that SEACOR Marine revise its restricted-service liftboat SMS and operations manuals to require the vessel to remain in port or jack up when an SMW has been issued for the vessel's planned route.

The Offshore Marine Service Association (OMSA) represents the offshore service industry in the United States, including about 60 companies that own and operate marine service vessels. OMSA "provides its members with effective tools to ensure the safety, security and environmental responsibility of their vessels and crew in compliance with government and industry standards." As the industry representative, OMSA is well positioned to inform members about this casualty and share information about safe operations during severe thunderstorms. The NTSB recommends that the OMSA inform its members of the circumstances of this capsizing and encourage them to implement policies to stop afloat operations for restricted-service liftboats when an SMW has been issued for the vessel's planned route.

As noted, the Coast Guard's postcasualty stability analysis verified the vessel met stability regulations as designed and as sailed with aft trim. However, the CFD analysis of the vessel in winds and waves like those encountered during the casualty found that the vessel could capsize in winds of 80 knots—just 10 knots above the 70-knot threshold for severe-storm wind speed used to calculate regulatory intact stability for a liftboat in restricted service.

Although stability criteria include a margin of safety, the margin was overcome by the thunderstorm conditions in the capsizing of the *SEACOR Power*. Operational adjustments, such as jacking up when a SMW is issued, can mitigate the risk of capsizing, but there are significant limitations—for example, liftboats transiting over deeper water cannot jack up or soft tag to avoid forecasted weather and may not be able to reach water shallow enough to jack up in time. Restricted-service liftboats are allowed 12 hours to reach safe harbor in the regulations, but severe thunderstorms can form in much shorter time. These factors reveal that the current regulatory stability requirements are not sufficient.

An increase in stability would give restricted-service liftboats a greater ability to resist capsizing (loss of stability) while afloat in winds and seas that may occur during a sudden thunderstorm. Therefore, the NTSB concludes that increasing minimum stability criteria for liftboats in restricted service would improve vessel survivability in severe thunderstorms.

Vessel designers and operators ensure that their ships meet the minimum required regulatory stability standards. Modifications of a vessel's hull, tankage, structure, and cargo capacity to change its stability characteristics are often not feasible on existing vessels. However, the Coast Guard can require that new vessels be designed to increased minimum stability standards. This could be accomplished by increasing minimum requirements for individual stability criteria currently in the regulations (righting arm to inclining arm ratio, range of stability, residual energy area, and GM), or by other methods as determined by Coast Guard or other stakeholders with expertise in vessel stability, such as ABS. Therefore, the NTSB recommends that the Coast Guard modify restricted-service liftboat stability regulations to require greater stability for newly constructed restricted-service liftboats.

2.3 Survival Factors

2.3.1 Vessel Egress

When the *SEACOR Power* capsized to starboard, all starboard exterior doors became immediately submerged and could not be used for egress. The accommodations flooded quickly following the capsizing. The port side and its exterior doors were then above survivors as they exited their staterooms, and they described the water rising below them in the athwartship passageway.

The crew had little to no warning of the capsizing. Survivors reported being unable to negotiate the now vertical passageways and being unable to open doors that were now vertical hatches. In one stateroom, fallen lockers blocked the door and the two occupants had to find a second egress, one through the window, the other through a 10-inch crawl space in the overhead. Three survivors egressed through two different stateroom windows after breaking them, with difficulty, using fire extinguishers. Although the vessel was fully outfitted with flares, handheld GMDSS radios, and a line-throwing apparatus, the lifesaving equipment was stored on the bridge and neither the captain nor the mate were able to reach them during the capsizing.

Of the 19 personnel on board the vessel, only 9 were known to have survived the initial capsizing and reached doors to get to the exterior of the vessel. Based on the liftboat's angle of capsizing and survivor accounts of their escape from the vessel, the NTSB concludes that the speed at which the vessel capsized and angle at which it came to rest made egress difficult and likely contributed to the fatalities.

2.3.2 Response Delays

The first indication ashore of the capsizing was the EPIRB alert at 1540, about 4 minutes after the capsizing, which was relayed to Coast Guard RCC watchstanders 2 minutes later. This first alert did not include a position for the *SEACOR Power*.

After receiving the first signal, the RCC continued to work on resolving other distress calls. The RCC had been "very heavily inundated with potential distress calls from both commercial and recreational vessels" and was resolving seven cases before the *SEACOR Power* capsized. Per procedure, watchstanders first attempted to contact the vessel's operator.

In the time between the first EPIRB alert and the call to SEACOR Marine (about 27 minutes after receiving the first alert), the RCC had received six additional EPIRB alerts from the *SEACOR Power* that included the vessel's location. The MEOSAR alerts with position information indicated the vessel was offshore, as did the *SEACOR Power*'s last recorded AIS transmission at 1539:32.

When the RCC watchstander contacted a shore-based employee at SEACOR Marine, the employee told the Coast Guard that the *SEACOR Power* was moored in Port Fourchon and that he would follow up with an email to the vessel. This conflicted with the EPIRB and AIS location information available to the watchstander and should have raised doubt about the situation. However, instead of correlating with other available data, the watchstander accepted the SEACOR Marine employee's report, and the RCC turned its attention other alerts. The NTSB concludes that the Coast Guard RCC did not effectively use available information to verify the validity of the location of the *SEACOR Power*'s EPIRB alerts, which led to a delay in dispatching SAR units and notifying Good Samaritan vessels of the emergency.

The SEACOR Marine employee who responded to the Coast Guard regarding the *SEACOR Power*'s EPIRB alert was working in a warehouse at the time of the call and did not have ready access to location information for the vessel or a way to quickly contact the vessel to confirm its status. Consequently, the employee provided erroneous information to the RCC watchstander, misleading the watchstander about the vessel's status. The NTSB concludes that inaccurate information about the *SEACOR Power*'s location provided to the Coast Guard by a SEACOR Marine employee when contacted regarding the vessel's EPIRB alert contributed to the delayed response.

When contacted by the Coast Guard regarding an EPIRB alert, company representatives must have the training and resources necessary to respond with accurate information to support rescue efforts. The contact number listed on the SEACOR Marine EPIRB registration was for a main office reception line. The employee who responded to the call was in an entry level position and had received no training on EPIRBs. He was not aware of standardized procedures for responding to vessel emergencies and received no notifications when vessels departed port. His job responsibilities included working in a warehouse, which took him away from the office and access to the vessel location data. The NTSB concludes that SEACOR Marine did not have adequate procedures nor did it provide its staff with training for responding to the Coast Guard when contacted regarding EPIRB alerts.

Following the capsizing, SEACOR Marine revised its procedures and phone system to ensure calls from the Coast Guard about EPIRB alerts are directly routed to the company's designated person ashore and alternate person ashore for response. Company employees also have access to a vessel tracking service that provides current location information on any vessel in the fleet.

An earlier determination that the *SEACOR Power* EPIRB alert was, in fact, a real emergency would have allowed for earlier dispatch of SAR units and notification to other vessels in the area via a UMIB. Having response assets in place sooner could have led to the rescue of additional personnel, had any others escaped the vessel or entered the water immediately after it capsized.

Weather conditions on scene at the time were severe and led to additional delays in rescue operations. The closest Coast Guard helicopters, based at Air Station New Orleans and at ATC Mobile, were grounded by the same weather event that occurred along the *SEACOR Power*'s route. Bristow's rescue-capable AW-139 helicopters were located closer to the scene, where different weather conditions were present. Bristow offered assistance to the Coast Guard at 1856, but by the time a commercial helicopter was on scene, the *SEACOR Power* had settled, seas had built, and the winds had veered, creating a risk of hoist entanglement.

The Coast Guard has a long-established practice of using radio broadcasts, known as UMIB or Marine Assistance Request Broadcasts, to alert mariners to nearby vessels in distress. *Rockfish*'s VHF call and the repeated UMIB's by Sector New Orleans summoned many OSVs to the scene, four of which rescued *SEACOR Power* crew and offshore workers. However, unlike this mechanism for enlisting the assistance of commercial and private vessels, there was no formal mechanism for employing air rescue providers in SAR operations. Had Bristow or other air resources also been on scene sooner, they may have been able to rescue personnel from the vessel. The Gulf of Mexico energy industry is supported by commercial air rescue operators, but the Coast Guard's Mass Rescue Operations Plan does not list those resources that may be available. If it did, Coast Guard personnel would have a clear procedure in place to reach additional air resources. Thus, the NTSB concludes that a detailed procedure in Coast Guard mass rescue operations plans combined with mutual aid agreements between the Coast Guard and air rescue providers would improve and expand SAR capabilities for future casualties. Therefore, the NTSB recommends that the Coast Guard develop procedures to integrate commercial, municipal, and non-profit air rescue providers into Sectors' and Districts' mass rescue operations plans, when appropriate.

On-scene vessels reported 45-knot winds and 10- to 12-foot seas during the late afternoon and evening. Additionally, with the *SEACOR Power*'s bow and port side exposed, the starboard and aft legs, the cranes, the crane boom rest, the helipad, and much of the superstructure was underwater. Some of the obstructions were just below the surface of the water and exposed in the trough of each swell. Survivors clung to the vessel on the same side as the obstructions and the weather. From downwind on the opposite side, vessels could only see the bottom of the *SEACOR Power's* hull, which had settled past 90° to about 114°. The *Glen Harris*'s captain stated he could not approach closer than 450 feet. The *Glen Harris* launched a small boat and almost immediately recalled it due to the seas. The Coast Guard RB-M approached to within a boat length to rescue AB 1 from the water, but risked entanglement or hard contact that would have endangered the rescue crew.

After the capsizing, survivors who were still on the vessel gathered on the bulkhead of what was the port superstructure. Strong winds caused seas to build, and survivors on the superstructure were exposed to the 62° air temperature. Port handrails and engine exhausts above the survivors precluded a helicopter rescue without risk of entangling the helicopter's cable and/or rescue swimmer. Diesel fuel, debris, and obstructions made both sheltering on the vessel and entering the water dangerous. Three of the five chose to enter the water or were swept overboard, two of whom survived. The NTSB concludes that high winds and heavy seas, combined with underwater and overhead obstructions, prevented both surface and air resources from getting close enough to the vessel to rescue personnel directly from the wreck, which contributed to the loss of life.

2.3.3 Personal Locator Beacons

The smaller liftboat *Rockfish* had arrived at its assigned worksite earlier in the day and jacked up about 1.1 miles away from where the *SEACOR Power* capsized. The crew noticed the *SEACOR Power*'s AIS signal disappear and initially believed it was weather related, such as an antenna casualty. As visibility improved, they saw that the *SEACOR Power* had capsized. The *Rockfish* master quickly requested help from a field boat and notified Coast Guard Sector New Orleans of the casualty at 1628 (about 46 minutes after the first EPIRB alert was received at the RCC).

At 1640, in response to the *Rockfish* captain's VHF distress call, the Sector Command Center broadcasted a UMIB requesting other vessels' assistance, an hour after the first EPIRB signal. Although Coast Guard air resources were grounded, 15 to 20 boats responded to the *Rockfish*'s distress call or the UMIB; the first vessel arrived on scene at 1630, just minutes after the call. The *Rockfish*'s call to Good Samaritans and to Sector New Orleans, followed by the Coast Guard's UMIB, directly resulted in the rescue of four individuals (OW 1, the mate, the well site supervisor, and the night captain), who had jumped into the seas and had drifted away from the wreck, and two individuals clinging to the wreck (OW 2 and AB 1).

PLBs are smaller and less expensive than EPIRBs and are used by personnel on board vessels. Unlike an EPIRB, which is designed to activate when it floats free in the water, a PLB is carried by a crewmember and must be manually activated. If vessel crewmembers have PLBs and manually activate them as soon as a vessel capsizes or sinks, rescuers are notified, even if the EPIRB fails to float free or activate. Additionally, if activated PLBs are carried by crewmembers, their positions, either remaining on board or drifting in the water are available throughout SAR operations.

The NTSB's recent investigation report about the November 10, 2021, fire aboard the fishing vessel *Blue Dragon* found that SAR controllers were able to correlate location data from multiple emergency beacons. Similarly, the NTSB's investigation of July 23, 2016, sinking of the commercial fishing vessel *Ambition* found that use of the vessel's SEND prompted an immediate response from the commercial response center when the Coast Guard did not receive the captain's Mayday call. Given the previous NTSB findings on the proven use of both PLBs and SENDs and their capability to derive and transmit a GNSS position, the NTSB concludes that mariners have benefited from their employers voluntarily providing PLBs or SENDs.

The Coast Guard did not receive any PLB alerts from *SEACOR Power* personnel, and the NTSB did not find evidence that anyone aboard *SEACOR Power* had a PLB with them. The well site supervisor, night captain, and mate drifted for 2.5 hours or more before they were rescued. Although they were eventually found, the longer a person remains in the water, the lower the chances of survival. Had they been equipped with PLBs, it is likely they would have been recovered earlier. Furthermore, if multiple PLBs had alerted in the immediate aftermath of the capsizing, the RCC could have correlated their information with the *SEACOR Power*'s EPIRB. The NTSB concludes that had the crewmembers of the *SEACOR Power* been required to carry PLBs on board, as recommended in Safety Recommendation M-17-45, and had they been activated when abandoning the vessel, SAR crews would have had continuously updated and correct coordinates of individual crewmembers' locations, enhancing their chances of being rescued. Therefore, the NTSB reiterates Safety Recommendation M-17-45. Additionally, the NTSB recommends that OMSA notify its members of the availability and benefits of PLBs. The mate had grabbed one of two SARTs when he egressed the *SEACOR Power* and turned it on after he was washed off by the seas. However, responders stated they never saw the SART's signal appear on their radars, even though the mate stated he saw the light on the device illuminate, indicating that the device was being interrogated by a vessel's radar. SARTs work best when they are at least 1 meter (3.3 feet) above the water—in order to accomplish this, a telescoping pole was available for the make and model aboard the *SEACOR Power*. However, telescoping poles were sold separately by SEACOR Marine's vendor and were not purchased with the SARTs for the *SEACOR Power*. The mate, therefore, did not have a way to hold the SART at optimal height above water, which likely delayed his rescue. During postcasualty testing of the *SEACOR Power*'s SART with a Coast Guard response boat and fire department boat, the NTSB found that crews were able to see the SART signal only after familiarization with procedures addressing radar gain, clutter, and range settings. Follow-on testing with Coast Guard aircraft was also successful after training the air crews what to look for. Crews of Coast Guard vessels and aircraft and Good Samaritan vessels responding to the *SEACOR Power* capsizing may not have been trained to tune their radars for optimal detection. The NTSB concludes that, although not causal to the fatalities and despite functioning as designed, the SART held by the mate in the water was not effective in signaling vessels or aircraft due to high seas, no means to hold the device high enough above the water, and lack of rescuer training.

The SART is optimized for use in locating liferafts, lifeboats, or distressed vessels. It is not designed to perform the function of alerting SAR units of the location of a single mariner in distress. A PLB is designed for this function and, as noted above, is recommended equipment for mariners. Further, AIS-SARTs, which have been approved equipment since 2007, alleviate the need for radar tuning for detection. Although AIS-SARTs are currently optional, their usage will likely proliferate as devices are replaced over time.

3. Conclusions

3.1 Findings

1. None of the following were safety issues for the casualty voyage: (1) mechanical and electrical systems, (2) watertight integrity, (3) crew experience and qualifications, or (4) fatigue.

2. Commercial pressure was not a factor in the captain's decision to get underway.

3. The weather forecast SEACOR Marine provided to the *SEACOR Power* crew on the morning of the capsizing was insufficient for making weather-related decisions about the liftboat's operation.

4. Given the conditions and the marine weather information available to the captain at the time the liftboat left Port Fourchon, the captain's decision to get underway on the day of the casualty was reasonable; although the captain was not aware of the severe thunderstorm watch, it likely would not have changed his decision.

5. Because the Coast Guard's New Orleans navigational telex site was not operational on the afternoon of the capsizing, the *SEACOR Power* crew did not receive the Special Marine Warning and was not aware of the severity of thunderstorms that were approaching that afternoon.

6. Data gaps, including a lack of low-altitude radar visibility over the Louisiana coastal areas, prevented the National Weather Service office that issued the Special Marine Warning for the casualty site area around the casualty time from identifying and forecasting the surface wind magnitudes that impacted the *SEACOR Power*.

7. Lowering the angle of the lowest radar beam at selected coastal weather radar sites would improve low-altitude radar visibility over coastal waters and, therefore, improve forecasters' ability to accurately monitor, forecast, and notify the public of weather conditions.

8. As designed, the *SEACOR Power* met applicable intact stability criteria.

9. The *SEACOR Power* capsized when it was struck by severe thunderstorm winds that exceeded the vessel's operational wind speed limits and, when combined with sea conditions, resulted in a loss of stability.
10. Although the *SEACOR Power* met stability criteria at the time of the casualty, the vessel's trim by the stern decreased the vessel's ability to resist capsizing.
11. Operation of the *SEACOR Power* with trim by the stern that exceeded the limit specified in the operating manual, stability documentation, and other required guidance was an accepted practice by vessel crews.
12. The *SEACOR Power*'s trim by the stern, its turn to port and speed through the water, a cargo shift, and movement of the vessel's legs may have contributed to the vessel's capsizing.
13. Due to the unpredictability of localized thunderstorm phenomena and the vulnerability of restricted-service liftboats in these storms, operating a restricted-service liftboat in the afloat mode at any time when a Special Marine Warning has been issued for the vessel's planned route increases its risk of capsizing.
14. Increasing minimum stability criteria for liftboats in restricted service would improve vessel survivability in severe thunderstorms.
15. The speed at which the vessel capsized and angle at which it came to rest made egress difficult and likely contributed to the fatalities.
16. The Coast Guard Rescue Coordination Center did not effectively use available information to verify the validity of the location of the *SEACOR Power*'s emergency position indicating radio beacon alerts, which led to a delay in dispatching search and rescue units and notifying Good Samaritan vessels of the emergency.
17. Inaccurate information about the *SEACOR Power*'s location provided to the Coast Guard by a SEACOR Marine employee when contacted regarding the vessel's emergency position indicating radio beacon alert contributed to the delayed response.

18. SEACOR Marine did not have adequate procedures nor did it provide its staff with training for responding to the Coast Guard when contacted regarding emergency position indicating radio beacon alerts.

19. A detailed procedure in Coast Guard mass rescue operations plans combined with mutual aid agreements between the Coast Guard and air rescue providers would improve and expand search and rescue capabilities for future casualties.

20. High winds and heavy seas, combined with underwater and overhead obstructions, prevented both surface and air resources from getting close enough to the vessel to rescue personnel directly from the wreck, which contributed to the loss of life.

21. Mariners have benefited from their employers voluntarily providing personal locator beacons or satellite emergency notification devices.

22. Had the crewmembers of the *SEACOR Power* been required to carry personal locator beacons on board, as recommended in Safety Recommendation M-17-45, and had they been activated when abandoning the vessel, search and rescue crews would have had continuously updated and correct coordinates of individual crewmembers' locations, enhancing their chances of being rescued.

23. Although not causal to the fatalities and despite functioning as designed, the search and rescue transponder held by the mate in the water was not effective in signaling vessels or aircraft due to high seas, no means to hold the device high enough above the water, and lack of rescuer training.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the capsizing of the liftboat *SEACOR Power* was a loss of stability that occurred when the vessel was struck by severe thunderstorm winds, which exceeded the vessel's operational wind speed limits. Contributing to the loss of life on the vessel were the speed at which the vessel capsized and the angle at which it came to rest, which made egress difficult, and the high winds and seas in the aftermath of the capsizing, which hampered rescue efforts.

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:

Develop procedures to inform mariners in affected areas whenever there is an outage at a navigational telex broadcasting site. (M-22-6)

Modify restricted-service liftboat stability regulations to require greater stability for newly constructed restricted-service liftboats. (M-22-7)

Develop procedures to integrate commercial, municipal, and non-profit air rescue providers into Sectors' and Districts' mass rescue operations plans, when appropriate. (M-22-8)

To the National Weather Service:

In collaboration with the Federal Aviation Administration and the US Air Force, determine if it is appropriate to lower the radar angle for coastal weather radar sites without compromising aviation safety or other products, and lower the radar angle at those sites where it is appropriate. (M-22-9)

To the Federal Aviation Administration and the US Air Force:

Work with the National Weather Service to determine if it is appropriate to lower the radar angle for coastal weather radar sites without compromising aviation safety or other products, and lower the radar angle at those sites where it is appropriate. (M-22-10)

To the Offshore Marine Service Association:

Inform your members of the circumstances of this capsizing and encourage them to implement policies to stop afloat operations for restricted-service liftboats when a Special Marine Warning has been issued for the vessel's planned route. (M-22-11)

Notify your members of the availability and benefits of personal locator beacons. (M-22-12)

To SEACOR Marine:

Ensure your vessel crews receive timely and accurate weather forecasts tailored to each vessel's location, including applicable National Weather Service watch and warning products when they are issued. (M-22-13)

Conduct a comprehensive review of your active fleet to ensure your vessels are being operated strictly within the limits specified in operating manuals, stability documentation, and other required guidance. (M-22-14)

Revise your restricted-service liftboat safety management systems and operations manuals to require the vessel to remain in port or jack up when a Special Marine Warning has been issued for the vessel's planned route. (M-22-15)

4.2 Previously Issued Recommendations Reiterated in This Report

The National Transportation Safety Board reiterates the following safety recommendation.

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: October 18, 2022

Appendixes

Appendix A: Investigation

The National Transportation Safety Board (NTSB) was the lead federal agency in this investigation. The NTSB was notified of this casualty on April 14, 2021. The next day, NTSB Vice Chairman Bruce Landsberg, three marine casualty investigators, two Transportation Disaster Assistance specialists, and support staff arrived on scene in Houma, Louisiana. The investigative team consisted of specialists in vessel operations, survival factors, and emergency response. The team was further supported by a meteorologist, a mechanical engineer, and a physician from the staff.

While on scene, investigators interviewed the six survivors of the casualty, casualty witnesses, Coast Guard responders and watchstanders, company representatives, classification society surveyors, and vessel inspectors. In addition, investigators gathered documentation relevant to the casualty. After returning from the scene, investigators interviewed National Weather Service personnel and other subject matter experts and reviewed additional documentary evidence.

From August 2 to 13, 2021, the Coast Guard conducted a formal hearing (Marine Board of Investigation) into the casualty. During the hearing, Coast Guard and NTSB investigators questioned 29 individuals, including survivors, first responders, company representatives, a National Weather Service forecaster, classification society surveyors, naval architects, and Coast Guard personnel.

To support the investigation, the American Bureau of Shipping, with oversight by the NTSB and support from the Coast Guard, conducted a stability analysis of the casualty vessel using computational fluid dynamics and other applications. Additionally, with the assistance of the manufacturer and the Norwegian Safety Investigation Authority, the NTSB conducted testing of survival equipment used on the vessel.

The Coast Guard, SEACOR Marine LLC, the National Weather Service, and the American Bureau of Shipping were parties to the investigation.

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-22-6
Develop procedures to inform mariners in affected areas whenever there is an outage at a navigational telex broadcasting site.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.2.1, Decision to Get Underway. Information supporting (b)(1) can be found on pages 82-84; (b)(2) can be found on pages 83-84; and (b)(3) is not applicable.

M-22-7
Modify restricted-service liftboat stability regulations to require greater stability for newly constructed restricted-service liftboats.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.2.4, Restricted-Service Liftboat Stability. Information supporting (b)(1) can be found on page 92; (b)(2) can be found on page 92; and (b)(3) is not applicable.

M-22-8

Develop procedures to integrate commercial, municipal, and non-profit air rescue providers into Sectors' and Districts' mass rescue operations plans, when appropriate.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.2, Response Delays. Information supporting (b)(1) can be found on page 95; (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 sections 1.12.2, EPIRBs and PLBs, and 2.3.3, Personal Locator Beacons. Information supporting (b)(1) can be found on pages 96-97; (b)(2) can be found on page 97; and (b)(3) can be found on pages 76-79.

To the National Weather Service:

M-22-9

In collaboration with the Federal Aviation Administration and the US Air Force, determine if it is appropriate to lower the radar angle for coastal weather radar sites without compromising aviation safety or other products, and lower the radar angle at those sites where it is appropriate.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.2.2, Forecasting Data. Information supporting (b)(1) can be found on pages 85-86; (b)(2) can be found on page 86; and (b)(3) is not applicable.

To the Federal Aviation Administration and the US Air Force:

M-22-10

Work with the National Weather Service to determine if it is appropriate to lower the radar angle for coastal weather radar sites without compromising aviation safety or other products, and lower the radar angle at those sites where it is appropriate.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.2.2, Forecasting Data. Information supporting (b)(1) can be found on pages 86-86; (b)(2) can be found on page 86; and (b)(3) is not applicable.

To the Offshore Marine Service Association:

M-22-11
Inform your members of the circumstances of this capsizing and encourage them to implement policies to stop afloat operations for restricted-service liftboats when a Special Marine Warning has been issued for the vessel's planned route.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.2.4, Restricted-Service Liftboat Stability. Information supporting (b)(1) can be found on pages 90-91; (b)(2) can be found on page 91; and (b)(3) is not applicable.

M-22-12
Notify your members of the availability and benefits of personal locator beacons.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.3, Personal Locator Beacons. Information supporting (b)(1) can be found on pages 96-97; (b)(2) can be found on page 97; and (b)(3) can be found on pages 76-79.

To SEACOR Marine:

M-22-13
Ensure your vessel crews receive timely and accurate weather forecasts tailored to each vessel's location, including applicable National Weather Service watch and warning products when they are issued.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.2.1, Decision to Get Underway. Information supporting (b)(1) can be found on pages 82-83; (b)(2) and (b)(3) are not applicable.

M-22-14
Conduct a comprehensive review of your active fleet to ensure your vessels are being operated strictly within the limits specified in

operating manuals, stability documentation, and other required guidance.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.2.3, Stability and Capsizing. Information supporting (b)(1) can be found on pages 86-89; (b)(2) can be found on pages 87-89; and (b)(3) is not applicable.

M-22-15

Revise your restricted-service liftboat safety management systems and operations manuals to require the vessel to remain in port or jack up when a Special Marine Warning has been issued for the vessel's planned route.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.2.4, Restricted-Service Liftboat Stability. Information supporting (b)(1) can be found on pages 90-91; (b)(2) can be found on page 90; and (b)(3) is not applicable.

Appendix C: Load Lines and Principles of Stability

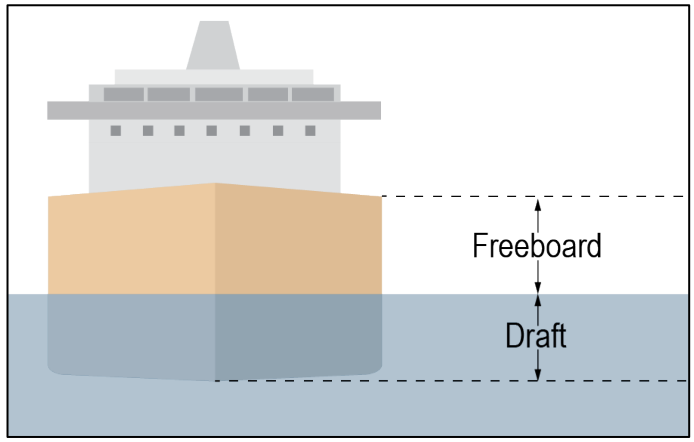

Figure C-1. Vessel freeboard and draft.

Load Lines. Load lines are marks at the midpoint along the length of each side of a vessel's hull that establish the minimum safe freeboard–the distance between the waterline and the freeboard deck (see Figure C-1). The freeboard deck is normally the uppermost complete deck exposed to weather and sea, which has permanent means of closing all openings in the weather part thereof, and below which all openings in the sides of the vessel are fitted with permanent means of watertight closing. Load lines are assigned following a survey that considers the vessel's hull and fittings, hull strength, stability at all loading conditions, and topside design. A typical set of load lines includes marks for various water densities, times of year, and geographical areas. The regulations for load lines are set forth in the *International Convention on Load Lines, 1966, as amended*, and codified in US law under Title 46 *United States Code* Chapter 51. Vessels operated in international service and offshore domestic service are required under Section 5102 of the *United States Code* to be assigned load lines.

Stability. Ship stability reflects the relationship between gravity (the force pushing the ship into the water) and buoyancy (the force pushing on a ship allowing it to float) (see Figure C-2). Gravity acts on all parts of the ship's structure, equipment, cargo, and personnel, while buoyancy acts on the hull and every part of the vessel below the water, including the 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 upright, the forces of gravity and buoyancy are vertically aligned.

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 a heeling moment on a ship, the ship's underwater volume shifts in the direction of the inclination, which causes the center of buoyancy to shift in the same direction. The shift does not affect the position of the ship'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 separate and exert a moment on the ship that tends to restore the ship to upright. 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.

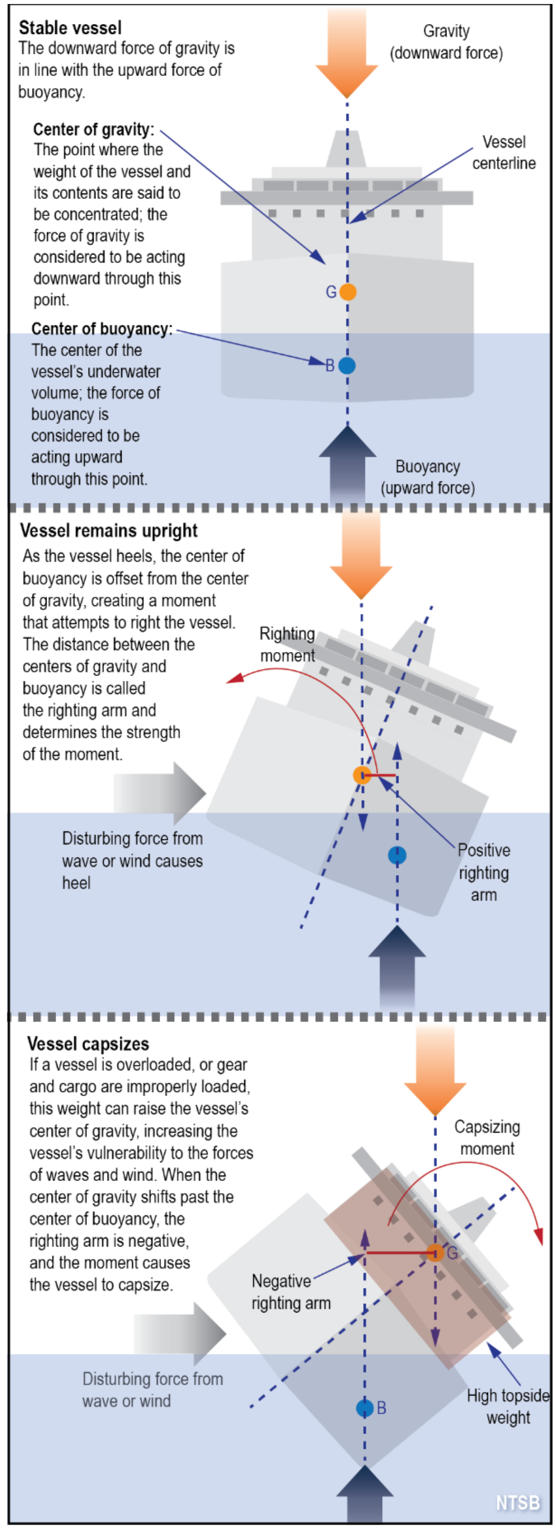

Figure C-2. Forces that make a vessel stable or likely to capsize.

That distance is known as the ship's righting arm. A stability curve is a plot of the righting moment or righting arm at successive angles of heel for a given loading condition. Because of the linear relationship between the righting moment and righting arm, the shape of the curve for both parameters for a given vessel is the same, and either can be used in stability analyses. The magnitude of the righting moment generally increases with the angle of heel to a maximum point, after which it decreases, reaching zero at an angle dependent on a vessel's hull. A reduction in the size of the righting moment usually means a decrease in stability. The angle of heel where the righting moment curve crosses zero, known as the angle of vanishing stability, denotes where a vessel's stability changes from positive (righting) moments to negative (capsizing) moments. The area under the positive righting moment curve represents the "energy" available to the ship to right itself, and in general, the more area under the curve, the larger the capsizing moments the vessel can resist. *Intact stability* refers to how an intact, or undamaged, vessel will respond when inclined in calm seas. 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.

Figure C-3 shows a righting moment curve for a sample vessel. It also shows an inclining moment curve for a specific disturbing force (for example, a 50-knot sustained wind). As stated earlier, the area under the righting moment curve represents the energy available to the vessel to right itself (righting energy). The area under the inclining moment curve represents the energy applied to incline the vessel (disturbing energy).

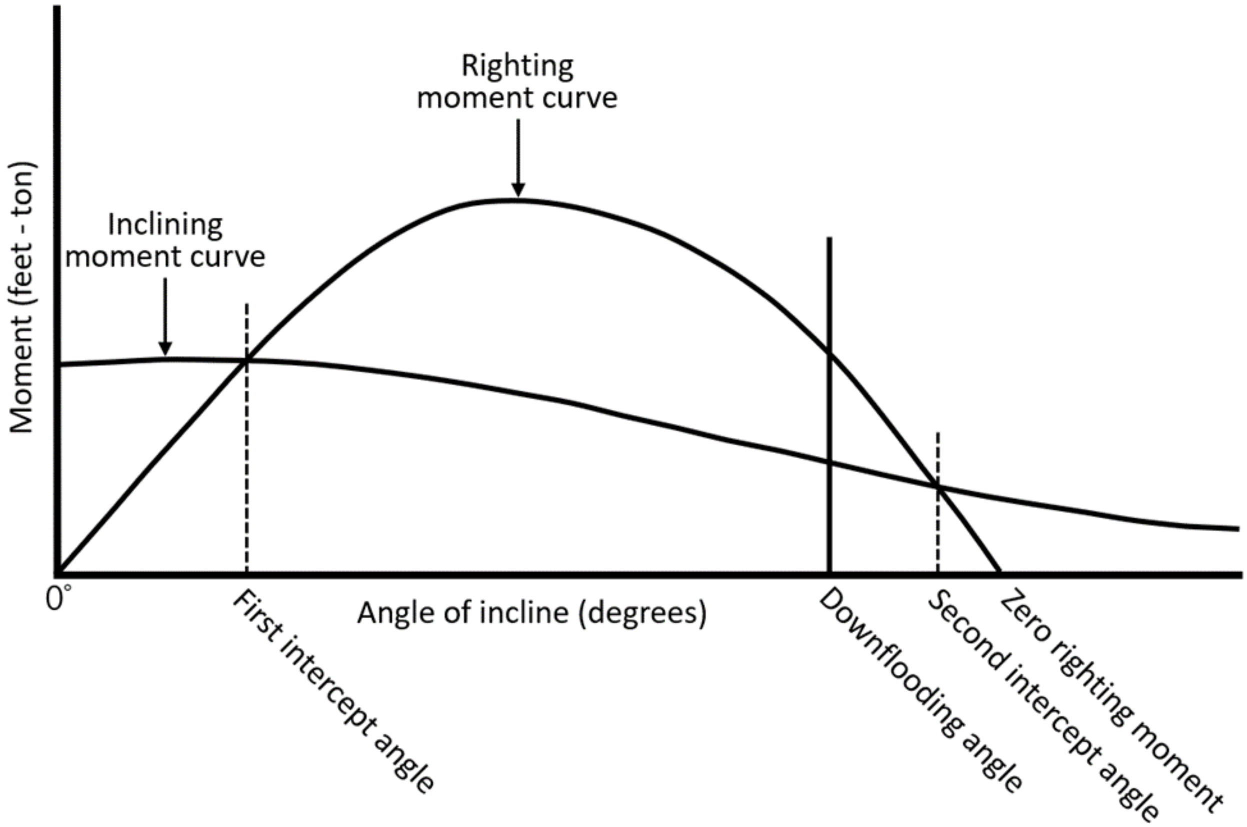

Figure C-3. Righting and inclining moment curves for intact stability. (Adapted from Graph 174.045, Title 46 *Code of Federal Regulations* 174)

For a stable vessel, the righting and inclining moment curves intersect at two points. The first intercept is a point of equilibrium and is the static angle to which the vessel will be inclined by a disturbing force such as the wind (for example, for a plot of righting and inclining moment curves for a 50-knot sustained wind on a stable vessel, the first intercept angle is the angle of inclination the vessel will be held to in such winds, assuming no other forces such as waves are acting on the vessel). The second intercept is also a point of equilibrium, but it indicates the angle of inclination beyond which positive stability is lost and the vessel will capsize. Depending on its design, a vessel it may reach an angle of inclination where openings such as engine room vents are submerged, allowing downflooding. If this angle is less than the second intercept of the righting and inclining moments, the downflooding angle will be indicated on the plot. Typically, and in US regulations for liftboats, the area under the righting moment curve after the downflooding angle cannot be considered as available righting energy when calculating a vessel's stability.

The range between the first intercept angle and the second intercept angle or the downflooding angle, whichever is less, is one measure of a vessel's stability; the greater the range, the greater the stability. Comparing the area under the righting moment curve (righting energy) with the area under the inclining moment curve (disturbing energy) for a given force of wind is an additional measure of stability. In general, the larger the difference between the two areas (known as the residual area or energy), the greater the stability of the vessel.

A ship's metacenter (M) is the virtual intersection of successive lines of action of the force of buoyancy when the ship heels through a set of very small angles (see Figure C-4). The initial position of the metacenter is used as a reference in stability calculations. The distance from a ship's center of gravity (G) to its metacenter is known as the GM, which measures the vessel's initial ability to right itself when experiencing an inclining moment. The mathematical relationship between the righting moment and the metacentric height makes GM a measure of the initial slope of the righting moment curve and an indication of whether the ship is stable or unstable at small angles of heel. The greater the value of GM, the greater the initial stability. Note that adding weight, such as cargo, below a vessel's initial center of gravity tends to lower G and increase GM, while adding weight above the initial center of gravity tends to raise G and decrease GM.

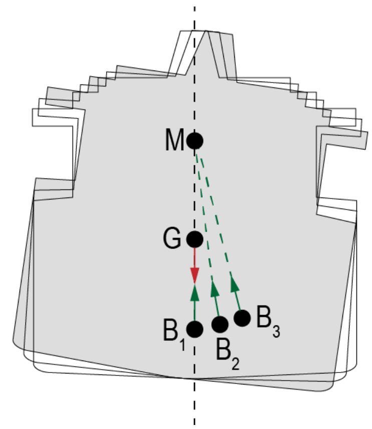

Figure C-4. Determination of vessel metacenter, M.

The specific stability characteristics of a vessel are calculated based on the model of its hull form (hydrostatics), developed from plans, expected vessel loading conditions, and lightship characteristics stability (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 necessitates the services of a naval architect.

Appendix D: Coastal Radar Sites

Through discussion with the National Weather Service (NWS), National Transportation Safety Board (NTSB) staff determined that the following WSR-88D radars that are owned by NWS, the Federal Aviation Administration (FAA), or the Department of Defense (DOD) could provide better (lower) radar coverage over coastal waters.[38] These WSR-88D sites would be candidates for environmental assessments aimed at determining feasibility for lowering the radars' beams and increasing their visibility at lower altitudes over coastal waters.

NWS

KBHX (Eureka, California)
KVTX (Los Angeles, California)
KSOX (Santa Ana Mountains, California)
KNKX (San Diego, California)
KBRO (Brownsville, Texas)
KMHX (Morehead City, North Carolina)[40]
KLCH (Lake Charles, Louisiana)
KTBW (Tampa Bay, Florida)
KMOB (Mobile, Alabama)
KTLH (Tallahassee, Florida)
KLIX (New Orleans/Hammond, Louisiana)[42]
KBYX (Key West, Florida)
KAMX (Miami, Florida)
KMLB (Melbourne, Florida)
KJAX (Jacksonville, Florida)
KLTX (Wilmington, North Carolina)[39]
KHGX (Houston, Texas)
KAKQ (Wakefield, Virginia)
KOKX (Upton, New York)
KBOX (Boston, Massachusetts)[41]
KCBW (Caribou, Maine)

FAA

TJUA (San Juan, Puerto Rico)
PAEC (Nome, Alaska)
PABC (Bethel, Alaska)
PACG (Sitka, Alaska)
PHKI (South Kauai, Hawaii)
PHMO (Molokai, Hawaii)

[38] The US Air Force is the DOD component responsible for the administration and operation of these WSR-88D weather radars.

[39] NTSB staff recognizes that a lower beam angle is not possible at KLTX's current location; however, an environmental assessment is planned during its relocation tentatively scheduled for FY2023-FY2025.

[40] NTSB staff recognizes that significant sea clutter issues do exist currently at the KMHX site.

[41] Because KBOX will likely need to be relocated around FY2026, an environmental assessment could be conducted as part of that relocation effort.

[42] KLIX is already approved for a lower beam angle (implementation tentatively scheduled for summer 2023) following its relocation to Hammond, Louisiana. The NWS has confirmed the radar's low-altitude coverage will improve over the Port Fourchon area when the radar moves to Hammond because of the lower elevation angle.

PAKC (King Salmon, Alaska)
PAHG (Kenai, Alaska)
PAIH (Middleton Island, Alaska)
PHKM (Kohala, Hawaii)
PHWA (South Shore, Hawaii)

DOD

KVBX (Vandenberg AFB, California)
KEVX (Eglin AFB, Florida)
KDOX (Dover AFB, Delaware)
PGUA (Anderson AFB, Guam)

Appendix E: Maritime Distress Communication Devices

The Coast Guard has published a Marine Safety Advisory that addresses maritime distress communication devices available to recreational and commercial mariners (2022). The following summarize the types of communication devices.

The following devices NOTIFY the US Coast Guard:

- Digital Selective Calling (DSC)—DSC is an international radio system protocol that works to establish digital and voice communications between other maritime and land-based radio stations. A DSC radio can generate a distress alert with vessel identification and position data, and an alert is relayed by other DSC-capable radios.

- High frequency (HF) radio—HF radios with DSC are typically carried by vessels operating in the open ocean or on transoceanic voyages. The radios may also be used for routine ship-to-ship communications with distress communications having priority and for receipt of high seas marine weather forecasts and warnings. When alerted, the Coast Guard will activate and respond via the associated HF voice frequency.

- Very high frequency (VHF) radio—VHF maritime radio operates in the maritime VHF band of 156 to 162 MHz (channel 01A to channel 88) and provides digital and voice communications within the radio line-of sight-range (approximately 5-20 miles depending on the antenna height above water). A radio equipped with DSC can use channel 70 (156.525 MHz) for reporting a distress or to contact other stations. The Coast Guard monitors channels 16 (voice) and 70 (DSC).

- Emergency position indicating radio beacon (EPIRB)—An EPIRB is an emergency alerting device operating in the dedicated 406.0- to 406.1-MHz distress band monitored by the Search And Rescue Satellite Aided Tracking (SARSAT) system. Orbiting satellites detect and relay the signals to ground operating stations, which can locate the source and relay the coordinates and associated registration information to the appropriate Rescue Coordination Center (RCC). Newer EPIRBs also include encoded Global Navigation Satellite System (GNSS) position data and an automatic identification system search and rescue transmitter (AIS-SART) locating signal.

- Personal locator beacon (PLB)—A PLB is a manually activated emergency alerting device operating in the dedicated 406.0- to 406.1-MHz distress band monitored by SARSAT. Orbiting satellites detect and relay the signals to ground operating stations, which can locate the source and relay the coordinates and associated registration information to the appropriate RCC. Newer PLBs also provide an AIS-SART locating signal as well as GNSS position data. Similar to EPIRBs, PLB distress alerts are routed directly to an RCC based on the beacon location.

The following devices DO NOT NOTIFY the US Coast Guard:

- Satellite emergency notification device (SEND)—A SEND is a portable emergency notification and locating device, which uses commercial satellite systems. The device uses an internal GNSS chip to gather location information. When the SEND is triggered, this information is sent via commercial satellite to a commercial monitoring agency whose role is to relay the information to an appropriate responding agency based on the device's reported location. A subscription service is required for a SEND, and the service area coverage depends on the satellite service provider, who may not provide worldwide coverage.

- Radar Search and Rescue Transponder (Radar-SART)—A radar-SART may be water-activated or manually activated, depending on the model. Once activated, the radar-SART listens for a 9-GHz X-band radar signal and, when a signal is detected, transmits a response that is displayed by the triggering radar as a line of 12 dots equally spaced by about 0.64 nautical miles (1.185 kilometers) from the center of the radar display. The performance of a radar-SART relies upon nearby vessels having a compatible radar operating in the 9-GHz X-Band. The radar-SART is not designed as a distress-alerting device but does assist in the location of those using it who may be in distress.

- Automatic Identification System Search and Rescue Transmitter—The AIS-SART is a search-and-rescue transmitter used for locating survival craft. It may be used in lieu of a radar-SART. It transmits messages from the survival craft that are received and displayed on automatic identification system (AIS) installations *International Convention for the Safety of Life at Sea*-regulated ships are required to carry AIS installations). The position and time synchronization is derived from a built-in GNSS receiver (e.g., global positioning system [GPS]) and updated at a rate of once per minute.

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Casualty Type	Capsizing/Listing
Location	Gulf of Mexico, 7 miles off the coast of Port Fourchon, Louisiana 29°0.39′ N, 090°11.85′ W
Date	April 13, 2021
Time	0537 central daylight time (coordinated universal time –4 hours)
Injuries	13 fatal; 2 serious; 2 minor
Property damage	$25 million est.
Environmental damage	Potential of 28,827 gallons diesel fuel, 5,566 gallons hydraulic oil, 187 gallons waste oil

NTSB investigators worked closely with our counterparts from the **Coast Guard Marine Board of Investigation into the Capsizing of the Liftboat *SEACOR Power*** throughout this investigation.

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