Collision of Tugboat/Barge *Caribbean Sea*/*The Resource* with Amphibious Passenger Vehicle *DUKW 34* Philadelphia, Pennsylvania July 7, 2010

Accident Report

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National Transportation Safety Board

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Marine Accident Report

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National Transportation Safety Board

490 L'Enfant Plaza, SW
Washington, DC 20594

National Transportation Safety Board. 2011. *Collision of TugBoat/Barge* Caribbean Sea/The Resource *with Amphibious Passenger Vehicle* DUKW 34*, Philadelphia, Pennsylvania, July 7, 2010*. Marine Accident Report NTSB/MAR-11/02. Washington, DC.

Abstract: This report discusses the July 7, 2010, collision of the tugboat/barge combination *Caribbean Sea*/*The Resource* with the amphibious passenger vehicle *DUKW 34* on the Delaware River in Philadelphia, Pennsylvania. As a result of the accident, two passengers on board *DUKW 34* were fatally injured, and several other passengers sustained minor injuries. Damage to *DUKW 34* totaled $130,470. Damage to the barge was minimal; no repairs were made.

Safety issues identified in this accident include vehicle maintenance, maintaining an effective lookout, use of cell phones by crewmembers on duty, and response to the emergency by Ride The Ducks International personnel.

As a result of this accident investigation, the National Transportation Safety Board makes safety recommendations to the U.S. Coast Guard, K-Sea Transportation Partners L.P., Ride The Ducks International, LLC, and The American Waterways Operators.

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Acronyms and Abbreviations

AB	able seaman (also known as able-bodied seaman), an unlicensed member of the deck department of a merchant ship.
ABS	American Bureau of Shipping
AIS	automatic identification system
AMS	American Maritime Safety, Inc.
APV	amphibious passenger vehicle
ASE	National Institute for Automotive Service Excellence
AVM	Amphibious Vehicle Manufacturing, LLC
AWO	The American Waterways Operators
CAMI	Civil Aerospace Medical Institute
CDL	commercial driver's license
CFR	*Code of Federal Regulations*
COI	Certificate of Inspection
COO	chief operating officer
DOT	U.S. Department of Transportation
ISM	International Safety Management Code, another name for the International Management Code for the Safe Operation of Ships and for Pollution Prevention
MMD	Merchant Mariner's Document
MRO	medical review officer
nm	nautical mile
NVIC	Navigation and Vessel Inspection Circular
OS	ordinary seaman, an unlicensed member of the deck department of a merchant ship
PFD	personal flotation device (lifejacket)
PVA	Passenger Vessel Association

RTDI	Ride The Ducks International, LLC
SMS	Safety Management System, a program required under the International Safety Management Code as a means of protecting people, property, and the environment
SOLAS	International Convention for the Safety of Life at Sea
SQMS	Safety & Quality Management System
TSAC	Towing Safety Advisory Committee
USACE	U.S. Army Corps of Engineers
UTC	universal coordinated time

Executive Summary

On Wednesday, July 7, 2010, the empty 250-foot-long sludge barge *The Resource*, being towed alongside the 78.9-foot-long tugboat *Caribbean Sea*, collided with the anchored 33-foot-long amphibious passenger vehicle *DUKW 34* in the Delaware River at Philadelphia, Pennsylvania. *DUKW 34* carried 35 passengers and 2 crewmembers. On board the *Caribbean Sea* were five crewmembers. As a result of the collision, *DUKW 34* sank in about 55 feet of water. Two passengers were fatally injured, and 26 passengers suffered minor injuries. No one on the *Caribbean Sea* was injured. Damage to *DUKW 34* totaled $130,470. Damage to the barge was minimal; no repairs were made.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the mate of the *Caribbean Sea* to maintain a proper lookout due to (1) his decision to operate the vessel from the lower wheelhouse, which was contrary to expectations and to prudent seamanship, and (2) distraction and inattentiveness as a result of his repeated personal use of his cell phone and company laptop computer while he was solely responsible for navigating the vessel. Contributing to the accident was the failure of Ride The Ducks International maintenance personnel to ensure that *DUKW 34*'s surge tank pressure cap was securely in place before allowing the vehicle to return to passenger service on the morning of the accident, and the failure of the *DUKW 34* master to take actions appropriate to the risk of anchoring his vessel in an active navigation channel.

The major safety issues identified in the accident investigation are as follows:

- Vehicle maintenance
- Maintaining an effective lookout
- Use of cell phones by crewmembers on duty
- Response to the emergency by Ride The Ducks International personnel

As a result of this accident investigation, the National Transportation Safety Board makes safety recommendations to the U.S. Coast Guard, K-Sea Transportation Partners L.P., Ride The Ducks International, LLC, and The American Waterways Operators.

Factual Information

Accident Narrative

At 1415,[1] on Wednesday, July 7, 2010, the amphibious passenger vehicle (APV) *DUKW*[2]*34*, carrying 35 passengers and a crew of two (master and deckhand), entered the Delaware River at a boat ramp just south of the Benjamin Franklin Bridge in Philadelphia, Pennsylvania (figure 1).

Figure 1. A Ride the Ducks APV similar to the one involved in this accident. (Photo by Ride The Ducks International)

[1] All times in this report are eastern daylight time (universal coordinated time [UTC] –4) according to the 24-hour clock.

[2] The acronym DUKW came from General Motors Corporation nomenclature in which the "D" indicated the first year of manufacture, the "U" indicated a utility vehicle, the "K" indicated all-wheel drive, and the "W" indicated a rear tandem axle. Production of the DUKW began in 1942, and 21,147 would eventually be manufactured. The vehicles are usually referred to as "ducks." Also see section "Vessel Information; *DUKW 34*" in this report.

DUKW 34, owned and operated by Ride The Ducks International, LLC (Ride The Ducks), was on a scheduled tour of historic sites and was embarking on a 20-minute river cruise as part of that tour. The route called for *DUKW 34* to turn south on entering the river and continue southbound for about 10 minutes, after which the vessel would reverse course for the return trip northbound to the boat ramp (figure 2). The master told investigators that as soon as the APV entered the river and turned south, he turned operation of the vessel over to the deckhand so that the master could narrate the tour from the crew "jump seat" beside the operator's seat at the front of the boat. According to the master, the vessel was operating normally when it entered the water. In postaccident interviews, the deckhand told investigators that he had noticed that the engine coolant temperature was registering (on the operating console temperature gauge) about 220° F during the upstream (northbound) waterborne portion of the tour. The deckhand did not inform the master of the high engine coolant temperature.

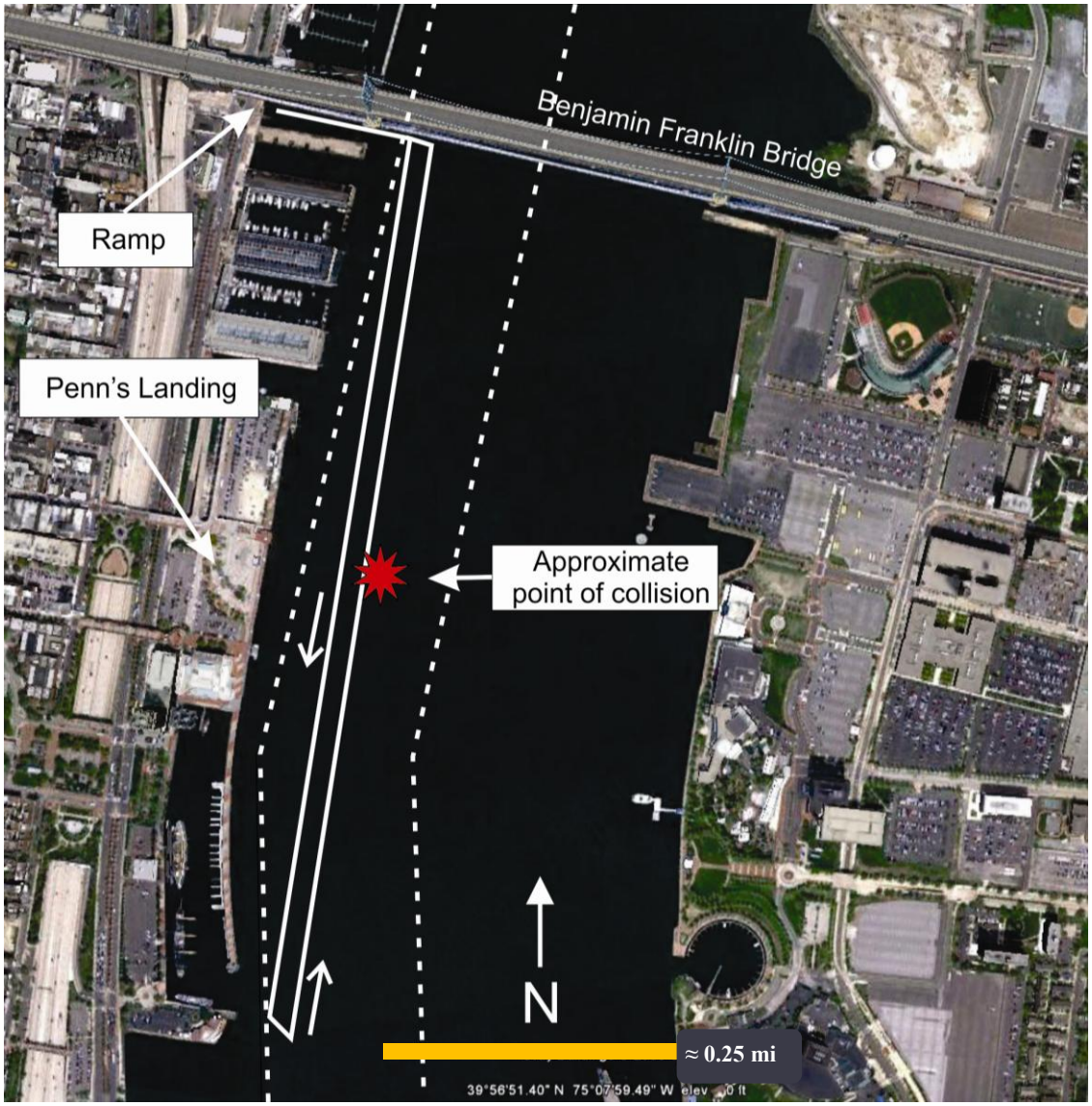

Figure 2. View of the Delaware River at the accident site. The solid white lines indicate the approximate route of Ride The Ducks APVs. The dotted white lines indicate the approximate boundaries of the navigational channel. (Background by Google Earth)

At this same time, the tugboat *Caribbean Sea*, owned and operated by K-Sea Transportation Partners L.P. (K-Sea Transportation), was traveling northbound up the Delaware River, about 3 miles south of *DUKW 34*, with the empty 250-foot-long barge *The Resource*, owned by the city of Philadelphia, configured in a starboard hip tow[3] (figure 3). The *Caribbean Sea* was being navigated by the mate, with a deckhand (referred to as "deckhand No. 1" in this report) and an engineer also on duty. The other two crewmembers, the master and another deckhand (referred to as "deckhand No. 2" in this report), were off duty and in their living quarters.

Figure 3. Tugboat *Caribbean Sea* with tank barge *The Resource* in a starboard hip tow as seen about 45 seconds before the accident. (Photo by Megan Scharpf)

The *DUKW 34* master told investigators that about 10 minutes into the voyage, shortly after the vessel had reversed course to begin its return trip to the boat ramp, he smelled an odor and saw what he thought was smoke coming from the starboard engine compartment vent. Believing that the vessel was on fire, he said he resumed his position in the operator's seat and initiated emergency procedures, which included shutting down the engine (by turning off the

[3] In a *starboard hip tow*, the barge is positioned on the tugboat's starboard side. In accordance with the master's preference and with accepted industry practice, the *Caribbean Sea* was positioned alongside the barge such that its propellers were aft of the barge stern. This positioning of the tugboat improves control of the barge.

ignition), activating the emergency fuel shutoff, turning off the battery switch, closing the port and starboard fire dampers,[4] and securing the forward hatch.

The master told investigators that he did not discharge the vessel's fixed CO_2 fire-suppression system because he believed that his earlier efforts to control the fire by securing the fuel and oxygen supply had been successful. He said he was also concerned that some of the extinguishing agent could migrate into the passenger space. He said he would consider use of the fire suppression system a "last ditch effort" and that he believed if he used it, he would not be able to restart the engine.[5]

The master told investigators that he made a call on VHF channel 13[6] to alert other vessels in the vicinity of the situation on board *DUKW 34*. (No such call at that time was captured on any of the available recordings of radio transmissions, nor did anyone interviewed for this accident investigation recall hearing such a call.) He said he then used the direct-connect radio feature on his company-supplied mobile phone to inform the Ride The Ducks manager-on-duty that he believed he had a fire on board, that he was taking emergency measures, and that he needed a tow. The manager-on-duty began making arrangements to dispatch another APV as a tow vessel for the disabled *DUKW 34*. According to U.S. Coast Guard regulations and company policy, the manager-on-duty should also have notified the Coast Guard, but she did not do so (see section "Coast Guard and Ride The Ducks Emergency Procedures" in this report).

About 1425, another Ride The Ducks APV, *DUKW 44*, was traveling about 100 to 150 feet behind *DUKW 34* on the same route. Seeing *DUKW 34* dead in the water, the master of *DUKW 44* maneuvered his APV to within hailing distance of *DUKW 34* and asked the crew if they needed help. The *DUKW 34* deckhand recalled telling the master of *DUKW 44* that the APV had overheated but that the problem had been radioed in and that "everything's good." The *DUKW 34* deckhand said that he told the other master to "finish the tour—everything's all right," after which the other APV departed.[7] During this time, the company manager-on-duty used the direct-connect radio to inform the master that *DUKW 46* was being dispatched to tow *DUKW 34.*The master told investigators that he then (about 1428) ordered the deckhand to go forward and drop the anchor to keep the APV from drifting downstream with the current. The deckhand deployed the anchor about 1429.

[4] As will be discussed in more detail later in this report, the engine bay of the vessel was equipped with two sets of doors (fire dampers) that could be closed to block air flow through the engine compartment and thus help contain or extinguish an engine fire.

[5] Release of the CO_2 activated a pressure switch, located near the operating station, that cut all electrical power to the engine. The pressure switch could be manually reset by the operator.

[6] VHF channel 13 (156.650 MHz) is one of the bridge-to-bridge navigation channels used in U.S. waters and is the channel that should be used to contact a ship when there is danger of collision. All ships 20 meters or more in length are required to monitor VHF channel 13, in addition to VHF channel 16, when operating in U.S. territorial waters.

[7] *DUKW 44* was full of passengers and was not equipped with the rigging necessary to safely tow the disabled vessel to shore.

By about 1433, the APV was anchored[8] in the navigational channel about 320 feet from the bulkhead of Penn's Landing, near Grand Plaza and almost in the center of the navigation channel. The deckhand remained on the bow, where he used his cellular telephone to send what investigators confirmed was a personal text message. A review of the deckhand's cell phone records indicated that two outgoing and two incoming text messages were transmitted to or from the deckhand's cell phone between 1431 and 1436.

Both the master and the deckhand told investigators that shortly after anchoring, they saw the tugboat and barge heading northbound in their direction. The master stated that he was not sure of the exact position of the tugboat and barge at that time but that he believed they were passing a moored tall ship known as the *Gazela Primeiro*. The deckhand estimated their distance at that time to be about 1 nautical mile (nm). According to location data transmitted by the *Caribbean Sea*'s automatic identification system (AIS)[9] and recorded by the Coast Guard, about 1433, the *Caribbean Sea* was about 0.3 nm from the APV.

The master said that he made another callout on VHF channel 13 regarding the situation on board his APV. (This call was also not captured by any radio transmission recordings.) He said that at that time he thought he could see the tugboat pushing the barge away and therefore believed his radio call had been heard by the tugboat crew. He said he then began applying duct tape to seal two access plates on the port and starboard side of the control panel from which "smoke" was still entering the passenger space.

The master said that when he had finished taping over the access plates, he noted that the tugboat and barge had not changed course to avoid the APV. He said he attempted to sound a warning using the APV's air horn, but the horn was inoperable.[10]

The master said he called out three times to the approaching tug and barge on VHF channel 13 to alert them that his vessel was broken down and anchored. A recording of marine VHF channel 13 made by the Burlington County Bridge Authority shows that, about 1436, a person identifying himself as *DUKW 34* began calling out to "the northbound tug near Penn's Landing" (this would have been the *Caribbean Sea*) that he was broken down and could not maneuver. Over the next minute, the same caller made several additional callouts to the northbound tug. Another caller was recorded making subsequent callouts to the northbound tug reporting that *DUKW 34* was broken down. These calls, beginning at 1436, were the first calls regarding the incident that were recorded. The recording did not capture a response from the *Caribbean Sea*. At 1436:54, the *DUKW 34* master made a final callout on channel 16 saying, "Hey ferry ferry . . . whoa whoa . . . ."

[8] Although the anchor was deployed about 1429, the anchor dragged along the bottom for about 155 feet (based on postaccident sonar imaging of the river bottom) before taking a set.

[9] AIS is a maritime navigation safety communications system. At 2- to 12-second intervals on a moving vessel, the AIS automatically transmits vessel information, including the vessel's name, type, position, course, speed, navigational status, and other safety-related information, to appropriately equipped shore stations, other vessels, and aircraft. The AIS also automatically receives such information from similarly fitted vessels.

[10] The investigation determined that the horn would only activate when the ignition switch was "on." After the accident, Ride The Ducks modified its fleet of APVs to allow the air horns to operate with the ignition switch off. The APV was equipped with a handheld air horn in a watertight emergency box that could have been accessed if time was available.

The *DUKW 34* master told investigators that shortly before the collision he realized the tugboat did not see them or hear his radio calls so he instructed passengers to put on lifejackets. Not all passengers recalled hearing the master's instructions; however, passengers did attempt to retrieve lifejackets before the collision. Many did so after seeing other passengers begin pulling them down from their overhead storage area. One passenger told investigators that

> one of the ladies . . . from our church got up, and she yelled, 'We've got to move.' And she started pulling down the life vests, and people started screaming, and other people were getting up and pulling life vests down, and that's right before the barge hit.

A video security camera on the New Jersey side of the river captured the accident sequence. According to the time correlation study[11] on the video, the barge made contact with the stern of *DUKW 34* at 14:37:23. Ten seconds later, at 14:37:33, the APV, having been turned to port, rolled over onto its starboard side and was pushed completely under the water (figure 4). Based on AIS data, in the minutes before the accident, the *Caribbean Sea* was near the center of the river's navigation channel and traveling at about 6 knots.

Figure 4. Tugboat *Caribbean Sea* and barge *The Resource* seconds after the bow of the barge made contact with *DUKW 34*, a portion of which is visible at far left. (Photo by Brian E. Stover)

None of the passengers on board *DUKW 34* had evacuated the vessel before impact. The only person not on board when the barge struck was the deckhand, who jumped off the starboard bow before impact and swam toward the middle of the river. Not all of the passengers had obtained a lifejacket before the barge struck. Of those who did, several stated that they had been able to get a lifejacket over their heads, but none of them was able to fully don the jacket and fasten it properly. Many passengers reported being unable to hold onto their lifejackets when the vessel was pushed under, so they grabbed the floating jackets when they surfaced.

[11] The NTSB performed a time correlation study that synchronized the time stamp from this video and other time information gathered during this investigation to eastern daylight time (UTC time adjusted to EDT offset).

Most passengers were unsure about how they evacuated the APV and made it to the surface. Several stated that one moment they were under water and the next they were on the surface. A number of passengers described seeing sunlight through the water and swimming toward it. A few reported feeling the metal either from the window frames or the side of the APV and swimming out of the vessel and up toward the water's surface.

According to interviews of the *Caribbean Sea* crew, at the time of the collision, deckhand No. 1 and the engineer were seated at the table on the port side of the galley (figure 5). They said that they noticed a reduction in the rpm of the vessel's engines and thought that it had arrived at the destination. The deckhand said that he looked out a galley porthole and noticed what appeared to be people in the water off the vessel's port side. Both crewmembers said they then left the galley and proceeded to the aft main deck area (fantail). From there, they said they saw several persons and some debris passing down the port side of their vessel.

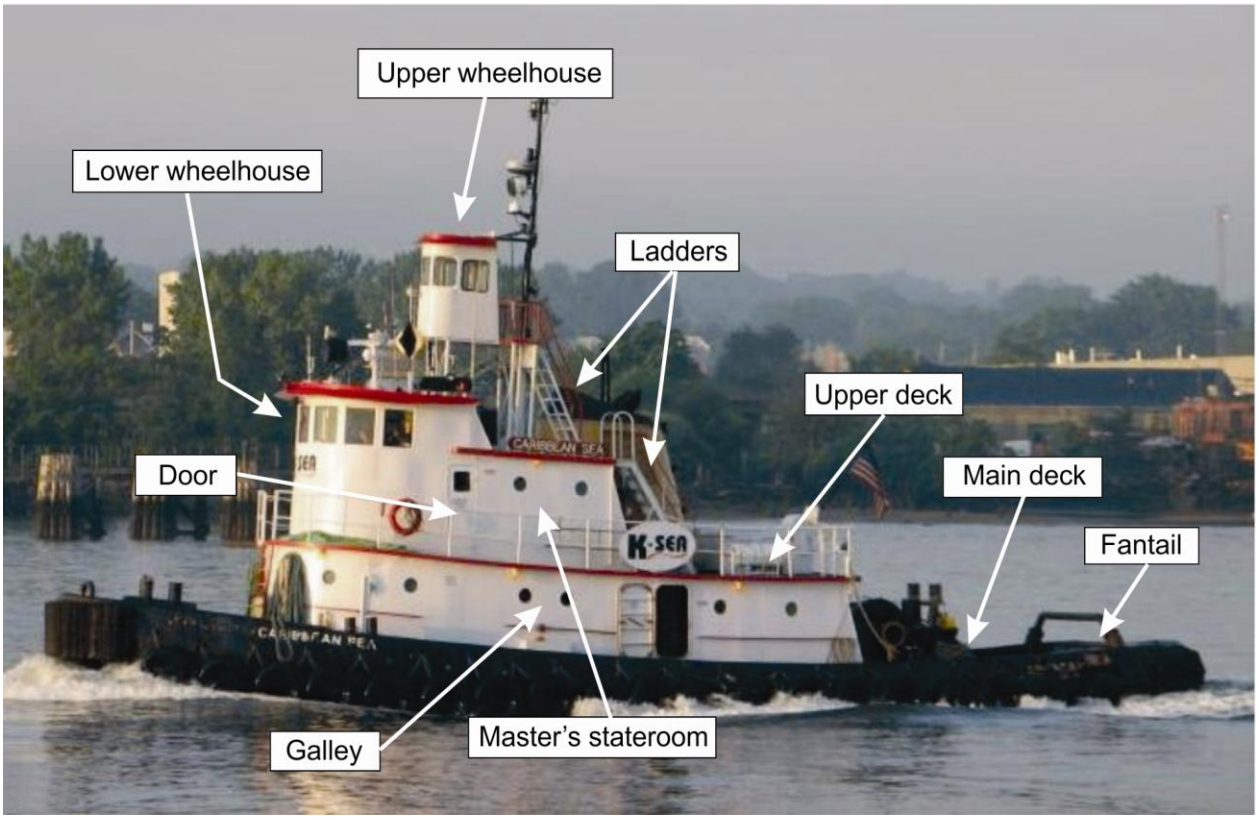

Figure 5. *Caribbean Sea*. (Photo by Joe Becker)

The engineer said he then went forward to alert the master of the situation. He said he climbed the ladder on the aftermost bulkhead to the upper deck (refer to figure 5) and then proceeded forward along the port side of the vessel to the exterior door that leads into a passageway between the master's stateroom and the lower wheelhouse. He said that when he opened the door, he saw the mate standing in front of the master's stateroom door. He said this was the first time he had seen the mate after the collision.

The master of the *Caribbean Sea* stated that he was sleeping when the accident occurred and was awakened by a knock on his stateroom door. The door was then opened, and the master said he saw the mate, who stated something to the effect that he "ran over a duck boat." The master said after getting dressed, he proceeded to the upper wheelhouse where he assumed control of the *Caribbean Sea*. The master said that when he arrived at the upper wheelhouse, the mate was already there, and control for the vessel's throttle was active. (The throttle control system for the vessel can be active at only one of the two wheelhouses at any time. Control must be transferred manually by activating an air control valve at the station to which control is being transferred.) The master further said that both VHF radios were on, with one tuned to channel 13 and the other to channel 16.[12] He said that the radar was turned on.

The master said he attempted to contact the Coast Guard on VHF channel 16 to inform them of the accident, but a local passenger ferry, *Freedom*, was already communicating with the Coast Guard on that channel regarding the casualty. The master said he swung the vessel and barge to starboard and held position while the engineer and deckhand No. 1 maintained lookout from the deck of *The Resource.* He said that because of the current and the limited maneuverability of the tug and barge combination, he was unable to assist other vessels in the recovery of persons in the water.

About 1530, Coast Guard personnel from Coast Guard Sector Delaware Bay boarded the *Caribbean Sea*, and two Coast Guard investigators jointly interviewed the mate in the galley. According to the Coast Guard written summary of that interview, the mate told the investigators that he had been in the upper wheelhouse at the time of the collision, that he had not seen the APV before the collision, and that he did not hear, see, or feel anything before seeing people in the water. He further stated that he did not hear any radio calls about the anchored APV or see any targets on the *Caribbean Sea*'s radar.

The mate told the Coast Guard investigators that he had seen an APV somewhere near the Benjamin Franklin Bridge when the *Caribbean Sea* was under way in the vicinity of Pier 38, (which is about 1.2 nm from the bridge) but that he could not determine its heading. He said that the last time he saw an APV before the collision was as the *Caribbean Sea* was near the southern end of the main pier at Penn's Landing. At that time, he said, the APV was out of the channel on the starboard (east) side. Following the mate's initial interview by the Coast Guard on the day of the accident, the NTSB attempted several times during its on-scene investigation to interview him. However, the mate declined to provide further statements or testimony regarding the accident.[13]

[12] VHF Channel 16 (156.8 MHz) is the international VHF/FM calling, reply, and safety channel. It may also be used for distress and urgency signals.

[13] On June 24, 2011, after this report, its conclusions, and its recommendations were approved by the NTSB, the mate indicated his willingness to provide information about his role in the accident. NTSB investigators interviewed the mate on July 11, 2011. Portions of that interview are summarized in Appendix C.

Emergency Response

The primary responders to this accident included the Philadelphia Marine Police (part of the Philadelphia Police Department), the Coast Guard, and two Good Samaritan vessels (a local ferry and a U.S. Navy small boat). The first responder on scene was the ferry *Freedom*.

The *Freedom* was making its regularly scheduled trip from Camden, New Jersey, on the east side of the river to Penn's Landing on the west side when the accident occurred. The master of the *Freedom* told investigators that he departed Camden at 1430. At about 1435, as he was heading north, he heard three calls from the APV to the tug on VHF channel 13, saying "I cannot maneuver; I'm at anchor." He was approximately 3/4 to 1 mile away and saw the barge heading toward the APV. He said he attempted to hail the tug on channel 13 but got no response. His view of the APV then became obscured by the barge. Shortly thereafter, his senior deckhand reported seeing lifejackets in the water. The ferry's master said he made best possible speed toward the accident site and, as they approached, he saw people in the water. He said he surveyed the area and noticed that one person was farther from shore than the others, toward the center of the river. He decided to assist that person first. That person was the deckhand. He said they rescued the deckhand, after which he saw that the marine police and Coast Guard boats had arrived and were assisting the rest of the passengers.

The Philadelphia Police Department was notified of the accident at 1439 via 911, and units were dispatched at 1440. Philadelphia Marine Police launched two boats. At about the same time, the Coast Guard launched three boats, including two 25-foot-long response boat-small (RB-S) vessels and a 41-foot-long utility boat. Philadelphia Marine Police and Coast Guard Sector Delaware Bay share the same office building and dock facilities on the Delaware River, about 0.9 nm south of the accident site. According to one marine police officer, marine police and Coast Guard boats arrived on scene "less than 3 minutes" after being notified. They immediately began helping APV passengers from the water.

Also assisting in the rescue effort were members of the U.S. Navy Special Boat Team 20, based in Little Creek, Virginia. The team had two special operations craft in port at the marina south of the Independence Seaport Museum at Penn's Landing and were providing vessel tours to the public at the time of the accident. A senior chief petty officer from the team said he heard a distress call on the VHF radio, heard first responder sirens, and noticed a commotion along the waterfront. He said he ran to the waterfront and saw "approximately 20–30 . . . people in the water." He said he returned to the marina, boarded vessel 976, and got it under way with several crewmembers. Once under way, they launched a small inflatable boat, called a combat rubber raiding craft, with four crewmembers on board. Crewmembers on the raiding craft helped pull survivors out of the water. Back on shore, other Navy personnel joined first responders in assisting survivors who swam to shore.

Thirty-five people on board the APV survived the accident. Of these, 19 were recovered by various vessels, and 16 managed to swim to shore. Ambulances transported six passengers to Hahnemann University Hospital and one passenger to Jefferson Hospital. Both hospitals were located within about 1 mile of the accident site. Two passengers (a 20-year-old male and a 16-year-old female) did not survive. Their bodies were recovered on July 9. The two fatalities had been seated next to each other on the starboard side, in the second row forward, in

an undamaged area. Investigators were unable to verify whether or not the two individuals were able to swim. Both were part of a Hungarian student group, and their level of English language comprehension is not known. Neither victim was wearing a lifejacket when they were recovered.

Injuries

Twenty-six passengers and one crewmember on board the APV reported being injured as a result of the accident. Most of the injuries were minor, consisting of bumps, bruises, and small cuts and scrapes. Autopsies for the two fatalities listed the cause of death as drowning with no external or internal evidence of traumatic injury for either individual.

Table 1. Injuries

Type of Injury	Crew (*DUKW 34*)	Passengers (*DUKW 34*)	Total
Fatal	0	2	2
Serious	0	0	0
Minor	1	26	27
None	1	7	8

Title 49 *Code of Federal Regulations* (CFR) 830.2 defines a fatal injury as any injury that results in death within 30 days of an accident. It defines serious injury as that which 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 (except simple fractures of fingers, toes, or nose); 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.

Damage

DUKW 34

DUKW 34 was raised from the river on July 9, 2010. Damage to the APV was principally to the port side of the hull and the aft portion of the port side of the canopy. The hull damage consisted of scrapes and indentations along the hull's external support members and hull shell, and to the "Ride The Ducks" sign attached to the side of the hull. The scrapes to the Ride The Ducks indicated the relative movement between the APV and the barge during their period of contact (figure 6).

Figure 6. *DUKW 34* after being raised from the river bottom.

Damage to the canopy framing system (figure 7) consisted of bending and buckling of the square and rectangular steel tubing and some tearing of the canopy awning, principally at the aft portion. The two aftermost port side vertical frames of the canopy were bent over about 45°, and other support members were similarly damaged. The port-side roller curtain was damaged and detached from its mountings, and the passenger loading ladder indicated distortion and impact damage. The left front wheel was slightly displaced from its axis of rotation, and a subsequent tear-down examination showed that its drive axle was slightly bent.

The damage to *DUKW 34* totaled $130,470.

Figure 7. View of *DUKW 34*'s damaged canopy, looking aft.

Caribbean SealThe Resource

The barge *The Resource* showed minor damage at its bow area (rake); the *Caribbean Sea* was not damaged. The damage to the barge bow consisted of contact scrapes to the port and starboard side of the bow area. According to an American Bureau of Shipping survey report, the contact scrapes affected the hull coating only, with no indication of damage to the hull plating or interior framing. A representative from the city of Philadelphia told investigators that the minor damage to the barge hull coating was not repaired after the accident.

Operations Information and Events Preceding the Accident

Ride The Ducks and *DUKW 34*

The APV involved in this accident was owned and operated by Ride The Ducks International, LLC. Ride The Ducks was founded in 1977 by an entrepreneur in Branson, Missouri, as a small sightseeing company. In 2001 the company partnered with the Herschend Family Entertainment Corporation (Herschend), and in 2004, Herschend became the sole owner of Ride The Ducks. Both Herschend and Ride The Ducks are headquartered in Norcross, Georgia.

Ride The Ducks operated a fleet of more than 90 amphibious vehicles at seven locations across the United States.[14] Company records show that about 1.2 million people take the company's amphibious tours annually at all locations.

Ride The Ducks began operations in Philadelphia in 2003 providing amphibious tours from March through November, weather permitting. At the time of the accident, the Philadelphia operation had a fleet of 15 APVs. The embarkation and termination point for each Ride The Ducks Philadelphia tour was the Independence Visitor Center (Visitor Center) at Independence Mall. Each tour began with a drive downtown along a route with sites of historical or other interest. The waterborne portion began at a boat ramp at the intersection of Race Street and Christopher Columbus Boulevard, just south of the Benjamin Franklin Bridge. The water tour took the vessel into the Delaware River southward along Penn's Landing for not more than 1 nm and returned along the same route. The APV left the water at the same boat ramp where it entered and returned to the Visitor Center. The entire tour took about 70 minutes, with the on-road portion lasting about 50 minutes and the waterborne portion lasting about 20 minutes.

For the land portion of the amphibious tours, the APV driver must hold a commercial driver's license (CDL) with a passenger endorsement. For the water portion, the operator must hold the appropriate Coast Guard master's license. Unless the operator conducts his or her own tour narration, another employee performs that task. This can lead to a variety of operator/tour guide/deckhand configurations on a tour.

Philadelphia staffing at the time of the accident consisted of 11 "Capt. III Tour Guide Captains" (Coast Guard-licensed masters with a CDL who also performed their own tour narration); 6 "Capt. II Ramp Captains" (Coast Guard-licensed masters without a CDL); 9 "Capt. I Tour Guides" (CDL holders without a Coast Guard license); 2 "Tour Guides" (tour narration only with no driving); 10 "ambassadors" (employees who worked in administrative positions or served as deckhands); 5 mechanics; and 7 administrators/managers.

The master on board *DUKW 3*4 on the day of the accident was a "Capt. III Tour Guide Captain," who held both a CDL and a master's license and performed his own tour narrations. In such cases, during the land portion of the tours, the master is normally the only company employee on board. At the boat ramp, a deckhand boards the APV in order to meet Coast Guard manning requirements for the water portion of the tour. On returning to the ramp, the deckhand disembarks and waits to board the next APV where his or her services are needed. Communication between vessel crews and the shore-side staff is conducted using company-supplied mobile telephones with direct-connect radio capability.

The *DUKW 34* master said that on the day of the accident he reported to the Ride The Ducks maintenance facility about 0840 to prepare the unit for operation and to complete a pre-trip inspection. As will be discussed in more detail later in this report, company procedures required that all captains or drivers inspect each APV before and after each operational period (for example, each day) and document these inspections on a form called "RTDI Captain's/Driver's Pre-Trip Inspection." Any deficiencies that would prevent the safe and legal

[14] Company-owned operations are in Branson, Missouri; Philadelphia, Pennsylvania; and San Francisco, California. Four other locations operate as licensees.

operation of the APV were to be brought to the attention of the maintenance manager so they could be corrected before the vehicle could carry passengers.

The master told investigators that when he inspected *DUKW 34* on the morning of the accident, he found no discrepancies. Investigators were unable to locate a completed captain's/driver's pre-trip inspection form for *DUKW 34* for July 7, 2010. The most recently completed pre-and post-trip inspection forms for the APV, including the pre- and post-trip inspection forms completed by the master on the day before the accident, were recovered from the salvaged vessel. Those forms indicated that no deficiencies had been noted during either inspection.

The master said that he left the maintenance facility about 0945 and drove the APV to the Visitor Center, arriving about 1000. The master's first tour of the day, with 35 passengers, began at 1030. The tour, which the master described as "uneventful," was completed at about 1140. At about 1205, the master began his second tour of the day with *DUKW 34*, again with 35 passengers. That tour was also completed uneventfully at about 1315. The master said he then took a break for lunch in the employee break room before returning to *DUKW 34*.

Just before 1330, a Ride The Ducks employee completed loading passengers on *DUKW 34* for its third tour of the day. The 35 passengers included a tour group comprising 13 Hungarian students, 2 Hungarian teachers, and 7 American citizens who were acting as group hosts or chaperones. At about 1335, after the master had conducted a Coast Guard-required pre-departure safety briefing, *DUKW 34* departed the Visitor Center and began the road portion of the tour. At about 1415, the APV arrived at the boat ramp, picked up the deckhand waiting there, and entered the Delaware River. The APV *DUKW 44* entered the water shortly after *DUKW 34.* After *DUKW 34* made its turn to starboard to begin the southern transit along Penn's Landing, the master allowed the deckhand to take control of the APV.[15] The master took a position in the jump seat adjacent to the helm and continued the tour narration.

The master told investigators that, about 10 minutes after the APV had turned and was returning northbound to the ramp, a dense, white smoke appeared, and that he believed he had a fire on board. He said he had not seen flames but that, "I can't [afford to] wait to see flames." The master said:

> I had no indications that my DUKW was running hot, no indications of any overheat conditions. That wasn't my first, that was my third tour. And if there was any things that even looked like that, the DUKW wouldn't have moved.

The deckhand told investigators:

> It was white smoke. It had a scent to it but it wasn't . . . something you could pinpoint. It wasn't like [a] . . . fire scent—it wasn't like it was fuel burning. . . . I kind of had a thought it had a fragrance of burning rubber . . . White smoke started pouring out the side vents on both sides. [The master] immediately told me to get out of the seat, I got out. He

[15] Both Ride The Ducks and Coast Guard policy permitted deckhands to operate the APV on water to provide the deckhands (potential captains) with experience under way.

> jumped into the seat, started pulling all the valves for both the vents. He closed both the side vents. He dropped the front hood. Because what we do for fire procedures, you know, you see smoke, regardless of what it is, you know, we're going to follow it. I'm like, that's fine. If we close the hatches, it can't hurt anything, and if there is a fire, it's out. But we knew there wasn't a fire. We saw the white smoke, so we knew it was something different.

When the master was later asked who was acting as lookout at that time, he responded, "I would hope [the deckhand] was." The deckhand told investigators he believed that maintaining a lookout was a shared responsibility between himself and the master.[16] He said that while he was on the bow after deploying the anchor he was generally focused on the northern portion of the river. Because the master was interacting with the passengers and generally facing toward the south, he thought the master would be monitoring vessel traffic from that direction.

K-Sea Transportation and the *Caribbean Sea*

The tugboat *Caribbean Sea* was owned by K-Sea Transportation Partners L.P., headquartered in East Brunswick, New Jersey. The company, founded in 1999, provided marine transportation, distribution, and logistics services primarily to oil companies, oil traders, and oil refiners domestically and internationally. In addition to its New Jersey headquarters, K-Sea Transportation had offices in Staten Island, New York; Philadelphia, Pennsylvania; Norfolk, Virginia; Seattle, Washington; and Honolulu, Hawaii. The company owned and operated 78 tugboats and 73 barges and employed about 850 people.

The *Caribbean Sea* was one of 13 tugboats operating out of the company's New York division and at the time of the accident was staged at the company's River Associates office in the Philadelphia Naval Business Center.[17] The vessel was manned by one licensed master, one licensed mate, two deckhands, and one licensed engineer. According to the *K-Sea Transportation Vessel Procedures Manual*, every deck watch was to have one licensed individual (master or mate) and one deckhand, with the licensed individual having ultimate responsibility for safe navigation, radio guard, lookout, and radar observation.

On June 17, 2009, the city of Philadelphia contracted with K-Sea Transportation to move two city-owned barges, *The Resource* and *The Recycler*, between the city's Northeast Water Pollution Control Plant on the Delaware River north of Philadelphia and the privately owned Biosolids Recycling Center on the Schuylkill River in the city's southeast—a distance of about 11.7 nm. Barges loaded with wastewater "sludge" at the pollution control plant were to be moved downriver to the recycling center where the sludge would be discharged for processing. The empty barges would then be returned to the pollution control plant for reloading.

[16] According to the Ride The Ducks job description, the deckhand was to "to assist the Captain with customers on the DUKW, to identify and assist in emergency situations, and to perform basic routine operations of the DUKW during the water portion of the tour." One of the "essential functions" was to "Recognize potential safety issues and follow company and Coast Guard procedures in emergency situations."

[17] The Philadelphia Naval Business Center was once known as the Philadelphia Naval Shipyard before the U.S. Navy ended most of its activities there in late 1995. The former naval base is now home to several maritime-based companies.

Several K-Sea Transportation tugboats worked on this project until the *Caribbean Sea* assumed the responsibility for the barge transits on June 23, 2010. The city provided the company with a weekly schedule of anticipated barge movements. The number of scheduled trips between the two locations in any 24-hour period ranged from one load or discharge to two or more loads and discharges.

At the time of the accident, the *Caribbean Sea* was in operation or standing by (tied up and available for service) 24 hours a day. The vessel was operated on a two-watch, or "square watch," system in which watchstanders are on duty for 6 hours followed by 6 hours off. On a towing vessel, the masters and mates standing a two-watch system concentrate on navigation, boat handling, communication with other vessels and with the company office, and crew supervision and direction. Deckhands are responsible for making and breaking tows, carrying out regular maintenance and housekeeping, and performing lookout duties as directed by the officer on watch. Engineers respond to alarms, perform routine maintenance and repairs, and perform other activities related to the vessel's engineering systems.

The *Caribbean Sea* master and deckhand No. 2 had the "front watch," (also known as the "captain's watch") which was from 0600 to 1200 and 1800 to 2400. The mate and deckhand No. 1 were on the "back watch" (also known as the "mate's watch") from 1200 to 1800 and 2400 to 0600. The engineer was on duty from 0700 to 1900 each day. On the *Caribbean Sea*, this rotation was maintained for 2 weeks, after which a crew change would take place. The crewmembers lived on board the tugboat during the 2-week assignment.

Just after midnight on July 7, 2010, the *Caribbean Sea* was at the pollution control plant waiting for the tank barge *The Resource* to finish loading. At 0510, the *Caribbean Sea* got under way en route to the recycling facility with the loaded tank barge made fast to its starboard side. The vessel and barge arrived at the recycling center at about 0805. After securing the tank barge to the facility for discharge, the crew shifted the *Caribbean Sea* to the River Associates dock about 1 nm away. It arrived there at about 0900 to reposition one of the company's smaller oil barges and to take on water and supplies.

At 1100, the mate (who would be navigating the vessel at the time of the accident) reported for duty and relieved the previous mate. He was beginning a 2-week tour of duty on board the *Caribbean Sea*, a vessel on which he had served previously. Although the master and the mate had never worked together, they knew each other from their service on other company vessels.

At 1200, the mate and deckhand No. 1 assumed the vessel's watch. At that time, the vessel was shifted from the River Associates dock to the recycling facility to begin preparing for the transit north back to the pollution control plant. Deckhand No. 2 told investigators that at that time he had lunch and then went to his stateroom to sleep. The mate, deckhand No. 1, and the engineer were responsible for making fast the vessel to the barge.

At the time of the accident, K-Sea Transportation had no written policy for tugboats with an upper and lower wheelhouse regarding which wheelhouse was to be used when towing an empty barge, and the master had not written his directive into the standing orders of the vessel. The master said that he told the mate that with a light (empty) barge and the resulting high

freeboard,[18] the vessel should be operated from the upper wheelhouse to provide better visibility. The master said that when he informed the mate that he should navigate from the upper wheelhouse, the mate responded, "No problem. You don't have to worry, that's normal. That's where I would be." The master said that shortly thereafter, between 1230 and 1245, he went to his stateroom to rest.

At about 1315, the mate got the vessel under way. According to deckhand No. 1, the mate was navigating the vessel from the upper wheelhouse at that time. Deckhand No. 1 said that, once under way, he began performing day work consisting of routine maintenance and housekeeping chores. The engineer said that he returned to the engineroom.

Family Medical Emergency of the *Caribbean Sea* Mate

A K-Sea Transportation official told investigators that, in a conversation with the mate after the accident, the mate informed him that he had learned while on watch that his young child had suffered a serious medical emergency earlier that day. The official said that the mate told him that he had been "consumed" with dealing with this family crisis (medical records obtained by the NTSB confirmed that the mate's child, who was undergoing a scheduled routine medical procedure that day, had suffered a potentially life-threatening complication less than an hour before the mate went on duty). The mate's postaccident conversation with the company official was the first mention that the mate had made of this emergency; he had not mentioned it to the master of the *Caribbean Sea* or to any of his other fellow crewmembers. K-Sea Transportation officials told the NTSB that, although the company had no written policy to cover such eventualities, these situations were covered in employee interviews and new-hire processing. The officials stated that, had the mate made his situation known, he would have been granted emergency relief. The company informed the NTSB of 15 instances from the 12- to 18-month period preceding the accident in which mariners had requested and been granted emergency relief from duty because of family emergencies.

Mate's Cell Phone Use

On August 25, 2010, the NTSB obtained from the wireless carrier for the mate of the *Caribbean Sea* a record of the calls made to and from the mate's personal cell phone on the day of the accident. Those records show that between 1222, just after the mate assumed the navigation watch, and 1432, about 5 minutes before the collision, the mate made 13 outgoing calls to five different telephone numbers. He made two outgoing calls to his personal voice mail. During this period, he also received six incoming calls, two of them from numbers he had previously called. Eighteen of the calls, lasting a documented total of 53 minutes, were made or received while the mate was responsible for navigating the tugboat and barge. Six of the calls were recorded as having lasted 1 minute. The two longest calls lasted 7 minutes each. The call he placed at 1432, about 5 minutes before the collision, lasted 6 minutes. Based on the records, the calls collectively lasted a total of 65 minutes; however, because the service provider rounds the

[18] *Freeboard* is the vertical distance from the waterline to the uppermost continuous deck.

calls upward to the nearest minute, the mate's phone calls may have lasted for a significantly shorter period of time.[19] (Also see section "Company Policies Regarding Use of Wireless Devices While on Duty.") NTSB investigators determined that all of the (non-voicemail) outgoing and incoming calls were to or from the mate's father, mother, or spouse.

Mate's Use of Company Laptop Computer

K-Sea Transportation provided all company vessels with laptop computers for the purpose of general communication, aids to navigation, and transmission of data for billing. K-Sea Transportation policy prohibited personal use of these laptops, and allowed only business use so long as such use was not distracting to operations. On the *Caribbean Sea*, the laptop computer, which had Internet connectivity, was located in the lower wheelhouse.

Following the accident, NTSB investigators removed the laptop computer for analysis. In June 2011, the Federal Bureau of Investigation, which had further examined the computer, informed the NTSB that on the day of the accident, between about 1400 and 1420, the computer had been used to look up medical information on the Internet.

Survival Factors

Fifteen of the 35 passengers on board *DUKW 34* at the time of the accident were from Hungary, including 13 teenage students and 2 teachers. Based on interviews with the passengers, English language skills varied greatly throughout the group. The Hungarian group was accompanied by a local American host group consisting of three adults and four teenagers. The remaining 13 passengers on board the APV were "walk-ups" (one group of 4, two groups of 3, one group of 2, and one solo passenger). Passenger ages ranged from 8 to 72 years.

Safety Briefing

Before getting under way, the master on a small passenger vessel such as *DUKW 34* is required by Coast Guard regulation at 46 CFR 185.506 to provide a safety briefing to passengers. The briefing must include the location of emergency exits, the location of lifejackets, and the proper method of donning and adjusting lifejackets, including a demonstration. The briefing must also inform passengers that they will be required to don lifejackets when potential hazardous conditions exist, as directed by the master. According to Coast Guard Navigation and Inspection Circular (NVIC)[20] 01-01 (*Inspection of Amphibious Passenger Carrying Vehicles*),

[19] Call initiation and duration times are rounded up to the next minute. For example, a call shown as having started at 14:32 could have been initiated as early as 14:31:01 or as late as 14:32. If the duration of the call is shown as 6 minutes, it could have ended as early as 14:36:02 or as late as 14:38:00. The NTSB calculated the mate's minimum possible cell phone activity level to be about 42 minutes.

[20] The Coast Guard uses NVICs to disseminate information or policy to the marine industry. Although the guidance in a NVIC is not enforceable, the industry usually makes an effort to comply with it. NVICs are sometimes used to disseminate information that will subsequently be proposed as regulations.

the safety briefing should also discuss the method of disembarking the vehicle during emergency egress and the method of removing obstructions to egress (windows or curtains):

> 177.500(o) requires only one means of escape.[21] Most DUKWs have been granted special consideration for reduced aisle widths with the stipulation that the primary means of escape is over the side. This goes against human nature, which is to exit in the same manner one enters. The method of boarding, for the majority of DUKWs, is over the stern; hence the perceived escape is over the stern. These vehicles have a tendency to sink stern first. This places the perceived escape in the opposite direction from which the passengers should go. Because of this, the master should give specific instructions to the passengers during the safety orientation concerning the method of escape from the vehicle.

At the time of the accident, the primary guidance document for operators of Ride The Ducks APVs was the *Captains' Operations Manual*, dated February 20, 2010. According to the manual's introduction, its purpose is to "standardize certain operations across the fleet and provide support and clarification of . . . day-to-day operations." With regard to safety briefings, the manual stated the following:

> **Safety Briefings**
>
> A safety briefing is an informational presentation that ensures the safety of all passengers from the time the tour starts until it ends. It is necessary to give the following safety briefings at the appropriate times:
>
> **Pre-Trip Safety Briefing**
>
> - Prior to starting your tour, cover the following items:
> - Keep arms and hands in the vehicle at all times
> - No smoking throughout the trip
> - Remain seated throughout the trip unless authorized by your Captain/Driver
> - Be prepared for sudden stops or turns and keep children firmly in laps/seats for their protection
>
> **Pre-Water Entry Safety Briefing**
>
> Prior to entering the water, cover the following items:
>
> - Location of Adult PFDs [personal flotation devices]
> - Location of Child PFDs
> - How to access the PFDs

[21] Title 46 CFR 177.500(o) states that only one means of escape is required if the space has a deck area less than 30 square meters (322 square feet). Normally, two means of escape are required.

- Demonstration of donning PFDs
- Location of PFD placard
- Location of emergency egress (over the side)
- Location of ring buoy
- How curtains will release in the event of emergency egress
- Passengers should follow the instructions of the Captain

According to Ride The Ducks Philadelphia employees, safety briefings, including the pre-water briefings, were always conducted before the APVs departed the Visitor Center. The master of *DUKW 34* told investigators that he always conducted a safety briefing before departing the Visitor Center on a tour. The briefing covered general safety requirements as well as safety issues specific to the marine environment. With regard to lifejackets, the master described his pre-departure brief to investigators as follows:

> [I tell them] 'Okay, folks, I want you to know this is a Coast Guard-inspected vessel. I am required to tell you about a PFD. Folks, we're not going to need these today, but I need to tell you about these. Okay. They're located here and there. This side is for adults. This side is for children.' (I'm holding the jacket, pointing to them, for children.) 'Okay. If you're not sure if you're an adult or a child, the Coast Guard really doesn't care about your emotional level of stability. They only care about weight. Ninety pounds and over, 90 pounds and under. If you're right at 90 pounds, like me, make sure you put the bigger jacket on, okay? Now folks, if I tell you, and only if I tell you to put the jackets on, here's what you need to do. Pull down on the yellow tab, the jacket comes down, looks like this. Unhook the clip. It looks like a dog leash clip. Open up, put it over your head and around your neck. This thing goes around the back of your body and comes back to the front.' (I don't do the procedure with the jacket over my head. I show them how to put it on . . . but to simplify this, I took it off.) I said, 'this thing goes around the back of your body, comes back and clips on the D ring. It doesn't matter what side you use. Both sides will work. Okay. Now if you do what I ask you to do, you, too, are going to float like a –' and everybody is supposed to yell "Duck."'

All passengers interviewed remembered hearing the master's safety briefing before departing on the tour. Although none of the American passengers commented negatively on the briefing, 11 of the 13 surviving Hungarian passengers had negative comments. Several Hungarian survivors commented on the fact that the master did not physically demonstrate how to don a lifejacket. One Hungarian passenger compared it to the safety brief on airplanes saying:

> Because yes, you know, if you were on an airplane, there is a video demonstration there, and everybody is so bored, because you can see it many times, as many times as you travel. But now, I would have been curious how it [a lifejacket] should be used, because it is the first time I am on that vehicle.

Two other Hungarians indicated that after listening to the master's brief, they did not know how to put on a lifejacket.

Lifesaving Equipment

DUKW 34 was required to carry lifesaving equipment on board as stipulated in its Coast Guard-issued Certificate of Inspection (COI).[22] The COI required 39 adult lifejackets and 4 child lifejackets, as well as a ring buoy with line attached. Because the tours often carried large groups of children, Ride The Ducks APVs were equipped with more than the minimum number of required child-sized lifejackets. Because not all lifejackets from *DUKW 34* were recovered after the accident, investigators were unable to verify the exact number carried on board; however, the vessel had been inspected by the Coast Guard on March 25, 2010, and had been found to be carrying all required lifesaving equipment.

Lifejackets were stowed in the overhead on both sides of the vessel. Adult lifejackets were stowed in stacks of two on the starboard side above all but the last row of seats. Child-size lifejackets were stowed similarly on the port side and were above all but the last 3 rows of seats. The bottom end of each lifejacket was resting in a metal channel just below the canopy on each side (figure 8).

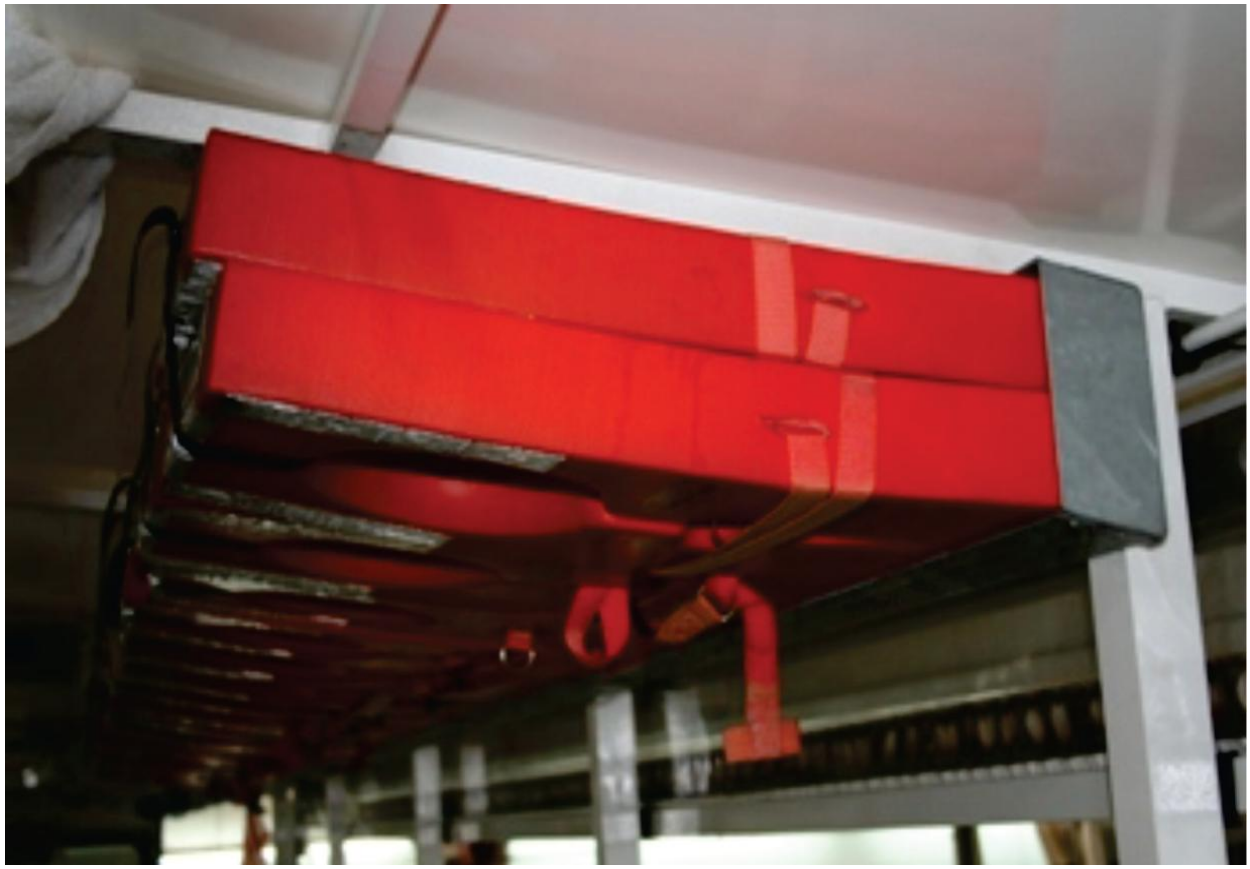

Figure 8. Lifejackets on Ride the Ducks APVs were stowed in stacks of two above each row of passenger seats. Adult jackets were on the starboard side; child jackets were on the port side.

[22] A COI is required by law (46 *United States Code* Section 3309), and an approved stability letter is required by regulation (46 CFR Part 170) before a small passenger vessel is allowed to carry more than six passengers at least one of whom is for hire. COIs for this particular class of vessel are issued for 5-year intervals, with annual inspections due within 3 months before or after each anniversary date of the certificate.

The top end of each lifejacket was secured to the overhead using a black nylon strap with a yellow tip and button-type snap. Passengers needed only to pull the yellow strap end to release the snap and free the lifejackets from the overhead.

Coast Guard regulations at 46 CFR 185.508 and Ride The Ducks policy[23] specify that lifejackets are to be donned by passengers when hazardous conditions exist, such as when the vessel is being towed. The Coast Guard regulations also cite "flooding, fire, or other events that may possibly call for evacuation" as circumstances under which passengers should don lifejackets.

Evacuation

The *DUKW 34* passenger cabin had nine rows of bench seats (each seat accommodating two passengers) arranged down the port and starboard sides of the vessel with a center aisle in between.[24] The cabin was covered overhead by a canopy consisting of a composite vinyl and polyester awning material supported by welded steel tubular framing. Coast Guard NVIC 01-01 states that:

> Canopies and canopy supports can impede the egress of passengers. Again, the primary egress on these vehicles is over the side. Canopy supports should be positioned to allow the majority of passengers unobstructed egress.

The canopy support stanchions on Ride-the-Ducks APVs were positioned in line with seat backs.

During inclement weather, roller curtains of clear plastic sheeting could be electrically lowered to enclose the otherwise open-sided cabin. In the event of an emergency requiring an over-the-side evacuation while the curtains were down, each roller curtain was fitted with a manually operated release mechanism that used gravity to quickly drop the curtain outward. The curtain release mechanisms were consistent with the recommendations of NVIC 01-01, as follows:

> If side windows or curtains are installed they should not cause an impediment to passenger egress. Arrangements should be in place to allow the master the ability to open all windows and or curtains on each side from a point located at the control station.

On the day of the accident, as was normal for operations during warm weather, the plastic curtains were rolled up, leaving the windows completely open.

DUKW 34 complied with the guidance of NVIC 01-01 with regard to evacuation, including requirements for seat spacing, aisle width, deck rails, window openings, and means of escape.

[23] The Ride The Ducks *Captain's Operations Manual* references 46 CFR 185.508.

[24] A folding seat between the rearmost bench seats was dropped down after the rear access door was closed to accommodate a 37th passenger.

Vessel Information

DUKW 34

The hull and mechanical systems of *DUKW 34* comprised mostly new but some rebuilt components installed on the chassis of an original 1945-vintage DUKW, classified by the U.S. Army as a "2 1/2 ton, 6 x 6, Amphibian Truck." The APV had six wheels—two forward, two middle, and two aft—of which four (the forward and mid-wheels) were driven.[25] The hull was constructed of 10-gauge steel at its bottom and 12-gauge steel at its sides and was reinforced by interior framing and exterior reinforcement ribs. The vehicle was 33 feet long and 8 feet wide. During water operations with a full passenger load, the vessel draft was about 5 feet with a freeboard of about 2 feet.[26]

Although the appearance of the APV closely matched the original 1945 model, most engineering systems had been updated from the original design, and some new systems and equipment had been added. These included a fire detection and manually activated suppression system in the engine compartment, a vapor detection system,[27] communications equipment, and additional electric bilge pumps.[28]

DUKW 34 was built in 2003. It was one of a series of sister APVs that were termed "Stretch Ducks" by their builder, Amphibious Vehicle Manufacturing, LLC, (AVM) of Branson, Missouri.[29] The "Stretch Duck" was lengthened by about 2 feet over the original 1945 DUKW. Ride The Ducks manufactured its last APV in 2008. Since 2008, construction of new Ride The Ducks APVs has been contracted out to Chance Morgan, Inc., and Chance Rides Manufacturing, Inc., of Wichita, Kansas.

The operator's station of *DUKW 34* had a bucket-style seat for the operator at the left side of the front of the passenger cabin. A jump seat to the right of the operator's was used by a deckhand or the tour narrator, depending on the circumstances. The vessel's COI authorized it to carry a maximum of 39 persons, including a 2-person crew.

The APV was propelled on both land and water by a Chevrolet, 8-cylinder, 235-hp gasoline engine that was fitted in an engine compartment located forward of the operating station and passenger cabin. For land operation, the engine output shaft was connected to an automatic

[25] The on-road drive arrangement had been modified from the original DUKW six-wheel drive (6 x 6) arrangement to a four-wheel drive (6 x 4) system.

[26] According to the stability letter issued for the vessel by the Coast Guard on March 19, 2009, "Freeboards of at least 2 feet 1/2 inches, as measured at the stem to the top of the bulwark, and 2 feet 4-7/8 inches, as measured to the top of the bulwark at a point 7 feet 6 inches aft of the bow, shall be maintained. This corresponds to a maximum draft at the stern of 5 feet 2-3/8 inches.

[27] Title 46 CFR 182.410 requires that small passenger vessels under 100 tons be equipped with a system that can detect flammable vapors. Title 46 CFR 182.480 requires that this vapor detection system provide a visual and audible alarm at the operator's station.

[28] Guidance regarding the additional bilge pumps is provided in NVIC 01-01.

[29] Amphibious Vehicle Manufacturing was merged into Ride The Ducks International, LLC, in 2005.

transmission. The transmission was connected to a single-speed transfer case that was then connected to differentials at the forward and mid axles, which were then connected to the forward and middle driving wheels. For water operation, a separate output from the transfer case was connected to the propeller through a 2:1 helical reduction gear and a propeller shaft. The operator had to engage and disengage the propeller manually before and after each waterborne operation. The three-bladed bronze propeller had a diameter of 24 inches and a pitch[30] of 14 inches.

A conventional (automotive style) power-assisted hydraulic steering system was used to steer the APV on the road. On the water, steering was accomplished by a mechanical linkage (a push-pull cable) from the steering column to the rudder tiller at the stern. In the event of an on-water steering failure, the APV was equipped with a redundant steering cable that could be connected manually to the tiller and operated with a hand crank stored near the operator's station.

The APV engine was cooled by a conventional (automotive style) closed and pressurized cooling system using a mixture of water and ethylene glycol (antifreeze).[31] The mixture was cooled by passing it through both a traditional air-cooled radiator and a water-cooled heat exchanger called a "keel cooler" mounted on the exterior of the APV, on the port side below the waterline.[32] A manually operated ball valve could be closed to prevent coolant flow through the keel cooler during cold weather. According to the lead mechanic for Ride The Ducks, the normal coolant temperature would be from 160° to 180° F, with "200[◦] not real bad, particularly in hot weather." The mechanic said that APV operators were told to contact the maintenance facility if the cooling water temperature reached 220° F.

The APV radiator was mounted at the front of the engine. Air flow across the radiator was generated by an engine-driven axial-flow fan and could be supplemented by ram air entering through the partially open engine compartment cover (hood). After passing across the radiator, the air was directed to port and starboard plenums on either side of the engine bay before exiting to the atmosphere through screened openings on the vessel bow just forward of the passenger cabin.

The APV cooling system included a metal surge tank[33] mounted near but external to the radiator. A pressure cap on the surge tank served to maintain an elevated pressure within the cooling system and thus raise the boiling temperature of the coolant.[34] The pressure cap, which was rated at 13 pounds per square inch (psi) (gauge), was attached to the fill neck for the surge

[30] *Pitch* refers to the theoretical distance a propeller would move forward in one revolution if it were moving through a soft solid.

[31] Ethylene glycol both lowers the freezing point and raises the boiling point of the water while inhibiting corrosion within the system.

[32] A second keel cooler, mounted on the starboard underside of the hull, was used for cooling the engine transmission oil.

[33] The *surge tank* is normally situated at the highest point in the vehicle cooling system and is where air is separated from the liquid coolant.

[34] The boiling point of water at 13 psi is 245° F. The presence of antifreeze in the cooling water raises the boiling point even higher.

tank, not to the radiator itself. A plastic expansion tank (sometimes referred to as a "reserve" tank or "overflow" tank) mounted near the surge tank allowed the coolant level in the system to rise or fall as the liquid was heated or cooled. Reference marks labeled "hot" and "cold" on the translucent tank indicated the proper coolant level for each condition.[35]

For communications, the APV was fitted with a fixed marine VHF-FM radio mounted near the operator station and a spare handheld VHF-FM marine radio. The master was also provided with a cellular phone with push-to-talk (direct-connect) capability for communicating with company personnel ashore.

Caribbean Sea

The *Caribbean Sea*, a 78.9-foot-long, 148-gross-tons uninspected[36] tugboat, was built in 1961 by Equitable Shipyard of Madisonville, Louisiana, as the *H.D. Campbell*. After two owner and name changes, the vessel was purchased by K-Sea Transportation in 2008 and became the *Caribbean Sea*.

The vessel was a twin-screw, twin-rudder tugboat of all-welded construction built for coastwise ocean towing service. The vessel had a single deck. Located amidships was a two-level deckhouse[37] that contained the original (lower) wheelhouse, crew quarters, and galley. The deckhouse was equipped with heating and air-conditioning systems. An upper wheelhouse was fitted atop the original wheelhouse some time after initial construction (refer to figure 5). The upper wheelhouse was equipped with two small heaters for cold-weather operations. In warm weather, the door and side windows of the upper wheelhouse could be opened for ventilation, but the space was not air-conditioned. The *Caribbean Sea* was fitted with two 1,200-rpm propulsion diesel engines rated at 1,200 hp, each driving two 72-inch-diameter, 52-inch-pitch, four-blade, stainless steel propellers.

During voyages, the *Caribbean Sea* steering and throttle system could be controlled from either the upper or lower wheelhouse, but throttle control could be active at only one of the wheelhouses at any time. Throttle control was transferred from one wheelhouse to the other through activation of an air control valve. Activating the valve at either station would transfer control to that station. The *Caribbean Sea* was actually equipped with four separate control stations—an aft deck station (usually used while configuring a tow), port and starboard lower wheelhouse stations, and the upper wheelhouse station. In all cases, the throttle could be controlled from only one station at a time. The *Caribbean Sea* was not equipped with a recording

[35] Coolant expands when heated, raising the pressure within the cooling system. When this pressure exceeds the pressure rating of the pressure cap, a valve within the cap opens to allow some of the coolant to be routed to the unpressurized expansion tank. As the liquid cools and contracts, pressure within the cooling system drops, drawing liquid from the expansion tank back into the system.

[36] *Uninspected* in this context refers to a vessel that does not carry passengers or freight for hire and is therefore not required to be inspected by the Coast Guard. Such vessels must comply with 46 CFR Subchapter C, "Uninspected Vessels."

[37] The "upper deck" referred to for clarity in this report is actually part of the deck house.

device that would have recorded steering and throttle inputs, rudder response, or the location of throttle control.

For communications and navigation, the lower wheelhouse was fitted with three VHF-FM marine radios (aft, port, starboard), two GPS receivers (aft, forward), satellite compass, two radars (2-3 cm X-band, port, starboard), AIS navigation unit, echo depth sounder, and a SIMRAD 50 autopilot. A company-issued laptop computer with Internet connectivity was also located in the lower wheelhouse. The upper wheelhouse was fitted with two VHF-FM marine radios (port, starboard), satellite compass,[38] magnetic compass, one radar (3 cm), and an AIS navigation unit.

The Resource

The tank barge *The Resource*, an uninspected, unmanned, and non-self-propelled vessel, was built in 1989 by Trinity Marine Group, Nashville, Tennessee. This barge and another, nearly identical tank barge called *The Recycler*, were designed and built specifically for the city of Philadelphia's water department to transport wastewater sludge between the city's pollution control plant and a recycling facility. *The Resource* was 250 feet long with a beam of 50 feet. It was raked on each end and had four cargo tanks with a total combined capacity of 1 million gallons. When loaded, the vessel draft was 15 feet 4 inches. When the barge was empty, as it was on the day of the accident, its draft was 3 feet 6 inches. Its freeboard when empty was about 20 feet at the bow and 16 feet at the stern, and when full about 7.5 feet at the bow and 4.5 feet at the stern. The barge was classed by the American Bureau of Shipping and was limited to river service. At the time of the accident, the barge was owned by the city of Philadelphia.

Personnel Information

DUKW 34 Master

The *DUKW 34* master, age 58, was first employed by Ride The Ducks as master on March 1, 2004. He remained in that position for 2 months. After leaving the company, he worked on charter fishing vessels and, for a time, operated his own charter fishing boat. He was rehired by Ride The Ducks in the spring of 2009 and worked as master with the company for the 2009 and 2010 tour season, until the time of the accident.

Licenses and Training. The master was operating under the authority of a Coast Guard master's license with a current issuance approved for steam or motor vessels of not more than 50 gross tons operating upon near-coastal waters, issued in March 2008. He obtained his first Coast Guard master's license in May 2003. That license was limited to steam or motor vessels of

[38] A satellite compass uses GPS technology to provide heading data for autopilot, radar, AIS, sonar, and plotting systems. The accuracy of heading data provided by a satellite compass is not affected by vessel pitch and roll.

not more than 25 gross tons operating upon near-coastal waters. The master also held a current CDL issued by the state of New Jersey.

Ride The Ducks had corporate and local office safety, operational, and emergency procedures and required all employees, based on the position held, to attend annual preseason and periodic training sessions.[39] The position of APV master was deemed by Ride The Ducks to be a safety-critical position, and all APV masters were required to meet with supervisors or designated safety trainers at least once each quarter to review and acknowledge the company- and Coast Guard-required emergency vessel procedures. These procedures included actions to be taken in the event of loss of steering, loss of propulsion, man overboard, an abandon ship emergency, and fire. The master's most recent formal training was a 3-day preseason training session in March 2010, which included 2 days of classroom instruction and 1 day in the field covering Coast Guard-required emergency drills and Pennsylvania Department of Transportation vehicle inspection refresher training. Subsequent to the formal training sessions, the master completed two safety standards review sessions, on April 30, 2010, and May 1, 2010. He had participated in a quarterly review of on-water emergency drill procedures on June 25, 2010.

Medical. According to his merchant mariner's medical evaluations and the associated records, the master had uncorrected vision in both eyes of 20/200, correctable to 20/20, and each Coast Guard license was issued with the following endorsement, "Corrective lenses to be worn with spare glasses carried on board." A video taken by a passenger on board *DUKW 34* before the APV's departure on the accident tour showed the master wearing glasses during the safety briefing. During his most recent Coast Guard merchant mariner's physical in 2008, the master reported no illnesses or disabilities. On a medical examination form associated with his CDL application in 2004, he checked the "NO" box for the symptom titled, "Sleep disorders, pauses in breathing while asleep, daytime sleepiness, loud snoring." When asked by the attending physician about his sleep patterns, he said he did not experience excessive tiredness. U.S. Department of Transportation (DOT) regulations require CDL holders to undergo a physical examination every 2 years. Ride The Ducks required its CDL holders to have a physical examination every year. The master's last physical exam before the accident took place in April 2009.

Work/Rest Cycle. In the days that preceded the accident, the master worked Sunday, July 4, and he indicated it was a hot and long day and that he was tired after work. He could not tell investigators exact times because he said he documented everything in his personal log book, which was lost overboard in the accident. He said that on Monday, July 5, he awoke around 0830 and went to bed at about 2100 or 2130. When asked how he slept that night, he replied "I usually sleep pretty good." He said that on Tuesday, July 6, he did not have to report to work until 1100, so he "slept in a little later." He could not remember the exact time he went to bed on the night before the accident. He said that on the morning of the accident, he awoke at about 0600 feeling rested.

[39] Ride The Ducks Safety Procedures Manual, dated February 16, 2010.

DUKW 34 Deckhand

The deckhand, age 18, was hired by Ride The Ducks in the spring of 2009 as an "ambassador."[40] He worked the 2009 tour season and the 2010 season up until the time of the accident.

Licenses and Training. The deckhand did not hold a Coast Guard license or merchant mariner's document, nor was either required by law or regulation. He self-reported that he had marine experience on small boats, and he stated that he had been around the maritime industry since he was a child because his father was a Coast Guard-licensed mariner. He further indicated that his father had previously been employed by K-Sea Transportation and was employed by Ride The Ducks at the time of the accident.

Because he held a position that was considered by Ride The Ducks to be safety critical, the deckhand had completed a 2-day preseason training session in April 2010, which included 1 day of orientation held in a classroom, and a second day that combined classroom and in-the-field training covering Coast Guard-required drills and Ride The Ducks safety standards for deckhands. The deckhand also completed three more reviews of the company safety standards on April 30, May 2, and June 2, 2010.

Work/Rest Cycles. In the days preceding the accident, the deckhand was off duty Sunday, July 4, through Tuesday, July 6. He said he had "a good night's sleep" on the two nights leading up to the accident. That Monday night, he recalled going to sleep around 2330 or 2400 and awoke the following day sometime between 1100 and 1300. He said he recalled going to sleep around 2330 or 2400 the evening before the accident and awoke sometime around 0730 the next morning in order to report for work by 0900.

Caribbean Sea Master

The master, age 31, was hired by K-Sea Transportation as mate on April 28, 2004. Before joining K-Sea Transportation, he had served as a third mate on seagoing vessels and as a deckhand on towing vessels. He assumed his very first position as master on board the *Caribbean Sea* on July 3, 2010, 4 days before the accident. In total, he had served 8 days as either mate or master on board the *Caribbean Sea* while the vessel was assigned to the tank barge movements.

Licenses and Training. The master was operating as a Coast Guard master of towing vessels upon oceans. The license was also endorsed as second mate of steam or motor vessels of any gross tons upon oceans, and radar observer (unlimited), issued on April 26, 2007. This was his second issuance of a Coast Guard license. The master also held a Merchant Mariner's

[40] In addition to greeting the passengers at the point of loading, Ride The Ducks personnel serving in the position of "ambassador" are responsible for taking tickets at the Visitor Center while loading the vessel and for counting passengers to make sure that all passengers who purchased tickets for the scheduled trip are on board. Ambassadors may also work as deckhands if they are assigned to the ramp where the vessels enter the water.

Document (MMD) as a person in charge/medical care provider, able seaman (AB), and tankerman/person in charge, dangerous liquids.

The master graduated from Maine Maritime Academy in 2002 with a B.S. degree in marine transportation. He received his first issuance of a Coast Guard license as third mate, steam or motor vessels of any gross tons upon oceans, and radar observer on April 29, 2002. On January 13, 2004, he obtained an endorsement on the original license for service as master of towing vessels. On March 18, 2008, the master's license was upgraded to master of steam or motor vessels of not more than 1600 gross tons (domestic tonnage), 300 gross tonnage (ITC[41] tonnage), upon oceans.

Medical. No physician-noted or self-reported sleep disorders were documented in the master's medical records. During his most recent physical evaluation, which took place in November 2009, a physician determined the master to be medically and psychologically fit for duty.

Work/Rest Cycles. The master reported to the *Caribbean Sea* as mate on June 30, 2010, and participated in the "back watch" from 1200 to 1800, and then again from 2400 to 0600. On Saturday, July 3, 2010, he assumed the position of master and transitioned to the "front watch," 1800 to 2400 and 0600 to 1200. He remained in that duty rotation until the time of the accident. He stated that he got most of his rest during his off-duty period between about 0010 and 0600 but that he also slept well during the afternoon off-duty period.

Caribbean Sea Mate

The mate, age 34, joined K-Sea Transportation in December 2000 as an ordinary seaman (OS)/deckhand. From that date until mid-2006, he served on various vessels in the company fleet and progressed from OS to AB/deckhand.

Licenses and Training. The mate was operating under the authority of his first issuance of a Coast Guard mate's license for steam or motor vessels of not more than 200 gross tons, upon near-coastal waters, mate of towing vessels upon near-coastal waters, and radar observer (unlimited), issued on November 13, 2006. The mate also held an MMD as an AB seaman, limited to service on non-lifeboat-equipped vessels, wiper, and steward or food handler.

The mate attended and completed several licensing courses at Quality Maritime Training (QMT) in St. Petersburg, Florida. He completed the 56-hour Operator of Uninspected Passenger Vessels course on September 16, 2006, a 24-hour Operator of Uninspected Passenger Vessels upgrade to master 100 gross ton course on September 21, 2006, and the 36-hour master 100 gross ton upgrade to master 200 gross ton course on September 29, 2006.

K-Sea Transportation had its own mate trainee program that established minimum levels of competency, awareness, and training that had to be met before a seaman would be considered for promotion to the position of mate. According to company records, the mate began that

[41] International Tonnage Convention.

program on January 24, 2007, on board the *Falcon*, and completed the training on March 5, 2007, on the *Davis Sea*. On March 7, 2007, he began his first service in the position of mate on the *Davis Sea*, and continued to serve on board various company vessels at that rank until the time of the accident. He had previously served as mate on the *Caribbean Sea* from October 21, 2009, through November 2, 2009, and then again on June 24, 2010, through June 30, 2010. In total, he served 118 days as mate on either the *Falcon* or the *Caribbean Sea* when the vessels were assigned to the tank barge movements.

Medical. The mate's most recent physical examination before the accident was completed on April 21, 2010. The physician determined at that time that the mate was medically and psychologically fit for duty. He had uncorrected vision of 20/20 in both eyes. No physician-noted or self-reported sleep disorders were documented in the mate's medical records.

Work/Rest Cycles. After an initial interview with Coast Guard investigators, the mate declined to provide any additional information or participate in further interviews. Therefore, the mate's 72-hour work/rest profile before the accident is unknown (see Appendix C). Records show that the mate was off duty from July 1, 2010, until the date of the accident.

Medical and Toxicological Information

Caribbean Sea Crewmembers

K-Sea Transportation used the consortium American Maritime Safety, Inc., (AMS) for the company's chemical testing program. At 1611 on the day of the accident, a local K-Sea Transportation employee certified by AMS to collect urine specimens and perform alcohol swab testing performed an alcohol screening of the accident mate. The swab test was negative for the presence of alcohol.[42] Between 1632 and 1739, this same individual also performed saliva swab testing on the four remaining crewmembers and collected urine specimens from each. The saliva test for each crewmember was negative for the presence of alcohol. The urine specimens collected from the mate and the other crewmembers were sent to MedTox Laboratories, Inc., for testing and were later confirmed by a medical review officer (MRO) to be negative for the presence of illicit drugs.[43] A specimen from the *Caribbean Sea* mate was also sent to the Federal Aviation Administration's Civil Aerospace Medical Institute (CAMI) for additional testing. The results of those tests were also negative for illicit drugs and alcohol as well as for prescription and over-the-counter medications.

[42] A Q.E.D. A150 brand saliva alcohol test swab was used for the test. These swabs meet both U.S. Department of Transportation standards and Coast Guard maritime requirements for alcohol testing.

[43] Regulations at 46 CFR 16.113 specify testing for marijuana, cocaine, opiates, phencyclidine, and amphetamines.

DUKW 34 Crewmembers

Sometime after the initial search-and-rescue effort, local Coast Guard personnel performed alcohol tests on the *DUKW 34* master and deckhand using an Alco-Sensor IV breath alcohol testing unit. The exact time of the alcohol test on each individual was not recorded; however, it is known that the testing took place sometime between 1442 and 1804, within the 8 hours required by Coast Guard regulations. The test results on both individuals were negative for the presence of alcohol.

A specimen collection technician collected a urine sample from the deckhand at 1804 and from the master at 1812. The urine specimens were sent to Laboratory Corporation of American (LabCorp) for testing. An MRO reported on July 9, 2010, that the test results for both the master and the deckhand were negative for the presence of illicit drugs. Specimens from both the deckhand and the master were sent to CAMI for additional testing. The results of those tests were negative for illicit drugs and alcohol as well as for prescription and over-the-counter medications.

Meteorological Information

The closest official National Weather Service weather reporting location to the accident site was Philadelphia International Airport, located about 6.5 miles southwest of the accident site. The following conditions were reported for the time period within which the accident occurred: At 1412, wind was from 010° at 8 knots gusting to 17 knots, visibility was unrestricted at 10 statute miles, temperature was 100° F, dew point temperature was 59° F. At 1454, wind was from 010° at 8 knots gusting to 19 knots, visibility was unrestricted at 10 statute miles, temperature was 101° F, dew point temperature was 58° F. No rainfall was reported on the day of the accident. The recorded low temperature of the day was 84° F; the high temperature was 101° F. An excessive heat warning was in effect in the Philadelphia area until 2000 hours. An excessive heat warning is issued when the heat index (the human-perceived temperature equivalent based on a combination of the actual air temperature and relative humidity) is expected to exceed 110° F for 3 hours or more during the day for at least 2 consecutive days and evening temperatures exceed 80° F.

At 1436, National Oceanic and Atmospheric Administration buoy station PHBP1, located about 1 mile south of the accident site in the Delaware River, reported an air temperature of 99° F and a water temperature of 82° F.

Waterway Information

The Delaware River runs 410 miles, from the Catskill Mountains of New York to the Atlantic coast. The river constitutes a part of the boundary between the states of Pennsylvania and New York and the states of Delaware and New Jersey. It is the entire boundary between Pennsylvania and New Jersey. The river is generally considered navigable by large oceangoing vessels and by tug/barge combinations as far as the Trenton, New Jersey, area. At the site of the

accident, water depth in the navigation channel was about 55 feet, with charted water depth immediately outside the eastern edge (New Jersey side) of the channel indicating a water depth between 35 and 42 feet. The western (Pennsylvania side) border of the navigation channel in the accident area was about 120 feet from the Penn's Landing bulkhead.

The shipping channel in the Delaware River is federally maintained by the U.S. Army Corps of Engineers (USACE). The channel originates at the entrance to Delaware Bay and terminates at Newbold, New Jersey. The channel has a controlling depth of 40 feet. As the channel proceeds upriver, its width gradually decreases: For the first 35 nm, the channel is 1,000 feet wide. From that point to an area known as Eagle Point Range, where the Schuylkill River feeds into the Delaware River, the channel is 800 feet wide. From that point to the Walt Whitman Bridge, the channel narrows to 400 feet. The channel width remains at 400 feet there, through the Penn's Landing area, and up to Newbold Island, about 22 nm north of Philadelphia, where both the water depth and channel width are further reduced.

The portion of the Delaware River where the accident occurred is subject to Federal jurisdiction with the Coast Guard being the primary Federal agency responsible for marine safety, search and rescue, law enforcement, and security on the waterway. The Mariners Advisory Committee for the Bay & River Delaware, an organization formed in 1964 by the Delaware Bay and River Pilots Association and local maritime stakeholders, is active in the area and makes recommendations to USACE on suggested improvements, navigational aid placement, and other areas which may enhance safe navigation. Additionally, the Maritime Exchange for the Delaware River and Bay, an organization originally chartered in 1882 to promote trade and harbor development and to enhance local maritime practices, provides the maritime community with various commercial, navigational and maritime security needs.

Postaccident Inspection and Testing

DUKW 34

After the damaged APV was salvaged, NTSB investigators performed extensive examination and testing of its mechanical systems. The results of those examinations and tests are as follows:

Water Pump. The water pump, which keeps the engine's coolant in constant circulation, was removed from the engine and disassembled. No deficiencies were found with the water pump impeller other than some indication of water leakage at the lower weep hole in the case (rust stains near hole).

Radiator. Examination of the vessel's engine compartment revealed that the pressure cap normally fitted to the radiator surge tank was missing (figure 9). The pressure cap was subsequently found undamaged in the lower part of the engine compartment. The pressure cap was tested and was shown to open at 11 to 13 psi. The pressure cap was rated for 13 psi.

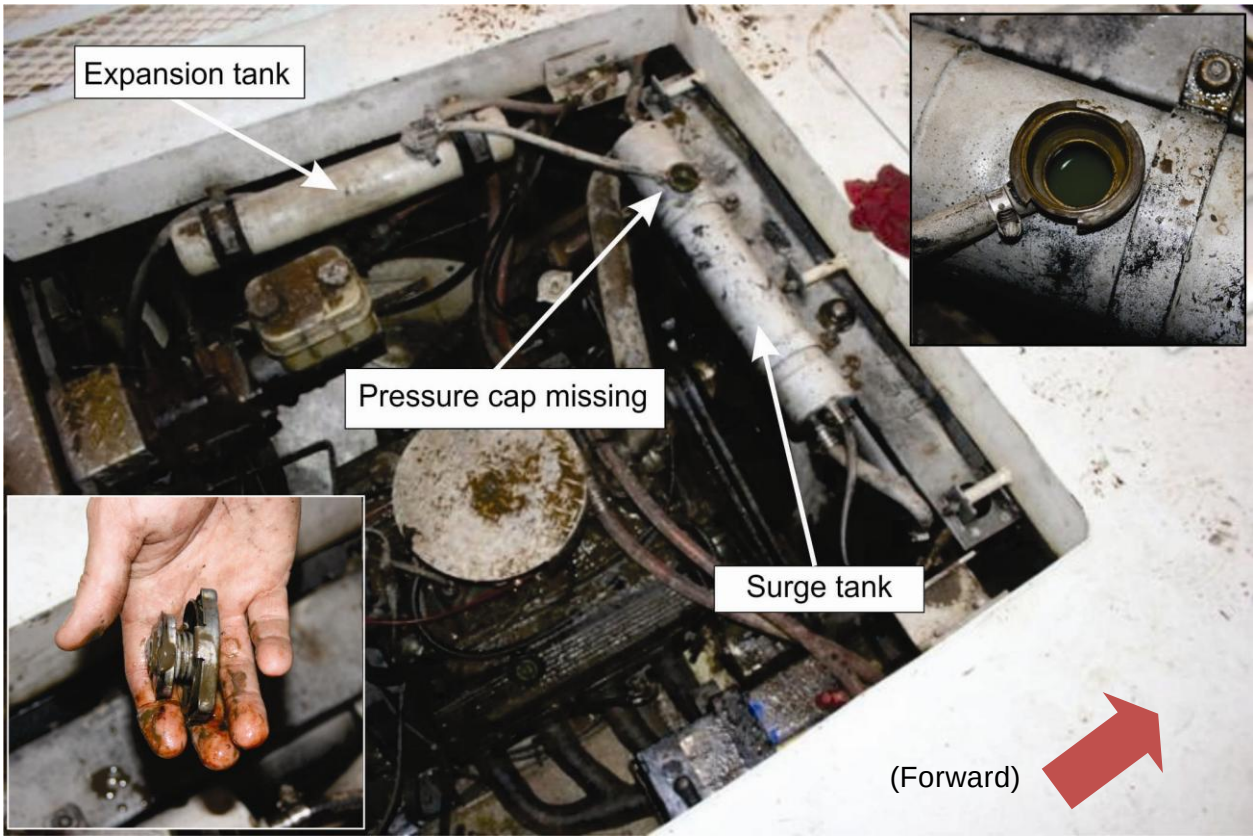

Figure 9. Engine compartment of the salvaged *DUKW 34*, with the surge tank pressure cap missing. The upper inset photo is a close-up of the uncapped tank; the lower inset photo shows the pressure cap recovered from the bottom of the engine bay.

Investigators collected a sample of the engine coolant using the drain valve at the bottom of the radiator. This sample was then tested for freeze protection[44] using a refractometer. The test indicated a coolant freeze protection level of +3° F.

After removing the radiator from the vehicle, investigators removed the radiator top cover (header) to expose the ends of the heat exchanger tubes. A water flow test showed that the radiator functioned normally.

Thermostats. The APV was fitted with two thermostats, both rated at 160° F. During testing, both thermostats began opening at 160° F and were fully open at 170° F.[45]

Keel Cooler. The ball valve controlling coolant flow through the keel cooler was found open after the vessel was salvaged. A water flow test through the keel cooler revealed no

[44] The amount of freeze protection is a function of the proportion of ethylene glycol in the cooling water.

[45] Thermostats help regulate engine coolant temperature to maintain most efficient engine performance. When coolant temperature is lower than the temperature rating of the thermostat, the thermostat remains closed, causing the coolant to circulate through the engine while bypassing the radiator. When the coolant temperature is higher than the thermostat rating, the thermostat opens to allow some or all of the coolant to be routed through the radiator (or other heat exchanger, such as the keel cooler).

significant blockage. No deficiencies were found with the keel cooler or the tubing connecting it to the engine cooling water system.

VHF Radio. Because the VHF radio had been submerged in water for almost 2 days, it was not tested. Testing of the same model radio on another Ride The Ducks APV revealed that when the radio was turned on or powered up, it defaulted to channel 16, regardless of the channel setting when it was last shut off or powered down.

Engine and Heads. The engine cooling system was pressure tested at 15 psi for 30 minutes, and a pressure drop of about 1 psi was noted after 30 minutes. The engine heads were then removed from the engine and sent to a specialized repair shop for examination. The heads indicated some minor warping and no cracks.[46]

Radiator/Engine Ventilation System. The APV's engine compartment was equipped with two fire damper doors that were controlled by levers on either side of the operator's station. The port fire damper was controlled by a lever at the lower left of the operator's station, near the position of the operator's left foot. The starboard fire damper was controlled by a similar lever on the right side of the operator's station.

Investigators examined and tested both fire dampers. The damper doors were held open against spring pressure by a two-stage latch, similar to an automobile hood latch. To close the damper, one had to pull upward on a trip lever. The force needed to trip (close) the damper was found to be about 3 pounds when latched in the first-stage position and about 12 pounds when latched in the second-stage position. The trip lever had to be moved about 0.5 inch to cause activation of the latch (which closed the damper door).

After the accident, the port-side fire damper was found closed; the starboard-side damper was open. A review of a video taken by a *DUKW 34* passenger during the incident indicates that the master closed the port damper and engine hood as part of his emergency procedures after he had shut down the engine.

Engine Compartment. The engine compartment was examined for evidence of fire/smoke damage, and none was found. All electrical wiring, belts, and hoses were in good condition and showed no evidence of having been subjected to fire or smoke.

Air Horn. Investigators determined through initial testing of the air horn that it would not operate with the ignition switch off. Some sediment was found on the trumpet diaphragm. After the horn trumpet and compressor were cleaned and inspected, the horn was tested (with the ignition switch on) and was found to function normally.

Test Runs. In an attempt to simulate scenarios that could possibly have led to the conditions observed by the *DUKW 34* master on the day of the accident,[47] investigators

[46] Both heads were warped between .005 and .007 inch. Based on vacuum tests, a valve repair was recommended.

[47] In his interview, the *DUKW 34* master stated that he smelled an odor and saw dense white smoke in the forward part of the passenger compartment near his operating station. The appearance of this smoke, which he believed to be from an onboard fire, prompted him to shut down the main engine and anchor the APV.

performed two sets of test runs in a Ride The Ducks APV similar to *DUKW 34*. The first test run was performed in Philadelphia on July 14, 2010. The test run was intended to duplicate, as closely as possible, the conditions present on the day of the accident. The APV was loaded with weights to simulate the load conditions at the time of the accident, and the pressure cap was removed from the surge tank. The ambient temperature at the time of the accident could not be simulated. At the time of the test, the air temperature was about 77° F, while the temperature at the time of the accident was about 100° F.

The route taken during the first test run was similar to the route taken by *DUKW 34* on the day of the accident, with one on-land trip preceding the on-water portion of the test. The engine coolant temperature was observed throughout the test run. The highest on-land coolant temperature was about 180° F; the highest on-water temperature was about 165° F.

The second test was performed in Branson, Missouri, with a similar APV to determine the temperature at which steam would be produced from an open water cooling system. In this test run, the pressure cap was removed from the radiator surge tank, and the port side fire damper was closed after the engine cooling water temperature had stabilized at a normal level. The test was conducted with the port fire damper closed because the door was closed when the vehicle was salvaged after the accident, and investigators believed that the closed fire door may have contributed to the high coolant termperature on the day of the accident. The investigation later determined that this door had been closed by the master after the incident began, indicating that it had not been a factor in the accident.

The test run consisted of on-road travel only,[48] and no attempt was made to match the test load to the passenger load on *DUKW 34* at the time of the accident. At the time of the test, the ambient air temperature was about 72° F. After about 10 minutes of on-road travel, the engine coolant temperature increased to about 220° F, at which time steam from the boiling coolant could be seen escaping from the vessel hood and began entering the passenger cabin from the starboard engine compartment vent (figure 10).

[48] The on-road trip was from the Ride The Ducks Branson maintenance facility to the parking lot near the point at which the on-water Branson tour would normally begin. The on-road trip in Branson took place over more "hilly" terrain than would be encountered during a normal on-road tour in Philadelphia.

Figure 10. Steam from the engine compartment of a test APV, with cooling water temperature of about 220° F.

Caribbean Sea

NTSB investigators and third party electronics technicians working under the direction of the NTSB examined and conducted functional testing of the tugboat's steering, navigation, and communications systems, including the radios and their volume levels. No deficiencies were found. During an underway trip performed on board the *Caribbean Sea* with *The Resource* configured in a hip tow similar to the day of the accident, investigators were able to tune and adjust the radars in both the upper and lower wheelhouses so that each unit acquired a small target such as the anchored APV.

Caribbean Sea AIS data (which included reported vessel position, ground speed, ground track angle, and true heading parameters before, during, and after the accident voyage) and post-accident photographic and video evidence were used to validate the visibility study blind zone position and orientation calculations. A review of the available AIS data and photographs/video that documented the vessel upper/lower wheelhouse radar image returns, GPS position, satellite compass true heading, date, and time indicated that the recorded AIS heading parameter was biased about 11 degrees clockwise (to starboard) of the vessel true heading.

Maintenance of Ride The Ducks Philadelphia APVs

General

At the time of the accident, Ride The Ducks Philadelphia APVs were maintained by three line mechanics, a "cleaner," and a supervisory mechanic (the fleet maintenance manager). Maintenance operations were overseen by the Philadelphia general manager, and technical support to the Philadelphia maintenance operations (as well as other company locations) was provided by personnel in Branson, Missouri. The company maintained a dedicated point-of-contact at headquarters to address maintenance- and repair-related issues.

According to the Philadelphia fleet maintenance manager, the company hired mechanics who were already experienced in heavy vehicle maintenance and then provided them with on-the-job training that focused on the differences between an APV and a commercial vehicle. The company also provided its maintenance staff with written maintenance procedures and checklists to guide them when performing maintenance and repairs. A mechanic exchange program that operated among the various company operating locations was intended to provide a means of information sharing among the company's mechanics.

The company had an internal website, known as "Duck Central," that served as a repository for operational and maintenance information and was available to employees with access to a computer. Duck Central was also used to provide employees with safety and training information. The company had also implemented an electronic parts and maintenance system, known as "Asset Works" that was used for parts inventory control and for the recording of maintenance actions performed on the APVs.

In addition to the daily inspections described below, more in-depth routine maintenance and inspection of APVs were performed based on engine operating hours. Most major maintenance actions were performed at 250-hour intervals. This routine maintenance covered such items as wheels, brakes, steering, suspension, lubrication, drive axles, struts, drive shafts, transfer cases, radiator, water pump, cooling fan, and electrical system (battery, alternator, wiring). The inspection items were listed on a 9-page "250 Hour Periodic Inspection and Repair" form. According to information provided by the company, the most recent 250-hour inspection for *DUKW 34* had been performed in February 2010.[49]

During the winter off-season, the APVs had annual maintenance and repair periods during which company mechanics performed major repairs, such as engine rebuilds.

[49] The form does not indicate the engine hour meter reading at the time of the inspection, and it was not signed by the person completing the inspection even though those items that were completed on the checklist are check marked "acceptable" or "repairs made" and initialed. Not all items on the form were indicated by either a checkmark or initials as having been inspected.

Daily Vehicle Inspections—General

Each operating APV was required to undergo three operational inspections each day. The first inspection of the day was to be performed by the assigned APV operator before the vehicle left the maintenance facility. This pre-trip inspection was based on the "RTDI Captain's/Driver's Pre-Trip Inspection" checklist. At the end of the day, the driver was required to inspect the vehicle again, this time using the "RTDI Captain's/Driver's Post-Trip Inspection" checklist (more below). Finally, at the end of each operating day, company mechanics were required to review each operator's post-trip inspection form and to perform additional checks of the APV's mechanical systems.

Pre-Trip Inspections. The pre-trip checklist incorporated both Pennsylvania Department of Transportation inspection requirements for operation as a highway vehicle and Coast Guard requirements for operation as a waterborne vessel. According to the checklist, the pre-trip inspection included, among other items, an examination of items responsible for ensuring hull watertight integrity (seal "boots" and hull drain plugs), an inventory and function check of safety equipment (VHF radio, navigation and road lighting, the air horn) a check of steering and rudder controls, and a check to ensure overall cleanliness of the APV.[50] The checklist did not require that the operator open the engine compartment cover (hood) to inspect any items within the engine compartment. The fleet maintenance manager told investigators that operators did not examine the engine bay during their pre-trip inspections because that area had already been checked by the mechanic performing the vehicle's most recent post-trip inspection (discussed below). The operator was required to sign and submit the inspection form before starting operation for the day.

The clipboard recovered from the salvaged APV contained the master's completed pre-trip inspection form for the day before the accident. No deficiencies were noted on that form. The inspection form for the day of the accident could not be found. Ride The Ducks representatives informed the NTSB after the accident that, "standard procedure was to leave the completed Pre-Trip Inspection Forms and Post-Trip Inspection Forms in the Maintenance Shop and not carry them on the vehicle."

Post-Trip Inspections. At the end of each operating day, the APV was subjected to a "post-trip inspection," again using checklists prepared by the company. The operator was required to complete the "RTDI Captain's/Driver's Post-Trip Inspection" form. This one-page checklist contained 13 items that had to be inspected, including brakes, steering mechanisms, lighting devices and reflectors, tires, horn, windshield wipers, mirrors, coupling devices, wheels and rims, emergency equipment, trash removal and fuel. In addition, space was provided for the operator to note any deficiencies.

In addition to the operator's post-trip inspection, company mechanics were required at the end of each operating day to review the operator's post-trip inspection form and to perform additional checks of each APV's mechanical systems. According to the mechanic's post-trip

[50] The version (version 3/12/2010) of the checklist in use at the time of the accident was a one-page checklist. A previous version (version 2/20/2010) was a two-page checklist that included both interior and exterior items and that had space for the operator to note any deficiencies.

inspection form, this inspection included an examination of the hull bottom, drive tube boots, tires, interior items, engine bay, prop shaft, and hour meter. The form indicated that the engine bay inspection required mechanics to "check the bay area, check all fluid levels, check engine coolant, check fan belts, and check water pump for excessive play." Coolant level could be checked either by removing the surge tank pressure cap and looking inside the tank[51] or by using the "hot" and "cold" coolant level indicator marks on the plastic expansion tank mounted near the surge tank.

Any significant deficiencies found during the post-trip inspections were to be corrected before the APV could be returned to service. The mechanics performing the post-trip inspection were required to note the deficiencies found and to sign the form.

Daily Inspections of *DUKW 34*

DUKW 34 was not operated on July 1, 2010. Based on post-trip inspection forms, the APV did operate on July 2 and 3, and no post-trip deficiencies were noted. On July 4, *DUKW 34* was in service and was inspected and signed-off on by the fleet maintenance manager with no deficiencies noted. On July 5, 2010, the fleet maintenance manager inspected three APVs, including *DUKW 34*, and no deficiencies were noted.

When *DUKW 34* was inspected on July 6, 2010, the evening before the accident, the inspecting mechanic (who had been with the company about 2 weeks) noted no deficiencies on the inspection form that he signed for *DUKW 34*; he did note deficiencies on three other APVs he inspected on his shift. The mechanic told investigators that he had not removed the surge tank pressure cap on *DUKW 34* and that he had checked the coolant level by looking at the level in the plastic expansion tank. He said that the level in the tank "was right at the level it should have been."

Recent Maintenance on *DUKW 34*

According to the lead mechanic, Ride The Ducks APVs did have occasional problems with engine high temperatures. The mechanic stated that the most common cause of DUKWs running hot was the operator's accidentally closing the damper doors, but that the problem was easily resolved by "a 2-second fix."

When asked about which APVs had experienced temperature problems, the lead mechanic told investigators:

> *[DUKW] 34* was one of them, and I put thermostats in it, everything else being good, and [the operator] said that it was still running a little warm. So, I got a sending unit from a local vendor here that was the wrong one, and then we took that out and put a used one in from another water pump and put that in there, and it was still running a little hot. Then I

[51] According to the Ride The Ducks lead mechanic, an acceptable coolant level would be 0.5 to 0.75 inch below the filler neck of the tank.

> got the correct . . . sending unit and put that in and as far as I know, it was within acceptable limits. The captain had stopped writing it up and each time I saw the gauge, it was fine.

Repairs to the APVs were documented on a company form titled "Equipment Repair Work Order." A review of the maintenance work orders for *DUKW 34* identified the following recent work items:

- 5/21/10 – Replace power steering pump
- 6/6/10 – Replace thermostat, engine running hot
- 6/12/10 – R & R [remove and replace] left front wheel seal races and bearings
- 6/30/10 – R & R [remove and replace] temp[erature] switch [sensor], high temp[erature] reading

Coast Guard Notifications and Ride The Ducks Emergency Procedures

With regard to mandatory reporting to the Coast Guard of a marine casualty, 46 CFR 4.05-1 states, in part:

> (a) Immediately after the addressing of resultant safety concerns, the owner, agent, master, operator, or person in charge, shall notify the nearest Marine Safety Office, Marine Inspection Office or Coast Guard Group Office whenever a vessel is involved in a marine casualty consisting in…
>
> (1)…
>
> (2)…
>
> (3) A loss of main propulsion, primary steering, or any associated component or control system that reduces the maneuverability of the vessel;
>
> (4) An occurrence materially and adversely affecting the vessel's seaworthiness or fitness for service or route, including but not limited to fire, flooding, or failure of or damage to fixed fire-extinguishing systems, lifesaving equipment, auxiliary power-generating equipment, or bilge-pumping systems….

The *Ride The Ducks Philadelphia Standard Operating Procedures* dated February 25, 2010, states the following:

> **Water Incidents**
>
> • Loss of Steering
>
> • Loss of Propulsion
>
> • Injury or Death

Procedures:

1. Captain must immediately notify the USCG by radio

The Ride The Ducks *Captains' Operations Manual*, dated February 20, 2010, also included procedures to be followed in case of an emergency. Regarding an on-water fire, the manual stated the following:

Fire Procedures on Water

- Shut off engine.
- Shut off fuel.
- Close all vent closures, engine hatch, side hatches and floor flaps.
- Activate CO_2.
- Ask passengers to don PFDs and to stay calm.
- Call in to Dispatch to let them know that you have activated your CO_2 your location (be specific) and that you are in need of assistance.
- Attend to your passenger's needs and wait for help to arrive.
- Monitor sea state and freeboard.
- One Manual Bilge Pump: This can be used on [*sic*] the same way as the buckets. Put the intake for the pump into the water and direct the discharge with the hose at the base of the fire.

Note: If you have a Higgins pump,[52] it will not work with your engine off. Also, don't ever turn your ignition switch back on, as it will turn your fuel pumps back on.

With regard to actions required as a result of a loss of propulsion, the manual states the following:

Loss of Propulsion Procedure

- Brief the passengers that there is no danger and to remain calmly seated calm [*sic*] and don PFDs.
- Notify Dispatch of your status.

  Dispatch is to notify the USCG and other Ducks in the vicinity in order to request their assistance.
- Increase attention to your surroundings and continually monitor your freeboard.
- In the event you have no radio communication, utilize your second means of communication and/or deploy the red distress flag to get the attention of other vessels.

[52] A Higgins pump is a chain-driven bilge pump powered by the main propulsion drive system.

- If your zone requires an anchor, deploy the anchor when conditions dictate.
- Continue to monitor vessel traffic and the freeboard and wait for a rescue Duck to arrive.

Company Policies Regarding Use of Wireless Devices While on Duty

K-Sea Transportation

The *Caribbean Sea* was outfitted with multiple VHF marine radios for communication with other vessels. For daily internal communications between the vessels in the fleet and shore-side personnel, K-Sea Transportation used a company-issued cellular telephone. This phone was assigned specifically to the vessel and was stored in the wheelhouse where it was to be used and monitored by the master or mate on watch.

K-Sea Transportation addressed the issue of potential watchstander distraction that could result from use of the company telephone and other electronic devices on board, such as a company-issued computer, by a procedure in the company's Safety & Quality Management System (SQMS) program. The procedure required each watch officer to maintain a focused watch, but it allowed use of the company telephone provided that it did not distract from operations or interfere with normal or emergency communications. The company prohibited crewmembers from carrying or using personal cell phones and or other personal electronic devices while on watch.

Before the SQMS procedure was issued, the company's chief operating officer (COO) had issued several memoranda to the fleet addressing the use of cellular telephones. The first, issued on March 22, 2002, prohibited the carriage of a personal cellular telephone by vessel crewmembers on deck and while on watch and restricted the use of personal cell phones to an enclosed area of the vessel. On February 10, 2004, the COO issued another memorandum to the fleet that addressed the company's expectations for the crew to comply with rules and regulations at each marine terminal at which the vessels moored, and also noted restrictions regarding cellular phone use.

On July 17, 2006, the COO issued a third memorandum to the fleet that restated the company's policy prohibiting the carriage of cellular telephones on watch and included a synopsis from a recent casualty report regarding the grounding of the containership *Berit*, which was attributed to the second officer's distraction because of text messaging. This particular memorandum, along with other memoranda issued in 2006 and 2007, was discussed at a 2-day seminar the company held on November 7 and 8, 2007, for individuals serving in the position of mate upon company vessels. The accident mate attended this seminar and received a Certificate of Completion.

Ride The Ducks

Ride The Ducks of Philadelphia personnel used company-issued cellular telephones with direct-connect radio capability for internal communications (except while driving) during business hours. The company assigned a cell phone to each APV unit in operation and issued phones to certain personnel. Although the APVs were outfitted with marine VHF radios for communication with other vessel traffic, APV-to-APV communications or between APV operators and company personnel were made using the direct-connect radio function.

Ride The Ducks corporate policy allowed APV masters/drivers to carry personal cell phones as long as they were set for vibrate or silent mode and were never used on tour or in sight of guests except in an emergency. Ride The Ducks Philadelphia policy stated that personal cell phones were not to be used at work and could not be used or displayed at the ticket booth, while on the curb, or while on an APV with guests. If an employee needed to make a call using a personal cell phone, he or she was required to obtain permission from a manager or supervisor and to move out of the view of guests while making the call.

The deckhand in this accident acknowledged using his cell phone once to send a personal text message while he was on the *DUKW 34* bow after he deployed the anchor. He said he did not recall receiving any response to his text. The video recording of the accident captured the deckhand on the bow of the APV at 1431 taking out his cell phone and sending a text message. Records obtained from the deckhand's wireless service provider and from the service provider for the device to which the text message was sent confirmed that the deckhand sent an outgoing text message at that time. Those records also indicated that two incoming text messages were subsequently received by the deckhand's cell phone and that the deckhand sent another outgoing text message at 1436, about 1 minute before the collision.

Visibility Study

After the accident, NTSB investigators conducted a study to determine the extent of the visual field available to a mariner navigating the *Caribbean Sea* while the vessel was transporting an empty barge in a starboard hip tow. For purposes of comparison, and based on the height of eye of the *Caribbean Sea* mate, investigators assessed the visual fields available from the tugboat's upper and lower wheelhouses.

The study used tugboat and barge loading and trim conditions similar to the accident configuration. Based on vessel draft measurements and drawings, investigators determined that the barge bow and stern freeboards were 19.8 feet and 16.2 feet, respectively, on the day of the accident. Investigators calculated that the height of eye (above the water) of the *Caribbean Sea* mate when operating from the upper wheelhouse was 31.3 feet. Height of eye when operating from the lower wheelhouse was 20.5 feet.

The study determined that, from the lower wheelhouse, the mate would have had the last full view of *DUKW 34* when the APV was about 5,400 feet ahead of the barge bow. From that point, the APV would have remained partly visible until it was about 3,500 feet away, at which time it would have been completely obscured by the barge. These distances equate to a

forward-over-the-barge-bow "blind zone" of 14 barge lengths, with an additional 7.5 barge lengths of partially obstructed view.

For the upper wheelhouse, *DUKW 34* would have remained completely visible to the mate until it was 360 feet ahead of the barge bow. It would have remained partially visible until it was about 230 feet away. In this case, the forward-over-the-barge-bow blind zone distance is less than one barge length, with less than one-half barge length of partially obstructed view.[53] At a speed of 6 knots, the tow combination traverses one barge length in about 25 seconds.

Coast Guard Oversight of Ride The Ducks Operations

Initiation of Operations

On April 27, 2003, the Ride The Ducks director of operations e-mailed the chief of the Inspection Department at Coast Guard Sector Delaware Bay proposing operation of amphibious sightseeing excursions on the Delaware River. The e-mail indicated that all voyages would begin at the Ride The Ducks ramp adjacent to the Benjamin Franklin Bridge (refer to figure 2), then continue into the channel and proceed southward along Penn's Landing for not more than 1 nm. The APV would then return along the same track line and exit the water at the ramp, with the entire time traveled on the water not to exceed 30 minutes.

The initial proposal also stated that the APVs' distance from the east end of the piers would not exceed 300 yards and that the vessels "shall stay well clear of the shipping lane traffic upon the Delaware River." The proposed course, along with planned areas of potential passenger egress in case of an emergency, was identified on a chart extract enclosed with the e-mail. The following day, Ride The Ducks provided the Coast Guard with a letter asking to have new-to-zone inspections performed on five APVs, each of which had an existing COI issued by other Coast Guard jurisdictions.[54]

Following Coast Guard approval for passenger service in the Delaware River, Ride The Ducks began operations in Philadelphia on Memorial Day 2003. During that first year, the Coast Guard limited the vessels to a route between the Benjamin Franklin Bridge and Pier 31. The vessels were not to operate more than 1,000 feet from shore, and the duration of each waterborne excursion was not to exceed 30 minutes. Each APV was authorized to be operated with one licensed master and was allowed to carry up to 38 passengers.

On January 22, 2004, Coast Guard Sector Delaware personnel met with Ride The Ducks personnel to discuss safety concerns that had arisen during the first year of operation. The Coast Guard's concerns included two instances of loss of propulsion due to floating debris; an instance

[53] These blind zone calculations are conservative because investigators did not take into account wheelhouse cabin structures and barge superstructure obstructions.

[54] The vessels had been in tour service elsewhere and had been relocated to Philadelphia to make up the initial fleet of vessels.

of delayed notification of a marine casualty; marginal results during man overboard drills, which was attributed to the presence of only a single crewmember combined with the APV's slow maneuvering; and incidents of children being allowed to sit at the helm. Before the 2004 operational season, the Coast Guard increased the required manning level to include one deckhand and reduced the maximum number of passengers to 37. The Coast Guard also reduced from 1,000 feet to 300 feet the distance from shore that the APV was authorized to operate and mandated that the APVs carry a VHF marine radio.

Inspection History of *DUKW 34*

DUKW 34, as a small passenger vessel under 100 gross tons, was subject to annual inspection by the Coast Guard, in accordance with 46 CFR Parts 175–185. Marine inspectors from Coast Guard Sector (formerly Marine Safety Office) St. Louis, Missouri, performed the plan review, construction oversight, and initial inspection of *DUKW 34*, which led to the issuance of the original COI and the stability letter for the APV on September 18, 2003. The initial COI required that the APV be manned by one Coast Guard-licensed master and allowed the carriage of 38 passengers. The stability letter indicated that the APV had adequate stability for 39 persons when operating on protected waters (such as the Delaware River). Ride The Ducks subsequently moved the APV to the Miami, Florida, area where inspectors from Coast Guard Sector Miami successfully performed a new-to-zone inspection on the APV on December 3, 2003, after which the vessel began operations on an inland portion of the waterways.

In March 2004, Coast Guard marine inspectors conducted a damage survey of the APV and noted fractures in the hull plating near the APV's propeller shaft caused by the rudder assembly striking the launch ramp. The APV was pulled from service and repaired. The Miami operation was subsequently closed, and *DUKW 34* was removed from certificated small passenger service and sent back to Amphibious Vehicle Manufacturing in Branson. On or about April 29, 2004, Coast Guard marine inspectors from St. Louis approved a redesigned rudder assembly configuration, and the APV was relocated to Philadelphia. Coast Guard Sector Delaware Bay marine inspectors completed the APV's second inspection for certification on May 28, 2004, and a new COI was issued.

The APV remained in continuous certificated service in Philadelphia until late summer 2008. On September 13, 2008, a Coast Guard inspector noticed that the APV was overdue for the required annual inspection, which was to have been completed within 90 days of the anniversary date of the COI, or no later than August 28, 2008. A two-person Coast Guard team comprising one investigator and one inspector visited the Ride The Ducks Philadelphia maintenance facility on October 8, 2008, with regard to the overdue inspection. At that time, company representatives informed the Coast Guard team *DUKW 34* had experienced a problem with a bearing in its transfer case around the first of September while in operation on the road, and because it was no longer needed for the remainder of the season, it had been taken out of service. The Coast Guard team removed the COI that had been issued for *DUKW 34*, and on November 3, 2008, the chief, Prevention Department, informed Ride The Ducks by letter that the APV's COI had been deactivated because of the missed required annual inspection.

On March 12, 2009, inspectors from Coast Guard Sector Philadelphia completed a COI examination and issued the APV's third COI. The COI authorized the carriage of 37 passengers, and required both a master and a deckhand, for a total of 39 persons. The APV was authorized to resume passenger service at that time.

The most recent Coast Guard annual inspection of *DUKW 34* before the accident began on March 12, 2010, and was completed on March 31, 2010. Inspectors identified three deficiencies on the initial visit. Addressing the deficiencies required repairing the APV's propeller engagement system, relocating a coolant overflow hose that was contacting the port muffler, and removing an unused starter solenoid wire. All deficiencies were resolved before the inspection was completed, at which time the APV was determined to be fit for service.

Safety Management at K-Sea Transportation and Ride The Ducks

General

In an effort to ensure safety at sea, prevent human injury or loss of life, and avoid damage to the environment, the International Maritime Organization (IMO) developed the International Safety Management (ISM) Code. The ISM Code was adopted by the International Convention for the Safety of Life at Sea (SOLAS) in 1994 and incorporated into SOLAS Chapter IX.

On December 24, 1997, the Coast Guard issued final regulations for implementing the ISM code, and the final rule became effective on January 23, 1998. The regulations included standards that would allow companies to satisfy international certification requirements for developing a vessel safety management system (SMS), and also provided a means for voluntary certification of SMS for U.S. domestic vessels.

According to 33 CFR 96.230, the fundamental objectives of a SMS are to provide for safe practices in vessel operation and a safe working environment on board the vessel. The SMS must establish and implement safeguards against all identified risks and provide a means to continuously improve safety management skills of personnel ashore and on board vessels, including preparation for emergencies related to both safety and environmental protection. An SMS should also provide a means to ensure compliance with mandatory rules and regulations.

Under the existing regulations, vessel operators that are not required to comply with the ISM code can voluntarily meet the standards and have their systems certificated. Guidance for voluntary compliance is provided in Coast Guard NVIC 5-99. As stated in the NVIC, "33 CFR 96 is the basis for the requirements of a voluntary safety management system." As outlined in the Coast Guard's *Marine Safety Manual*, an equivalent to ISM code compliance has been established for vessels not engaged in foreign voyages. The Coast Guard has prepared guidance documents (booklet and computer disc) for use in developing safety management systems. Vessel operators must apply in writing to participate in the "equivalent" SMS program.

In the Coast Guard and Maritime Transportation Act of 2004, Congress added towing vessels to the list of vessels subject to Coast Guard inspection and authorized the agency to establish an SMS appropriate for towing vessels."[55] In response to this mandate, the Coast Guard sought and obtained input from the Towing Safety Advisory Committee (TSAC), as well as from interested members of the public and other maritime stakeholders, to develop the draft of the proposed regulations.[56] The effort resulted in the draft regulations known as 46 CFR, Subchapter M, which are expected to be released as a notice of proposed rulemaking (NPRM) in mid-2011.[57]

The Coast Guard Authorization Act of 2010 amended the existing law and provided the Coast Guard with the authority to require SMS on certain U.S. domestic passenger vessels and small passenger vessels, with the requirement based on the number of people who could be killed or injured in a marine casualty.[58] The applicability of SMS is also based on vessel characteristics, methods of operation, and nature of the vessel's service. The enabling regulations for the new authority have not yet been developed by the Coast Guard.

K-Sea Transportation and the *Caribbean Sea*

Although the *Caribbean Sea* operated domestically, K-Sea Transportation did operate some of its vessels in international waters, making the company subject to the applicable provisions of SOLAS and the ISM Code. The American Bureau of Shipping (ABS) issued K-Sea Transportation a 5-year Document of Compliance (with the ISM code) on October 18, 2008, and completed its first annual verification audit of compliance on October 21, 2009.[59] K-Sea Transportation was also a member of The American Waterways Operators (AWO) industry association's Responsible Carrier Program[60] and had successfully completed a third-party audit under that program on March 7, 2010.

[55] Public Law 108-293, dated August 9, 2004, which amended 46 *United States Code* Sections 3301 (15) and 3306 (j).

[56] TSAC was established by Congress to advise the Coast Guard on matters concerning shallow draft inland and coastal waterway navigation and towing safety. Its members include representatives from the barge and towing industry, the offshore mineral and oil supply vessel industry, and from maritime shippers and labor forces, port stakeholders, and the general public.

[57] To facilitate the implementation of these regulations and to ease the industry's transition into inspected service, which will affect over 5,200 vessels, the Coast Guard has developed the Towing Vessel Bridging Program and established the Towing Vessel National Center of Expertise in Paducah, Kentucky. For more information, see Coast Guard Memorandum from Commandant (CG-543) dated June 12, 2009, Towing Vessel Bridging Program, and <http://www.uscg.mil/tvncoe>.

[58] Public Law 111-281, enacted October 15, 2010.

[59] If an initial audit determines that the company has developed safety management procedures that meet the ISM code requirements, the company is issued a 5-year Document of Compliance (DOC). Annual audits are required to verify continued compliance.

[60] The AWO established the Responsible Carrier Program as a guide for developing company-specific safety and environmental programs tailored to the barge and towing industry. The program incorporates best industry practices in the three primary areas of company management policies, vessel equipment, and human factors. The program requires that participating companies undergo a third-party audit by an AWO-certified auditor to verify compliance.

On September 7, 2010, NTSB investigators visited the corporate offices of K-Sea Transportation and interviewed personnel involved with the company's SQMS program. These included the president; the health, safety, quality, and environmental officer; the chief operating officer; and the Philadelphia operations manager. During this visit, investigators examined the results of the previous audits performed by ABS and AWO auditors; the management reviews for the last three quarterly meetings of the company's safety, quality, and environmental team held before the accident; near-miss and nonconformity reports submitted from vessels in the fleet for the preceding year, including the analysis performed of the incidents; and corrective actions and the follow up measures. Investigators also reviewed the captain and vessel superintendent inspection reports for the *Caribbean Sea* and other vessels, as well as documentation associated with the company processes related to vessel inspection, vessel maintenance, and training of maritime personnel. No deficiencies were identified.

Ride The Ducks

At the time of the accident, Ride The Ducks operated passenger vessels on limited domestic routes. Therefore, neither the company nor its vessels were required to comply with the domestic regulations or the SOLAS provisions that required development and implementation of an SMS. Ride The Ducks did have a series of written corporate safety, operations, and procedures manuals[61] that outlined company expectations for safe vessel operational practices and safe working environments, identified risk and implemented appropriate safeguards, provided for training of personnel, and ensured compliance with rules and regulations.

According to company policy, any Ride The Ducks employee was empowered to stop any operation when it was deemed a hazard or not consistent with company safety standards. The company also had a hotline to link local operators with corporate managers and had established an internal website containing information, service bulletins, announcements, various forms, and links to the above guidance manuals. In addition, the Philadelphia office had established its own standard operating procedures[62] that provided staff with local and site specific policy and guidance.

Besides periodic statistical analysis of the company's accident and injury data, Ride The Ducks used internal and independent, third-party audits, both scheduled and random, as an on-going monitoring and measurement tool. The president, director of fleet operations, company safety specialist, operations manager, maintenance manager, and local general managers all were assigned specific audit responsibilities that were to occur at certain intervals. Locally, each general manager was required to conduct random bi-monthly audits of employees in safety critical positions to evaluate and monitor the implementation of and compliance with the company's safety procedures. According to Ride The Ducks representatives, from the beginning of the 2010 operating season until the time of the accident, the general manager in Philadelphia performed eight audits of employees in safety-critical positions. None of the internal audits

[61] Ride The Ducks *Fleet Operations Manual* dated January 2, 2010; *Safety Procedures Manual* dated February 16, 2010; *Captains' Operations Manual* dated February 20, 2010; and *Authorized Operator's Manual* dated January 27, 2010.

[62] *Ride The Ducks Philadelphia Standard Operating Procedures* dated February 25, 2010.

resulted in any documented nonconformity with emergency procedures or other safety concerns. At the time of the accident, no independent, third-party mechanical, safety, or procedural audits had been performed at the Ride The Ducks Philadelphia location to validate or confirm the internal findings of the general manager.

On September 9, 2010, NTSB investigators visited Ride The Ducks company headquarters and interviewed management personnel, including the company president, the safety specialist, and the director of fleet operations. Investigators also examined internal audit reports, reviewed meeting minutes from the last three quarterly management safety review meetings held at the corporate level before the accident, and explored relevant elements of the company's policy and guidance to employees found in the company's guidance manuals. The company president told investigators that about three times each month he would make unscheduled and unstructured visits to various company locations to observe operations. During these site visits, he would interact with company personnel at all levels and get under way on board a company APV to assess the quality of the tour and the crew interaction.

Other Information

Postaccident Actions—Ride The Ducks

Just over a week after the accident, the Coast Guard issued a requirement to all operational Ride The Ducks APVs in Philadelphia to cease operations in the Delaware River with passengers.[63] Per an operational plan submitted to and approved by the Coast Guard on August 27, 2010, the company is required to have a pre-staged rescue boat that is either manned and in operation or is in a ready-to-deploy status at all times while APVs are in operation on the river. In addition, a maximum of three APVs may be in operation on the river at any time. The revised routing for the water portion of the tours will not take the APVs more than 100 feet from the bulkhead (which will keep the vessels out of the navigation channel). Water tours are limited to 15 minutes. APVs are also prohibited from entering the river and performing the water portion of the tour if deep draft, or tugboat/barge combinations are approaching within 1/2 mile of the APV's designated route. APV operations are prohibited if the master cannot establish radio communication with the rescue boat or if there is a loss of visual contact between the APV and the rescue boat. The APV master and the rescue boat operator are both required to monitor VHF channels 13, and 16, and the Ride The Ducks VHF working channel. Additionally, the rescue boat operator will also be monitoring AIS data transmitted by other vessels in the area.

According to Ride The Ducks management, the city of Philadelphia initially expressed a preference that Ride The Ducks not resume operations on the Delaware River and instead move the waterborne tours to the nearby Schuylkill River. In January 2011, the city denied Ride The Ducks' proposal that it be allowed to operate on the Schuylkill River. The city of Philadelphia

[63] The Coast Guard issued inspection requirements, dated July 16, 2010, to each of the remaining 14 operational APVs in the Philadelphia fleet. By the form CG-835, the Coast Guard de-authorized Ride The Ducks vessels to operate in the Delaware River while carrying passengers. The inspections were completed and the Form CG-835s were resolved by August 31, 2010.

subsequently approved a revised operating plan for passenger service in the Delaware River. Ride The Ducks Philadelphia resumed APV operations on the Delaware River with passengers for hire on April 21, 2011.

According to Ride The Ducks officials, the company took the following additional actions after the accident:

Immediate Actions. Immediately following the accident, Ride The Ducks suspended operations at all locations and initiated a review of safety and operational procedures. The company also held training classes for all its masters, drivers, and mechanics. Operations remained suspended until each of the company's APVs could undergo an inspection of the engine compartment, fire-fighting systems, and safety equipment. Company representatives stated that the few minor (non-safety) discrepancies that were found were corrected immediately.

Safety Equipment. A full review and inspection of all onboard safety equipment was conducted. Some safety equipment was repositioned to make it more visible and accessible to the master.

Horns. The fixed horn was re-wired to support operation regardless of ignition switch position. A second hand-held air horn was added and mounted in the helm area.

Radios. All Ride The Ducks vehicles have been equipped with hand-held VHF radios in addition to the existing hard-wired, dash-mounted radio to provide maritime communication redundancy and monitoring capability. Company representatives affirmed and clarified, both internally and with the Coast Guard, communication requirements and procedures regarding APVs and any response boat dispatched in the event of an on-water incident. Radios and horns were evaluated for effectiveness, and radio procedures were enhanced. In one city, radio repeaters were installed to enhance radio communication.

Safety Briefing. Ride The Ducks standardized and re-scripted the complete pre-water-entry safety briefing for all locations to include, among other things, a standardized, formal, live demonstration of how to don a personal flotation device (appendix B).

Response Boat. Ride The Ducks has purchased and staffed a custom-built, dedicated response boat to maintain line-of-sight of the entire Delaware River operating area during tour operations and to provide coordination and rapid assistance, including towing when necessary. This boat carries multiple VHF radios, is equipped with AIS, and is manned by a licensed master.

Waterways Management. Ride The Ducks has joined the Marine Advisory Committee of the Maritime Exchange for the Delaware River and Bay to improve communication with other river users and to receive local notice of pertinent river conditions and planned vessel activity. The company has consulted with third-party marine consultants, participated in safety conferences, and solicited industry partners for marine safety. Additionally, Ride The Ducks has formed mutual-aid pacts with local marine operators and has held meetings with vessel operators in all of its operating cities so that all parties are aware of one another's routes and operating

patterns. Ride The Ducks also coordinates with other industry members and organizations to increase awareness of these issues.

Routes. Company managers and operations personnel conducted a route study at each of its locations.

Procedures Review. Ride The Ducks conducted a full review of all of the company's manuals, forms and procedures, with the intent of clarifying procedures and facilitating training. All locations contributed content particular to their operations.

Safety Management System. Ride The Ducks compared the company's safety procedures and directives to the SMSs used by other operators. In the interest of clarity in the marine industry, the company has begun translating its procedures, processes and safety systems into the SMS-type format. Additionally, the company is working with the Passenger Vessel Association (PVA) to assist other passenger vessel owners with the same task.

Audits. Ride The Ducks contracted with an engineering firm to conduct comprehensive audits at all of its locations. These audits covered paperwork procedures, daily operations, occupational safety and health compliance, driver safety, and mechanical procedures. Any deficiencies noted have been corrected, and ongoing evaluations continue.

Engine Bay Attention Signs. The company has installed placards near the engine compartment of each APV reminding mechanics to "ensure all fluid caps are securely fastened . . . before closing engine hood."

Training Program. The company reviewed its 2011 training program for operations personnel, masters, safety representatives, and mechanics and made changes as follows:

- All masters/deckhands must complete training in bridge resource management and situational awareness in addition to their safety training, emergency procedures training, and driver's training.

- All company mechanics will enter training for ASE certification[64] or ASE M&I,[65] as appropriate.

- Operations personnel will complete Federal Emergency Management Agency (FEMA) crisis management training. The company's safety director has already completed this course.

- Visual and/or tactile training aids are being developed for more comprehensive operator education of the propulsion and steering systems.

[64] ASE certification is awarded by the National Institute for Automotive Service Excellence (ASE). To achieve certification, a candidate must pass an ASE examination and provide proof of at least 2 years of relevant mechanical work experience. To maintain certification, the individual must be retested every 5 years.

[65] The ASE maintenance and inspection (M&I) program consists of online training and test modules intended primarily for prospective or entry-level mechanics.

- An enhanced training program has been established for new-hire mechanics and masters.

Personnel Actions. Ride The Ducks promoted a safety specialist to the position of safety director. The safety director has reviewed all procedures for the 2011 operating season and has made site visits to or audits of all Ride The Ducks locations. The company has identified a specific "safety representative" at each location to be a point of contact for any safety issues.

Postaccident Actions—K-Sea Transportation

After the accident, the city of Philadelphia terminated its sludge transport contract with K-Sea Transportation, but later reinstated the contract. When the contract was reinstated, K-Sea Transportation replaced the *Caribbean Sea* with another company vessel and relocated the *Caribbean Sea* to New York. The company has opened its own internal investigation, and that investigation remains open.

According to K-Sea Transportation officials, after the accident, the company held seminars that addressed distractions while on duty, reviewed company policies regarding cell phone use and watchstanding, and hired a consultant to observe barge movements and to make safety recommendations.

In October 2010, the sludge transport contract between the city of Philadelphia and K-Sea Transportation was amended to add, among others, the following provisions:

- Designated tug boats shall be equipped with an upper pilot house.

- The helmsman shall pilot from the upper wheelhouse when maneuvering an empty barge.

- In addition to the requirements of the Inland Navigational Rules, at any and all times while transporting a barge pursuant to this agreement, [K-Sea Transportation] shall ensure that an experienced and proficient lookout be posted on the barge with radio communication capabilities and clear line of sight of the waterways in the immediate path of the vessel(s).

- The tug boat will have 2 radios in both the upper and lower wheel houses and the galley. One will be keyed to Channel 13 and the other to Channel 16. Both channels will be monitored by the helmsman or his designee at all times when the barge is in tow.

- The tug boat must be equipped with radar. The helmsmen or mate on watch must have received training on how to interpret radar and effectively use it for navigation and must hold a radar observer endorsement on his/her U.S. Coast Guard License.

- At no time during the operation of the tug boat with barge in tow may the helmsman or designated lookout use a cell phone for personal reasons. The off-watch is to be alerted if watch stander is distracted for any reason.

- Voyage Plan to favor course on Eastern limit of channel.

A placard with all the new contract provisions is posted on board the tugboat assigned to the contract.

According to K-Sea officials, the above provisions apply only to this contract. Fleet-wide, the requirement remains for watchstanders to "maintain a proper lookout."

Analysis

The four individuals most directly involved with this accident—the master and the deckhand of *DUKW 34* and the master and the mate of the *Caribbean Sea*—met all state and Federal requirements applicable to their positions.

A review of the government- and company-maintained medical records of the crewmembers of both vessels revealed no medical conditions that would have affected the crewmembers' ability to perform their jobs safely on the day of the accident. Postaccident toxicological tests conducted on each individual were negative for the presence of alcohol, illegal drugs and prescribed or over-the-counter medications.

The National Weather Service reported visibility as 10 statute miles at the time of the accident. Winds were light to moderate, and river current was as predicted. The width of the navigation channel to the north and south of the accident site was about 400 feet, with no obstructions that would have prevented either vessel's crewmembers from seeing the other vessel in time to prevent the collision.

At the site of the accident, the navigation channel was also 400 feet wide. The anchored APV was in the approximate center of the channel, allowing sufficient room for the tugboat/barge combination to maneuver around the APV and still remain within the navigation channel. Had it not been possible for the tow combination to remain within the channel, sufficient water depth was available outside the right (east) boundary of the channel to allow the tug/tow combination to safely make any maneuvers necessary to avoid the accident.

The propulsion and steering systems of the salvaged *DUKW 34* were tested to the extent possible. No significant deficiencies were found in the steering system other than those that could be attributed to the damage caused by the accident. Function testing of the nonpropulsion mechanical systems on board the APV revealed no defects or indications of mechanical failure that would have caused or contributed to the accident.

Postaccident inspection and testing of the steering and propulsion systems of the *Caribbean Sea* revealed no defects. A third-party electronics service company tested the electronic and communications equipment on board the vessel and found no significant deficiencies. In postaccident statements to investigators, neither the vessel master nor the mate mentioned any problems they had detected in shipboard systems. Although investigators found an approximate 11 degree bias in the satellite compass heading information, when small vessels navigate on narrow rivers during clear visibility conditions, precise heading information, whether derived from the satellite compass, magnetic compass, or GPS, is not essential to safe navigation.

The NTSB therefore concludes that the following were not factors in this accident: qualifications of crewmembers on board the *Caribbean Sea* and *DUKW 34* for the positions they held; use of alcohol, illicit drugs, or prescribed or over-the-counter medications by the master and the mate of the *Caribbean Sea* or by the master and the deckhand of *DUKW 34*; meteorological conditions; river conditions and waterway configuration; functioning of the

mechanical, electronic, and communications systems on board the *Caribbean Sea*; and functioning of the nonpropulsion mechanical systems on board *DUKW 34*.

Investigators interviewed personnel on both vessels about their work and sleep schedules leading up to the accident. No one interviewed reported being tired or having reason to be fatigued on the day of the accident; however, the sleep/rest information collected was limited, and crew fatigue or wakefulness could not be verified.

Fire Emergency on Board *DUKW 34*

The master and the deckhand of *DUKW 34* told investigators that about 10 minutes into the water portion of the accident tour, they saw smoke entering the passenger cabin. Fearing an engine fire, the master shut down the engine. Postaccident examination of the engine compartment of the APV revealed no evidence of fire or smoke damage. The examination did, however, reveal that the pressure cap was not in place on the radiator surge tank. The cap was found in the bottom of the engine compartment.

A radiator or surge tank pressure cap is a critical component in an engine cooling system. By raising the boiling point of the coolant, the pressure cap allows the coolant to operate at higher temperatures without being converted to steam, which would cause it to lose its effectiveness as a heat-transfer agent.

The *DUKW 34* pressure cap was rated at 13 psi. At 13 pounds of pressure, water, which at standard atmospheric pressure boils at 212° F, will not boil until it reaches 245° F. The presence of antifreeze solution in the water raises the boiling point even higher. Thus, under pressure, the *DUKW 34* engine coolant should not have begun to boil away even at the 220° F temperature the deckhand reported seeing on the vessel's temperature gauge. At atmospheric pressure, however, which would have been the case if the pressure cap was not installed, the coolant solution could easily have begun to boil at that temperature and evaporate as steam.

This was confirmed by the test run investigators conducted in Branson, Missouri, of an APV similar to *DUKW 34*. During that testing, with the surge tank pressure cap removed and a coolant temperature of 220° F, the vapor from the boiling coolant filled the passenger cabin of the APV in a manner similar to that described by the master and the deckhand as having occurred on the day of the accident. The NTSB therefore concludes that the *DUKW 34* surge tank pressure cap was not in place at the time of the accident, and the missing pressure cap allowed the engine coolant to boil and create steam that entered the passenger compartment and prompted the master to shut down the engine because he believed he had an onboard fire.

The NTSB could not determine why the *DUKW 34* coolant temperature rose to 220° on the accident trip or why it had not reached a similar temperature on earlier tours that day. No defects were found in the engine's mechanical and cooling systems during postaccident inspections, suggesting that the overheating was likely due to a combination of high ambient temperature, slow speeds (reducing the flow of cooling air across the engine), high water temperature (reducing the efficiency of the vessel's keel cooler), high engine load caused by operating with a full load of passengers northbound against the current, and a loss of coolant due

to evaporation during the period in which the APV was operating with an improperly secured or missing pressure cap.

Performance of Ride the Ducks Maintenance Personnel

The missing pressure cap was found in the bottom of the engine bay when *DUKW 34* was salvaged. Given the fact that the APV's engine compartment was documented as having been inspected the evening before the accident, the misplaced cap could be explained by two possible scenarios.

First, the cap could have been removed to check or add to the coolant level and then reinstalled improperly so that, as a result of vibration or pressure within the cooling system, it worked loose until the spring pressure within the cap caused it to separate from the surge tank filler neck.

Another possibility is that a mechanic may have removed the cap to replenish the coolant and become distracted and forgotten to finish the task. The cap would have fallen to the bottom of the engine bay after the vehicle left the maintenance facility for the Visitor Center.

The mechanic who performed the post-trip inspection of *DUKW 34* the evening before the accident told investigators that he had used the coolant level markings on the expansion tank to check the coolant level in the APV. He said that the coolant was "right at the level it should have been" and that he had not removed the pressure cap from the surge tank. But *DUKW 34* was one of four APVs that the mechanic inspected that evening, and it is possible that his recollection was faulty about which actions he had performed on which vehicle. If his recollection was correct, he simply may not have noticed if the cap had been improperly installed.

Thus, Ride The Ducks mechanical personnel either failed to reinstall the cap after removal or failed to install the cap properly to prevent it from becoming dislodged during vehicle operation. In any event, the mechanics who were responsible for inspecting Ride The Ducks APVs allowed *DUKW 34* to be put into service with a missing or improperly installed pressure cap.

The NTSB therefore concludes that the mechanics who performed post-trip inspections of *DUKW 34* failed to ensure that the surge tank pressure cap was securely in place before allowing the vehicle to enter passenger service.

Ride The Ducks hired mechanics experienced in heavy-vehicle maintenance and gave them on-the-job training that highlighted the difference between an APV and other commercial or heavy vehicles. Although APVs must be able to function in two very different operating environments and are thus equipped with components and systems that are not found on trucks or buses, learning to perform effective routine inspections of APVs should not be difficult for any competent and experienced vehicle mechanic. In this accident, the inspection failure involved a common component (surge tank or radiator pressure cap) found on almost all gas- or diesel-driven highway vehicles.

To assist its mechanics with inspection and maintenance duties, Ride The Ducks had written maintenance procedures and checklists in place to guide the mechanics in their work. The company had also developed information resources, such as "Duck Central," which it made available to fleet maintenance managers and mechanics to track maintenance issues and procedures. The company also established a mechanic exchange program to encourage knowledge-sharing among the various company operating locations and identified a dedicated point of contact at company headquarters for maintenance and repair issues.

Ride The Ducks has reported to the NTSB that, after the accident, the company reviewed its 2011 training program for mechanics and now requires that its mechanics enter training for ASE or ASE M&I certification, as appropriate. The company reports that it has also established an enhanced training program for its mechanics. Also since the accident, the company has modified its mechanics' checklists and has posted a placard on the underside of the APV hoods reminding mechanics to makes sure all fluid caps are secured before they close the engine compartment cover.

The NTSB acknowledges the proactive steps that Ride The Ducks has taken to improve its maintenance program. Although ASE certification of its mechanics will not assure the company that mistakes and oversights in the inspection and maintenance of APVs will not occur in the future (no amount of training and no type of certification can make such an assurance), requiring such training reflects the company's recognition that an effective maintenance program is a key to safe operations, and it should elevate the professionalism of the maintenance staff. Similarly, the other changes the company has made in the maintenance area should provide additional protection against the type of low-level error that was implicated in this accident.

Performance of the Operating Crews Before the Accident

At the first sign of what he believed to be a fire, the *DUKW 34* master immediately shut down the APV's engine and anchored. But this loss of propulsion and subsequent anchoring, even occurring as it did in the center of a navigation channel, should not have led to a collision because crewmembers of the APV and the tugboat/barge combination had opportunities after that time to take actions that may have prevented the accident. The NTSB evaluated the performance of the crewmembers in an attempt to determine why this did not happen.

Location of Mate While Navigating the *Caribbean Sea*

At the time of the accident, the *Caribbean Sea* was being navigated by the mate. The mate was an experienced mariner who had about 118 days of service on either the *Caribbean Sea* or the *Falcon* as those vessels made the daily sludge barge run between two wastewater facilities. Both the *Caribbean Sea* and the *Falcon* were outfitted with an upper wheelhouse above the main wheelhouse that provided improved visibility. The *Caribbean Sea* master told investigators that before the accident trip he had spoken with the mate about using the upper wheelhouse during the northbound voyage. The master said that the mate had assured him that this was where he

would be. In a postaccident interview with Coast Guard investigators, the mate said that he was operating from the upper wheelhouse when the accident occurred.

Because of the number of tourists in the area at the time and the prevalence of digital cameras, this accident was well documented photographically. A number of individuals who had been on the bulkhead at Penn's Landing at the time of the accident provided the NTSB with photographs taken just before, during, and just after the collision.

At least two of the still photographs (included as figures 3 and 4 in this report) provide fairly clear images of the upper wheelhouse of the *Caribbean Sea* just before and just as the barge struck the APV. Figure 11 shows enlargements from figures 3 and 4 that provide close-up views of the upper wheelhouse just before and after the accident. The enlargement from figure 3 shows the upper wheelhouse in a profile view. The door is open, and the wheelhouse appears to be empty. Anyone at the helm would have been visible through the un-tinted windows. The enlargement from figure 4, taken just after the bow of the barge *The Resource* struck the APV, shows the upper wheelhouse from almost a rear 3/4 view. A portion of the interior of the wheelhouse is visible through the open door. In this image, too, the upper wheelhouse appears to be empty.

Figure 11. (Left) Enlargement from figure 3, showing the *Caribbean Sea*'s upper wheelhouse about 45 seconds before the collision. (Right) Enlargement from figure 4, showing the *Caribbean Sea*'s upper wheelhouse just as the bow of the barge strikes *DUKW 34*.

Almost immediately after the accident, based on their interview statements, the *Caribbean Sea*'s deckhand No. 1 and engineer ran to the aft portion of the main deck. The engineer said that he then climbed the ladder on the aftermost bulkhead to the upper deck and went forward along the port side to notify the master (refer to figure 5). He said when he opened the exterior door leading to a passageway between the master's stateroom and the ladder to the lower wheelhouse, he saw the mate standing in front of the master's stateroom door.

To get from the upper wheelhouse to the master's stateroom, the mate would have had to descend two exterior ladders that terminated on the upper deck near the same aft ladder used by the engineer immediately after the incident. He then would have had to proceed forward along the same route as the engineer and enter the same exterior door into the passageway. But neither deckhand No. 1 nor the engineer saw the mate at this time. Given the brief time that elapsed between the time the engineer and the deckhand (who were in the galley) felt the engine rpm decrease and emerged from the galley onto the main deck, it is unlikely that the mate would have had time to travel from the upper wheelhouse, down two ladders, then forward to the exterior door without being seen by the other two crewmembers.

The master said that the mate, after he had alerted the master to the collision, left the master's stateroom. The master said that he got dressed and went to the upper wheelhouse, where he found the mate. The master said that when he arrived, he found the throttle active for operation from the upper wheelhouse. He said he also found that both VHF radios and the radar were turned on. But there was sufficient time for the mate, after leaving the master's stateroom, to have gone to the upper wheelhouse and activated the valve to change the throttle control location from the lower to the upper wheelhouse before the master arrived. The NTSB therefore concludes that, contrary to the master's instructions and contrary to his own postaccident statements, the mate of the *Caribbean Sea* was not navigating the vessel from the upper wheelhouse at the time of the collision.

Based on the postaccident statements of the engineer and deckhand No. 1, engine rpm was reduced almost immediately when the bow of the barge struck the APV, which indicates that at the moment of impact, the mate was in a position to respond quickly with a throttle manipulation. Other than the upper wheelhouse, only two locations on the vessel would have permitted the mate to respond so quickly: the aft deck station and the lower wheelhouse. When the engineer and the deckhand exited the galley and went toward the stern of the tugboat, neither saw the mate near the aft deck control station. When the engineer went forward to notify the master, the mate was already standing at the master's stateroom door. He could have been able to reach this position within that time frame and without being seen by other crewmembers only if he had been operating the vessel from the lower wheelhouse at the time of the accident. From the lower wheelhouse, the mate would also have been able to see the bow of the APV (and recognize it as a DUKW vehicle) as it swung to the port side of the barge after it had been struck. This could explain how the mate became aware of the collision so quickly (indicated by his timely throttle response) and how he was instantly aware of the type of vehicle that had been struck (as indicated by his statement to the master).

Lack of Attention to Duty by the *Caribbean Sea* Mate

Had an upper wheelhouse not been available, the mate could have navigated the tow combination safely from the lower wheelhouse. The lower wheelhouse was equipped with radars and radios that would have helped the mate monitor his surroundings and avoid hazards. Despite the presence of these navigation aids, however, with the limited visibility ahead because of the high freeboard of the barge, the mate would have needed to assign the deckhand, with a radio, as an additional lookout on the bow area of the barge.

In this case, the mate moved from the upper wheelhouse to the lower one without posting an additional lookout to ensure adequate visibility in the direction of travel. Based on the results of the NTSB's visibility study, from the lower wheelhouse, the mate's view of *DUKW 34* would have begun to be at least partially obstructed when the APV was still about 5,400 feet, or about 21 barge-lengths, away. Once the barge approached within 3,500 feet, or about 14 barge-lengths, the mate would have had no view of the anchored APV. At a barge speed of 6 knots, the mate's view of the APV would have begun to be partially obstructed about 9 minutes before the collision and would have been totally obstructed about 6 minutes before. Thus, from about the time *DUKW 34* was firmly anchored (at 1433) until the collision, it was partially or completely out of the view of the mate in the lower wheelhouse. By contrast, had the mate been navigating from the upper wheelhouse, the anchored APV would have been at least partially visible until it was less than one barge-length away.

Evidence also indicates that the mate was not actively monitoring the radars and radios while in the lower wheelhouse. Even if the DUKW master did not make a securité radio call[66] immediately when the APV was shut down and anchored (the lack of recorded transmission indicates that he did not), he and other mariners clearly radioed warning calls to the tugboat and barge about a minute before the collision. Had the mate been monitoring the radios and radar, even from within the lower wheelhouse, he would have been alerted to the presence of the APV and may have been able to take action to avoid the collision. Based on the mate's own postaccident statements to the Coast Guard, however, he was not aware of the presence of the anchored APV until after the barge had struck it.

The NTSB attempted to determine why, on the day of the accident, a trained, experienced, and otherwise competent mariner failed to effectively carry out routine, but highly crucial, tasks central to his profession. No evidence indicates that the mate was fatigued, and his postaccident toxicological tests showed no signs of alcohol or illegal drugs.

Personal Use of Cell Phone and Laptop Computer by the *Caribbean Sea* Mate

The mate's cell phone records revealed a likely explanation for his poor judgment and inattentiveness to his duties on the day of the accident. The records showed that the mate was engaged in voice communications with several family members beginning just 22 minutes after he assumed the watch and continuing up until the time of the accident. The mate's cell phone records indicated 65 minutes of activity during the 135-minute period from the time he made the first call at 1222 (after relieving the watch at 1200) until the time of the accident at 1437. Eighteen outgoing or incoming calls totaling about 53 minutes were made after 1315 while the mate was solely responsible for navigating the tugboat and barge. Even allowing for the fact that the call durations on the records are rounded up to the next minute, the mate spent from one-third to almost one-half of his time making or taking calls when he should have been attending to the safe passage of his vessel. The last call initiated before the accident, as indicated by the phone records as having started at 14:32, could actually have been initiated up to 1 minute earlier

[66] A securité radio call, usually broadcast on a common frequency, such as VHF channel 16 or medium frequency (MF) 2182 kilohertz, is used to alert shore stations and vessels that important safety information is about to be transmitted. Such radio transmissions begin with "securité, securité, securité," which is followed by the safety-critical information.

(14:31:01), according to the mobile carrier. Based on the reported 6-minute duration of this call, the earliest it could have ended would have been 14:36:02 (actual duration 5 minutes 1 second rounded up to 6 minutes). This would have been about 10 seconds before the master of the APV made the first of his series of calls just before the collision. But this calculation represents the extremes. It is not likely that this call began and ended at the earliest possible times, making it likely that the mate was using his cell phone at least during the time of the radio calls from the APV master and possibly at the time of the collision itself. Moreover, he simultaneously conducted Internet searches on the company laptop computer, which further distracted him from his navigational responsibility. The NTSB therefore concludes that the mate of the *Caribbean Sea* failed to maintain an appropriate lookout, including monitoring the radios, while navigating the vessel because he was distracted by personal use of his cell phone and the company laptop computer in dealing with a serious family medical emergency.

As a result of its preliminary investigations of two marine accidents that occurred in December 2009 and involved collisions between Coast Guard and civilian vessels, the NTSB, on August 11, 2010, issued Safety Recommendation M-10-3 to the Coast Guard:

> Issue a safety advisory to the maritime industry that (1) promotes awareness of the risk posed by the use of cellular telephones and other wireless devices while operating vessels and (2) encourages the voluntary development of operational policies to address the risk.

In response to Safety Recommendation M-10-3, the Coast Guard, on October 29, 2010, issued Marine Safety Advisory 01-10, *Distracted Operations–Don't let it be you*, which warned mariners of the danger and potential for distraction from duty caused by the use of a cellular telephone or wireless device for purposes unrelated to vessel operation. That safety alert specifically mentioned the risk of using these devices when mariners were performing navigation duties alone, as was the mate on the *Caribbean Sea*. Based on this response, Safety Recommedation M-10-3 was classified "Closed—Acceptable Action" on December 14, 2010.

The mate had been an employee of K-Sea Transportation since late December 2000. As early as March 22, 2002, the company had issued a memorandum to its personnel prohibiting mariners from using personal cell telephones while on watch. This policy was reinforced with a second memorandum issued to all personnel on February 10, 2004, and by a third memorandum issued on July 17, 2006. Additionally, the company's policy prohibiting personal use of cell phones while on watch was specifically discussed at a 2-day seminar that the mate attended in 2007 as part of his training. K-Sea Transportation also prohibited personal use of company-provided laptop computers while on watch. The NTSB concludes that the mate of the *Caribbean Sea* should have been aware of his employer's prohibition of personal use of cell phones and company-provided computers while on watch, but on the day of the accident, he did not follow the policy. The NTSB therefore recommends that K-Sea Transportation review its existing safety management program and develop improved means to ensure that the company's safety and emergency procedures are understood and adhered to by employees in safety-critical positions. Because K-Sea Transportation is a member of the AWO's Responsible Carrier Program, the NTSB further recommends that the AWO notify its members of the circumstances of this accident, and

encourage them to ensure that their safety and emergency procedures are understood and adhered to by employees in safety-critical positions.

A K-Sea Transportation official told investigators that the mate had met with him briefly after the accident and told him about a serious medical emergency that affected the mate's child. The NTSB confirmed that such an emergency had occurred less than an hour before the mate reported for duty at 1200 on the day of the accident.

All of the calls on the mate's cell phone were of relatively short duration and were to or from an immediate family member, which suggests that all of the calls were in regard to the medical emergency. The fact that the calls involved an emotionally troubling event that was likely evolving over a period of time increased the likelihood that the calls would distract the mate from his duties. Although such a distraction is understandable, personal concerns cannot be allowed to create risks for others. If the mariner is unable to fully carry out his responsibilities, for whatever reason, his duty is to turn over those responsibilities to someone else.

No one else on board the *Caribbean Sea* was aware of the emergency that the mate was dealing with. Had he informed the master of the situation and asked for relief, at least temporarily, the master likely would have acceded to the request. The company provided the NTSB with 15 instances during the 12- to 18-month period before the accident in which crewmembers had been granted emergency relief from duty to attend to a family emergency or other family matter. But rather than seek relief, which would have been justified under the circumstances, the mate erroneously attempted to attend to his duties while dealing with the distractions presented by a serious personal issue and frequent cell phone use. The NTSB therefore concludes that, had the mate of the *Caribbean Sea* informed the master or K-Sea Transportation management of the serious family medical emergency, he would likely have been granted relief from the watch.

Performance of the *Caribbean Sea* Master

At the time of the accident, the *Caribbean Sea* master was off watch and asleep in his stateroom. After the master was awakened by the mate and went to the upper wheelhouse, he immediately relieved the mate of his navigational duties, and swung the tug and barge around to assist with locating the survivors from *DUKW 34*. He positioned the barge in such a manner that deckhand No. 1 and the engineer could take advantage of the height of *The Resource*'s deck from the water to scan for survivors. He also actively monitored the ongoing search and rescue effort of the many first responders and stood ready to assist as directed. Because of the limited maneuverability of the barge and tug combination, and the number of other smaller craft performing rescue functions, the master did not engage the *Caribbean Sea* in any rescue activities. The NTSB concludes that the actions of the *Caribbean Sea* master, before and after the accident, were appropriate.

Performance of the *DUKW 34* Master and Deckhand

On seeing and smelling what he believed to be smoke from a fire in the APV's engine space, the *DUKW 34* master took action to mitigate the emergency situation as he understood it. His actions included securing the fuel source, the electrical supply, the ignition switch, and the ventilation closures to the engine compartment. He also directed the deckhand forward to the bow to deploy the anchor to stop the APV from drifting uncontrollably in the river current. Although anchoring in a navigational channel is never preferred and is typically prohibited by regulation during normal operations, it is appropriate in an emergency. The master's actions in this regard did keep the vessel from drifting with the river's current (which could have delayed assistance by the APV that was being dispatched as a tow vessel) and reduced the potential for the APV to be damaged by contact with fenders, bulkheads, and other structures along the west side of the river. The NTSB therefore concludes that the *DUKW 34* master's initial response (shutting down the engine and anchoring) to what he believed to be a fire on board the vessel was reasonable given his perception of the nature of the emergency.

But although the master's initial actions were reasonable given his understanding of the situation, his subsequent actions were not. The Ride The Ducks *Captains' Operations Manual* contains procedures to be followed in the event of an onboard fire during waterborne operations and in the event of a loss of propulsion. They included that the master, "immediately notify the USCG [Coast Guard] by radio." However, the master did not notify the Coast Guard that he had lost propulsion and anchored in the navigation channel. Thus an opportunity was missed to have the Coast Guard issue an early securité call on channel 16 using the agency's high-wattage VHF output capability as well as to make the Coast Guard aware of a potentially hazardous situation. Other than the four VHF marine radio transmissions from the master attempting to contact the *Caribbean Sea* on channels 13 and 16 when the collision was imminent, the NTSB was unable to verify that the master actually transmitted any securité or other callouts on either channel 13 or channel 16 to inform vessel traffic in the area of the situation on board *DUKW 34*.

Anchoring in the middle of an active navigation channel placed the APV and its occupants in a vulnerable position because of the deep-draft or limited-maneuverability vessels that routinely use the channel. Awareness of that vulnerability and its associated risk to the APV occupants should have prompted the master to maintain the highest levels of alertness with regard to vessel traffic and to fully employ the deckhand to assist in that effort. Nevertheless, the master never specifically directed the deckhand—who in accordance with Coast Guard regulations was on board to assist the master—to serve as lookout once he had deployed the anchor. During the 8 minutes that passed between dropping the anchor and the collision, the master did not task the deckhand to perform any safety-related function, such as assisting passengers with donning lifejackets in preparation for the planned tow or explaining emergency egress.

Furthermore, in the event of either an onboard fire or a loss of propulsion, Ride The Ducks procedures called for masters to ask passengers to remain calm and don lifejackets. Although this incident involved both a fire on board (as believed by the master) and a loss of propulsion (by way of the master's shutting down the engine), the master did not immediately direct passengers to don their lifejackets, nor did he make any attempt to apprise the passengers of the situation. It may be argued that the master's first actions were rightly directed toward containing what he believed to be a fire; nevertheless, his belief that there was a fire on board

should have been enough to prompt him to prepare the passengers for an evacuation of the vessel. If the master felt that he needed to continue working to contain the fire, he could have directed the deckhand to have passengers take the lifejackets down from their overhead storage and prepare to put them on.

Only when the collision was imminent did the master direct passengers to don lifejackets. Even then, not all the passengers heard the master's order. As described by the passengers, the last few moments before the collision were chaotic as passengers tried to secure lifejackets from the overhead storage and put them on. Because of the delay in the master's order, which came less than 1 minute before the collision, no passengers had time to fully put on a lifejacket or evacuate the vessel before the barge struck. Some passengers were able to hang onto a lifejacket as the vessel was forced under water; others were able to grab a floating jacket when they surfaced. As a result of the master's combined failures to (1) notify the Coast Guard of anchoring in the channel, (2) direct the deckhand to perform safety-related functions after deploying the anchor, and (3) instruct passengers to don lifejackets, the NTSB concludes that the *DUKW 34* master did not fully appreciate or appropriately respond to the risk of a collision that faced *DUKW 34* and its occupants once he had shut down the vessel's engine and anchored in the navigation channel.

Personal Cell Phone Use by the *DUKW 34* Deckhand

While standing on the bow, the deckhand was the individual on board with the greatest height of eye and a 360° unobstructed field of view. He could have used this vantage point to continuously monitor the position of the approaching tugboat/barge combination and, at a minimum, keep the master informed about its progress. Instead, according to the deckhand, he only acted as lookout in the upriver direction (forward), assuming that the master was covering the lookout responsibilities downriver (aft). Additionally, cell phone records reviewed by the NTSB revealed that, while the deckhand was on the bow, he transmitted two text messages and his phone received two others. The last text message that the deckhand sent was about 1 minute before he jumped into the water, just before the collision. The deckhand's use of his cell phone to send text messages diverted his attention away from what should have been his duty of maintaining a proper lookout. The NTSB therefore concludes that the *DUKW 34* deckhand's use of his cell phone to send text messages while he was on the bow of the vessel distracted him from effectively performing his duty as a lookout.

Nonoperational Use of Cell Phones and Other Wireless Devices

Using cellular telephones and other wireless electronic devices has been demonstrated to be visually, manually, and cognitively distracting.[67] Talking on cell phones can have serious consequences in safety-critical situations, and sending or reading text messages is potentially

[67] For research information, see U.S. Department of Transportation website on distracted driving <http://www.distraction.gov>.

even more distracting than talking because texting requires visual attention to the display screen of the device.

Cell phone use has been a factor in accidents in all transportation modes. For example, the NTSB has investigated several fatal railroad accidents in which use of a wireless device was identified as causal or contributing. In its investigation of a May 28, 2002, head-on collision of a coal train with an intermodal train near Clarendon, Texas,[68] in which the engineer of the intermodal train was killed, the NTSB determined that the probable cause of the accident was the coal train engineer's use of a personal cell phone during the time he should have been attending to the requirements of the track authorization under which his train was operating. As a result of that accident investigation, the NTSB made the following safety recommendation to the Federal Railroad Administration:

> Promulgate new or amended regulations that will control the use of cellular telephones and similar wireless communication devices by railroad operating employees while on duty so that such use does not affect operational safety. (R-03-1)

In its investigation of the September 12, 2008, head-on collision of a westbound commuter train with an eastbound freight train near Chatsworth, California,[69] in which 25 people were killed, the NTSB determined that the probable cause of the accident was the failure of the engineer of the commuter train to observe and appropriately respond to a red signal aspect because he was engaged in prohibited use of a wireless device, specifically text messaging, that distracted him from his duties.

Inappropriate use of cell phones or other wireless electronic devices has also been cited as a causal or contributing factor in highway accidents that the NTSB has investigated.[70]

In this accident, the *Caribbean Sea* mate was operating the vessel from the lower, rather than the upper, wheelhouse when the accident occurred, an action possibly explained by his desire for an environment favorable for using his cell phone and accessing K-Sea's laptop computer for Internet searches. On *DUKW 34* leading up to the collision, the deckhand was using his personal cell phone to send text messages instead of performing his duty as lookout.

The NTSB was unable to determine the extent to which cell phone use by mariners has caused or contributed to marine accidents. Coast Guard investigations typically have not verified nonoperational cell phone use following marine accidents. As a result, the Coast Guard's marine

[68] *Collision of Two Burlington Northern Santa Fe Freight Trains Near Clarendon, Texas May 28, 2002*, Railroad Accident Report NTSB/RAR-03/01 (Washington, DC: National Transportation Safety Board, 2003).

[69] *Collision of Metrolink Train 111 with Union Pacific Train LOF65–12, Chatsworth, California, September 12, 2008*, Railroad Accident Report NTSB/RAR-10/01 (Washington, DC: National Transportation Safety Board, 2010).

[70] See (a) *Ford Explorer Sport Collision with Ford Windstar Minivan and Jeep Grand Cherokee on Interstate 95/495 near Largo, Maryland, on February 1, 2002*, Highway Accident Report NTSB/HAR-03/02 (Washington, DC: National Transportation Board, 2003) <http://www.ntsb.gov/publictn/2003/HAR0302.pdf>; (b) *Motorcoach Collision With the Alexandria Avenue Bridge Overpass, George Washington Memorial Parkway, Alexandria, Virginia, November 14, 2004*, Highway Accident Report NTSB/HAR-06/04 (Washington, DC: National Transportation Safety Board, 2006) <http://www.ntsb.gov/publictn/2006/HAR0604.pdf>.

accident database does not explicitly record instances in which nonoperational use of a cell phone or other wireless device has been causal in an accident. The ability to determine the extent of inappropriate cell phone or other wireless device use will provide investigators and policymakers with important information about this form of distracted operations on board marine vessels, but this information will have been gathered after accidents have occurred. The NTSB believes that critical measures can be taken to keep those accidents from happening. These include a continuing outreach program of information and education to the maritime industry on this issue, regulations to prohibit nonoperational use of communication devices, and enforcement mechanisms to ensure that the regulations are being adhered to.

The NTSB recognizes the difficulty of this task. Establishing that a wireless communication device was actually used leading up to an accident can be an involved and time consuming process. Additionally, the devices in question are small and therefore easily concealable, and those individuals or employees wishing to circumvent the prohibitions on their use can frequently do so undetected. But the consequences that can result from such use, as shown by this accident, are serious enough to demand that every feasible action be taken to prevent it. Because cell phones and other wireless electronic devices have come to play such a prominent role in the day-to-day activities of people in all walks of life and because their use has been implicated in accidents across all transportation modes, the NTSB concludes that increased Coast Guard focus on and oversight of mariners' use of cell phones and other wireless electronic devices will prevent accidents and save lives. The NTSB therefore recommends that the Coast Guard develop and implement an investigative protocol that directs its investigation officers to routinely check for nonoperational use of cell phones and other wireless electronic devices by on-duty crewmembers in safety-critical positions involved in marine accidents. In addition, the NTSB recommends that the Coast Guard revise its commercial vessel accident database (MISLE) to maintain a record of nonoperational use of cell phones and other wireless electronic devices by on-duty crewmembers in safety-critical positions when such use is causal or contributory to marine accidents. Further, the NTSB recommends that the Coast Guard regulate and enforce the restriction on nonoperational use of cell phones and other wireless electronic devices by on-duty crewmembers in safety-critical positions so that such use does not adversely affect vessel operational safety. Finally, the NTSB recommends that until the Coast Guard can develop regulations governing nonoperational use of cell phones and other wireless electronic devices by on-duty crewmembers in safety-critical positions, the Coast Guard continue its outreach program of information and education to the maritime industry on this issue.

Survival Factors

Emergency Response

At impact, *DUKW 34* rolled to starboard and across the bow of *The Resource* before being pushed underwater at the port side of the barge's bow. It therefore escaped the crushing damage it would have received had it ridden under the barge. As a result, most of the passengers, even though submerged in the vehicle, were able to escape from the almost-intact APV (refer to figure 6).

Other vessels were operating in the area at the time of the accident. Also, various Coast Guard, marine police, and U.S. Navy resources were on duty close by. As a result, within minutes of the accident, a variety of vessels, including Good Samaritans (most notably the ferry *Freedom* and small U.S. Navy boats that were on temporary duty nearby), Coast Guard rescue boats, and marine police boats were on the scene rescuing passengers. The combined efforts of these responders resulted in all passengers on the surface of the river quickly being recovered and accounted for. Those requiring medical attention were transported to local hospitals. The NTSB therefore concludes that the emergency response to this accident was timely and effective.

Safety Briefing

Coast Guard regulations and Ride The Ducks policy required that DUKW masters provide a safety briefing to passengers before taking a vessel onto the water. By regulation, the briefing must include the location of emergency exits, the location of lifejackets, and the proper method of donning and adjusting lifejackets, including a demonstration. As related by the master and confirmed by passenger interviews and a passenger video, the master of *DUKW 34* gave the passengers a safety briefing before the APV left the Visitor Center on the accident trip.

The briefing that the master gave was presented in a jocular tone, but it did cover the essential information regarding the location of lifejackets. The master held the lifejacket up and showed how the clip worked, but he did not actually put on and fasten a jacket. Partly as a result, two Hungarian passengers told investigators that, after hearing the master's safety briefing, they did not know how to put on a lifejacket.

The passengers on board *DUKW 34* at the time of the accident included a group of 15 Hungarian students and teachers with different levels of familiarity with or fluency in English. Eleven of the 13 Hungarian passengers who survived the accident commented negatively about the quality of the safety briefing. Some of the comments centered on the fact that the master had not demonstrated how to don a lifejacket, but the fact that none of the native English-speaking passengers had negative comments on the quality of the briefing suggests that at least some of the negative comments of the Hungarian passengers reflected a lack of fluency in spoken English.

It is critical for passenger safety that the safety briefing (1) include the specific information that passengers will need in the event of an emergency, and (2) be presented in a way that is understood by everyone affected by it. In this case, the safety briefing the master gave was ineffective in that it did not convey the importance of the information and did not fully explain what passengers may need to do in the event of an emergency. The deficiency was exacerbated by the fact that the information was not presented in a way that made it fully comprehensible to passengers with limited fluency in English. The NTSB concludes that the *DUKW 34* master's safety briefing before the accident trip was ineffective and did not adequately convey to the passengers the critical information they needed to be prepared to respond effectively to the emergency. After the accident, Ride The Ducks standardized and re-scripted the complete pre-water-entry safety briefing for all the company's locations. The briefing now includes, among other things, a standardized, formal, live demonstration of how to

don a lifejacket. The new briefing was implemented before the start of the 2011 operating season.

Safety Management Systems and Corporate Safety Culture

K-Sea Transportation

At the time of the accident, the *Caribbean Sea* was not required to meet the provisions of the ISM code because the vessel was engaged in domestic trade. However, K-Sea Transportation had an SQMS in place to meet the provisions of the ISM Code, and also participated in the AWO's Responsible Carrier Program. With regard to both the ISM Code and the Responsible Carrier Program, K-Sea Transportation had a history of independent and successful audits performed by qualified ABS surveyors (in the case of the SQMS), and independent AWO auditors (in the case of the Responsible Carrier Program).

When interviewed by the NTSB, the president, the COO, and the vice president for health, safety, quality, and environment expressed an in-depth knowledge of both the ISM and AWO programs and provided examples of actions they had taken to ensure that elements of each program were successfully implemented. These elements included fleet-wide implementation of the policy and procedure related to safety and environmental protection, safe ship operation, personnel training, communications between ship and shore, procedures for reporting and evaluating accidents, addressing nonconformities, and trends analysis.

Safety on any vessel depends largely on the competence and professionalism of the mariners on board, and an SMS must minimize the risks associated with human error. Effective implementation of an SMS is achieved when it leads to the development of a safety culture in which each individual employee internalizes the need to keep safety as the first priority when performing any task. Based on its assessment of K-Sea Transportation's actions with regard to implementing an SMS and its interactions with the four *Caribbean Sea* crewmembers who cooperated with investigators, the NTSB found that an effective safety culture was in place within K-Sea Transportation and that the company's programs met the intended objectives of a SMS.

The mate on the *Caribbean Sea* was properly licensed by the Coast Guard and had been appropriately trained by the company. Of the two licensed mariners on board the *Caribbean Sea* at the time of the accident (the other being the master), the mate was the more experienced in making the daily transits between the water treatment facilities and should have been aware of the potential for encounters with APVs and other small vessel traffic near the Penn's Landing area. The master, crew, and the company had no reason to believe that the mate would not conduct his watch in accordance with the master's direction and company policy, with law and regulation, and with good marine practice.

Ride The Ducks

At the time of the accident, Ride The Ducks operated passenger vessels on limited U.S. domestic routes; therefore neither the company nor its vessels were required to comply with domestic regulations or international treaties with regard to establishing or implementing an SMS. Ride The Ducks did, however, have systematic and comprehensive processes in place that met some elements of an SMS. The company's manuals and guidance provided established practices for safe vessel operation and a safe working environment. Ride The Ducks identified the potential risks related to operation of APVs both on the road and on the water, and outlined specific actions that were to be taken by personnel in each instance to mitigate that risk. Personnel received annual training in these written safety and emergency procedures. Additionally, for employees in safety-critical positions such as the master and the deckhand of *DUKW 34*, the company provided periodic safety and emergency procedure reviews that were intended to reinforce the actions learned during the initial pre-season training.

Audits can never guarantee that a true safety culture exists within an organization or ensure the safe performance of individuals within that organization. However, audits that are conducted properly by knowledgeable and unbiased personnel can help reduce risk and ensure compliance with applicable procedures and regulations. The overall intent of a safety audit, whether it is performed internally by company personnel or externally by an independent third party, is to identify potential hazards or other safety concerns so that preventative measures can be implemented. If an audit is to be carried out internally, it should be carried out by personnel who are independent of the areas being audited.

In the months preceding the accident, the general manager in Philadelphia had performed eight random, internal audits of safety-critical positions to ensure that the employees under his direction understood the emergency procedures required of their respective positions and that they performed them as trained. Those internal audits resulted in no documented non-conformities with the company's safety or emergency procedures. Both internal and independent third-party audits are integral elements of recognized quality systems. Before the accident, no independent, third-party audits had been performed at the Philadelphia location to validate or confirm the general manager's audit findings.

The effectiveness of the company's internal audits in ensuring adherence to written safety procedures became questionable on the day of the accident when personnel in safety-critical positions did not take emergency actions consistent with their training and did not implement important elements of the company's safety and emergency procedures. For example, the master did not immediately issue a securité call as soon as he shut down the APV engine and began to drift within the navigation channel; the master did not properly prepare the passengers for the risk they faced by having them don lifejackets while awaiting a tow; both the master and the deckhand failed to effectively monitor vessel traffic; and neither the master nor shore-side personnel immediately notified the nearest Coast Guard office of the possible fire and the subsequent loss of propulsion, as required by Federal regulation and by company policy.

After *DUKW 34* was anchored in the channel and the urgency of the perceived fire situation had diminished, the master had sufficient time to evaluate the risk of being anchored in

a navigation channel with passengers on board and to prioritize his next actions based on his emergency procedures training. But he failed to do so.

If the failures to perform critical elements of the company's emergency procedures had been limited to the master, those failures could be attributed to poor judgment or lack of experience with this type of emergency. However, other Ride The Ducks personnel—such as the manager-on-duty who did not notify the Coast Guard of the incident, the deckhand who did not maintain an effective lookout and inappropriately used a personal cell phone while on duty, and the line mechanics who did not perform effective inspections of the APV before the accident—also failed to properly execute company procedures in accordance with their training. If a more effective safety culture existed at the Ride The Ducks Philadelphia operation, these and other noted systemic failures to properly execute company safety procedures may have been detected. The NTSB concludes that Ride The Ducks International's written procedures for safe operational practices and emergency procedures on the water were comprehensive and exceeded requirements; however, they were not fully implemented by the crew of *DUKW 34* or the shore-side personnel on the day of the accident. The NTSB therefore recommends that Ride The Ducks International review its existing safety management program and develop improved means to ensure that the company's safety and emergency procedures are understood and adhered to by employees in safety-critical positions.

Conclusions

Findings

1. The following were not factors in the accident: qualifications of crewmembers on board the *Caribbean Sea* and *DUKW 34* for the positions they held; use of alcohol, illicit drugs, or prescribed or over-the-counter medications by the master and the mate of the *Caribbean Sea* or by the master and the deckhand of *DUKW 34*; meteorological conditions; river conditions and waterway configuration; functioning of the mechanical, electronic, and communications systems on board the *Caribbean Sea*; and functioning of the nonpropulsion mechanical systems on board *DUKW 34*.

2. The *DUKW 34* surge tank pressure cap was not in place at the time of the accident, and the missing pressure cap allowed the engine coolant to boil and create steam that entered the passenger compartment and prompted the master to shut down the engine because he believed he had an onboard fire.

3. The mechanics who performed post-trip inspections of *DUKW 34* failed to ensure that the surge tank pressure cap was securely in place before allowing the vehicle to enter passenger service.

4. Contrary to the master's instructions and contrary to his own postaccident statements, the mate of the *Caribbean Sea* was not navigating the vessel from the upper wheelhouse at the time of the collision.

5. The mate of the *Caribbean Sea* failed to maintain an appropriate lookout, including monitoring the radios, while navigating the vessel because he was distracted by personal use of his cell phone and the company laptop computer in dealing with a serious family medical emergency.

6. The mate of the *Caribbean Sea* should have been aware of his employer's prohibition of personal use of cell phones and company-provided computers while on watch, but on the day of the accident, he did not follow the policy.

7. Had the mate of the *Caribbean Sea* informed the master or K-Sea Transportation management of the serious family medical emergency, he would likely have been granted relief from the watch.

8. The actions of the *Caribbean Sea* master, before and after the accident, were appropriate.

9. The *DUKW 34* master's initial response (shutting down the engine and anchoring) to what he believed to be a fire on board the vessel was reasonable given his perception of the nature of the emergency.

10. The *DUKW 34* master did not fully appreciate or appropriately respond to the risk of a collision that faced *DUKW 34* and its occupants once he had shut down the vessel's engine and anchored in the navigable channel.

11. The *DUKW 34* deckhand's personal use of his cell phone to send text messages while he was on the bow of the vessel distracted him from effectively performing his duty as a lookout.

12. Increased Coast Guard focus on and oversight of mariners' use of cell phones and other wireless electronic devices will prevent accidents and save lives.

13. The emergency response to this accident was timely and effective.

14. The *DUKW 34* master's safety briefing before the accident trip did not adequately convey to the passengers the critical information they needed to be prepared to respond effectively to the emergency.

15. Ride The Ducks International's written procedures for safe operational practices and emergency procedures on the water were comprehensive and exceeded requirements; however, they were not fully implemented by the crew of *DUKW 34* or the shore-side personnel on the day of the accident.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the mate of the *Caribbean Sea* to maintain a proper lookout due to (1) his decision to operate the vessel from the lower wheelhouse, which was contrary to expectations and to prudent seamanship, and (2) distraction and inattentiveness as a result of his repeated personal use of his cell phone and the company laptop computer while he was solely responsible for navigating the vessel. Contributing to the accident was the failure of Ride The Ducks International maintenance personnel to ensure that *DUKW 34*'s surge tank pressure cap was securely in place before allowing the vehicle to return to passenger service, and the failure of the *DUKW 34* master to take actions appropriate to the risk of anchoring his vessel in an active navigation channel.

Recommendations

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

To the U.S. Coast Guard:

Develop and implement an investigative protocol that directs your investigation officers to routinely check for nonoperational use of cell phones and other wireless electronic devices by on-duty crewmembers in safety-critical positions involved in marine accidents. (M-11-1)

Revise your commercial vessel accident database (MISLE) to maintain a record of nonoperational use of cell phones and other wireless electronic devices by on-duty crewmembers in safety-critical positions when such use is causal or contributory to marine accidents. (M-11-2)

Regulate and enforce the restriction on nonoperational use of cell phones and other wireless electronic devices by on-duty crewmembers in safety-critical positions so that such use does not adversely affect vessel operational safety. (M-11-3)

Until you can develop regulations governing nonoperational use of cell phones and other wireless electronic devices by on-duty crewmembers in safety-critical positions, continue your outreach program of information and education to the maritime industry on this issue. (M-11-4)

To Ride The Ducks International, LLC:

Review Ride The Ducks International's existing safety management program and develop improved means to ensure that your company's safety and emergency procedures are understood and adhered to by employees in safety-critical positions. (M-11-5)

To K-Sea Transportation Partners L.P.:

Review K-Sea Transportation's existing safety management program and develop improved means to ensure that your company's safety and emergency procedures are understood and adhered to by employees in safety-critical positions. (M-11-6)

To The American Waterways Operators:

Notify your members of the circumstances of this accident, and encourage them to ensure that their safety and emergency procedures are understood and adhered to by employees in safety-critical positions. (M-11-7)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

DEBORAH A.P. HERSMAN
Chairman

ROBERT L. SUMWALT
Member

CHRISTOPHER A. HART
Vice Chairman

MARK R. ROSEKIND
Member

EARL F. WEENER
Member

Adopted: June 21, 2011

Chairman Hersman filed the following concurring statement on July 1, 2011. She was joined by Vice Chairman Hart and Members Sumwalt, Rosekind, and Weener.

Chairman Hersman, consenting:

It is time to change public tolerance for distracted operations, and elevate society's opprobrium for transportation operators who use personal electronic devices.

This behavior is unsafe and unacceptable.

On July 7, 2010, the *Caribbean Sea* tugboat/barge combination ran over a sightseeing boat loaded with passengers on the Delaware River in Philadelphia. Although the mate made 13 outgoing calls and received 5 incoming calls in the 80 minutes prior to the accident, the tugboat's crewmembers did not report the mate's repeated use of his personal cell phone. They likely did not report it because they are used to this type of behavior. The fact that the mate repeatedly made and received calls unrelated to vessel operations showed that he, too, was comfortable with this behavior.

Further, the mate spoke on his cell phone when other people were nearby. The potential for coworkers to observe him violating company policy did not deter his inappropriate behavior. Nor was the company's clear policy against using personal electronic devices a deterrent.

The NTSB has seen pervasive use of personal electronic devices across all modes of transportation. Perhaps the best known aviation instance was when two airline pilots were out of radio communication with air traffic control for more than an hour because they were using their personal laptop computers. They overflew their destination by more than 100 miles and only realized their error when a flight attendant inquired about their arrival over the intercom.

The NTSB identified distraction due to text messaging as the cause of a September 12, 2008, commuter train engineer running a red signal near Chatsworth, California. The result: a head-on collision with a freight train. Twenty-five people died and dozens were injured. The engineer,

who had a history of using his cell phone for personal communications, sent 136 and received 114 text messages while on duty during the 3 days leading up to the accident.

Distractions, as we all know, are a growing concern in our motor vehicles, especially as the handheld and infotainment options in our vehicles increase. The consequences can be deadly. In one accident the NTSB investigated, in the 24 hours preceding the accident, the driver of a tractor-trailer truck made 97 calls and received 26 calls. In the half hour preceding the crash, the driver spent 14 minutes—nearly half his time—on the phone. Ten people died that day after the truck crossed the median.

Even with company policies, widespread public education campaigns, and, in some places, laws to minimize distractions like cell phone use, many people continue to think, "I'll make this quick call or I'll send a brief text message."

The technology that created these problems also offers the potential to provide solutions. But, as a society, how do we convey to manufacturers and operators that distractions at the wheel/helm/controls are just as unacceptable as driving under the influence? When will we say, "This must stop; we cannot do this anymore."

Here's a long view of transportation that may shed light on a path to address distracted operations. In 2006, the NTSB received a request from a historian to reconsider one of the first aviation accidents that the Board investigated. The 1967 accident involved a Piedmont Airlines Boeing 727 and a private twin-engine aircraft that had a mid-air collision over North Carolina. All 82 people on board both planes were killed.

The cockpit voice recorder identified that shortly after takeoff, the flight crew of the 727 discussed one of the cockpit ashtrays being on fire. As they put out the fire, the crew joked with the captain about burning his steak at that night's barbecue. However, smoking or burning cigarette ashtrays were such a common occurrence back then that the Board did not even mention the event in the final report.

In this time and culture, can you even begin to imagine smoking in an airplane, much less in the cockpit?

What changed since 1967? The culture changed. We do not allow smoking on airplanes. It is not even remotely considered. The consequence—society's disapproval—is that strong.

I want our society to reach the point when texting or telephoning—whether you're operating a vessel, a train, or a motor vehicle—is just as unacceptable as smoking in a cockpit, or not wearing a seat belt, or driving under the influence of alcohol.

Culture change is possible. It has happened before. It must happen again—now. How many more lives will be lost before our society corrects its deadly acceptance of distractions?

Appendixes

Appendix A

Investigation

The NTSB learned of this accident from the Coast Guard Command Center on the afternoon of July 7, 2010. A team of three investigators launched to the accident and arrived on scene later that same day. The Board Member on scene was Member Robert L. Sumwalt. The investigative team was also accompanied by a public affairs officer and a family affairs specialist.

Parties to the investigation were the U.S. Coast Guard, Ride The Ducks International, LLC, and K-Sea Transportation Partners L.P. The on-scene portion of the investigation was completed on July 16. Follow-on interviews of company managers were conducted at the offices of K-Sea Transportation and Ride The Ducks on September 7 and 9. A team of four investigators returned to the scene January 12-13, 2011, to collect information needed for a tugboat visibility study and an accident 2-D animation. Additionally, a team of four investigators visited the *Caribbean Sea* in Norfolk, Virginia, on April 15, 2011, to take additional measurements on the vessel in support of the visibility study.

Public Hearing/Depositions

No public hearing was held, and no formal depositions were taken during the course of this accident investigation.

Appendix B

Ride The Ducks International Guidance for Safety Briefings

Safety Briefing is to be delivered at the beginning (or prior to water entry) of all tours. This briefing should be delivered in a serious manner with no jokes.

The components of a required safety briefing are: Must be delivered in a serious manner with no jokes. Communicate and show where PFDs are located and the appropriate PFD based on guest weight. Communicate and show that additional PFDs are also available for an infant under 30 pounds. Communicate and show how to retrieve the PFD from its storage area. Communicate and demonstrate step by step the entire process of donning a PFD. The individual delivering the message must be wearing a PFD at the end of the demonstration. Identify and point out the exits to be used by guests in the case of an emergency. Identify and point out the location of the two ring buoys. Identify and point out the location of the fire extinguishers. Ask that guests keep their arms and heads inside the duck, remain seated unless instructed to move by the Captain and refrain from smoking while onboard. In Branson, instruct guests to brace for splashdown and if seated in the middle of the last row fasten the seat belt.

The following is an example of how this safety briefing can be delivered.

"Please take note of the Personal Floatation Devices above your heads. The ones located on this side (point to and touch the appropriate PFDs) are for people 90 pounds and over and the ones located on this side (point to and touch the appropriate PFDs) are for people 90 pounds and under. In addition, we do have available a Personal Floatation Device for infants under 30 pounds. These can be found… … (point to their location).

In case of an emergency you will be instructed to pull the strap above your head releasing the flotation device. They are easy to use. (Driver will demonstrate all actions and will be wearing a PFD at the end of the demonstration). First, pull the strap to release the PFDs. Place your head through the opening. The PFD is reversible and your head can be placed through the opening from either side. Now wrap the strap around your body and place the black hook into the D ring pulling the T strap tight. A placard demonstrating the use of the personal floatation device is located at the rear of the vessel where you entered the Duck.

In case of an emergency, the nearest opening to your seat should be considered your emergency exit. (Driver will point out exits.)

We are equipped with two ring buoys- one located here at the Captain's station, and the other on the outside rear of the Duck. (Driver will point out ring buoy closest to him/her during this segment.)

Finally, I'd like to point out the location of the fire extinguishers. One is located next to the Captain's station, and the other is located in the rear of the Duck on the floor. (Driver will point out extinguishers during this segment, and if a guest is sitting near the other extinguisher have that guest acknowledge its location.)

Please keep your arms and heads inside the Duck, remain seated unless instructed to move by the Captain and refrain from smoking while onboard.

Appendix C

Summary of Interview with the *Caribbean Sea* Mate

As noted in the report, the NTSB attempted to interview the *Caribbean Sea* mate as part of its investigation of this accident, but he declined. On June 24, 2011, 3 days after the NTSB Board Meeting at which this report and its conclusions and recommendations were adopted, the NTSB was notified that the mate was willing to be interviewed regarding this accident. NTSB investigators interviewed the mate on July 11, 2011, and relevant portions of that interview are summarized below. Because the information that the mate provided during that interview did not alter the findings already contained in the final report, the additional information is being appended to the report rather than being incorporated within it.

With regard to his work/rest cycles, the mate said that he normally went to bed about 2300 and awakened about 0700 on his days off. He said that he followed this same pattern leading up to the day of the accident and that he felt well-rested that day. He said that the only medication he was taking was for a thyroid condition that he took daily and that he had no other physical or medical conditions that would have affected his ability to perform his work.

According to the mate, his young child was scheduled for corrective eye surgery on July 7, 2010. The mate said that this date would have occurred during his normal off-duty rotation schedule; however, about a week before the scheduled surgery, K-Sea Transportation contacted him and asked if he could return to duty a week early. The mate said that he spoke with the child's doctor and was assured that the surgery was routine and that the mate did not need to be concerned if he had to be at work that day. Consequently, he did not decline to comply with K-Sea Transportation's request that he return to duty a week early.

The mate stated that he typically operated the tugboat from the upper wheelhouse when the barge was light. With regard to his operating location on the day of the accident, the mate recalled that the master had said for him to "take it up there," as the mate normally did.

The mate said that the first cell phone call he received after going on duty was from a family member informing him that the surgery was successful and that the child was in the recovery room. The mate said that later, about the time the tugboat and barge entered the Delaware River from the Schuylkill River, he received a call from his wife informing him of serious complications that had developed. He said that shortly afterwards, he moved from the upper wheelhouse to the lower wheelhouse to be more comfortable and to hear his wife better when she called him back. He explained to investigators that because the barge was on the starboard side, he thought that it would be "pretty safe to navigate up the river." He said that, while in the lower wheelhouse, he made and received several other phone calls to discuss his child's condition with family members. He said that he also used the company computer in the lower wheelhouse to search the internet for information related to the medical emergency.

The mate said that he did not notify the master or other crewmembers of his personal emergency because he was "generally in shock . . . nauseous . . . [and his] legs were shaking." He said that he "wasn't thinking clearly." He went on to say that it was very warm in the upper

wheelhouse; that it was "pretty gassy" from the nearby smoke stacks and that there was no fresh air. He "didn't feel comfortable at all."

The mate also acknowledged that he knew at the time that he could have requested relief to deal with his personal emergency because K-Sea Transportation is "pretty reasonable [and] understanding . . . they do the best they can to get you off the boat and home" to handle emergency or family situations.

The mate said that sometime afterwards, he received another call from his wife saying that their child was being discharged from the hospital, and he was then able to speak with the child. He said that he was in tears and happy to hear the child's voice. He said that he then called his parents to inform them of the development. About this time, the accident occurred.

Asked if, at the moment of the collision, he was on his cell phone, the mate replied, "It's very hard to say. I would have to say it was—I would have to say yes. It's hard to say, though. I didn't—I never saw the boat collide with the DUKW boat. . . ."