Capsizing of New York State-Certificated Vessel *Ethan Allen*, Lake George, New York October 2, 2005

Marine Accident Report

NTSB/MAR-06/03

PB2006-916403
Notation 7755B

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Adopted July 25, 2006

National Transportation Safety Board
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Washington, D.C. 20594

National Transportation Safety Board. 2006. *Capsizing of New York State-Certificated Vessel* Ethan Allen, *Lake George, New York, October 2, 2005.* Marine Accident Report NTSB/MAR-06/03. Washington, DC.

Abstract: On the afternoon of October 2, 2005, the New York State-certificated public vessel *Ethan Allen,* with a state-licensed operator and 47 passengers on board, was on a narrated cruise of Lake George, New York. As the tour boat operator was beginning to make a turn to the right, a wave or waves generated by one or more vessels impacted the starboard side of the *Ethan Allen*. The public vessel rolled to port and overturned within seconds. The overturned vessel remained on the surface of the water several minutes before righting itself and sinking. Operators of recreational vessels nearby observed the accident, proceeded immediately to the site, and began rescuing survivors. Twenty passengers died, three received serious injuries, and six received minor injuries in the accident. The operator and 18 passengers survived without injury.

Major safety issues discussed in this report include stability standards and procedures for passenger vessels; New York State's use of manufacturer's capacity plates to determine public vessel passenger loading; and regulation of New York State's public vessels.

As a result of its investigation of this accident, the Safety Board made safety recommendations to the U. S. Coast Guard and the State of New York.

Contents

Abbreviations and Acronyms

CAMI	Civil Aerospace Medical Institute
CDC	Centers for Disease Control and Prevention
CFR	*Code of Federal Regulations*
CO_2	carbon dioxide
COI	certificate of inspection
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
LGFD	Lake George Fire Department
OCMI	(Coast Guard) Officer in Charge, Marine Inspection
SST	simplified stability test
TCG	transverse center of gravity
VCG	vertical center of gravity

Executive Summary

On the afternoon of October 2, 2005, the New York State-certificated public vessel *Ethan Allen,* with a New York State-licensed operator and 47 passengers on board, departed the marina at Lake George, New York, for a cruise of the lake. The vessel proceeded northbound along the western side of the lake at an estimated speed of 8 mph. As it neared Cramer Point, the operator began a turn to the right. At the same time, the *Ethan Allen* encountered a wave or waves generated by one or more vessels on its starboard side. Within a few seconds, the *Ethan Allen* rolled to port and overturned. It began to sink about 15 minutes later. Operators of recreational vessels nearby observed the accident, proceeded immediately to the site, and began rescuing survivors. Twenty passengers died, three received serious injuries, and six received minor injuries in the accident. The operator and 18 passengers survived without injury. The resulting damage to the vessel and its components was estimated at $21,000.

The Safety Board's investigation of this accident identified the following major safety issues:

- Stability standards and procedures for passenger vessels;
- New York State's use of manufacturer's capacity plates to determine public vessel passenger loading; and
- Regulation of New York State's public vessels.

The National Transportation Safety Board determines that the probable cause of the capsizing of the *Ethan Allen* was the vessel's insufficient stability to resist the combined forces of a passing wave or waves, a sharp turn, and the resulting involuntary shift of passengers to the port side of the vessel. The vessel's stability was insufficient because it carried 48 persons where postaccident stability calculations demonstrated that it should have been permitted to carry only 14 persons. Contributing to the cause of the accident was the failure to reassess the vessel's stability after it had been modified because there was no clear requirement to do so.

As a result of this investigation, the Safety Board makes recommendations to the U.S. Coast Guard and to the State of New York.

Factual Information

Accident Narrative

About 1415[1] on October 2, 2005, members of a seniors tour group from Michigan began arriving at the loading dock for Shoreline Cruises, Inc., in Lake George Village, New York, for a 1-hour round-trip narrated boat cruise of historical and other sites along the lakeside. The tour group had chartered two public vessels: the *Ethan Allen* (figure 1) and its sister vessel, the *de Champlain*.

Figure 1. The *Ethan Allen*, shown above after the accident, was a New York State-certificated public vessel, a category of powered vessels that is permitted to transport passengers or freight for commercial purposes solely on state waters.

The *Ethan Allen* was scheduled to take the first group out at 1500. The tour boat had made two trips earlier in the day, and the vessel operators on those cruises later told investigators that the trips had been uneventful. The vessel operator said that, in preparation for his trips that day, he had checked the bilge area and did not observe any water.[2]

[1] All times are eastern daylight time, based on a 24-hour clock.

[2] Because of the antipollution restrictions for Lake George and the fines that boat operators were subject to, Shoreline Cruises required its boat crews to check the bilges before their cruises and manually remove bilge waste into shoreside containers to ensure that the onboard bilge pumps did not discharge into the lake during a trip.

Members of the seniors group began to embark on the *Ethan Allen* through the portside door opening near the stern. In anticipation of viewing historical and other sites along the western shore, passengers began filling the eight three-person benches along the port side of the *Ethan Allen*. (See figure 2.) According to the passengers, only about seven to 10 people had boarded when the boat began to list noticeably to port. One of their members shouted out that someone had to sit on the other side of the boat. The vessel operator also advised passengers to sit on the starboard side. As people filled the starboard benches, the vessel began to level out. One of the passengers said that those boarding filled in where sitting space was available and that "we had some large people in our group." She added that the group "didn't seem to be balanced" across the boat when everyone was seated.[3]

The vessel operator extended an invitation to board to two more women; however, they later told investigators that they told the group they preferred to go shopping but they declined to board because they thought the boat looked "crowded." Another woman said that while standing in line to board, she noticed the vessel listing to port. She stated, "I decided it wasn't safe to be on, so I didn't get on. I told the others that I wasn't going."

The vessel operator stated that before leaving the dock, he delivered a safety briefing to the passengers. All passengers who were interviewed said that they received no safety briefing. Most indicated, however, that at the time, they were talking with one another and that "it was very noisy."

When the *Ethan Allen* ultimately sailed at 1430, the vessel had a total of 48 occupants: the vessel operator and 47 passengers. The vessel operator told Safety Board investigators that the boat's trim was proper before it departed the dock.

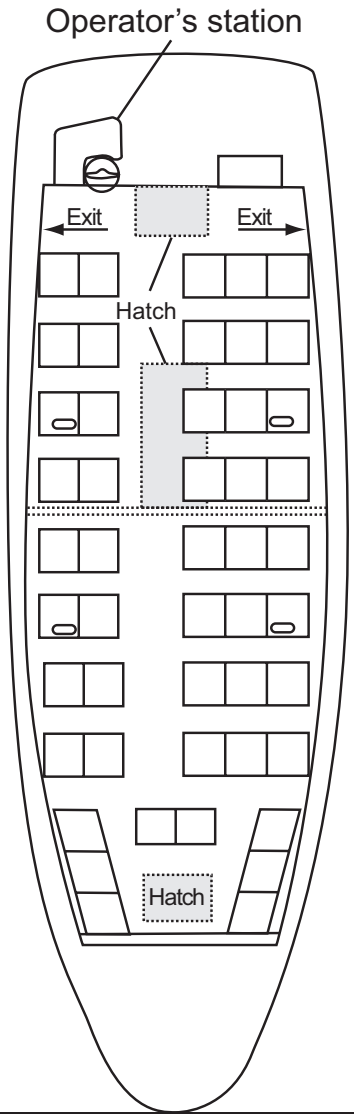
After leaving the marina area, the operator increased the vessel speed from the 5 mph maintained in the no-wake area of the lower lake to 8 mph, its standard speed on the lake. The operator told investigators that with as large a passenger load as he experienced on the accident cruise, the *Ethan Allen* was "maybe a bit slower to respond, [with] just minimal" differences in maneuverability between its fully and partially loaded conditions. He described vessel maneuverability as very good, even when fully loaded, and said that he had about "normal" freeboard.[4] The operator told Safety Board investigators that he had taken the *Ethan Allen* out several times each season with a full load of passengers.

For the voyage, the vessel's windows, which opened inward, were in the up position and hooked to the underside of the wooden canopy (figure 2). The passengers described the conditions for the lake tour as "beautiful" and "perfect." The lake waters were "calm." The operator indicated that vessel traffic was normal for a Sunday afternoon. Several members of the tour group had either recreational or commercial boating experience, and most of them indicated that the master operated the boat "properly." They said that whenever a passing vessel caused a wake,[5] the operator of the *Ethan Allen* would turn their boat so that the bow headed into the waves.

[3] Based on hospital records and interviews, the total weight of the passengers seated in the portside seats was 5,088 pounds and the total weight on those in the starboard-side seats was 3,434 pounds.

[4] Distance from the vessel's deck to the surface of the water.

[5] A track of waves caused by a vessel or object moving through the water.



Vessel interior, looking aft. Plexiglas side windows are in up position and hinged to canopy roof, as during accident voyage.

Close-up of operator's station. Cabinet for adult lifejackets, shown without the door, is next to operator's station.

Figure 2. Three views of *Ethan Allen* interior. The vessel had 19 slatted-wood, park-style benches whose metal legs were bolted to the deck. Eight benches designed to accommodate three people faced forward along the port side of the vessel and eight benches that accommodated two people faced forward along the starboard side. Three three-person benches were in the forward portion of the vessel. One bench was positioned so that its back was against the port bulkhead and one bench was against the starboard bulkhead. The nineteenth bench, positioned center forward, had a box beneath it that stored 10 child-size lifejackets.

According to witnesses, the *Ethan Allen* operated without incident until it reached a cove near Cramer Point (figure 3). As the vessel neared Cramer Point, some passengers observed a vessel traversing the lake to the right of the *Ethan Allen,* creating a wave or waves that moved toward it. Witnesses varied in their identification of the particular vessel

and in their descriptions of the size of the wave or waves. One passenger described the wave as several inches high. A recreational boater, who observed the *Ethan Allen* from a 50- to 75-yard distance, reported seeing no wave strike the vessel. The *Ethan Allen* operator said the wave was 2 1/2 to 3 feet high. The wave reportedly first contacted the starboard stern area and then moved forward along the side of the vessel, raising it upward. The operator told investigators that as he was turning to the right and proceeding out of the bay, he noticed "this wave coming at me, good-sized wave. And I started to cut into it …[but] it caught me on the right side, starboard side back by the stern corner, and flipped it [the vessel] over to the left side, the port side."

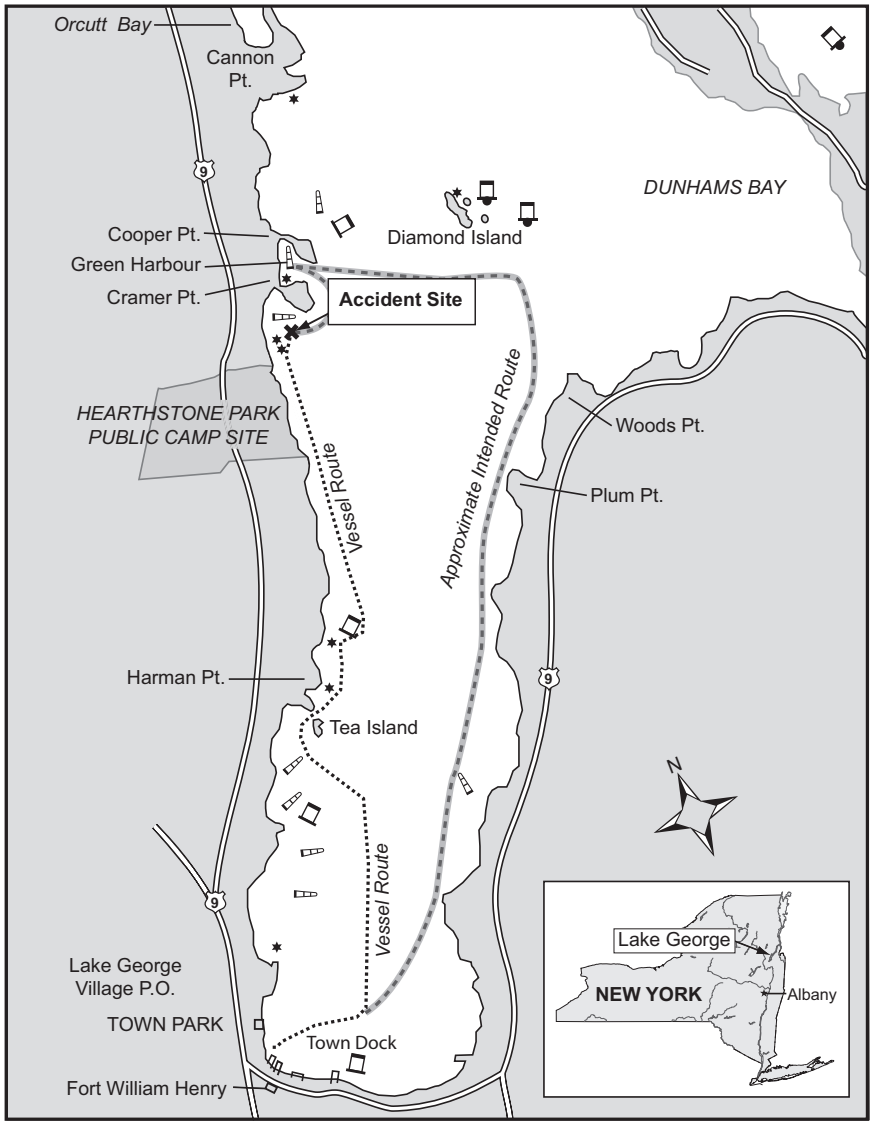


Figure 3. The 1-hour tour of the *Ethan Allen* on Lake George began at Lake George Village and went north to Green Harbour, a distance of about 3 miles. The tour was to continue north along the west shore and enter Green Harbour before crossing the lake and heading back along the east shore. The accident occurred off Cramer Point, a point of land directly below Green Harbour.

A passenger seated in the last row on the port side said that she had extended her arm out the window during periods of the cruise, and when the vessel operator went into the sharp turn, the boat began to "tip" [heel] to port. She said that she looked out the window and [her hand] appeared to be "inches from the water." She also felt the people sitting next to her begin "sliding into me."

Other survivors said that the passengers all shifted to the left in their seats and that two "large ladies" tumbled off their seats and slid to the port side of the vessel when the vessel made the turn. Another passenger stated that the vessel "never stopped rotating to the left along the axis of the boat." As the vessel's list to port increased, more people sitting on the starboard side tumbled to the port side, in many instances, falling onto the passengers seated on the port benches. The vessel continued to roll over, and several passengers were swept out the open windows. Both the operator and the survivors estimated that the vessel capsized in a matter of seconds.

The accident occurred about 1454. The *Ethan Allen* remained afloat upside down for several minutes. Several survivors described the conditions inside the *Ethan Allen* after it overturned as "chaos underwater" or "total confusion." In the darkness, people were "stepping on" or "crawling on" one another. One woman said that when she attempted to swim toward the light, "People were pulling on my legs to crawl up me, so they pulled me down."

Survivors said that they never had time to retrieve lifejackets; however, they also said that if people had donned lifejackets, more fatalities would have occurred because the only way for those trapped in the vessel to escape was to "swim down" and go through the open windows, which were now below water. One passenger told investigators that she initially was blocked by a Plexiglas window but was able to swim under it to escape the vessel. Once the boat occupants escaped, they clung to the overturned vessel on the surface.

Several recreational boats were in the vicinity. Many of the boaters observed the capsizing and immediately proceeded to the site to render aid by throwing life preservers and flotation cushions to the survivors and rescuing them. The witnesses also called 911 on their cell phones to report the accident. After several minutes, the overturned vessel righted itself and then sank to the bottom of the lake, coming to rest upright on its keel in 59 feet of water.

Injuries

The injuries sustained in the *Ethan Allen* accident, shown in table 1, are categorized according to the injury criteria of the International Civil Aviation Organization (ICAO). The Safety Board uses the ICAO injury criteria in most of its accident reports, regardless of transportation mode. Passengers listed as seriously injured remained hospitalized for more than 48 hours.

Table 1. Injuries to passengers and crew

Type of Injury	Crew	Passengers	Total
Fatal	0	20	20
Serious	0	3	3
Minor	0	6	6
None	1	18	19
Total	1	47	48

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. Serious injury means any injury which (1) requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; **(2)** results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burns affecting more than 5 percent of the body surface.

Damages

According to reports, the *Ethan Allen* sustained cosmetic damage to the hull and engine damage consistent with its being submerged. Repairs totaled about $21,000. See "Wreckage" section of this report for additional information.

Personnel Information

According to the *Ethan Allen*'s state certificate of inspection (COI) authorizing it to operate on New York waters, the tour boat was required to have a crew of two: a master and a deckhand when the vessel carried more than 20 passengers. On the day of the accident, a deckhand did not accompany the tour group.

New York State Vessel Operator Regulations

New York guidance specifies three types of licenses for operators of public vessels. A "master" license is required for the operation of a public vessel that exceeds any of the following criteria: 65-foot length, 50-ton displacement, or 65 passengers. A "joint pilot & engineer" license is required for anyone who operates smaller vessels that do not meet the vessel and carriage criteria for a master's license. A deckhand or operator licensed as a pilot/engineer seeking a master's license must first obtain an "apprentice master" license. To be issued a license, vessel operators are required to demonstrate both knowledge of vessel regulations and operating principles and proficiency in handling the vessel on the waters in which the vessel is operated.

Ethan Allen Operator

General. The *Ethan Allen* operator, age 74, had graduated from high school in upstate New York, enlisted in the Army, and later joined the New York State Police, where he had served as a trooper for 25 1/2 years. During his tenure with the state police, he had served in the marine unit on Lake George, operating a state police boat.

In 1982, after retiring from the state police, he joined Shoreline Cruises, which provided him with qualifying training to operate all of the company's vessels, small and large. In 1984, he obtained a New York State Master's License to operate public vessels. His last license renewal was valid through June 20, 2006. The owner of Shoreline Cruises characterized the operator as a good worker who was "a very conscientious person." He further stated that the *Ethan Allen* operator "was always looking out for the safety of the public."

Medical. The vessel operator said that he took prescription medications for high blood pressure and cholesterol, as well as several over-the-counter vitamins.

Work/Rest History. The vessel operator told Safety Board investigators that he had maintained the same schedule for several weeks before the accident, including the day of the accident. He arose by 0530, and typically left home for work around 0920 to arrive at the Shoreline Cruises office at least 30 minutes before his first scheduled cruise at 1030. He went to bed by 2100 or 2130. On October 2, he operated the *Ethan Allen* with a passenger load of two or three on his 1030 cruise.

Vessel Information

History

The vessel now known as the *Ethan Allen* was built in 1964 by Anchorage Shipyard of Warren, Rhode Island, for Whaling City Dredge & Dock Corporation (Whaling) of Groton, Connecticut. Whaling contracted for a fiberglass excursion vessel using the Dyer 40 hull design.[6] The hull, the seventh in a series based on a design for 40-foot fiberglass cruisers, was designated the Dyer 40-7. Because of the vessel's intended operation as a small passenger vessel, it was subject to Federal oversight. U.S. Coast Guard regulations pertaining to commercial vessels the size of the *Ethan Allen* are contained in 46 CFR Subchapter T, "Small Passenger Vessels (Under 100 Gross Tons)."[7]

The Coast Guard official with the oversight responsibility for ensuring compliance with marine safety standards, including the requirements in Subchapter T, is the Officer-in-Charge, Marine Inspection (OCMI) at each Marine Safety Office, which is a local Coast Guard office having jurisdictional authority for a specific area. Any restriction or

[6] The first production Dyer 40 hull design was built in the early 1960s. The hull form has been used in a variety of other vessels as well, such as sport fishing vessels, lobster boats, yacht club tenders, cruisers, pilot boats, and U.S. Army Corps of Engineers utility boats.

[7] Subchapter T was promulgated in 1957 as a result of Public Law No. 106-519, which was enacted by the U.S. Congress following the capsizing of the M/V *Pelican* off Long Island, New York. The small commercial fishing vessel, which was designed to safely accommodate 30 persons, was carrying 64 people when it capsized in heavy seas. Because of the vessel's overloaded condition, the sea state, and the failure of the boat's occupants to don lifejackets, 45 people died. Subchapter T stipulates that to operate a small passenger vessel, the owner/operator must have various programs and policies, maintain various documents, and install and maintain various navigation and radio equipment, lifesaving equipment, and firefighting equipment on that vessel.

contingency that the OCMI deems necessary for the safe operation of a vessel is listed on its COI. In the case of the Dyer 40-7 excursion boat contracted by Whaling, the Coast Guard OCMI, Providence (Rhode Island), approved the initial construction plans for the vessel, which was to be named the *Double Dolphin*.

Anchorage Shipyard did not do the finish work on the *Double Dolphin*. Rather, the excursion boat was delivered to Whaling for completion. Because the vessel was not fully completed at the time the vessel left the Anchorage Shipyard, the OCMI Providence did not issue a Coast Guard COI authorizing the *Double Dolphin* for operation.

According to documentation provided by Anchorage Shipyard, the *Double Dolphin* was in service for Whaling in 1965.[8] In January 1966, Whaling contracted with Anchorage Shipyard for two additional vessels, requesting that the vessels be similar in construction, appearance, finish, and quality to the *Double Dolphin.* After the two sister[9] vessels were delivered to Whaling*,* the company operated the three Dyer 40-model boats until spring 1979, when Shoreline Cruises, based in Lake George Village, purchased them.

Because Shoreline Cruises intended to operate the three Dyer 40-model boats solely on New York State waters, the vessels no longer fell under Coast Guard jurisdiction[10] but became subject to state oversight. Chapter 37, "Navigation Law," New York State Consolidated Laws, governs vessels that operate solely on New York State waters. Excerpts from the regulations pertaining to commercial passenger vessel operations are published in separate study guides issued by the New York State Office of Parks, Recreation, and Historic Preservation (Office of Parks), which has oversight responsibility for public vessels.

When Shoreline Cruises acquired the vessels, the *Double Dolphin*'s sister vessels were configured the same as when they were delivered by the boat builder to Whaling in 1966. The *Double Dolphin*, however, had been modified by the installation of a canvas-covered metal-truss-frame canopy. Additional information about the structural modifications to the three vessels appears in the section entitled "Vessel Certification and Inspection."

Shoreline Cruises renamed all three vessels. The *Double Dolphin* became the *Ethan Allen* and the sister vessels became the *de Champlain* and the *Algonquin*. Table 2

[8] Draft press release circa May 1966.

[9] The Coast Guard *Marine Safety Manual* provides the following guidance on the assignment of vessel sister status: "the proposed sister vessel should have been built within approximately 2 years from one another; the vessels must be built by the same shipyard; and the same basic drawings should have been used in the construction of both vessels."

[10] Vessels operating exclusively on inland waters that have not been determined to be "navigable waters of the United States" are not subject to Coast Guard inspection and regulation. The Coast Guard does not make such determinations about every body of water within the United States. Therefore, waters that have not been determined to be "navigable waters of the United States" fall under the jurisdiction of the state in which they are located. The Coast Guard has never determined Lake George to be "navigable" for Coast Guard regulatory or inspection purposes.

summarizes events pertaining to the construction and modification of the *Ethan Allen* and its sister vessels.

Table 2. Events in the history of the *Ethan Allen* and its sister vessels

	Event
1964	Anchorage Shipyard builds and delivers *Double Dolphin* to Whaling. Vessel comes under Coast Guard certification.
1966	Anchorage Shipyard builds and delivers sister vessels to Whaling.
May 1966	Stability test may have been performed on *Double Dolphin*.
1966-1979	*Double Dolphin* fitted with metal canvas canopy.
May 28, 1976	Last COI issued to *Double Dolphin* by Coast Guard.
May 1979	*Double Dolphin* and sister vessels sold to Shoreline Cruises.
1979-1989	*De Champlain* and *Algonquin* fitted with metal canvas canopies by Shoreline. *Ethan Allen (*ex. *Double Dolphin)* and *de Champlain* fitted with Plexiglas windows.
1989	*Ethan Allen*'s metal canvas canopy replaced with a wooden canopy.
1990	*De Champlain*'s metal canvas canopy replaced with a wooden canopy.
1991	*Algonquin*'s metal canvas canopy replaced with a wooden canopy.
April 2005	Last COI issued to *Ethan Allen* by New York State.
October 2, 2005	*Ethan Allen* capsizes.

Construction

The main characteristics of the *Ethan Allen* at the time of the accident are listed below:

Registration:	NY1267FP
Hull form:	Dyer 40 fiberglass monohull
Canopy:	Wood
Windows:	Plexiglas
Length:	38 feet
Beam:	12 feet
Propulsion:	Cummins diesel engine, model 6BT5.9M, 210 horsepower
Propulsion type:	Conventional single-shaft, three-blade propeller, single rudder

The belowdeck area was divided into four spaces: a forward space, which held a 100-gallon fuel tank; the engineroom compartment; the lazarette, which contained the steering gear; and an aft port storage space. Hatch covers on the main deck allowed access

to the belowdeck areas. In addition, a side cover on the aft storage space permitted access to the lazarette.

The engine compartment was equipped with a bilge pump mounted on the port side of the forward bulkhead. The pump removed bilge water from either the engine compartment itself or the forward space, according to the setting on a selector valve.

The *Ethan Allen* was not equipped with a bilge alarm to alert crewmembers of a high water level in the bilge area. New York state laws did not have a requirement for public vessels to be equipped with a bilge alarm.[11]

The *Ethan Allen* employed a "wet exhaust" system. Water was pumped from the lake through the engine's cooling system and into the exhaust gas piping by the main engine raw water pump. The mixture of exhaust gases and cooling water exited the vessel stern through a common pipe.

Lifesaving Apparatus and Safety Equipment

New York State required the *Ethan Allen* to carry sufficient lifesaving equipment on board for 50 people. The vessel typically carried the following safety equipment:

Adult lifejackets	50 type I
Child lifejackets	5 type I
Fire extinguishers	One portable 5-pound carbon dioxide (CO_2) and one portable 44-pound CO_2
Ring buoys	One type IV throwable device

The adult lifejackets were stowed inside a cabinet near the operator's console at the stern and secured by an unlocked latch. The children's lifejackets were inside a wooden box, the top of which formed the seat of a 36-inch-wide bench near the vessel's bow. Both adult and children's lifejacket storage locations were marked.[12] The 5-pound fire extinguisher was near the operator's console, and the 44-pound one was inside the engine compartment.[13]

[11] New York has proposed a state requirement similar to the Coast Guard's current requirement that small passenger vessels have high level bilge alarms in engine spaces below the deepest load water. The legislation is pending. See "Additional Information" for a discussion of the actions New York has taken following the accident.

[12] Coast Guard regulations (46 CFR 180.78) require that lifejackets be stored "in convenient places distributed throughout accommodation spaces." New York State Navigation Law 2 (67) requires life preservers to be located in "convenient, accessible places."

[13] Coast Guard regulations (46 CFR 181) require that a portable fire extinguisher used for an engine space be in a fixed location immediately adjacent to the entry door or hatch to the space. The New York "Public Vessel Operator's Study Guide" in effect at the time of the accident specifies the number of portable extinguishers a vessel must carry based on its length. The guide indicates that at least one extinguisher must be located near the operator's station, but is silent on where the other extinguishers should be located.

Vessel Certification and Inspection

Stability Assessments. Coast Guard regulations specify the amount of stability a vessel must have, depending on its type and its service, as well as the methods of assessment for verifying its stability. An in-depth discussion of the stability concepts involved in the Coast Guard's passenger vessel standards appears in "Other Information."

When the *Ethan Allen* (formerly *Double Dolphin*) was built, the September 6, 1963, version of Subchapter T was in effect. These Coast Guard rules did not require stability tests for passenger vessels that were shorter than 65 feet in length and that carried fewer than 50 passengers.[14] Rather, an OCMI certifying a vessel for operation could require that a stability test be performed if he or she considered it necessary that the vessel's stability be demonstrated. If the OCMI had required a stability test for the monohull vessel, the initial assessment typically would have been a simplified stability test (SST). The OCMI also could accept alternatives, equivalents, or departures from standards if the owner or operator could show they were warranted.

In the course of its investigation, the Safety Board researched Coast Guard, state, and company records on the *Ethan Allen* (formerly the *Double Dolphin*). Investigators found that few documents were on file for the period when the *Double Dolphin* had been subject to Federal oversight (1964 through 1979). Anchorage Shipyard provided a February 22, 1966, letter that it sent to the OCMI Providence stating that the shipyard had been contracted by Whaling to build two 40-foot excursion launches based on the previous Coast Guard approval of the *Double Dolphin*. Anchorage Shipyard also provided the March 1, 1966, response letter that it received from the OCMI Providence approving the submitted plans and recognizing the *Double Dolphin* as the original sister vessel. The OCMI Providence response letter indicates that the *Double Dolphin* would be given an SST in the near future.

Two Whaling employees who were interviewed said that they observed a stability test on one of the Dyer 40 excursion vessels, although they could not recall when the stability assessment occurred. No Coast Guard or Whaling company files contain any record of a stability assessment for the *Double Dolphin*. Shoreline Cruises' files contained a copy of the *Double Dolphin*'s May 28, 1976, COI issued by the OCMI New London. The *Double Dolphin*'s 1976 COI references a stability letter dated May 28, 1966.[15]

Shoreline Cruises' files also contained COIs for the two sister vessels acquired from Whaling. In the form block labeled "Stability letter (date and time)," the COIs for the two sister vessels contain no information.

New York Office of Parks officials indicated that when Shoreline Cruises applied for state certification of the *Ethan Allen* (formerly *Double Dolphin*), state officials based

[14] On March 10, 1996, the Coast Guard revised 46 CFR Subchapter T, requiring all small passenger vessels carrying more than six persons to pass an SST or to demonstrate compliance with the vessel stability requirements of Subchapter S.

[15] The Safety Board was unable to find a copy of the stability letter, which would have indicated the date and type of stability test performed, as well as the results of the test.

their certification of the vessel, in part, on the Coast Guard's May 28, 1976, COI, and did not require the boat to undergo a stability assessment. The Coast Guard's COI permitted up to 48 passengers and required a master and second crewmember regardless of passenger carriage. New York Office of Parks officials indicated that the state COI permitted a maximum of 48 passengers on the *Ethan Allen* and required a master and also a crewmember when the tour boat carried more than 20 passengers.

Vessel Modifications. Federal regulations at 46 CFR 176.700 stipulate, in part, that modifications to a vessel that might affect its safety must not be made without the approval of the OCMI. New York State did not have regulations requiring vessel owners to notify the state in the event of a major vessel modification; however, a New York State study guide, "Public Vessel Operator's Manual," in effect at the time of the modification states, in part,

> When major alteration to the structure of a public vessel is to be accomplished…it is the duty of the owner to promptly report the same to the [State] inspector, so that he may make a thorough inspection, if the condition or age of the vessel, in the judgment of the inspector renders such examination necessary.

The manual is silent on whether the owner or operator should notify the state inspector verbally or in writing.

As noted earlier, when Shoreline Cruises acquired the three Dyer 40 excursion vessels from Whaling, the two sister vessels built in 1966 had the same configuration as when they had been delivered by the boat builder, that is, with no canopy structure. The *Double Dolphin*, however, had been modified by the installation of a metal[16] truss frame that supported a canvas canopy.

Shoreline Cruises then modified the *de Champlain* by installing a full canvas canopy with metal framework and the *Algonquin* with a partial canopy (figure 4). In addition, Shoreline equipped the *Ethan Allen* and the *de Champlain* with Plexiglas windows.

In 1989, Shoreline Cruises contracted with Scarano Boatbuilders, Inc., of Albany, New York, to modify the *Ethan Allen* by installing an all-wood canopy with Plexiglas windows that could be latched open. The finished canopy had six 36-inch-high windows along each side. Moving from stern to bow, three windows measured 58 inches wide, two measured 59 inches wide, and the forwardmost side window measured 50 inches wide. The bow area had three windows. A movable window measuring 26 inches wide by 38 inches high was in the middle of the bow windows. On each side of the center window was a fixed window measuring 29 1/2 inches wide by 37 1/2 inches high.

The wooden canopy that Scarano Boatbuilders installed was about 15 inches lower than the metal and canvas canopy it replaced, providing a smaller lateral surface area[17] than the previous canopy.

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[16] There is no record of and no one interviewed recalled what type of metal was used in the frame. Materials traditionally used in such construction were steel pipe or aluminum tubing.

[17] Lateral surface geometry is a factor in Coast Guard stability criteria.

Figure 4. This circa 1980 photograph shows the canopies and metal framework on the *de Champlain* (foreground left), the *Ethan Allen* (foreground center), and the *Algonquin* (foreground right).

According to Office of Parks representatives, state inspectors examine public vessels annually and require discrepancies to be corrected before the vessel is allowed to carry passengers. New York's policy on records retention was to maintain a document for 5 years and then discard it. The state's file on the *Ethan Allen* contains no record of inspections and/or stability assessments performed between 1979 and 1991, when modifications to the vessel's canopy reportedly were accomplished.[18] Office of Parks files indicate that the last state inspection of the *Ethan Allen* was conducted on May 20, 2005, and covered navigation, lifesaving, machinery, electrical, fire protection, firefighting, and documentation. Inspectors noted one deficiency, a chafed rubber inlet line on the raw water pump, which Shoreline Cruises replaced.

Wreckage

Investigators examined the vessel after it was recovered from Lake George and observed no damage on the outside of the fiberglass hull, the rudder, the keel, the propeller, or the drive shaft components. One window at the port bow and one window on the starboard side were missing Plexiglas panes. The passenger benches were undamaged and still bolted to the main deck. The engine hatch cover was missing but was later recovered from the lake. The engine exterior was free of damage; however, further tests showed that the engine sustained internal damage after the vessel overturned and the inverted engine either ingested water or lost lubrication while it briefly continued to operate.

Investigators next had the vessel returned to the water and allowed it to float for about 20 minutes to determine whether the hull had any leaks. None were found. The engine exhaust pipe had several pinhole leaks and several weld beads suggestive of previous repairs to pinhole leaks.

The main engine raw water pump was bolted externally to the port forward end of the engine. This pump was located above the vessel's waterline when fully loaded with

[18] New York provided the Safety Board with records for the *Ethan Allen* from 1997 to 2005.

passengers. Investigators found a gap measuring 0.076 inches at the widest point between the pump base and its impeller housing. When investigators removed the raw water pump from the engine, they noted that one of the two bolts on its mounting flange was backed out 0.063 inches and was loose to the touch. The on-scene investigative team subsequently sent the raw water pump to the Safety Board's materials laboratory in Washington, D.C. for examination and arranged for an exemplar pump to be tested at the manufacturer's testing facility. The raw water pump previously installed on the *Ethan Allen*'s engine was also acquired and sent to the materials laboratory for examination. See "Tests and Research" later in this report.

Investigators observed no indications of engine damage, other than that to the raw water pump. Engine compartment hoses and piping showed no signs of wear, holes, or abrasions. The engine space and the engine exterior were coated with what appeared to be lubricating oil. The vessel's two 12-volt batteries were found cabled together and dislodged, resting over the exhaust pipe, about 3 feet aft of the engine.

The bilge pump selector was positioned to the forward space. Twenty-one lead blocks used for ballast, each weighing about 55 pounds, were found unsecured in the belowdeck forward space, near the 100-gallon fuel tank. Fourteen lead blocks were under the fuel tank's plywood support; the remaining seven were found in different locations on the port side of the space. The interior of the forward space had minor cosmetic damage from the blocks' moving during the capsizing event.

Waterway Information

Lake George, located at the southernmost end of New York's Adirondack Park region, is 32 miles long and nearly 3 miles across at it widest point. The maximum lake depth is 195 feet. Over 10,000 boats of varying sizes operate on the lake each year. Public vessel operations on the lake are conducted under regulations established by the New York State Office of Parks. The Lake George Commission, which also issues marina and special activities permits, provides law enforcement services on the lake, as do the New York State Police–Marine Unit on Lake George and the Warren County sheriff's office.

Operations

General

Shoreline Cruises began in 1974 when the owner of the company began renting small recreational boats for the purpose of conducting sightseeing tours on Lake George. In 1979, the Shoreline Cruises owner purchased his own fleet of small passenger vessels (the *Ethan Allen,* the *de Champlain,* and the *Algonquin*) for the tours. He later acquired two additional vessels: the *Horicon,* an 85-foot vessel with a capacity of 200 passengers, in 1988; and the *Adirondack,* a 115-foot vessel with a capacity of 400 passengers, in 2004.

The owner said that the year before the accident, an estimated 60,000 passengers had taken Shoreline Cruises sightseeing tours in its vessels. He said that at the height of the tourist season in 2005, the company transported about 300 passengers a day on sightseeing tours on its three small vessels, although he indicated that he would conduct a sightseeing cruise with as few as two passengers. The company recorded the number of passengers on its small vessels but did not retain those records, and therefore Safety Board investigators were unable to determine how many times the various vessels had sailed with a full load of passengers.

Maintenance

Shoreline Cruises had its own personnel maintain its vessels, except when extensive engine repairs were needed. The company required operators to check their vessel's engine fluids and bilge levels at the beginning of each day. Occasionally, company maintenance personnel would perform similar checks to verify vessel and engine status that the operators reported.

In July 2005, Shoreline Cruises replaced the *Ethan Allen*'s main engine raw water pump at the recommendation of the company's maintenance technician after he noticed a leak at the pump's internal water seal during a routine check.

Meteorological Information

The Lake George water temperature was 68° F at the time of the accident. Witnesses described the lake water as calm, except for waves created by vessels.

The National Weather Service office in Albany, New York, issued no hazardous weather advisories for the area on the day of the accident. Weather observations at Floyd Bennett Memorial Airport in Glens Falls, New York, about 6 miles east-southeast of the accident site, were taken both before and after the accident. Weather observations recorded at 1353, 1453, and 1553, indicated that the wind was calm, visibility was unrestricted at 10 statute miles, the sky was clear, and the air temperature was 71° F.

Medical and Pathological Information

Medical Information

Autopsies were performed on each of the 20 fatalities in the accident, in accordance with New York State requirements. All victims were determined to have died as a result of asphyxia due to drowning. The Safety Board examined the results of the autopsies. Thirteen of the drowned passengers suffered significant traumatic injuries, including rib fractures and head and neck injuries. Of the seven drowned passengers who did not have significant injuries, five had evidence of significant heart disease, but only

two of these had age-associated atherosclerotic heart disease. The survivors either had minimal traumatic injuries or were uninjured.[19]

Toxicology Testing

At the time of the accident, New York State did not require postaccident toxicological testing of mariners as a matter of course; however, in the case of an accident in which a passenger was seriously or fatally injured, a law enforcement official or the local district attorney could request a state superior court judge to compel toxicology testing through a court order, if he or she believed this was warranted.

In this case, local and state officials did not ask the *Ethan Allen* operator to provide blood and urine samples, although he offered to submit to testing within an hour of the capsizing. The Warren County sheriff said that he observed the operator at close range shortly after the accident and noted no evidence of impairment. The operator then remained with the sheriff for several hours while he provided a statement pertaining to the accident events. The sheriff indicated that based on his observations, he did not ask that court-ordered toxicology samples be obtained.

On October 4, 2006, the Safety Board asked that a toxicological test of the operator be accomplished, and the operator voluntarily submitted blood and urine samples for analysis. He told Safety Board investigators that he had consumed a glass of wine with his dinner the evening of the accident but no alcohol after that time. Investigators sent the samples to the Federal Aviation Administration (FFA) Civil Aerospace Medical Institute (CAMI) in Okalahoma City, Oklahoma, for testing. The CAMI report indicated no positive results for legal and illegal drugs. The urine analysis indicated the presence of an alcohol metabolite.[20]

Survival Aspects

Emergency Response

Several people on boats and on shore saw the capsizing and called 911 on their cell phones. Warren County sheriff's office logs indicate that these calls took place at 1454. Lake George Fire Department (LGFD) records indicate that the first units were dispatched at 1456 and arrived at 1504. The LGFD fire chief established an onshore incident command post near Cramer Point and served as the incident commander for the response to the accident.

A total of 49 emergency response vehicles and vessels were dispatched to the scene. In addition, recreational boaters who observed the accident immediately went to the scene to assist in the rescue. A group of divers at a Lake George dive school saw the

[19] Three survivors were hospitalized for more than 48 hours (all for less than 72 hours). One was admitted for a heart attack, one for water inhalation, and one to rule out the possibility of a heart attack.

[20] The metabolite ethyl glucuronide can be detected in urine for up to 80 hours after the elimination of alcohol from the body.

capsizing and called 911 to report the accident. They advised the dispatch center that they could assist in the rescue but needed boats to take them to the site. About 15 minutes later, a recreational vessel took five dive instructors to the site, where they assisted in recovering victims from the water and the sunken vessel.

Ambulances transported survivors to a hospital in Glens Falls, New York. The operator was uninjured and elected not to be taken to a hospital. Eighteen survivors were treated for minor injuries or exposure to cold and released the same day. One was admitted overnight, treated for stress and exhaustion, and released the next day; five were admitted and discharged after 2 nights; and three were discharged after 3 nights. Their injuries included water aspiration, hypothermia, possible myocardial ischemia, chest pain, and shoulder trauma.

Survivability-Related Rules

At the time of the accident, the Consolidated Laws of the State of New York and the study guide provided to public vessel operators were silent about crews providing passengers with a predeparture safety briefing or a safety card or pamphlet with safety-related information.[21] In addition, New York laws did not specify minimum dimensions for means of escape.

Following the *Ethan Allen* capsizing, the Office of Parks issued a pamphlet, "Technical Guidance for the Public Vessel Operators," which states that each level on a public vessel that is occupied by passengers should have two means of egress, and that the minimum opening for doorways should be 32 inches and for windows, 24 inches. In addition, state legislation has been proposed to require that all public vessels certified to carry 20 or more passengers be equipped with at least two means of exit on each deck.[22]

Tests and Research

Raw Water Pump

Exemplar Pump Tests at Cummins Facility. To test the effect of the gap that investigators found in the raw water pump housing and to avoid possible damage to the *Ethan Allen*'s actual pump before it was subjected to Safety Board laboratory examination and analysis, investigators had operational tests performed on a same model and similarly configured raw water cooling pump at the engine manufacturer's facility on

[21] The *Ethan Allen* was not inspected by the Coast Guard and therefore was not subject to Federal regulations at 46 CFR 185.506, which require a vessel operator to ensure that, before getting underway, passengers receive an announcement or a pamphlet informing them about the location of emergency exits and ring life buoys, the locations of lifejackets, the proper method for donning or adjusting lifejackets, and the location of instruction placards for lifejackets and other lifesaving devices. The State of New York has since proposed regulatory changes, which are discussed later in this report.

[22] See appendix C.

December 20, 2005. The engine test cell was configured to replicate the operating conditions on the *Ethan Allen* in the following conditions:

- The raw water temperature was matched to that of the lake at the time of the accident.
- The raw water inlet plumbing was configured to replicate the theoretical raw water inlet restriction calculated from the *Ethan Allen*'s actual plumbing.
- The raw water inlet plumbing was configured to allow the adjustment of waterline height in relation to the pump centerline to simulate the unloaded and loaded vessel conditions.
- The engine was coupled to a dynamometer to replicate the theoretical load on the engine at the time of the accident.
- The engine with the installed exemplar pump was operated under several test conditions to assess its operational characteristics. Investigators then introduced a 0.076-inch gap in the pump housing that matched the gap found on the *Ethan Allen*'s pump. The following results were obtained:

    1. Initially, the engine was running with no gap in the pump. Immediately after the gap was introduced, the pump completely lost flow.
    2. The pump was unable to establish prime when starting the engine with the gap in place.
    3. While operating with no water flow, internal friction within the pump caused the impeller and housing to overheat and emit white smoke.
    4. With the pump not supplying water flow through the engine's cooling system and the engine running within routine operational parameters, the engine operated 4 minutes before it overheated and had to be shut down because of high cooling water temperature.

The maximum leak rate during any testing phase was 0.2 to 0.3 gallons per minute.

Pump Examination at Safety Board Laboratory. Because of the observed gap in the raw water pump on the accident vessel, investigators removed it for disassembly and examination in the Safety Board's materials laboratory. Technicians also examined the pump removed from the *Ethan Allen* by the Shoreline Cruises maintenance technician in July 2005 and the exemplar pump tested at the Cummins facility in December 2005 for comparison with the pump from the accident vessel.

Examination of the pump removed from the *Ethan Allen* following the accident revealed that all three pump housing bolts were loose and the lock washer was free to rotate on the bolt. Lock washer contact was observed around two of the three pump housing bolt holes located on the bearing housing. The lock washer contact face on the bolts displayed limited plating removal and circumferential scratches consistent with the bolt being in contact with the lock washer, but no indications that it had been loosened. As

a test, exemplar bolts and lock washers were torque-loaded in accordance with the manufacturer's specification and loosened. Examination under the head of the exemplar bolts revealed a radially oriented curl of material on the surface, consistent with the loosening action. Despite the gap between the pump and bearing housings, one side of the wear plate between them displayed a uniform imprint from the O-ring in the pump housing and the other side displayed a uniform imprint from the gasket between it and the bearing housing. The impeller contact face on the wear plate was severely discolored and significant wear was observed on the impeller tips.

The examination of the three raw water pumps, conducted on January 10, 2006, revealed that the previously installed pump (removed in July 2005) had significant wear around the pump housing bolt holes, consistent with repeated tightening and loosening of the housing bolts. The impeller shaft was extremely loose in the bearing housing and the shaft's key slot, key, and impeller keyway showed significant wear. The impeller tips had negligible wear.

The exemplar pump used in the December 2005 tests at Cummins had loosening contact marks, from the lock washers, on all three pump housing bolts and wear on the impeller tips.

On-site Stability Assessment

Following the accident, Safety Board investigators had the *Ethan Allen* recovered from the water and transported to a hangar where it could be retained as evidence and examined to determine whether hull sections or equipment needed to be removed for further testing and analysis. To obtain a preliminary determination of whether stability, overloading, or both might have been factors in the capsizing, Safety Board investigators conducted a series of stability-related tests on the *de Champlain,* which investigators considered for test purposes to match the critical dimensions of the *Ethan Allen*.[23] The first test was an SST, conducted in accordance with 46 CFR 178.330, "Simplified stability proof test."[24]

The Coast Guard SST verifies a vessel's stability for carrying passengers. The number of passengers to be carried is initially determined before the test is conducted, based on a review of the vessel's drawings or physical measurements, using one of several criteria.[25] The stability of the vessel is then assessed using the minimum number of passengers allowed based on the initial determination. An SST is conducted, based on Coast Guard criteria of 140 pounds per person for vessels to be operated on protected

[23] Safety Board investigators compared the two vessels and found the general arrangement and construction of the hulls to be the same with some minor differences in ballast, canopy structure, type of main engine, and outfitting noted and accounted for in the tests.

[24] Coast Guard criteria were used because New York State applied Coast Guard stability requirements to public vessels.

[25] *Length of rail*—one passenger for each 30 inches of rail at the sides and stern. *Deck area*—one passenger per 10 square feet of deck area, excluding spaces listed in 46 CFR 176.113, which include, among other areas, concession stands, toilets, lifesaving gear storage spaces, required aisle area, and fixed seating areas. *Fixed seating*—one passenger for each 18 inches of fixed seating width.

waters. The areas where the vessel operated as the *Double Dolphin* and Lake George are considered to be protected waters.

The SST protocol includes calculating wind and passenger heeling moments[26] to determine whether a vessel, as built and proposed to be operated, has the required stability and reserve buoyancy. The greater of the calculated wind moment or the passenger moment is applied to the vessel, and the vessel's reduction in freeboard is then determined. The calculation of the passenger heeling moment is based on the beam of the vessel and the number of passengers carried, while that of the wind heeling moment is based on the projected lateral surface of the vessel exposed to wind pressure. Passenger heel and wind heel moments test conditions, as well as immersion of the freeboard, were calculated and are provided in table 3.

Table 3. On-site SST test conditions

Passenger Heel		Wind Heel		Allowable Immersion
Test Weight (calculated)	**Moment**	**Lateral Wind Area**	**Moment**	**14º Limit Angle of Heel**
6,720 pounds	11,659 foot-pounds	330 square feet	13,060 foot-pounds	17.16 inches

Investigators initially filled 12 55-gallon barrels with water and positioned them on wooden blocks along the vessel's centerline. This test weight replicated loading 48 passengers with an average per person weight of 140 pounds.[27] The vessel's freeboard and the lateral area exposed to wind were then measured. To reach the maximum heeling moment of 13,060 foot-pounds, eight of the 12 barrels were emptied and repositioned against the vessel's port side, in a two-by-four combination, with the intent of refilling all eight barrels to produce the required heeling moment. However, after only three outboard barrels had been filled, which produced a heeling moment of about 7,164 foot-pounds, the vessel heeled to within 3 inches of the reference immersion mark. Investigators noted that the vessel felt tender[28] and terminated the test rather than risk endangering the vessel and test personnel by filling the remaining empty barrels (figure 5).

The SST simulates a full vessel passenger load using the number of passengers allowed by the vessel design and the number of required crewmembers, multiplied by the weight standard. If the vessel's loss of freeboard from heel with this load is greater than that stipulated in the standard, it is not permitted to carry the number of passengers determined initially. The owner must then reduce the heeling moment to enable the vessel to pass the proof test, by reducing the maximum permitted number of passengers,

[26] In engineering terms, a "moment" is a force applied at some distance from a reference point. The distance may be referred to as a "moment arm" or "lever arm." A moment may also be referred to as torque. If an object is not constrained, a moment will cause it to rotate.

[27] The calculated wind heel was based on the SST conducted on the *de Champlain*.

[28] A vessel is described as "tender" when its center of gravity is too high, making it top-heavy and "conducive to capsizing" (*International Maritime Dictionary*).

ballasting the vessel, or reducing the vessel's wind profile area, if possible. As an alternative to the SST, the owner can also show, by an inclining test and design calculations, that a vessel's loading and operation meet the stability criteria of 46 CFR Subchapter S.[29]

Figure 5. *De Champlain* after on-site stability assessment was terminated.

Investigators then conducted an inclining test on the *de Champlain* to determine its weight and vertical center of gravity (VCG). The test measured changes in the equilibrium heel angle of the vessel after moving water barrels, each weighing 477 pounds, transversely to various positions on the main deck. The test also derived the vessel's lightship condition (displacement and vertical center of gravity).[30] At the time of the inclining test, the wind was slack and wave action on the lake was minimal. The inclining experiment results on the *de Champlain* were conducted in accordance with ASTM Standard F 1321-91.[31]

[29] Title 46 CFR 178.320 (e) allows an owner to perform rigorous stability calculations if the SST fails.

[30] The lightship condition is when the vessel is complete in all respects but is without consumables, stores, cargo, crew, or passengers and has only operating fluids in the vessel's machinery. Both the vessel's lightship weight and the center of gravity are necessary if the vessel's stability is to be calculated according to 46 CFR Subchapter S standards.

[31] "Standard Guide for Conducting a Stability Test to Determine the Light Ship Displacement and Centers of Gravity of a Vessel."

Both the *de Champlain* and the *Ethan Allen* were then placed in the water and freeboard measurements were taken around each vessel. The *Ethan Allen* measured a consistent 0.5 inch deeper in the water than the *de Champlain.* Both vessels were then placed on a New York State Police-certificated truck scale and weighed. The *de Champlain* weighed 14,870 pounds and the *Ethan Allen*, 15,400 pounds.

Postaccident Stability Study—Method

The Safety Board contracted with JMS Naval Architects and Salvage Engineers to derive the static and dynamic stability of the *Ethan Allen* in both the intact condition and the flooded condition.[32] The contractor was to perform seven tasks:

1. Develop an accurate computer model of the *Ethan Allen* hull form.
2. Calculate the lightship weight and VCG of the *Ethan Allen* at the time of the accident, based on the inclining experiment conducted on the *de Champlain.*[33]
3. Calculate the *Ethan Allen* lightship weight and VCG for previous vessel conditions—as delivered by the builder and with various canvas canopy configurations, or variants.
4. Determine the maximum passenger loading that would meet Coast Guard simplified stability criteria in 46 CFR 178.330, based on the lightship weights and VCGs found in tasks 2 and 3.
5. Determine the maximum passenger/crew loading that would meet the following Coast Guard passenger vessel stability criteria in 46 CFR Subchapter S[34]:
    - 46 CFR 170.170, "Calculations Required" minimum GM[35] with wind heeling moment [weather criterion],
    - 46 CFR 170.173(e)(2), "Criterion for Vessels of Unusual Proportion and Form" (weather criterion), and
    - 46 CFR 171.050, "Intact Stability Requirements for a Mechanically Propelled or a Nonself-propelled Vessel" minimum GM with passenger heeling moment [passenger loading criteria for large vessels].
6. Evaluate the effects of transverse passenger movement and internal flooding of the main engine and forward compartments on vessel stability.
7. Evaluate the dynamic effects of wave action on the vessel.

[32] Static stability is a measure of a vessel's stability characteristics in calm water. Dynamic stability is a measure of a vessel's characteristics and response to external forces such as wind and waves. Intact stability assumes no damage to or flooding of the vessel.

[33] See "On-site Stability Assessment" section.

[34] As required by 46 CFR 178.310 if the cognizant OCMI questions the stability of a small passenger vessel or if the owner chooses not to assess the vessel's stability by means of an SST.

[35] GM or metacentric height is the measure of a vessel's ability to return to the upright position after it has experienced a heel from an external force.

Before beginning its study, the contractor performed a laser survey of the *Ethan Allen* to determine the hull form. The contractor then used the results of the laser survey to generate a three-dimensional computer hull model to import into naval architecture software for use in the stability analysis.[36] The vessel conditions analyzed were as follows:

1. As delivered from boat builder (without a canopy).
2. With a steel canopy installed—operated in fresh water.
3. With a steel canopy installed—operated in salt water.
4. With an aluminum canopy installed—operated in fresh water.
5. With an aluminum canopy installed—operated in salt water.
6. With a wood canopy installed—operated in fresh water.

Postaccident Stability Study—Results

The *Ethan Allen* hull form created by the contractor as task 1 is shown in figure 6.

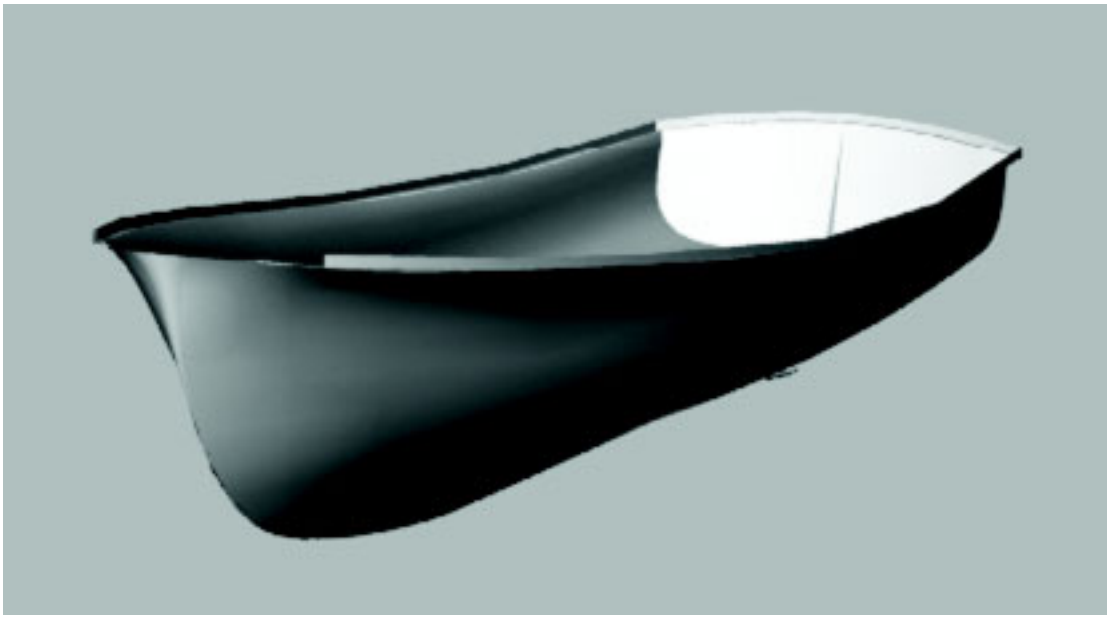

Figure 6. Computer-generated *Ethan Allen* hull form.

Estimates of the *Ethan Allen*'s lightship weight and longitudinal center of gravity at the time of the accident were based on the weight measured on the truck scale and from freeboard measurements taken while the vessel was afloat. The VCG was derived from the results of the *de Champlain* inclining test. The hydrostatic properties based on task 1 were used for both vessels.

[36] Analysis used "HECSALV," proprietary software developed by Herbert Engineering Corporation.

In tasks 3 through 5, the contractor calculated passenger vessel stability in accordance with Coast Guard regulations in 46 CFR Subchapters S and T, in various vessel configurations, three canopy designs,[37] and salt and fresh water because the vessel had operated in both.

Lightship weights and centers of gravity of the five types of vessel configurations are shown in table 4. The *de Champlain* is included for comparison purposes, using the results of the October 5, 2005, inclining experiment.

Table 4. Lightship conditions of alternate vessel configurations

Item	*Ethan Allen* 1964	*Ethan Allen* Steel Canopy	*Ethan Allen* Aluminum Canopy	*Ethan Allen* 2005	*De Champlain* 2005
Weight (pounds)	12,759	14,590	13,542	14,689	14,315
VCG (feet above baseline)	4.5	5.4	4.9	5.3	5.4

The task 4 stability analysis showed that the only version of the *Ethan Allen* (formerly *Double Dolphin*) that could pass the SST with a 48-passenger load was the as-delivered variant from the boat builder, that is, the vessel without a canopy. All other variants failed the SST for any passenger loading. With the canopy installed, the wind heeling moment was found to govern over the passenger heeling moment.[38]

The results of task 5—maximum passenger loading for Subchapter S criteria—are shown in table 5. As noted, passenger counts were based on 140 pounds per person, the Coast Guard standard for operation in protected waters. As in the simplified criteria, no metal-framed canvas canopy was found to meet the wind heel criteria, regardless of the total passenger count. The wood canopy was found to meet the criteria with a reduced number of passengers because the height of the wood canopy was lower than the height of the canvas one, resulting in a lower vertical center of gravity and a smaller wind profile than for the canvas canopy.

[37] Canvas canopy with steel frame, canvas canopy with aluminum frame, and wooden canopy.

[38] That is, it became the more severe of the two stability criteria that the vessel had to meet. Thus, if the vessel met the wind heeling moment, it met the passenger heeling moment as well.

Table 5. Maximum passenger/crew loading for Subchapter S stability criteria

Condition	46 CFR 170.170 Wind Heel		46 CFR 170.173 Unusual Form		46 CFR 171.050 Passenger Heel	
	Weight (pounds)	Passengers/Crew (number)	Weight (pounds)	Passengers/Crew (number)	Weigh (pounds)	Passengers/Crew (number)
1	>21,000	>150	8,260	59	8,120	58
2	DID NOT PASS		1,540	11	6,860	49
3	DID NOT PASS		1,400	10	6,720	48
4	DID NOT PASS		5,180	37	7,560	54
5	DID NOT PASS		5,040	36	7,560	54
6	2,940	21	1,960	14	6,860	49

NOTE: Weight = total weight of passengers at 140 pounds per passenger.

In task 6, the Safety Board examined the effects of the three-by-two passenger seating configuration on the vessel's center of gravity, given the weight of those on board the vessel. The results indicate that the total passenger/crew transverse center of gravity was 0.2 foot to port of centerline and the longitudinal center of gravity was 0.36 foot forward of amidships, which created a 2.2º heel to port and 0.71-foot trim by the bow.

During interviews of survivors, investigators asked whether any passengers moved shortly before the onset of the accident, and every person said that no one stood up or moved from one side of the vessel to the other. Almost all said that passengers shifted in their seats and slid or fell toward the vessel's port side as the operator was attempting to turn starboard and the *Ethan Allen* began to roll to port. The Safety Board study analyzed the potential effect of the transverse movement of passengers and crew on the tendency of the *Ethan Allen* to capsize. In the accident condition, the righting arm was reduced to zero[39] when the total passenger/crew weight load was shifted 1.0 foot off centerline, or 0.8 foot from the initial loading condition.

Task 7 was a roll sensitivity study, which was conducted to understand the dynamic behavior of the *Ethan Allen* under varying wave conditions. Simulations were completed using Oceanic Consulting Corporation's numerical seakeeping time-domain panel code MOTSIM.[40]

The characteristic waves in the wake of a vessel are governed by many factors, including vessel speed, hull size, hull shape, and whether or not the vessel in question is maneuvering. Consequently, there is no simple answer as to the height, steepness, or wave period (frequency) of the waves that will exist in a generated wake. The wake generated

[39] At zero righting arm, the boat has no righting energy to resist a vessel's heeling action, meaning it will capsize.

[40] MOTSIM is a non-linear time-domain seakeeping simulation program that can predict vessel motions in six degrees of freedom in any wave condition.

by a vessel can be assessed by means of a physical model test or by using numerical simulation. For the purposes of this report, it is sufficient to state that such generated wakes may have wavelengths as long as the *Ethan Allen*. Such waves generally last a few seconds. In the case of the *Ethan Allen,* its natural rolling period also was a few seconds. Without specific knowledge of which vessel(s) created the wave(s) that impacted the *Ethan Allen,* the actual wave conditions experienced by the *Ethan Allen* are unknown. It was therefore deemed appropriate to undertake a study using regular wave analysis to examine influences on the dynamic response of the vessel.

Based on witness accounts of the *Ethan Allen*'s movements and their descriptions of the waves encountered by the vessel as it turned and rolled and the resultant involuntary shifting of passengers and crew, this analysis examined a number of parameters in combination, shown in table 6. The 1-foot wave height was initially chosen based on passenger and operator observations. The parameters that were examined included vessel speed, heading, wave period, wave height, and passenger/crew transverse center of gravity (TCG[41]) position. The issue of turning was beyond the capability of the seakeeping code.

Table 6. Original motion analysis simulation parameters

Loading Conditions	Speeds	Headings	Wave Height
Passenger/crew TCG = -0.2ft ACTUAL	6, 7 & 8 mph	15°, 30°, 45°, 60°, 75°, and 90°	1 foot

None of the study simulations using the parameters in table 6 resulted in a capsize event, indicating that a wave height of greater than 1 foot would have been required to capsize the vessel for the load condition assessed. In simulations based on encountering a 1-foot wave, the maximum roll response was about 8° to port. Maximum vertical and lateral accelerations tended to occur in beam seas (at all speeds). Lateral accelerations were also high at the 75° headings.

Investigators next examined the parameters outlined in table 7. A limited set of simulations was run at higher wave heights. Over the speed range examined, the analysis identified that vessel speed had little influence on the results, and additional simulations used a nominal vessel speed of 7 mph. The results illustrated that larger motions could be expected at wave headings that were closer to beam seas (that is, headings of 90°, 75°, or 60°). The vessel response was not as pronounced at headings that were closer to following or stern quartering seas (that is, headings of 15°, 30°, or 45°).

The static stability study (task 6) had determined that the vessel's reserve righting energy was sensitive to the location of the center of gravity of the passengers and crew.

[41] The transverse location of the center of gravity of passengers/crew relative to the centerline of the vessel. The TCG = -0.2 foot represents the actual departure condition of the vessel and resulted in the vessel's initial 2.2° list to port. A TCG of –0.8 foot would produce a list of about 10° to port.

Almost all survivors stated that as the vessel rolled to port during the turn toward starboard and encountered the wave(s) from the starboard direction, passengers slid to the low (port) side of the *Ethan Allen*. The simulations that considered shifts in passenger/crew TCG positions as well as increased wave heights showed that the maximum roll and pitch angles occurred at headings of 60°, 75°, and 90°, with a maximum roll response of about 16° to port. Over the range of frequencies that were examined, the peak responses (that is, largest roll angles) tended to occur at higher wave frequencies. These cases were where the wavelength equaled the boat length.

Table 7. Parameters for additional motion analysis simulations

Loading Conditions	Speeds	Headings	Wave Height
Passengers/crew weight TCG= -0.2ft actual	7 mph	60°, 75°, 90°	1.5 foot
Passengers/crew weight TCG= -0.2ft actual	7 mph	60°, 75°, 90°	2.0 foot
Passengers/crew weight TCG= -0.4ft	7 mph	60°, 75°, 90°	1.0 foot
Passengers/crew weight TCG= -0.6ft	7 mph	60°, 75°, 90°	1.0 foot
Passengers/crew weight TCG= -0.8ft	7 mph	60°, 75°, 90°	1.0 foot

Maximum roll angles increased when wave height was increased. Maximum roll angles increased when the TCG was moved farther outboard. While no capsize event occurred, it was noted that some roll angles were substantial.

The Safety Board's stability study did not include a rigorous engineering evaluation of the vessel's roll response to the combined effects of wave action and turning because of limitations of the numerical seakeeping time-domain panel code MOTSIM. However, certain factors associated with a vessel's roll response actions are applicable to vessels such as the *Ethan Allen*. If an operator turns the vessel to starboard either in calm waters or in waves, the boat will experience a roll to port during the maneuver. Calculations performed in conjunction with other tasks showed that the *Ethan Allen* operated with a 2.2° port list. When a listing vessel makes a turn, the added angle of roll further reduces the amount of righting energy available to counter the effects of passing waves and transverse weight shifts. Saunders discusses the heel angles associated with vessels in a turn in *Hydrodynamics in Ship Design*,[42] stating

> Usually,…the center of gravity lies above the centers of pressure on the underwater hull and on the rudder, and the hull-lift force is greater than the rudder force, so that the resultant transverse moment created by these three forces causes the ship to heel outward while making a turn, despite the righting moment due to positive transverse metacentric stability. The heel due to the offset centripetal and centrifugal forces increases until the moment caused by them equals the righting moment….

[42] Harold E. Saunders, *Hydrodynamics in Ship Design*, Vol. 3, ch. 4, "Ship Motion Involved in Maneuvering" (New York: Society of Naval Architects and Marine Engineers, 1965), pp. 56-57.

> The heel may become dangerously large if the metacentric height and the range of positive transverse metacentric stability are both small….
>
> A boat or a ship with a surface waterplane which has fore-and-aft asymmetry changes trim as it lists or heels. There may be some disadvantage if this occurs during a turn. An everyday example is the craft with a wide transom stern which trims by the head as it heels, because it picks up more volume aft than forward with a given inclination.

The Safety Board's stability study showed that in its accident condition, the *Ethan Allen* had a high center of gravity, and marginal righting energy and GM. With its transom stern and its fine bow, the vessel had a significant asymmetric water plane at its accident draft. In addition to the vessel's 2.2° list to port, it was trimmed by the bow almost 1 foot.

Other Information

Stability Concepts

A vessel that is floating upright in still water will heel when an off-center force or heeling moment is applied. Stability is the tendency of the vessel to return to its original upright position when the force is removed. In still water, a vessel's stability is a function of its underwater hull form and the distribution of mass of the vessel. The properties of stability are usually expressed in terms such as the magnitude of a heeling moment necessary to heel the vessel to a certain angle, the angle a vessel may heel to before capsizing, the amount of reserve energy available to return the vessel to its upright position, and other parameters that can be calculated. Coast Guard regulations and international standards specify the amount of stability a vessel must possess, depending on the type of vessel and its service. The requirements are usually expressed in terms that are easily calculated, such as GM, range of positive stability, righting energy, or other recognized technical measures. The specific stability characteristics of an individual vessel are determined based on the design drawings of its hull form (lines plan) and an inclining experiment of the vessel while afloat to determine its actual weight (displacement) and center of mass (center of gravity).

Although obtained under stationary conditions, the stability characteristics represent the vessel's ability to return to the upright position when the vessel is in service and is subject to external forces such as wind and waves, people moving about, and from inertial effects resulting from the accelerations and motions of the vessel as it moves around on the water's surface. Such dynamic influences on a vessel are random processes and can only be predicted statistically. Studies comparing the stability characteristics of vessels that capsized (inadequate stability) and vessels that did not capsize (adequate stability) form the basis of stability criteria that are in use today. To account for unknowns, uncertainties, and randomness of the physical environment and vessel response, large safety margins are built into the criteria. The stability criteria are generally recognized as providing an adequate level of safety for vessels that are operated prudently, which means not overloaded and not operating in dangerous conditions such as hurricanes.

The stability analyses of most vessels involve substantial calculations that generally require the services of a naval architect. The calculations are based on an inclining experiment, in which very precise measurements are taken on board the vessel in order to determine its displacement and center of gravity. The inclining experiment and associated calculations and analysis cost several thousand to tens of thousands of dollars. For large oceangoing ships, the stability assessment is minor compared to the total cost, and is necessary in order to determine the maximum amount and stowage of cargo. In small passenger vessel design, stability is not optimized and usually exceeds the Coast Guard stability criteria. Because of the relatively high cost of an inclining experiment and full stability assessment, the Coast Guard permits an SST to be performed. The SST is quick, inexpensive, and more conservative than a full stability analysis. Being more conservative, the SST results in fewer passengers permitted than would be allowed based on a full stability assessment. Because the number of passengers permitted on a small passenger vessel is based on several criteria, such as deck area and seating capacity, stability is often not the governing criteria. In those cases, the SST is sufficient. However, the owner of a small passenger vessel might have space to carry more passengers than would be allowed by the SST, and so the cost of performing a full stability assessment with an inclining experiment is justified to show that additional passengers may be carried in compliance with the detailed stability regulations.

The margin of safety built into the stability criteria is what provides the safety of the vessel against capsizing. The margin of safety is intended to accommodate all the things that happen with a vessel, such as rolling in waves, heeling due to wind, or listing as passengers move from one side to the other. The margin of safety is reduced if the vessel is operated in extremely high winds, surf, or is overloaded. The stability criteria are not intended for such conditions. In such extreme operating conditions, the margin of safety may be still adequate to keep the vessel upright, or it may not be adequate, resulting in a capsizing. In any case, if the intended margin of safety is not maintained, the vessel should not be considered seaworthy (safe), whether or not it capsizes.

Because of the nature of stability, and the randomness and variabilities associated with it, safety is not absolute. Not meeting stability standards does not mean a vessel will capsize; it only means the margin of safety is lower than what the regulations require. A vessel can operate for years in an overloaded condition that does not meet the stability standards; because the margin of safety is less than it should be, the probability of capsizing is higher, but it could still be remote. It would take other forces, such as high winds or large waves, to cause a vessel to capsize. The more a vessel is overloaded, the less the margin of safety for stability and the higher the probability of capsizing.

There is no obvious way to tell if a vessel fails to meet the stability criteria, other than through a stability test. This is why a stability test is required for all small passenger vessels. If something changes about the vessel, such as a structural modification that might affect the vessel's stability, another stability test and assessment should be conducted. After the stability assessment is completed, the results of the assessment and any limitations, such as number of passengers or limiting operating conditions, will be placed on the vessel's stability letter or COI.

Capacity Plates

In the course of its investigation of the *Ethan Allen* accident, the Safety Board determined that the number of boats registered in New York as "public vessels," that is, vessels permitted to transport freight or passengers for commercial purposes on state waters, totaled 447. Of these, state officials had based the number of passengers that 382 public vessels were permitted to carry on manufacturers' capacity plates.[43] Investigators determined that of these 382 public vessels, 125 carried more than six passengers.

The required display of capacity information on a plate in sight of the helm (steering area) is contained in 33 CFR 183, Coast Guard standards governing monohull noncommercial boats less than 20 feet long, except sailboats, canoes, kayaks, and inflatable boats. Information on the plate must include the maximum horsepower recommended for the boat, the maximum person capacity (listed both as number of people and as cumulative pounds), and the vessel's maximum carrying weight capacity (listed as the combined poundage of persons, motor, and gear). Vessels longer than 20 feet are not required to have a capacity plate; however, some manufacturers elect to install the plates on their vessels over 20 feet long.

As noted earlier, New York State did not have regulations governing stability assessments for public vessels. Office of Parks representatives indicated that the state accepted either a Coast Guard-approved stability assessment or a manufacturer's capacity plate as evidence of acceptable vessel passenger loading for public vessels. If a state inspector questioned a vessel's stability or if the owner made major modifications to the vessel, state officials required that a stability assessment be conducted using the testing protocol in Coast Guard regulations for small passenger vessels.

The Coast Guard does not rely on capacity plate information for inspected small passenger vessels. All small passenger vessels that carry more than six passengers must comply with full certification and inspection requirements, including the stability criteria in Coast Guard regulations.

Accidents Involving Out-of-Date Passenger Weight Standard

Following the March 6, 2004, capsizing of the pontoon-style small passenger vessel *Lady D* in Baltimore Harbor,[44] the Safety Board identified that the Coast Guard's passenger weight standard of 140 pounds used to assess the stability of vessels operating on protected waters posed a substantial safety risk for vessels carrying near the maximum number of permitted passengers. As a result, in advance of its final report on the accident, the Safety Board issued the following safety recommendation to the Coast Guard on December 20, 2004:

[43] This category did not include the *Ethan Allen*, the *de Champlain*, or the *Algonquin.*

[44] *Capsizing of U.S. Small Passenger Vessel* Lady D*, Northwest Harbor, Baltimore, Maryland, March 6, 2004*. Marine Accident Report MAR/06-01 (Washington, DC: National Transportation Safety Board, 2006).

M-04-4

> Revise your guidance to Officers in Charge, Marine Inspection, to determine the maximum occupant capacity of small passenger pontoon vessels either (1) by dividing the vessel's simplified stability proof test weight[45] by the per person weight allowance for an average adult stipulated in Federal Aviation Administration Advisory Circular 120-27D (174 pounds per person, assuming summer clothing and a 50-50 gender mix), or (2) by restricting (at the time of loading) the actual cumulative weight of passengers and crew to the vessel's simplified stability proof test weight.

In its April 7, 2005, response to this recommendation, the Coast Guard informed the Safety Board that it "partially concurred with this recommendation," noting that it agreed with the premise behind "option 1" but did not agree with "option 2." The Coast Guard stated, with regard to option 2:

> The actions necessary to implement a change to the standard weight per person used in the simplified stability proof test for small passenger pontoon vessels go beyond a simple revision of guidance to OCMIs. The current weight standards are set in regulation at 46 CFR 178.330 and extend to all other types of small passenger vessels as well. Therefore, any change would, and realistically should, affect all other small passenger vessel types. However, passenger weight is only one of many variables in our vessel stability calculations.

The Coast Guard added that it had chartered a working group to analyze the passenger weight issue and assess the potential impact of regulatory changes on vessel stability determinations.

In the Safety Board's final report on the *Lady D* accident, issued March 7, 2006, the Board agreed with the stated intent of the Coast Guard to address the passenger weight standard in the stability criteria for all domestic passenger vessels and classified Safety Recommendation M-04-4 "Closed—Superseded." The Board noted however that if statistically representative average passenger weights were used, the Coast Guard needed to address how best to update the weight standard as needed. The Board further advised that even if the number of passengers permitted on board a vessel was based on a statistically representative average passenger weight, "the problem remains that a vessel can become overloaded if many of the passengers on board are heavier than the standard," and that operators needed "an easy way of identifying whether the passenger load they are intending to carry will compromise the stability of their vessels." To address these passenger vessel stability concerns, the Safety Board issued the following safety recommendations to the Coast Guard:

[45] Subchapter T contains a separate protocol for the pontoon vessel stability test (PSST).

M-06-5

Revise regulations to require that passenger capacity for domestic passenger vessels be calculated based on a statistically representative average passenger weight standard that is periodically updated.

M-06-6

Identify a method for determining the maximum safe load condition of a small passenger vessel at the time of loading, such as a mark on the side of the hull, and require that the vessel owners implement that method.

On April 26, 2006, the Coast Guard published "Domestic Vessel Passenger Weights–Voluntary Interim Measures" in the *Federal Register*.[46] The purpose of the notice was to advise owners and operators of small passenger vessels of prudent actions to take to address potentially unsafe operating conditions and to request comments on the measures. Several of the recommended measures addressed, in part, issues identified in the Safety Board's report on the *Lady D* capsizing.

In the voluntary interim measures, the Coast Guard asked owners and operators of small passenger vessels less than 65 feet long to reduce the total passenger capacity by using a per passenger weight standard of 185 pounds in calculating the number of passengers permitted on board the vessel. The Coast Guard said that if necessary, passengers should be weighed before boarding to verify that the vessel is not overloaded.

The Coast Guard asked owners and operators of vessels for which stability was evaluated according to Coast Guard regulations in Subchapter S to review their stability guidance to ensure that they did not carry excessive passenger weight, or that increasing the per passenger weight to 185 pounds did not reduce vessel stability below Subchapter S requirements. It also recommended that owners and operators of all small passenger vessels notify the OCMI "if any significant structural or equipment changes have been made to the vessel" since stability was "evaluated by the owner and approved by the Coast Guard."

The Coast Guard also suggested that owners and operators may consider voluntarily reevaluating a vessel's stability using a per passenger weight of 185 pounds. Finally, the Coast Guard noted that it would amend its regulations to "address the stability issues caused by increases in passenger and vessel weight."

New York State Actions Since Accident

Shortly after the accident, New York State legislation was proposed to address deficiencies noted in the state's oversight of public vessels.[47] In particular, the proposed legislation called for mandatory postaccident drug and alcohol testing of vessel operators and a reduction in passenger loads on public vessels to comply with the intent of Safety

[46] *Federal Register*, vol. 71, no. 80 (April 26, 2006), pp. 24732-24735.

[47] See appendix C for more information.

Recommendation M-04-04, which called for using a passenger weight standard of 174 pounds when assessing vessel stability.

On March 2, 2006, the Governor announced a comprehensive legislative effort to address additional deficiencies in the state's oversight of public vessels. Among the initiatives was legislation requiring:

- Vessels carrying 20 or more passengers to have at least two exits on each deck.
- Operators and engineers to crew vessels with the number of crewmembers specified in the vessel COI, under penalty of suspension or revocation of licenses, with owners facing misdemeanor charges for violations.
- Owners to inform the state before modifying vessels in a way "that would affect the stability of the vessel…," with owners also facing misdemeanor charges for violations.
- Vessels carrying more than 49 passengers to be equipped with radar.

Several weeks thereafter, the Office of Parks' Marine Services Unit circulated to the owners and operators of public vessel two draft pamphlets that contained the proposed state regulatory changes that New York intended to enact. The first pamphlet, "Technical Guidance for the Public Vessel Operators," addresses operations, primary and auxiliary vessel systems, emergency procedures (preparatory drills and safety briefings and response activities), and safety equipment carriage requirements. The second pamphlet, "Technical Guidance for the Public Vessel Operators–Simplified Stability Test," discusses stability concepts, offers instructions for conducting a stability test, and provides a list of navigating precautions for avoiding a capsizing.

Analysis

General

The analysis first identifies factors that can be eliminated as causal or contributory to the cause of the accident. It then discusses safety issues identified in the accident investigation. These include:

- Stability standards and procedures for passenger vessels;
- New York State's use of manufacturer's capacity plates to determine public vessel passenger loading; and
- Regulation of New York State's public vessels.

This analysis also looks at survivability and toxicological testing in the *Ethan Allen* accident.

Exclusions

At the time of the accident, visibility was good, the winds were calm, and the temperature was moderate. The waves that were present on the lake were produced primarily by the activity of other vessels. Given the clear sky, moderate temperature, and calm winds, the Safety Board concludes that weather conditions were not a factor in this accident.

The Safety Board examined the actions of the operator to determine what role, if any, he may have played in the cause of the accident. Passenger and witness reports were consistent that just before accident, the operator turned the vessel to starboard. He told investigators that he had begun to turn the vessel at Cramer Point to proceed along the route of the vessel's tour, and that he continued the turn when he saw a wave about to strike the vessel. The vessel operator's sharp turn was an attempt to meet the wave head on, which would have enabled him to better handle the force exerted by the wave. Some witnesses reported that as the vessel turned starboard, the wave struck the vessel broadside, on its aft starboard quarter, before the vessel could be turned into the wave. Therefore, the Safety Board concludes that the attempt of the *Ethan Allen* operator turning the vessel into the oncoming wake before the capsizing was a normal reaction to the circumstances, but not timely enough to be effective.

The Safety Board also considered personal factors that could have influenced the operator's decision-making, including whether his physical condition was affected by a sleep deficit or the use of alcohol or drugs. The operator had maintained the same work/rest schedule for several weeks before the accident, which provided him 8 to 8 1/2

hours of sleep nightly. Thus, he was not suffering from sleep deprivation. The Safety Board therefore concludes that operator fatigue was not a factor in this accident**.**

Within an hour of the accident, the operator volunteered to provide samples for toxicological testing; however, New York law enforcement officials did not request the testing, based on their observations of him and his behavior. Upon arriving on scene, Safety Board investigators asked the operator to submit to testing. He freely agreed, and samples were obtained 2 days after the accident. The operator advised Safety Board investigators at the time of testing that he had had a glass of wine the evening before the accident. The analysis of the blood samples was negative for drugs; the urine analysis showed a metabolite of alcohol, which merely indicated that he had consumed alcohol at some point within 80 hours of giving the sample. Because of the timeliness of the testing, the findings as they relate to this accident are not conclusive. The Safety Board concludes that because drug and alcohol testing of the *Ethan Allen* operator was not done in a timely manner, the toxicological analysis was inconclusive. The issue of timely toxicological testing, including new Federal standards and proposed New York regulatory changes, is discussed later in this analysis.

Safety Board investigators examined the vessel after the accident and determined that the hull structure and propulsion and steering components were free of preexisting defects. The Safety Board therefore concludes that the *Ethan Allen*'s hull structure and steering and propulsion components were not factors in this accident.

The nature of the capsizing led investigators to question whether water had been in the hull, which might have degraded the stability of the vessel. The bilge was among the items that the operator was to check at the start of each day. He indicated that he checked the bilge that morning and found nothing unusual. He was the second operator to captain the *Ethan Allen*, and the bilge check he completed would have been the second one conducted on the vessel on the day of the accident. Consistent with the company requirement, the first operator also checked the bilge, and he said that he found nothing unusual.

During postaccident examination of the vessel components, investigators found a 0.076-inch gap in the main engine raw water pump. They then measured the leak rate of the pump into the bilge to determine the amount of water that could have leaked into the bilge from the pump during the 20-minute accident voyage. Investigators observed that, at most, 6 gallons of water would have leaked in, assuming the highest leak rate possible. Given the low leak rate of the pump, the two independent checks of the bilge by the operator, and the lack of any other possible source of water ingress, it is unlikely that a noticeable amount of water was in the bilge at the time of the accident. Therefore, the Safety Board concludes that at the time of the accident, the bilge might have contained, at most, an insignificant amount of water, which would not have affected the *Ethan Allen*'s stability.

Cause of the Capsizing

The monohull-style small passenger vessel *Ethan Allen* (New York public vessel) was built in 1964 and had operated in commercial service for almost 40 years. According to the owner of Shoreline Cruises, in the 26 years that the *Ethan Allen* had operated as a passenger vessel on Lake George, it probably had made 14,000 trips and had never experienced a major incident. The *Ethan Allen* very likely had operated with a full load of passengers during various weather and wave conditions on Lake George. On the day of the accident, a sister vessel configured exactly like the *Ethan Allen* (the *de Champlain*) and carrying a full passenger load followed the route of the accident vessel but experienced no problems.

The Safety Board sought to determine what so greatly affected the stability of the *Ethan Allen* on the day of the accident that it capsized, and found that a combination of factors probably contributed to the vessel's overturning. The primary conditions that affected the stability of the *Ethan Allen*, listed below, are discussed in greater detail in the following sections.

- Modifications affecting vessel stability
- Overloading due to out-of-date passenger weight criterion
- Influence of vessel motions on stability

Modifications Affecting Vessel Stability

Postaccident Test Findings. Following the accident, the *Ethan Allen* was recovered from the water and transported to a hangar where it was retained as evidence relating to the accident and its components could be examined and, if necessary, removed for testing and analysis. To obtain a preliminary determination of whether stability, overloading, or both might have been factors in the capsizing, the Safety Board investigators arranged an SST of the *de Champlain*. Like the *Ethan Allen*, the *de Champlain* and the *Algonquin* had been based on the Dyer 40 boat design and built for the same owner. They had originally been under the jurisdiction of the Coast Guard, which certificated each of them to carry 48 passengers in addition to two required crewmembers. When Shoreline Cruises purchased the vessels, they came under the jurisdiction of New York. State officials indicated that they established the same load restrictions (48 passengers, two crewmembers) for the three vessels, based on the COIs issued by the Coast Guard.

After surveying the *de Champlain* and the *Ethan Allen*, investigators determined that the vessels were similar enough in design and construction that the *de Champlain* would yield comparable results from a stability test. The assessment was then conducted in accordance with the Coast Guard's SST criteria found in 46 CFR 178.330, which New York officials indicated the state would require for a public vessel like the *Ethan Allen* if its stability were questioned.

Calculations for the SST indicated that the wind heeling moment and the passenger heeling moment were respectively 13,060 foot-pounds and 11,659 foot-pounds; thus the wind heeling moment was the governing criterion to use in the SST of the *de Champlain*. The magnitude of the required wind heeling moment was determined by the lateral wind area that included the vessel's large canopy structure.

The maximum heeling angle allowed during the SST was 14º. Testers placed twelve full test-weight water barrels on blocks along the vessel's centerline to replicate a load condition for 48 passengers. Using the water surface as the baseline, testers placed a freeboard mark on the outside of the hull that corresponded to 14º of list. Safety Board investigators next attempted to obtain the required maximum moment for wind heel by emptying eight of the barrels, placing them on wooden blocks along the vessel's port side, and then refilling them. Investigators had filled about three of the eight barrels when the waterline neared the reference freeboard mark on the listing *de Champlain*. In other words, only about half the required heeling moment was applied to the vessel before it neared the mark, meaning it would fail the SST for the carriage of 48 passengers. Safety Board investigators terminated the test because it was clear the vessel would not pass the SST, and they did not want to endanger the vessel or themselves.

Because the *de Champlain* failed the stability proof test for the carriage of 48 passengers on a protected route, the Safety Board had reason to question the intact stability of the *Ethan Allen* for the carriage of 48 passengers. Subsequent investigation revealed that during the 40-year history of the *Ethan Allen*, the *de Champlain*, and the *Algonquin*, all had been modified by the addition of various types of canopies, but new stability assessments had not been done to determine the effects of the modifications on the vessels' stability.

The Board contracted for a study to examine the static and dynamic stability of the *Ethan Allen*. The study used both the SST and Subchapter S criteria to evaluate possible variants[48] of the *Ethan Allen* for its ability to carry passengers, including the vessel in its as-delivered condition without a canopy (1964), the vessel with a metal and canvas canopy (several versions beginning in 1979), and the vessel with a wooden canopy (1989).

For the SST, the number of passengers that a vessel can carry is calculated based on a review of the vessel's drawings or physical measurements of such features as rails, seating, or deck area and verified by a simple physical test involving the movement of test weights. Because of how the SST and stability criteria were developed, the SST is considered more conservative than the criteria in Subchapter S, usually resulting in a lower allowable passenger load.

The Subchapter S protocol begins with an inclining experiment on the vessel and is followed by stability calculations. Determining the allowable passenger capacity by

[48] The Safety Board was unable to find documentation on the materials used to fabricate the metal and canvas canopy installed on the *Ethan Allen* (formerly *Double Dolphin*) in Groton. The Board therefore examined the effects on the vessel of an aluminum canopy and a steel canopy because these construction materials respectively represented the lightest and the heaviest materials used at that time by the marine industry for a substantial marine canopy structure.

using Subchapter S stability criteria is more costly than by using an SST because an owner usually has to hire a naval architect to conduct the inclining experiment and perform the rigorous calculations. However, the results of the evaluation may show that the vessel is capable of safely carrying more passengers than would be allowed based on an SST.

The SST results showed that the only configuration of the *Ethan Allen* that passed the SST with a 48-passenger load was the as-delivered vessel that did not have a canopy. All other variants of the *Ethan Allen* (formerly the *Double Dolphin*) failed the SST for any passenger loading because the canopy structure so greatly increased the lateral area projected to the wind that the required wind heeling moment calculated for the SST could not be accommodated.

For the Subchapter S evaluation, an inclining experiment was performed on the sister vessel *de Champlain* at Lake George on October 5, 2005, and witnessed by Safety Board investigators and representatives of the parties to the investigation. The findings from the experiment were then used to perform the stability analysis for the *Ethan Allen*.

The stability analysis showed that the original vessel configuration with no canopy could pass the stability criteria contained in Subchapter S for the carriage of 58 passengers. In the cases of the variants with canopies, however, the calculations yielded dramatically different results for several reasons:

- The weight of each canopy caused the vessel to ride lower in the water, which reduced its reserve buoyancy.
- The higher center of gravity created by a canopy reduced the righting energy and GM of the *Ethan Allen*, reducing its ability to resist overturning moments from forces such as wind, waves, and passenger movement.
- The wind profile created by each canopy, combined with that of the vessel itself, so greatly increased the overall projected lateral area and corresponding wind heeling moment of the *Ethan Allen* that it could not meet the required stability criteria.

By adding a canopy, the governing criterion for stability was no longer the passenger heeling moment, but rather the wind heeling moment, which was much larger than the passenger heeling moment.

None of the variants having metal frame canopies with canvas covers satisfied the Subchapter S stability criteria for the carriage of any passengers. The only variation of the *Ethan Allen* with a canopy that could accommodate any passengers at all was the vessel with a wooden superstructure. The *Ethan Allen* wooden canopy was heavier than both the canvas-covered steel frame and the aluminum frame canopy variants; however, because the wood superstructure was about 15 inches lower, it presented a smaller lateral wind profile and thus a smaller wind heeling moment. The Subchapter S calculations determined that the *Ethan Allen* with the wooden canopy could carry only 14 passengers, using the current regulatory standard of 140 pounds per passenger.

The Safety Board therefore concludes that the addition, and subsequent modification, of a canopy changed the *Ethan Allen*'s stability characteristics.

Failure to Reassess Stability After Modifications. Documentation provided by Anchorage Shipyard and statements by former Whaling employees indicated that an SST may have been conducted in 1966 on the *Double Dolphin*. The Safety Board found no evidence to indicate that a stability evaluation using the tests in either Subchapter T or S was conducted after adding a metal frame canopy to the vessel while it was still in service in Groton and under Coast Guard jurisdiction. At the time, the regulations in Subchapter T concerning alterations and modifications did not specifically require testing the vessel after modifications.

In 1979, Whaling sold the *Double Dolphin* and its two sister vessels to Shoreline Cruises, and the three vessels became subject to New York State regulations. According to Office of Parks officials, New York based the vessels' permitted passenger capacity on the Coast Guard COIs. At this time, canopies had not yet been added to the *de Champlain* and the *Algonquin*; consequently the passenger loads permitted on their state COIs were appropriate, based on the Coast Guard stability criteria. Shoreline Cruises subsequently added metal/canvas canopies to the *de Champlain* and the *Algonquin.* During the period of 1989 to 1991, Shoreline Cruises contracted to replace the metal/canvas canopies on the three Dyer 40s with wooden canopies.

Before this accident, state laws did not address stability assessments and state guidance documents contained vague language about assessments that were necessary if a public vessel was to be modified. Chapter 37 of the Consolidated Laws of the State of New York contains no regulation requiring vessel owners to notify a state inspector or inspectors if they intend to make or have made a modification to their vessels that might affect stability. The Office of Parks manual for public vessel operators that was in effect before this accident states that it is the duty of the owner to promptly report when a major alteration to a public vessel is to be accomplished so that a state inspector can determine whether a "thorough inspection" is necessary.

The Safety Board found no evidence to indicate that a stability evaluation using the tests in either Subchapter T or S was conducted after any of the canopy modifications at Lake George. If a stability assessment had been conducted after the canopy installations and modifications, it would have been necessary for Shoreline Cruises to reduce the passenger capacity and/or change the design of the canopies of the three vessels in order to pass the Coast Guard stability test criteria applied by New York State.

The Safety Board concludes that although Coast Guard regulations and New York State guidance to vessel owners did not contain clear requirements pertaining to testing after modifications, the *Double Dolphin*/*Ethan Allen* should have undergone a stability reassessment after each canopy installation and modification. Moreover, because the *Double Dolphin*/*Ethan Allen* did not undergo stability assessments after the addition and modification of its canopies, it was certificated to carry too many passengers. Its COI permitted 50 persons, but stability criteria should have limited the number to 14 persons.

The *Ethan Allen* and *de Champlain* were retrofitted alike; thus they were sister vessels, and the results of the Safety Board's stability study applied to both vessels. Shoreline Cruises first installed a smaller metal canvas canopy on the *Algonquin* and then refitted it with a partial wooden deckhouse in 1991. Consequently, the *Algonquin* had a smaller lateral wind profile, its displacement was less, and its VCG was lower than that of the other two vessels. The reduction in its freeboard and stability would not have been as significant as that of the *Ethan Allen* and the *de Champlain*. The Safety Board concludes that although it was the *Ethan Allen* that was involved in this accident, the potential for capsizing was substantially the same for the *de Champlain*.

Overloading Due to Out-of-Date Passenger Weight Criterion

From survivor interviews and its review of emergency room records, the Safety Board found that the average weight of the *Ethan Allen*'s occupants on the day of the accident was almost 178 pounds, significantly more than the per person weight standard of 140 pounds used to verify the allowable number of passengers in stability proof tests. The combination of the number of passengers permitted by the COI and the higher-than-assumed average weight of the people on board the *Ethan Allen* resulted in the vessel being significantly overloaded when it capsized.

The Safety Board stability study, which used the current regulatory weight standard of 140 pounds per passenger, determined that the maximum number of persons that should have been allowed for the *Ethan Allen* was 14, or a total occupant capacity of about 2,000 pounds. On the day of the accident, however, the vessel carried 48 persons (1 crewmember and 47 passengers) averaging about 177.5 pounds each, or more than 8,000 pounds total weight, about four times its safe load carrying capacity. The additional weight caused the *Ethan Allen* to sit deeper in the water and significantly raised its center of gravity, which, in turn, reduced its reserve buoyancy, available GM, and righting energy necessary to resist overturning moments from forces such as wind, waves, and passenger movement.

There was no wind on the day of the accident. When the Safety Board analyzed the effect of transverse passenger movement in the *Ethan Allen* accident condition, the stability study found that the vessel's reserve righting energy was reduced to zero with only 6,800 foot-pounds of passenger heeling moment to the port side.[49] All survivors stated that no one stood up or moved before the onset of the capsize; however, the lack of righting resistance to passenger heel was indicative of the minimal stability of the *Ethan Allen*.

The Safety Board concludes that the combination of too many passengers, as permitted by the *Ethan Allen*'s inappropriate COI, and the use of an out-of-date average weight standard for passengers on public vessels resulted in the *Ethan Allen* carrying a load that significantly reduced its stability, which made it more susceptible to capsizing on the day of the accident.

[49] The *Ethan Allen* had an initial 2.2º port list due to the asymmetrical bench seating arrangement that placed more passengers on the port side of the vessel.

Influence of Vessel Motions on Stability

The static stability analysis of the *Ethan Allen* on the day it capsized showed that while the vessel had marginal stability, it would not capsize without some other heeling force(s) or influence(s). The transverse movement of passengers, significant amounts of water in the bilges, the effects of lateral wind loading, or the grounding of the vessel could have reduced its stability, although the latter three factors can be ruled out in this case. The stability study calculated the stability sensitivity of the *Ethan Allen* to transverse passenger weight shifts; if enough passengers moved to one side of the vessel, a capsize could follow. This tenderness of the vessel, or lack of stability, was apparent when the passengers boarded the *Ethan Allen* at the dock, and then had to redistribute themselves to try to bring the vessel back on an even keel.

When the overloaded *Ethan Allen* departed the dock, it already had a 2.2° list to port, which would have reduced the vessel's port freeboard and limited the maximum angle of roll to port that the vessel could sustain before the deck edge submerged. In addition, the vessel had almost 1 foot of trim by the bow when it sailed. In determining the cause of the capsizing of the *Ethan Allen*, the Safety Board looked at the effects of the following dynamic conditions that were reported:

- The *Ethan Allen* encountered waves generated by passing vessels.
- The operator of the *Ethan Allen* attempted to maneuver the vessel in a sharp starboard turn to head into these waves, but did not complete the maneuver before the wave or waves hit the vessel.
- As the vessel rolled to port, passengers said that they fell to the low (port side) of the vessel.

Dynamic Response in Waves. At the time of the accident, the waves in the lake were produced by vessel activity. The Safety Board was unable to specifically identify the vessel or vessels that caused the particular wave or waves in question. Varying accounts of the size of the wave or waves were reported. Several passengers reported one wave that was less than a foot high, and some passengers and a boater reported seeing no wave at all. The operator estimated that the wake was 2 1/2 to 3 feet high. Because of the differences in their descriptions and the absence of other evidence, the Safety Board could not determine the precise height, frequency, and number of the waves in question. The Board therefore had simulations performed for varying heights of waves to determine their potential impact.

The dynamic response in waves of the 40-foot tour boat *Ethan Allen* was examined using Oceanic Consulting Corporation's time domain seakeeping panel code MOTSIM. For the conditions analyzed, a capsize event was not observed. However, the results were still useful in that they highlighted the influence of particular variables. For the conditions assessed, vessel speed was shown to be of minimal importance with respect to wave-generated motion response. Motion response was greatest at headings that were near beam seas and was less at headings that were closer to quartering or following seas. Increasing wave height and increasing shifts in passenger/crew transverse center of gravity (TCG)

positions increased the dynamic response of the vessel to waves. When the study looked at a passenger/crew weight shift of 0.6 foot to port with a 1-foot wave, the wave would have produced a vessel roll of almost 16° to port. This passenger/crew weight shift could be achieved if everyone on board moved 7 inches to port. The most significant roll angle reached from the effects of wave action alone was 14° to port.

While a capsize event was not produced in the simulation, the study results led to the conclusion that the actual capsize of the *Ethan Allen* resulted, in part, not from a single dynamic factor, but was probably from a unique set of dynamic factors that overwhelmed the vessel's marginal stability.

Dynamic Response in Turns. The *Ethan Allen*'s characteristics on the day of the accident met criteria that would have predicted the vessel's rolling outboard as the operator turned the vessel into the approaching wave(s). The vessel's high center of gravity created a significant heeling moment that tended to roll the vessel outboard in a turn. In this condition, the vessel had low GM and reserve righting energy to resist heeling moments. The vessel was designed with a fine bow and full transom, and would have had a significant asymmetric water plane at the accident condition draft. This asymmetry would have caused the *Ethan Allen* to trim forward as it rolled to the side. This would have increased the bow-down aspect of the vessel with its existing 1-foot static trim. While the *Ethan Allen* rolled to port as a result of the operator turning the vessel to starboard, the magnitude of the roll is unknown.

Loss of Stability Due to Passenger Movement. The wave that impacted the *Ethan Allen,* together with the vessel rolling away from the turn, may have been large enough to capsize the vessel. However, according to testimony, the rolling action caught the occupants off guard. The point at which passengers lost their seating was determined by a number of factors such as their position in the vessel, their situational awareness, and the actions of passengers next to them. The survivors indicated that when the vessel turned, most passengers initially shifted to port in their seats. As the vessel continued to roll, first a few passengers and then the remaining passengers on the starboard side tumbled and slid to the low side of the vessel (port side). This shift in passenger weight shifted the overall TCG of the vessel to port, further compromising the vessel's stability. As one survivor described, the vessel rolled to port along it axis and continued to roll over until it capsized.

The Safety Board concludes that the *Ethan Allen* capsized as a result of insufficient stability, which made it unable to right itself from the combined forces of a passing wave or waves, a sharp turn, and the resulting involuntary shift of passengers to the port side of the vessel.

Capacity Plates

During its investigation, the Safety Board determined that New York State officials used the manufacturers' capacity plates to establish the number of passengers permitted on 382 of 447 public vessels. Of the 382 public vessels with capacity plates, 125 carried more than six passengers.

The display of capacity information standard, found in 33 CFR 183, requires boat manufacturers to rate the total number of persons their boats can safely carry. The standard specifically applies to noncommercial vessels under 20 feet in length and is not intended to be applied to a commercial passenger vessel carrying more than six passengers for hire. The Coast Guard requires that any commercial passenger vessel carrying more than six passengers comply with the small passenger vessel regulations found in 46 CFR Subchapter T. Consequently, the Safety Board concludes that New York State's reliance on manufacturers' capacity plate data to determine maximum passenger limits on public vessels that carry more than six passengers for hire is an inappropriate use of the Coast Guard noncommercial boat standard. Therefore, the Safety Board believes that New York State should discontinue the use of capacity plate data associated with the U.S. Coast Guard's noncommercial boating standards for determining passenger loading on public vessels that carry more than six passengers and adopt the Coast Guard small passenger vessel inspection standards.

Postaccident Actions by Regulatory Authorities

Following the *Ethan Allen* accident, New York State took prompt action, proposing legislation to address safety on its public vessels. The Coast Guard issued interim measures in advance of final rulemaking aimed at addressing stability issues for small passenger vessels.

New York Actions

On March 2, 2006, the Governor of New York proposed legislation to strengthen the state's regulations governing public vessels, addressing such issues as stability (as it pertained to maximum passenger carriage), drug and alcohol testing, and manning.

In the area of stability, the proposed legislation included increasing the state weight requirement to 174 pounds. The weight standard proposed by New York is based on an FAA weight standard identified in a safety recommendation (M-04-4) that the Safety Board issued to the Coast Guard in advance of the Board's report on the 2004 *Lady D* capsizing in Baltimore Harbor. The specific weight value was adopted in 2004 by the FAA, using the most current study findings at that time.[50]

In addition, the Governor directed the Office of Parks to take interim measures to ensure the safety of public vessels, which resulted in an immediate review of all existing COIs to ensure compliance with the proposed new weight standards and periodic certification of the weight capacity of all public vessels.

New York's proposed legislation to update the average passenger weight standard is a positive step toward ensuring that a vessel is properly certificated for the number of

[50] In October 2004, the Centers for Disease Control and Prevention (CDC) issued the report, "Mean Body Weight, Height, and Body Mass Index, United States 1960–2002," based on data collected annually since 1960 by the CDC's National Health and Nutrition Examination Survey program.

passengers it can safely carry. However, as current studies and sources show, weight is a variable that is subject to change. The Coast Guard now recommends that the passenger weight standard used in evaluating vessel stability be 185 pounds based on 2005 CDC studies. The Safety Board has asked the Coast Guard to periodically review national studies and update the weight standard as necessary. The Board suggests that New York monitor the regulatory changes made by the Coast Guard and update its state regulations accordingly.

Even if the number of passengers permitted is based on an increased average weight standard, the problem persists that a vessel can become overloaded if many of the passengers on board are heavier than the standard weight. Operators therefore need an easy way of identifying whether the passenger load they are preparing to carry will overload their vessels. If a mark were painted on the hull that corresponded to the waterline when the vessel was under maximum approved load, any crewmember could easily determine whether the vessel was overloaded simply by observing the vessel's draft in relation to that mark. The Safety Board concludes that New York State public vessel operators do not have a simple and ready means such as a mark on the hull to determine whether their vessels are overloaded.

The legislation proposed by New York also attempts to address other issues that were not causal to the capsizing. Some of these proposed changes are discussed in the analytical sections "Postaccident Toxicological Testing" and "Survival Issues."

Coast Guard Actions

The Coast Guard has been working to address the issues of an out-of-date weight standard since the capsizing of the pontoon-style small passenger vessel *Lady D* in Baltimore Harbor on March 6, 2004. The agency contracted for a 1-year study in 2005 to determine the potential impact on the marine industry that would result from increasing the passenger weight and size standards used when calculating the stability of domestic passenger vessels. The Coast Guard concurrently evaluated various weight studies, and on April 26, 2006, published voluntary interim measures for domestic passenger vessels in the *Federal Register*. The notice advised boat owners and operators that they should use 185 pounds as the weight standard when evaluating a vessel's stability. The notice also reminded owners and operators that they are required by regulation to submit plans or specifications for any vessel changes to the cognizant OCMI. The Coast Guard asked for comments on the measures, advising the public that the changes were in advance of a final rulemaking effort. The Safety Board expressed its support of the Coast Guard's voluntary interim measures by stating that it was

> pleased with the intended action of the Coast Guard and the direction of several measures. If adopted by vessel owners and operators, the measures can genuinely contribute to safeguarding the traveling public. The Board is aware that the Coast Guard intends to incorporate these measures into regulatory changes and is hopeful that this will be accomplished expeditiously.

The Safety Board was also encouraged by the Coast Guard's stated objective to establish an outreach program to vessel owners and operators to advise them of this notice and to seek the marine industry's support of the published voluntary safety measures. This is a proactive approach that could facilitate the adoption of final rules. The Coast Guard's efforts would benefit by enlisting the support of the state agencies that regulate commercial passenger vessels. As this accident demonstrated, New York had guidance and policies that were intended to provide the same measure of vessel safety as Coast Guard regulations; however, the language in some of the guidance was vague and did not provide clear instructions to vessel owners and operators about stability requirements. The Coast Guard can best assist the states in understanding the Coast Guard's stability standards. The Safety Board therefore believes that the Coast Guard should provide guidance to the states on Coast Guard standards for and assessment of stability of small passenger vessels.

Postaccident Toxicological Testing

As noted earlier in this analysis, New York law enforcement authorities did not obtain samples for toxicological testing, although the operator of the *Ethan Allen* volunteered to submit to testing within a hour of the capsizing. New York State did not require compulsory postaccident testing for alcohol or drug use. There is no reason to suspect that the operator was under the influence of alcohol or illegal drugs at the time of the accident. The Safety Board is nonetheless concerned that the operator was not tested as soon as possible after the accident.

Operators of passenger vessels engaged in commercial operations have an obligation to provide the highest levels of safety to their passengers and crew. For this reason, the Safety Board has worked with the Coast Guard for almost 30 years to improve the postaccident drug and alcohol testing requirements of vessel operators who have been involved in a serious marine incident. The Coast Guard recently adopted revisions to 46 CFR Part 4 that address postaccident chemical testing requirements. The new standard, which became effective on June 20, 2006, stipulates that alcohol testing must be conducted within 2 hours and drug testing must be conducted within 32 hours of the time of a serious marine incident.

The legislation proposed by New York state officials after the *Ethan Allen* accident would require that law enforcement officials immediately obtain samples for alcohol or drug testing from operators of public vessels that have been involved in an accident causing death, disappearance, or serious physical injury. The Safety Board supports the quick enactment of this proposed legislation.

Survival Issues

Twenty of the 48 persons on the *Ethan Allen* did not survive the accident. The majority of these individuals had significant traumatic injuries, which were most likely sustained either during the capsizing itself or during attempts to escape the capsized

vessel. By contrast, survivors showed little evidence of significant traumatic injuries. Several survivors described considerable confusion during their escape due to vessel inversion, submersion, darkness, and the presence of a large number of other frightened passengers. Significant traumatic injuries sustained during the capsizing could have increased disorientation and appreciably decreased the probability of successful egress from the vessel.

Seven drowned passengers did not have significant injuries, and five of these had significant preexisting heart disease. Any of these five individuals possibly had some sort of abnormal heart rhythm that resulted in loss of consciousness following the capsizing, accounting for their drowning without apparent injury. However, for the majority of the drowned victims, there is no evidence that preexisting medical conditions adversely affected their survival. Therefore, the Safety Board concludes that for almost all of the passengers, survivability was not adversely affected by the presence of preexisting medical conditions.

It is noteworthy that only two of the five drowning victims with preexisting heart disease had disease specifically associated with aging. The lack of an obvious association of age-related disease with survivability suggests that, for the most part, the age of the passengers per se did not affect passenger survivability. Passengers who were uninjured in the capsizing or in attempting to escape were generally able to be rescued and survive.

Survivability was enhanced by the proximity of recreational vessels to the accident site and the willingness of their operators both to notify emergency personnel of the accident and to actively assist in rescuing survivors. Warren County sheriff's office dispatch center logs indicate that emergency service personnel were informed quickly about the accident and that rescue vehicles, vessels, and personnel were dispatched to and arrived on the scene within minutes. Therefore, the Safety Board concludes that the emergency response was timely and effective.

Before this accident, the Consolidated Laws of the State of New York and the study guide provided to public vessel operators were silent about safety briefings being provided to passengers; consequently, the operator of the *Ethan Allen* was not obligated to provide one. In this case, the vessel operator said that he gave a safety briefing before the *Ethan Allen* departed the dock at 1430. All survivors reported that the operator did not perform a safety briefing; however, they admitted that they were all talking to each other while the boat was docked. Such a briefing, if done properly, would have included the location of lifejackets, the method of donning them, and emergency exit guidelines. Survivors also stated that although they never had time to retrieve lifejackets, they realized that if people had donned lifejackets, probably more fatalities would have occurred. In this case, the only way for those in the overturned vessel to escape was to "swim down" and go through the open windows, which were below water.

Shortly after the accident, New York proposed legislation that would require verbal safety briefings for passengers to include descriptions of the use and location of personal flotation devices and other safety devices before commencing vessel operation.

A draft of the state's "Technical Guidance for the Public Vessel Operators" described the type of information to be included in a safety briefing, information that is consistent with Coast Guard requirements. The Safety Board supports this proposed regulatory change.

In this accident, surviving passengers were able to escape the capsized *Ethan Allen* because the windows were latched in the open position or had become separated from the vessel during the capsizing. The vessel had two means of egress at the stern. In an emergency in which the vessel did not capsize, those most likely would have been sufficient for passenger egress. The March 2006 legislation proposed by New York State includes a requirement that public vessels certified to carry 20 or more passengers be equipped with at least two means of exit on each deck. The Safety Board supports this proposed legislation.

The *Ethan Allen* did not proceed with a second crewmember, in addition to the operator, as required by its COI. Shortly after the accident, the Governor of New York called for legislation to criminalize the operation of a public vessel with fewer than the required number of crewmembers specified in the COI or temporary permit. The Safety Board supports the regulatory proposal and looks forward to seeing it enacted into law.

In sum, the Safety Board notes the timely efforts that New York State is taking to make regulatory changes related to stability, passenger carriage, postaccident toxicological testing, and manning. If adopted, the proposed changes should ensure a higher level of safety for travelers on public vessels. The Safety Board therefore concludes that the postaccident actions of New York State to improve the level of safety of public vessels were prompt and, if implemented, will address issues identified in the accident investigation. Once the regulatory changes are enacted, owners and operators need to promptly receive guidance on the new rules. The Safety Board therefore believes that New York State should address the safety deficiencies identified in the investigation of the *Ethan Allen* accident and issue technical guidance to vessel owners on inspection requirements for modified vessels, stability assessments and criteria, means for determining maximum safe load condition, drug and alcohol testing, manning, and safety briefings.

Conclusions

Findings

1. Weather conditions were not a factor this accident.

2. The attempt of the *Ethan Allen* operator to continue turning the vessel into the oncoming wake before the capsizing was a normal reaction to the circumstances, but not timely enough to be effective.

3. Operator fatigue was not a factor in this accident.

4. Because drug and alcohol testing of the *Ethan Allen* operator was not done in a timely manner, the toxicological analysis was inconclusive.

5. The *Ethan Allen*'s hull structure and steering and propulsion components were not factors in this accident.

6. At the time of the accident, the bilge might have contained, at most, an insignificant amount of water, which would not have affected the *Ethan Allen*'s stability.

7. The addition, and subsequent modification, of a canopy changed the *Ethan Allen*'s stability characteristics.

8. Although U.S. Coast Guard regulations and New York State guidance to vessel owners did not contain clear requirements pertaining to testing after modifications, the *Double Dolphin*/*Ethan Allen* should have undergone a stability reassessment after each canopy installation and modification.

9. Because the *Double Dolphin*/*Ethan Allen* did not undergo stability assessments after the addition and modification of its canopies, it was certificated to carry too many passengers. Its certificate of inspection permitted 50 persons, but stability criteria should have limited the number to 14 persons.

10. Although it was the *Ethan Allen* that was involved in this accident, the potential for capsizing was substantially the same for the *de Champlain*.

11. The combination of too many passengers, as permitted by the *Ethan Allen*'s inappropriate certificate of inspection, and the use of an out-of-date average weight standard for passengers on public vessels resulted in the *Ethan Allen* carrying a load that significantly reduced its stability, which made it more susceptible to capsizing on the day of the accident.

12. The *Ethan Allen* capsized as a result of insufficient stability, which made it unable to right itself from the combined forces of a passing wave or waves, a sharp turn, and the resulting involuntary shift of passengers to the port side of the vessel.

13. New York State's reliance on manufacturers' capacity plate data to determine maximum passenger limits on public vessels carrying more than six passengers for hire is an inappropriate use of the Coast Guard noncommercial boat standard.

14. New York State public vessel operators do not have a simple and ready means such as a mark on the hull to determine whether their vessels are overloaded.

15. For almost all of the passengers, survivability was not adversely affected by the presence of preexisting medical conditions.

16. The emergency response was timely and effective.

17. The postaccident actions of New York State to improve the level of safety of public vessels were prompt and, if implemented, will address issues identified in the accident investigation.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the capsizing of the *Ethan Allen* was the vessel's insufficient stability to resist the combined forces of a passing wave or waves, a sharp turn, and the resulting involuntary shift of passengers to the port side of the vessel. The vessel's stability was insufficient because it carried 48 persons where postaccident stability calculations demonstrated that it should have been permitted to carry only 14 persons. Contributing to the cause of the accident was the failure to reassess the vessel's stability after it had been modified because there was no clear requirement to do so.

Recommendations

As a result of its investigation of the *Ethan Allen* accident, the National Transportation Safety Board makes the following recommendations.

To the U.S. Coast Guard:

Provide guidance to the states on U.S. Coast Guard standards for and assessment of stability of small passenger vessels. (M-06-15)

To New York State:

Address the safety deficiencies identified in the investigation of the *Ethan Allen* accident and issue technical guidance to vessel owners on inspection requirements for modified vessels, stability assessments and criteria, means for determining maximum safe load condition, drug and alcohol testing, manning, and safety briefings. (M-06-16)

Discontinue the use of capacity plate data associated with the U.S. Coast Guard's noncommercial boating standards for determining passenger loading on public vessels that carry more than six passengers and adopt the Coast Guard small passenger vessel inspection standards. (M-06-17)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

MARK V. ROSENKER
Acting Chairman

DEBORAH A. P. HERSMAN
Member

KATHRYN O'LEARY HIGGINS
Member

Adopted: July 25, 2006

Appendix A

Investigation

The Safety Board learned of this accident through media reports on the afternoon of October 2, 2005. A six-person investigative team as well as the Acting Chairman of the Safety Board and representatives of the Office of Public Affairs, the Office of the General Counsel, and the Office of Transportation Disaster Assistance were launched to the scene. The following investigative groups or technical specialists were assigned to the investigation: deck operations, survival factors, engineering, materials analysis, and naval architecture/stability. The on-scene investigation was completed on October 15, 2005.

The Safety Board investigated the accident according to its rules under the authority of the Independent Safety Board Act of 1974. The designated parties to the investigation were Shoreline Cruise, Inc.; New York State Office of Parks, Recreation and Historic Preservation; Warren County Sheriff's Office, Cummins MerCruiser Diesel; Hypro Pumps; and Scarano Boat Building, Inc.

Appendix B

Passenger Information

Seat No.	Sex	Age	Weight (pounds)	Fatal	Seat No.	Sex	Age	Weight (pounds)	Fatal
1	F	75	189	No	26	F	74	190	No
2	F	58	110	No	27	F	76	129	No
3	F	67	144	No	28	M	81	146	No
4	F	77	141	No	29	F	78	135	No
5	F	76	185	No	30	F	82	176	Yes
6	M	87	194	Yes	31	F	89	204	Yes
7	F	75	180	Yes	32	M	79	170	No
8	M	82	211	Yes	33	F	77	142	No
9	F	76	128	Yes	34	F	78	210	Yes
10	F	75	135	No	35	F	74	180	No
11	F	79	141	No	36	F	67	155	No
12	M	69	205	No	37	F	68	217	Yes
13	M	79	200	No	38	F	67	198	Yes
14	F	77	164	Yes	39	F	74	126	Yes
15	F	76	150	No	40	F	64	247	Yes
16	M	77	170	No	41	M	80	173	Yes
17	F	73	194	Yes	42	F	80	155	Yes
18	M	67	260	No	43	F	73	165	No
19	F	62	165	No	44	M	77	175	No
20	F	67	137	No	45	M	76	235	Yes
21	F	79	198	Yes	46	F	74	230	No
22	F	54	195	No	47	F	65	268	No
23	M	83	158	Yes	48	M	74	170	No
24	F	78	204	Yes	Total			8,522	
25	F	78	170	Yes	Average			177.5	

Appendix C

New York Press Release

FOR IMMEDIATE RELEASE: March 02, 2006

GOVERNOR PROPOSES COMPREHENSIVE BOATING REFORM LEGISLATION

Legislation Will Strengthen Laws to Improve Safety for Commercial Boat Passengers and Crews

Governor George E. Pataki today unveiled comprehensive legislation that would improve safety for commercial boat passengers and crews by strengthening the laws governing public vessel operation on the State's waterways.

The proposed bill follows legislation submitted by the Governor last Fall that requires operators of commercial boats involved in incidents -- where passenger(s) are severely injured or killed -- to undergo an immediate, mandatory chemical test to determine if an operator was under the influence of alcohol or drugs. The Governor proposed the new legislation after a fatal incident with the tour boat Ethan Allen on Lake George, when 20 passengers were killed.

"We have worked to make New York's boating laws among the strongest in the nation," Governor Pataki said. "But we must do everything we can to prevent another tragedy like the Ethan Allen from occurring. Our comprehensive legislation will take the necessary steps to further strengthen New York's boating laws and ensure that owners and operators of public vessels take all the necessary precautions to ensure the safety of both their passengers and crew."

The Governor's comprehensive boating reform legislation would:

- Require a minimum of acceptable marine protection and indemnity insurance for all public vessels operating on State waters, as follows:

Number of Passengers	Minimum Amount of Insurance
1 to 10	$1,000,000
11 to 20	$2,000,000
21 to 50	$5,000,000
51 to 100	$7,000,000
More than 100	$10,000,000

- Require proof of insurance as part of the annual marine inspection by the Office of Parks, Recreation and Historic Preservation and make the operation of a public vessel without such insurance a misdemeanor;
- Require all public vessels certified to carry 20 or more passengers be equipped with at least two means of exit on each deck and make it a violation for individuals who obstruct an exit;
- Make it unlawful to operate a public vessel with less than the required crewmembers specified in the certificate of inspection or temporary permit, authorize the suspension or revocation of the license of any operator, pilot, or engineer who operates the vessel in this unlawful manner, and charge the vessel owner with a misdemeanor if found guilty of permitting operation;
- Require that vessel owners report to Marine Inspectors prior to making any modifications that would affect the stability of the vessel including adjustments to the vessel structure or engineering plant, authorizes Marine Inspectors to inspect any vessel if deemed necessary, makes failure to notify a Marine Inspector a violation, and charges the vessel owner with a misdemeanor if found guilty of permitting operation of an un-inspected vessel;
- Require that all public vessels certified to carry passengers be equipped with either a VHF radio or an operating cellular phone and require public vessels certified to carry more than 49 passengers to have radar;
- Authorize the Office of Parks, Recreation and Historic Preservation Commissioner to adopt, amend and rescind rules and regulations concerning the regulation of public vessels.

In the aftermath of the Ethan Allen tragedy last year, the Governor proposed legislation that would make it mandatory for law enforcement officials to immediately administer a chemical test to all operators of public, or commercial, vessels that have been involved in a accident causing death, disappearance or serious physical injury. This would allow for the identification and/or elimination of alcohol or drugs as a factor in a boating accident in the earliest stages of an investigation.

In the event that an operator of a commercial boat fails to submit to a chemical test, the Governor's proposal calls for the immediate suspension of the operator's boating privileges and the immediate revocation of any public boating licenses issued by the State. Together with a fine of not less than $2,500, this provision would be stronger than current federal regulations. In addition, the proposal allows for the refusal of an operator of commercial vessel to submit to a chemical test to be used as evidence at any subsequent criminal or administrative hearing.

In addition, the Governor directed the Office of Parks, Recreation and Historic Preservation to increase the State weight requirement to 174 pounds, exceeding the federal standard of 141 pounds, and called on the United States Coast Guard to expedite their adoption of a higher threshold for weight when determining capacity. The prior standard

used for capacity on lakes, rivers, and streams was based on the United States Coast Guard's rating of 141 pounds.

The Coast Guard is currently reviewing the weight requirement and the National Transportation Safety Board has also joined in the Governor's call for an increase in the Coast Guard's weight standards to 174 pounds.

State Parks Commissioner Bernadette Castro said, "The operation of public vessels on state waters has historically been a very safe and important industry within New York. This package of proposed reforms follows Governor Pataki's steps to strengthen existing statues and safety requirements. In the aftermath of the Ethan Allen accident and the tragic loss of life, it is imperative that we take an even closer look at these commercial boating ventures and the laws and regulations governing them."

In addition, these proposed safety measures build upon a number of interim steps undertaken by the State Office of Parks, Recreation and Historic Preservation at the Governor's direction, which include, the immediate review all existing certificates of inspection to assure compliance with new weight standards; periodic recertification of the weight capacity of all public vessels; strengthened staff requirements for public vessels including experience and training requirements for crewmembers; mandatory verbal safety briefings for passengers on the use and location of personal flotation devices and other safety devices before commencement of vessel operation; increased penalties for owners and operators who fail to comply with statute, regulations and conditions of certificate of operation.

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