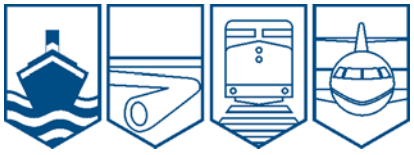
Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

MARINE INVESTIGATION REPORT
M06W0052



STRIKING AND SUBSEQUENT SINKING

PASSENGER AND VEHICLE FERRY *QUEEN OF THE NORTH*
GIL ISLAND, WRIGHT SOUND, BRITISH COLUMBIA
22 MARCH 2006

Canada

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Marine Investigation Report

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Synopsis

At 2000 on 21 March 2006, the passenger and vehicle ferry *Queen of the North* departed Prince Rupert, British Columbia, for Port Hardy, British Columbia. On board were 59 passengers and 42 crew members. After entering Wright Sound from Grenville Channel, the vessel struck the northeast side of Gil Island at approximately 0021 on March 22. The vessel sustained extensive damage to its hull, lost its propulsion, and drifted for about 1 hour and 17 minutes before it sank in 430 m of water. Passengers and crew abandoned the vessel before it sank. Two passengers were unaccounted for after the abandonment and have since been declared dead.

Ce rapport est également disponible en français.

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1.0 Factual Information

1.1 Particulars of the Vessel

Name	*Queen of the North*
Official Number	0368854
Port of Registry	Victoria, B.C.[1]
Flag	Canada
Type	Passenger and vehicle ferry
Gross Tonnage[2]	8889
Length	125 m
Draught	5.25 m
Built	1969, Bremerhaven, Germany
Propulsion	Two MAN V-16 diesel engines, totalling 11 631 kW and driving two controllable-pitch propellers
Cargo	Passengers and vehicles
Passengers	On board: 59 Maximum: 650
Crew Members	On board: 42 (including 2 being trained) Maximum: 50
Vehicles	On board: 22 Maximum (nominal): 157
Owner/Manager(s)	British Columbia Ferry Services Inc. (BC Ferries),[3] Victoria, B.C.

1 See Glossary at Appendix D for all abbreviations and acronyms.

2 Units of measurement in this report conform to International Maritime Organization (IMO) standards or, where there is no such standard, are expressed in the International System of units.

3 British Columbia Ferry Services Inc. and its predecessor, British Columbia Ferry Corporation, are referred to as BC Ferries throughout this report.

1.1.1 Description of the Vessel

The passenger roll-on/roll-off (ro-ro) vehicle ferry *Queen of the North*, originally named the *Stena Danica,* was built in Germany in 1969. In 1974, it was purchased by the Government of British Columbia, and its registry was transferred to Canada. The vessel was then renamed the *Queen of Surrey* and put into service between Nanaimo, British Columbia, and Horseshoe Bay, British Columbia, on home trade voyages, Class III. In 1980, the vessel underwent a modification for the northern British Columbia ferry routes and was renamed the *Queen of the North*.

Photo 1. *Queen of the North*

The vessel was built of steel and had eight decks, including a double bottom, as follows (see Figure 1):

- Deck 8 Ventilation Deck
- Deck 7 Boat Deck
- Deck 6 Promenade Deck
- Deck 5 Saloon Deck
- Deck 4 Platform Deck
- Deck 3 Main Car Deck
- Deck 2 Tween Deck
- Deck 1 Double Bottom

The hull below the main car deck was subdivided by 11 main transverse watertight bulkheads, with 11 sliding watertight doors providing access to the main compartments. The engine rooms were located amidships. Deck 2 (Tween Deck) contained crew accommodation spaces.

There were two car decks: the main car deck and the platform deck—Decks 3 and 4, respectively. Vehicles had access to Deck 3 by way of the stern or the bow doors and ramps. Deck 3 was arranged for three lanes of cars on the port side and two lanes on the starboard side. The engine casing was mounted slightly off the centreline. Two sets of transverse flood-control doors were fitted on this deck. Deck 4 was divided into five sections port and starboard, with three hoistable platforms on each side.

Deck 5 (Saloon Deck) contained passenger common areas such as the cafeteria and the bar, and also the galley and purser's office. Deck 6 (Promenade Deck) contained a passenger accommodation space aft, a port midship lounge, and an enclosed reserved passenger seating area, as well as a lounge and a passenger seating area forward. Deck 7 (Boat Deck) contained another passenger accommodation space aft, the officers' accommodation space amidships, and the wheelhouse at the forward end.

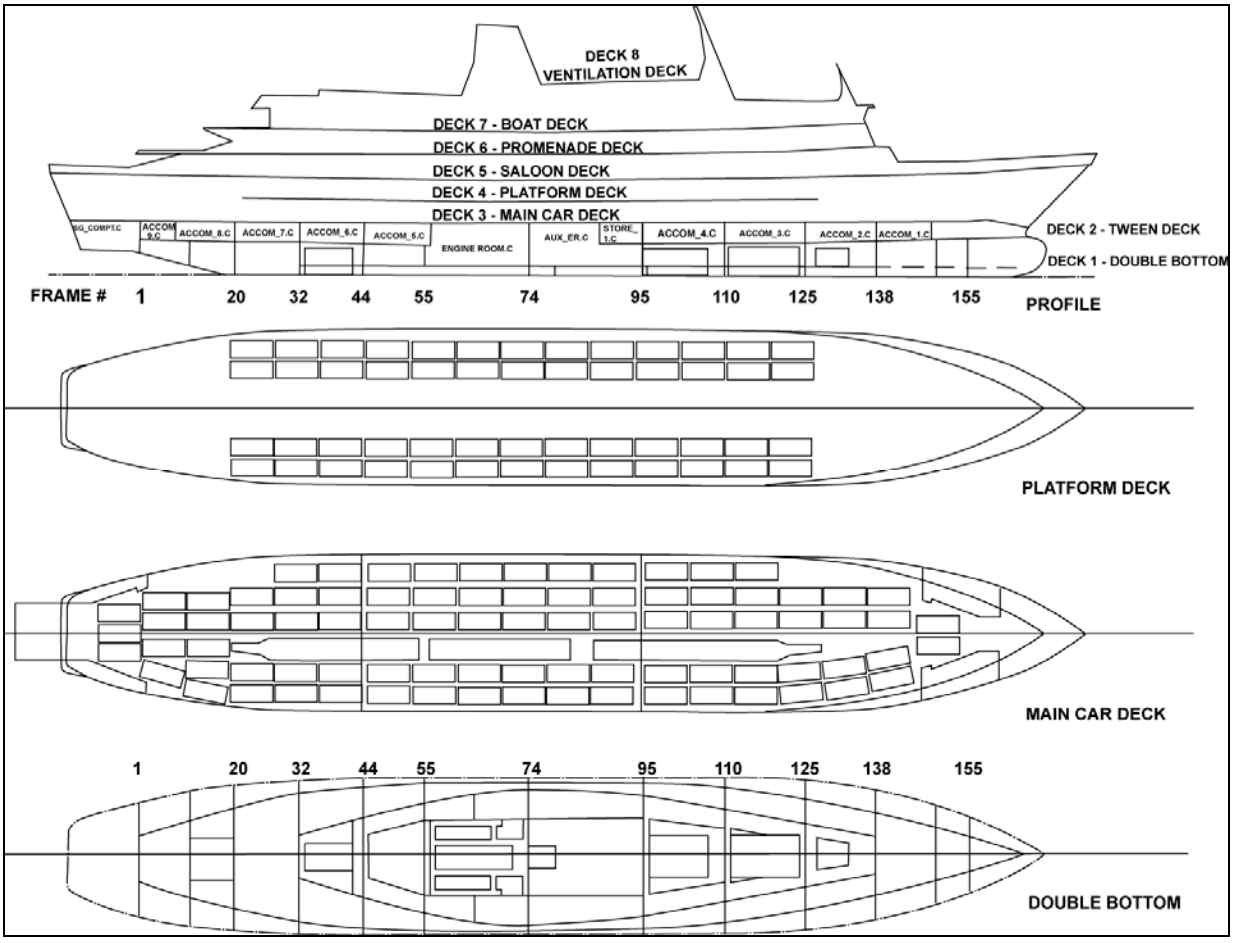

Figure 1. General arrangement

1.2 *History of the Voyage*

The vessel was crewed by a live-aboard crew with two two-week watches, A and B. The A watch had brought the vessel out of its recent four-month refit in Richmond, British Columbia, and handed over to the B watch on 15 March 2006. At 1700 Pacific standard time[4] on 21 March 2006, the *Queen of the North* arrived from Skidegate, British Columbia, at the BC Ferries terminal at Prince Rupert, British Columbia. After unloading passengers and vehicles, the crew prepared the vessel for departure to Port Hardy, British Columbia.

The crew commenced loading vehicles and embarking passengers and, at 2000, the *Queen of the North* departed for Port Hardy with a crew of 42 and 59 passengers. Scheduled arrival time was 1330 the following day, March 22.

4 All times are Pacific standard time (coordinated universal time minus eight hours).

The bridge team on departure comprised the master, the second officer (2/O), the quartermaster[5] (QM1), and an additional QM. The additional QM was on the bridge to support QM1, who had requested assistance due to unfamiliarity with the steering system. The fourth officer (4/O) joined them after completing his vessel-departure duties. QM1 was hand-steering the ferry from the aft steering station in the wheelhouse,[6] while the ferry was on "standby"[7] and proceeding in a southerly direction. QM1's duties included being a lookout, but not while steering the vessel. As it neared Ridley Island, the vessel was taken off standby but remained on hand steering.

At about 2050, QM1 was relieved by QM2 and at approximately 2100 the master handed the con of the ferry to the 2/O and wrote out his night orders. The 2/O was also instructed to call the master if there was traffic at Stella Creek.[8] The master then retired to his cabin. The weather was clear with good visibility and light winds.

Between 2200 and 2350, QM3 and QM4 rotated watches as did the 2/O and 4/O. The 2/O had the conduct of the vessel. At some point during this period, the 4/O went below to the crew's mess to eat lunch. QM1 returned to relieve QM2 at approximately 2345 and took over the helm at 2350. The vessel was on autopilot, with steering controls at the forward steering station. The ferry was on a course of about 139° true (T) through Grenville Channel, maintaining a speed made good of about 17.5 knots with engines under bridge control (see Appendix A for the vessel's track).

Before midnight, when the 4/O returned to the bridge, the 2/O informed him that there was no reported traffic[9] but that there was a southbound vessel ahead. This vessel, later identified as the fishing vessel *Lone Star*, was about 4.4 nautical miles (nm) fine on the port bow, southbound, at a speed of 5.9 knots. The 4/O—now the officer of the watch (OOW)—was also informed that the wind was gusting to 30 knots on the ferry's starboard bow. The 2/O then retrieved a laptop computer from his cabin to play music and, after leaving it on the bridge, proceeded on his break. A personal conversation ensued between the 4/O and QM1, who were now alone on the bridge. At 2359, a course adjustment of 4° to port was made to keep the vessel on track.

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5 A deckhand who has received training and is clear to carry out steering duties is referred to as a quartermaster.

6 Hereafter referred to as the "aft steering station."

7 While on standby, a vessel is hand-steered, and both watch officers are required on the bridge with the engineering watch officers stationed in the engine control room. Both steering pumps are also activated.

8 A creek that flows into Grenville Channel, approximately 22 nm north of Sainty Point light; it is generally considered to mark the beginning of the narrow portion of the channel.

9 Commercial vessels of 20 m or more in length or private yachts of 30 m or more, operating inside of the Prince Rupert vessel traffic services system, and required to report to Marine Communications and Traffic Services (MCTS).

The 4/O used the electronic chart system (ECS)[10] to determine his estimated time of arrival at the next calling-in point and then used a dimmer knob to turn down the brightness on the ECS monitor to prevent the screen's light from interfering with the visual lookout. At 0002:34, approximately 1.3 nm in advance of a planned course alteration to 118° T, the 4/O reported the ferry approaching Sainty Point[11] to Prince Rupert Traffic.[12] The call took about 40 seconds and music could be heard on the bridge at this time. The 4/O subsequently logged his communication then resumed a personal conversation with QM1.

At about this time, the *Queen of the North* encountered a squall of heavy winds, rain, and reduced visibility. The *Lone Star*, meanwhile, having already passed Sainty Point and now rounding Waterman Point, proceeded east to seek shelter from the weather behind Promise Island. At 0005, the *Lone Star* was 2.8 nm away and bearing 22° on the port bow. It was then no longer visible on the radar screen, and the target-lost alarm was displayed and acknowledged. No attempt was made to communicate with the vessel.

At 0007, the vessel, without making the required course alteration, proceeded past Sainty Point and into Wright Sound. At a speed of 17.5 knots, the next course-alteration point on the planned route would have been 27 minutes ahead, off Point Cumming light.

As the vessel proceeded in Wright Sound, the 4/O and QM1 sat in their chairs next to the radar and forward steering station, respectively, and conversed intermittently for the next 12 minutes while music was being played in the background. Shortly after the *Lone Star* had rounded Waterman Point and proceeded north toward Brodie Point, the squall passed and visibility improved.

At about 0020, with the vessel now 13 minutes past the planned course-alteration point at Sainty Point, the 4/O moved between the bridge's front window and the radar, and subsequently ordered a course change to 109°, which QM1 queried and he reaffirmed. As QM1 stood to make the change, she looked up and saw trees off the starboard bow. The 4/O also saw trees and moved to the aft steering station. As he did so, he ordered QM1 to switch from autopilot to hand-steering. QM1, however, was unfamiliar with the operation of the switch at the forward steering station and did not know how to comply.

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10 ECS is a navigation information system that electronically displays vessel position and relevant nautical chart data and information from an ECS database on a display screen, but does not meet all the IMO requirements for electronic chart display and information system (ECDIS) and is not intended to satisfy the International Convention for the Safety of Life at Sea (SOLAS Convention) Chapter V requirements to carry a navigational chart. ECDIS refers to a navigation information system that, with adequate backup arrangements, can be accepted as complying with the up-to-date chart required by regulations V/19 and V/27 of the 1974 SOLAS Convention.

11 The call was made with the vessel's position 1.2 nm from the specified calling-in point.

12 MCTS Prince Rupert is comprised of Prince Rupert Traffic, which provides vessel traffic services, and Prince Rupert Coast Guard Radio, which provides marine radio services.

The investigation was unable to ascertain whether QM1 initiated the ordered course change using the autopilot, or if steering was switched to hand-steering by the 4/O, or both. However, data from the ECS indicate that at 0020:50 the vessel's course over ground (COG) began to alter to port, subsequently striking Gil Island at 0021:20 in position 53°19.2' N, 129°14.3' W.

QM1 left the bridge to get the master. The ferry continued to travel forward for a short time, but at a reducing speed as it struck along the island, and then drifted off in a northerly direction.

There is no information to suggest that, up to the time of the striking, navigational equipment or machinery malfunctioned during the voyage.

In late April 2007, BC Ferries forwarded new information to the TSB that suggested that QM1 may have been alone at the time of the grounding.

The TSB thoroughly investigated this new information and the suggestion that QM1 was alone on the bridge at the time of the accident. This included conducting additional interviews, taking into account conflicting statements, and undertaking extensive analysis.

1.2.1 Events Following Striking

After the ferry struck the island, the 2/O, who was in the officers' lounge, ran to the bridge. At the end of the hallway, he passed QM1. On the starboard radar display, the 2/O saw land. He moved the engine throttle controls from full ahead to full astern, but the vessel did not respond. The master entered the bridge after the general alarm had been sounded. He turned on the deck lights. Shortly thereafter, he ordered the watertight doors to be closed. It was reported that the familiarizing chief officer[13] closed the doors.

Between 0023 and 0027, the vessel's latitude and longitude were incorrectly communicated to Prince Rupert Traffic on three occasions. The *Queen of the North* reported that there were 101 persons on board. Meanwhile:

- Water ingress into the hull was immediate, rapid, and extensive.
- As the bilge pumps could not keep up with the ingress of water through the breached hull, the engineers of the watch closed the watertight door at frame 74 between the main engine room and the auxiliary engine room using the local control handle. They then informed the bridge that the engine rooms were being evacuated. The watertight door at frame 55 between the main engine room and the workshop was obstructed by debris, and, as there was flooding on both sides, the crew did not close it. The crew did not have the time to fully ascertain the extent of damage to the hull before evacuating.

[13] He was a supernumerary officer being familiarized as a chief officer on this vessel.

- The chief officer (C/O), who was off duty and sleeping in his cabin, woke up, proceeded to the bridge, and phoned the engine room, but the call went unanswered. He informed the master and, taking a radio with him, proceeded to check the engine room. He descended to Deck 4 midships in the area of frame 100, and noted that the main car deck (Deck 3) was awash. He also noted the ferry had a small list to starboard and was trimmed by the stern.

- The 2/O and 4/O proceeded to the main foredeck, and both anchors were let go. The 2/O then went below through Decks 5, 4, and 3 calling out, looking for people, and assessing the flooding.

- The Prince Rupert BC Ferries marine superintendent, who was on board, informed BC Ferries management of the striking.

At 0026, the *Queen of the North* advised Prince Rupert Traffic that the vessel was aground and required immediate assistance. At 0027, Prince Rupert Coast Guard Radio broadcast a Mayday Relay on very high frequency (VHF) radiotelephone channel 16, indicating that the *Queen of the North* was aground, listing severely, and taking on water just south of Sainty Point in Grenville Channel.

At 0038, Prince Rupert Traffic was informed that the watertight doors were being closed. At 0140, following abandonment, the ferry sank by the stern in 430 m of water in position 53°19.9' N, 129°14.7' W. After the stern struck the bottom, the ferry came to rest on its keel. The hull was buried in silt to a depth of about 9 m.

1.3 Abandonment Phase

1.3.1 Passenger Muster

After the ferry struck the island, water was rapidly accumulating in the crew accommodation spaces on Deck 2. In some cases, water was waist deep by the time crew members evacuated. An announcement was made over the public address system that passengers and crew were to go to the upper-deck boat and liferaft stations.[14] Some crew members attended with lifejackets, but not all donned the reflective crew identification vests as required by BC Ferries *Fleet Regulations*.

Some passengers, many having taken their lifejackets from their state rooms, went to Deck 8, but most proceeded directly to Deck 7. A few passengers experienced difficulties doing so,[15] and there were reports of baggage being displaced in the cabins. One crew member on Deck 2 was briefly trapped in her cabin when a locker fell and blocked the door. She freed herself, by which time some four feet of water had accumulated inside the cabin. Once passengers reached

[14] Boat and liferaft stations were on Deck 7 (see Figure 1).

[15] For example, one passenger found a cabin door temporarily jammed.

Deck 7, passengers and crew shared clothing with those who were not warmly dressed, and crew members ensured that everyone wore lifejackets. No head count was made while the crew prepared the survival craft for boarding.

1.3.2 Clearing of Cabins and Passenger Spaces

Just after the striking, some crew members knocked on other crew members' doors and began clearing crew cabins on Deck 2. The second steward from the night shift reported to the purser's office on Deck 5 and laid out gear for catering staff to clear passenger and crew cabins.[16]

As crew members proceeded to muster stations, all passenger cabins except those on the starboard side of Deck 7 were eventually cleared.[17] Clearing was not carried out according to procedures in BC Ferries *Fleet Regulations*: chalk marks were not placed on doors, and not all rooms were physically searched. Not all cabins were cleared by those assigned to that particular muster duty: some crew members were delayed by water ingress; others had already cleared the areas; and there was some confusion about whether to follow the public announcement (directing people to proceed directly to the upper-deck boat and liferaft stations) versus following the procedure of clearing all passenger areas.

On Deck 6, the lounges were cleared. It is not known if the washrooms on this deck were cleared. On Deck 5, the cafeteria and bar were locked and inaccessible to passengers. It is not known if other public areas on Deck 5, such as washrooms, were cleared.

Deck 3 was observed to be flooding and was not cleared.

1.3.3 Abandonment

Once mustered on Deck 7, passengers were directed to stay clear, and the crew prepared to launch the survival craft. A few blankets were brought to the muster station, yet although the lifeboats were equipped with space blankets, these were not used. As the port lifeboat was made ready and passengers embarked, a rigid-hull inflatable rescue boat was launched with two crew members. Three liferafts were rigged, slewed out, inflated, bowsed in, loaded with passengers, and davit launched. The roof of one liferaft did not fully inflate, but this did not impede the abandonment.

Passengers and crew used three liferafts, one lifeboat, and one rescue boat during their abandonment. At 0053, the master and remaining crew members abandoned ship using an additional lifeboat, this one on the starboard side.

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16 Clearing procedures call for a physical search of the cabin and, upon completion, that the door be marked with chalk.

17 The two missing passengers had been allocated a cabin on the aft port side of Deck 7.

1.3.4 Abandonment Concerns

Regarding the process of abandonment, as well as mustering and clearing of cabins, the investigation revealed the following:

- **Awareness of Emergency:** Although most passengers had been asleep, the majority were alerted by the noise and motion of the striking. Roughly half of them—mostly those on Deck 6, as well as some crew on Deck 5—reported that they did not hear the public announcement or the general alarm. Nearly all had left their staterooms before crew members arrived to begin clearing cabins.

- **Communication with Passengers/Crowd Control:** This proved difficult. For instance:

  - Some passengers who had sought information from the purser's office were directed to Deck 7; crew members there were busy clearing away the survival craft, and the passengers were sent back down, below-decks.

  - Instructions to passengers were passed by word of mouth, some crew were not easily identifiable, and some passengers could not differentiate between port and starboard when told to move to the port side of Deck 7.

  - Although some crew members and passengers recognized the need to restrict passenger movements, as demonstrated by the spontaneous response of blocking off several exits to the outer decks of Deck 7, this procedure had not been included in the formalized vessel-specific evacuation plan.[18]

- **Counts:** Difficulties were encountered when making accurate passenger counts. These were attempted at various stages of abandonment, often yielding differing numbers. For instance:

  - As passengers boarded each survival craft, a count was carried out to prevent overcrowding, and these counts were relayed to the master but were not recorded. One person designated to perform this count was reportedly distracted by a passenger with young children, and only later returned to complete the count.

  - After abandoning the vessel, the master detailed one person in each lifeboat and liferaft to do a head count, but this was hampered by insufficient flashlights, no means of recording the counts, and no practised method of carrying out counts. The master requested several recounts as the totals were not consistent.

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[18] Although crew members were not familiar with the need to prevent re-entry to the vessel interior, this procedure was documented in the 1998 emergency operating procedures. Note also that, for this report, the terms "evacuation" and "abandonment" are used interchangeably.

1.4 Search and Rescue Operation

At 0026, the Joint Rescue Coordination Centre in Victoria (JRCC Victoria) was informed by MCTS Prince Rupert that the *Queen of the North* had reported running aground and required assistance, setting in motion search and rescue (SAR) operations.

Immediately after the 0027 Mayday Relay broadcast, the *Lone Star*, about 5 nm from the scene, informed MCTS Prince Rupert that it would provide assistance. Residents of Hartley Bay, British Columbia, which is six miles away, heard the Mayday Relay at home and quickly responded, organizing several small craft to provide assistance. These included the *April Augusta*, *Miss Yolanda*, *Mad Max*, *Miss Ardell*, and *Crystal Jean*. The cultural centre in Hartley Bay made preparations to receive survivors.

The Canadian Coast Guard ship (CCGS) *Sir Wilfrid Laurier*, which was at anchor 17 nm to the south and would later be tasked as the on-scene coordinator (OSC), informed MCTS Prince Rupert that it would be underway shortly and was sending its fast-rescue craft, *Laurier 1*.

JRCC Victoria tasked a number of resources, including two SAR aircraft and four Canadian Coast Guard (CCG) vessels.

At 0113, the *April Augusta* arrived and was instructed by the 2/O to make a sweep around the *Queen of the North* using a high-powered light, but no one was seen on board or in the water. The 2/O, with the master's permission, took the fast-rescue boat, with two deckhands, and circled the vessel looking for people. The interior of the vessel was visible through the windows. The outer decks were still lighted. The rescue boat remained on station as the vessel sank, and afterward conducted a surface search. Other vessels arrived, including the CCGS *W.E. Ricker*, and began to transfer some survivors to bring them to Hartley Bay. Arrangements were made to have the survivors met at the Hartley Bay dock for a head count and to take their names. The chief steward was detailed by the master to take charge of persons going ashore. Some survivors displayed signs of mild hypothermia by the time they reached Hartley Bay.

When the ferry sank, many of the lifejackets floated free from their stowage lockers. The inflatable liferafts did not float free or auto-inflate, nor were these features required by regulation. The ferry's float-free emergency position-indicating radio beacons (EPIRBs) began transmitting automatically shortly after the vessel sank. These signals were received by the Canadian Mission Control Centre (CMCC) at Trenton, Ontario. At 0151, CMCC informed JRCC Victoria of the signals.

At 0144, the *Lone Star* arrived on scene and, after loading 17 survivors, took them to Hartley Bay.

At 0154, the C/O of the *Queen of the North* informed the CCGS *Sir Wilfrid Laurier*, using a hand-held VHF radio, that they were not confident that all persons had been accounted for. Throughout the remainder of the rescue operation, the number of survivors reported recovered fluctuated and, given this variance in passenger counts, the search was continued.[19]

At 0156, the *Laurier 1* arrived on scene. At 0220, the CCGS *Sir Wilfrid Laurier* arrived on scene.

At the request of BC Ferries, the remaining survivors in Hartley Bay were put aboard the CCGS *Sir Wilfrid Laurier* and taken to Prince Rupert. With that vessel's departure, the CCGS *W.E. Ricker* took over as OSC.

Canadian Forces aircraft searched a radius of 5 nm from the debris field. Barrier searches[20] were established at 1.5 nm and 5 nm from the accident site to search for anyone who did not make it into survival craft. At 1415 on March 22, the search was placed on reduced status, and officially concluded at 1856 on March 23.

Two persons were unaccounted for, and the matter was handed over to the Royal Canadian Mounted Police as a missing-persons case. The TSB investigation could not determine where on board the vessel the two missing persons may have been at the time of the striking.

1.5 Injuries to Persons

Two passengers, who boarded the ferry at Prince Rupert, have been declared dead.

Although there were no other serious injuries, some people received first-aid treatment, and 11 people were airlifted to Prince Rupert. Of those airlifted, 3 were crew members who suffered minor injuries; 4 others were passengers, and 4 were other crew members who required medical attention due to stress.

	Crew	Passengers	Others	Total
Fatalities	0	2	0	2
Serious	0	0	0	0
Minor/None	42	57	0	99
Total	42	59	0	101

19 At 0158, the C/O of the *Queen of the North* informed Prince Rupert Coast Guard Radio using a hand-held VHF radio that there had been 102 persons on board. At 0833, BC Ferries reported to JRCC Victoria that an examination of the lists indicated only 99 persons on board (42 crew members and 57 passengers).

20 A barrier search is used to detect an object that is being swept away by current. It is conducted by searching downstream and perpendicular to the direction of the drift.

1.6 Damage to the Vessel

When the vessel struck the island, the starboard-side hull plating was ruptured along the keel at the forward end and also in way of at least two other main watertight compartments: the main engine room, and one crew accommodation area aft on Deck 2, including the workshop below. Although a more detailed assessment was not possible due to the limited information available from crew members and the disposition of the vessel in the silt, it is known that at least three main compartments experienced initial flooding.

Once the vessel sank, it struck the bottom stern-first. This created buckling at various places along the side shell, which was later observed during the post-occurrence underwater survey. The vessel came to rest upright on the bottom, deep in sediment. The bridge was covered in silt and several bridge front windows were missing. The engine controls were in the full-astern position. Various overhead panels, fittings, and furniture had been dislodged. The ECS computer was intact. There was also a release of pollutants.

1.7 Geographical, Weather, and Current Information

The Inside Passage between Prince Rupert and Port Hardy is largely sheltered from southwesterly to northwesterly winds and from offshore sea states. Wright Sound is located at the south end of Grenville Channel, which leads north to Prince Rupert. The sound is deep throughout and leading into it are various channels and passages, the sides of which are mountainous. The south side of the sound is bordered by Gil Island, a 27 km, tree-covered island with a summit of 844 m. The seabed along the last 300 m of the vessel's track shoals from a depth of 70 m to approximately 5 m at the point of striking.

The following aids to navigation are located in the immediate area (see Appendix A):

Location of Light	Characteristics	Range
Sainty Point	Flashing white; once every 4 seconds	4 miles
Cape Farewell, southern tip of Promise Island	Flashing white; three times every 12 seconds	7 miles
Point Cumming, southeast of Gribbell Island	Flashing white; once every 6 seconds	5 miles

There is no weather-observation station near the occurrence area. Heavy rain and windspeeds as high as 40 knots were reported as a cold front moved through from the southeast. An Environment Canada analysis of the meteorology suggests that winds changed dramatically with the passage of the cold front. The wind shifted and rose from moderate northeasterly to gale force southeasterly just as the *Queen of the North* was approaching Sainty Point. This was consistent with the conditions experienced on board the vessel at that time. Air temperature was approximately 7°C. Tidal streams in the sound are one knot or less. Low tide occurred at 2332, and moonrise was at 0339.

At the time of the striking, it was reported that there was little or no wind or rain, the seas were relatively calm, and the visibility was good.

1.8 Vessel Certification

The *Queen of the North* held a Transport Canada (TC) Ship Inspection Certificate (SIC 16), issued at Vancouver, British Columbia, on 02 March 2006 and valid until 01 March 2007. The vessel was certified for its intended operations. Attached to the SIC 16 was a Ship Inspection Notice (SI 7) citing 13 deficiencies. The following deficiencies with respect to lifesaving equipment and plans were noted:

1. The lifesaving equipment plan had not been approved by TC.[21]

2. There was no evacuation plan.

3. No general alarm bells were fitted on the exterior of Decks 7 and 8, which were accessible to passengers.

4. Tween Deck, alleyways, and rescue routes were not clearly marked with differential low-level markings visible under low-lighting conditions.

A proposal to correct deficiencies 1 and 2 was required to be submitted to TC within 60 days of issuing the SIC 16. Deficiencies 3 and 4 were required to be rectified by 01 April and 30 November 2006, respectively. The deficiencies noted in the SI 7 attached to the SIC 16 were not considered by TC to be of a nature that would render the vessel unsuitable for its intended operation.

1.9 Watertight Doors

The vessel's hull below the main car deck was subdivided by 11 main transverse watertight bulkheads. A total of 11 sliding watertight doors were fitted in the bulkheads at frames 32, 44, 55, 74, and 95 on Deck 1, which contained engine spaces and tanks, and at frames 20, 32, 44, 110, 125, and 138 on Deck 2, which contained crew accommodation spaces.

These doors were power-operated and could be closed by a master lever on the bridge. They could also be operated from the emergency station on the platform deck or locally at the doors themselves. The arrangement was such that, with the master lever in the "closed" position, a locally opened door would automatically close. Conversely, if the master lever was open, doors opened locally would remain open.

[21] At the time of the occurrence, a previously approved plan with noted revisions was posted on board, while a revised plan was with TC and awaiting approval.

Canadian regulations require that the master and persons in charge of the navigation and engine-room watches ensure that all watertight doors are kept closed during navigation except when necessarily opened for the working of the ship.[22]

In 1981, after a BC Ferries crew member was crushed to death by a watertight door, BC Ferries deemed it potentially unsafe to allow anyone, particularly untrained passengers,[23] to routinely operate the watertight doors in the passenger accommodation areas. The company then made a request to TC for an interpretation of the regulations that would allow watertight doors on the *Queen of the North* and the *Queen of Prince Rupert*[24] to be left open except in emergencies or when the master or officer in charge deemed it prudent to close them.

TC subsequently indicated that the doors' status should be an operational decision, taking into consideration factors including operation, design, layout, weather, sea conditions, environment, and traffic. BC Ferries interpreted this to mean that the vessels could operate with watertight doors open. This has been the case since 1981, a fact of which TC was aware.

In 1995, a safety audit by British Columbia's auditor general[25] questioned this practice, and that August, at the auditor general's request, BC Ferries sought confirmation of its interpretation of the regulations—requesting that the Board of Steamship Inspection rule on the matter.[26] TC's regional office stated that it agreed with the BC Ferries interpretation, and it did not request a Board of Steamship Inspection ruling as it believed that the situation had been previously reviewed. When contacted by the auditor general, however, TC could find no record of the Board of Steamship Inspection having addressed this issue.

The auditor general therefore made an official recommendation that BC Ferries again request a Board of Steamship Inspection ruling on the practice, which the company did in May 1996. To support its position, in August 1996, BC Ferries issued a modified version of the practice to masters of vessels on the northern run, copying it to TC. The new risk-based practice allowed watertight doors within the accommodation and engine spaces to be left in the open position at the master's discretion.

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22 *Hull Construction Regulations*, Subsection 16 (10).

23 At this time, passengers were also accommodated on Deck 2. More recently, the vessel's inspection certificate restricts berthed passengers to Decks 6 and 7 only.

24 These two vessels were unique in the fleet in that they carried berthed passengers below the vehicle deck.

25 British Columbia, Office of the Auditor General, *Performance Audits: British Columbia Ferry Corporation, 1995/96, Report 2*, ISBN 0-7726-2697-9.

26 The Board of Steamship Inspection is a body within TC that adjudicates on ship safety matters.

On 05 September 1996, the Board of Steamship Inspection ruled that the *Queen of the North* and the *Queen of Prince Rupert* must comply with the regulatory requirements.[27] The Board of Steamship Inspection also pointed out that the margin line[28] would quickly become submerged should flooding occur while any watertight doors were open. As the *Hull Construction Regulations* are ambiguous as to when the doors may be kept open, the Board of Steamship Inspection also considered the requirements of Regulation 15, Chapter II-1, of the International Convention for the Safety of Life at Sea (SOLAS Convention) when considering BC Ferries' request. Vessel masters were further instructed to take all precautions to ensure the safe transit of passengers and crew through the watertight doors.

Although no correspondence was found in TC's file showing that action was taken to advise BC Ferries in writing of the Board of Steamship Inspection's decision, BC Ferries was in possession of a copy of the document.[29] However, the practice of operating with some watertight doors left open has persisted.

When the *Queen of the North* struck Gil Island, the master lever on the bridge was in the "open" position and at least two watertight doors were open—those in the forward and aft bulkheads of the main engine room.

1.10 Navigation Equipment

Navigation equipment in the wheelhouse included three radars,[30] ECS,[31] a differential global positioning system (DGPS), and an automatic identification system (AIS). Also within the wheelhouse were paper charts, the controls for the watertight doors, the fire alarm panel, fire door indicator panel, ventilation shut-down panel, and the general alarm/public address system.

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27 Subsection 16 (10) of Part I of the *Hull Construction Regulations*, Board Decision 6175.

28 An imaginary line used in making calculations regarding hull flooding, the margin line is drawn at least 76 mm below the upper surface of the bulkhead deck, which in this case is the vessel's main car deck.

29 This was kept in the vessel-specific manual in the engineering department ashore.

30 Two S-Band radars and one X-Band radar. Weather-related interference is less of an issue on 10 cm S-Band radars than on 3 cm X-Band radars.

31 The ECS had been installed on the bridge in 1998.

Visibility forward of the beam was not significantly hindered by the design of the bridge or the layout of its equipment (see Figure 2).

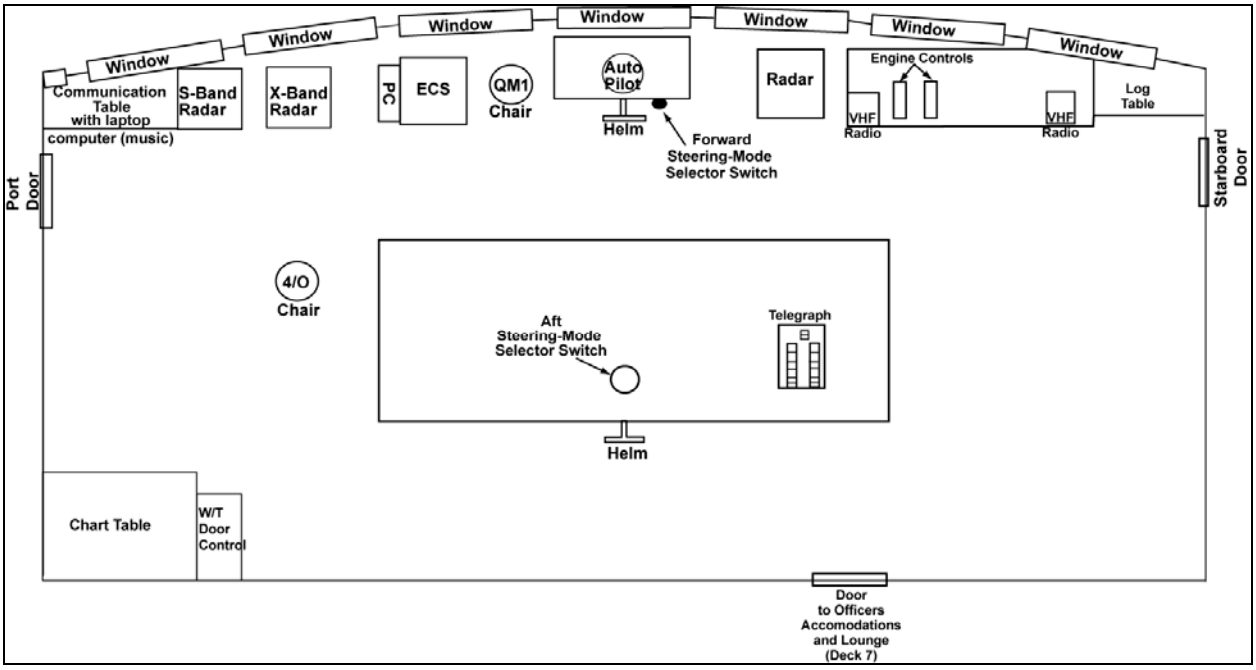

Figure 2. Layout of the bridge (not to scale)

1.10.1 Dive Operations and Data Recovery

Extensive dive operations, using a remote operating vehicle (ROV), were carried out by the TSB on the *Queen of the North* from 15 to 17 June 2006. The following equipment was recovered:

- ECS/Transas computer
- Sperry GPS/AIS receiver
- Northstar DGPS
- digital selective call (DSC) VHF radio

1.10.2 Navigation Equipment Alarm Features

ECS is a navigation information system that electronically displays vessel position and relevant nautical chart data.[32] It provides chart information with real-time vessel position and navigation information. It also provides alerts and prompts for track monitoring, planned course alterations, and other navigation and safety features, including continuous data recording for later analysis. These include waypoint alarms, which sound once a desired waypoint is reached and a course alteration is required, and cross-track error (XTE) alarms, which are activated when the vessel leaves the course line's set parameters. When vector charts are used, a

[32] ECS is not a substitute for any required navigation equipment or paper charts.

navigation-danger alarm may be set up that establishes a radius of navigation danger centered on the ship's position. The area delineated within this circle is then constantly checked for any dangers pre-determined by the user.

Alarm features are also available with other navigational aids, namely:

- DGPS: cross-track feature alarm
- Radar: cross-track feature alarm (when used with loaded routes)
- Autopilot: off-course feature alarm

Alarms may be tailored to reduce distractions on the bridge by configuring them to alert only in situations where they would normally be expected to provide useful information.

1.10.3 Electronic Chart System Setup on the Queen of the North

Unlike the electronic chart display and information systems (ECDIS)—for which monitors must meet strict international standards for factors such as brightness, contrast, and colour—the purchaser of an ECS system may use any monitor.

On the *Queen of the North,* some bridge officers on both shifts found the ECS display overly bright during the night watch. This problem is exacerbated when the system is displaying raster charts,[33] because land is shown as yellow-orange in colour and water is shown in white, regardless of whether the ECS is in day or night display mode.[34] As a result, raster charts are inherently brighter than vector charts when the system is in night mode.

To alleviate this, the crew in a previous season had placed a screen over the monitor. A rotary dimmer was later installed to let bridge officers dim the screen beyond the standard setup brightness option for the monitor, even if night-setting palettes had already been selected. Some officers had developed the practice of dimming the screen, using this dimmer, and brightening it only when they wanted to check their position.

At the time of the occurrence, the ECS was displaying a raster chart, and the display had been dimmed by the 4/O. In addition, the investigation revealed the following points regarding the setup of the ECS on board the vessel:

- The chart portfolio for the areas being navigated by the *Queen of the North* was mostly in raster format.

- The navigation-danger alarm was unavailable while the raster chart was loaded.

- The cross-track alarm had been manually deactivated around the time of the refit.

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[33] Raster charts are produced by converting paper charts to digital image by scanner; the resulting image is similar to a digital camera photograph. Vector charts are digitally created and may contain information additional to that available on a paper chart, such as sailing directions.

[34] In contrast, the colour coding on vector charts is altered between day and night modes.

- The software was configured such that all alarm sounds were deactivated. As a result, active alarms would provide visual warning only.

To defend against the ad hoc modification of parameters, such as alarm settings, the system was provided with a password. However, this password was well known and easily accessible to any who wanted it. Furthermore, BC Ferries had no policies or procedures in place to define the desired configuration of the ECS safety features. This effectively left the system setup at the discretion of each operator.

The waypoint, cross-track, and navigation-danger alarm features available with the other electronic navigation equipment had not been set up or enabled.

1.10.4 Electronic Chart System Recorded Data

The ECS data log files for the occurrence were successfully retrieved. They contained a record of the electronic information originally obtained from both external sensing devices and screen presentations. The data log was updated every minute with date, time, latitude, longitude, heading, course over ground, and speed over ground. Latitude and longitude were recorded every 10 seconds (see Appendix B). No system malfunction was recorded by the ECS.

During a voyage, an ECS also maintains a recorded log of some, but not all, actions undertaken, be they undertaken automatically by the ECS or manually by an operator. The ECS logbook indicated that four charts were loaded by the ECS system while the 4/O was on the bridge. The chart displayed while transiting Grenville Channel was a vector chart; the chart displayed for Wright Sound was a raster chart. The last recorded operator action was a scale change/set scale of 1:10 000 at 2302:04.

Appendix B presents the vessel's track as recorded by the ECS for the final minutes of the voyage.

1.11 Voyage Data Recorders

Various modes of transportation have used data recorders to assist investigators and provide owners and operators with a means to continually improve operations. Although the aviation industry has enjoyed the benefits of flight data recorders for 50 years and cockpit voice recorders for 43 years, experience with voyage data recorders (VDRs) in the maritime industry is relatively new.

In addition to bridge audio, a VDR is capable of recording such items as time, vessel heading and speed, gyrocompass, alarms, VHF radiotelephone communications, radar, echo sounder, status of hull openings, windspeed and direction, and rudder/engine orders and responses.

Passenger vessels built on or after 01 July 2002 are required to carry a VDR when engaged on international voyages. In 2006, cargo vessels on international voyages became subject to the requirement for a VDR or, alternately, a simplified VDR (S-VDR).[35] Although such S-VDRs do not store the same level of detailed data, they nonetheless record at a minimum:

- date and time (GPS)
- latitude and longitude (GPS)
- speed (speed log)
- heading (gyrocompass)
- bridge and VHF audio
- main radar (substitute AIS if radar is impossible to record)

Moreover, should a vessel sink, such units containing the stored data may, in some instances, float free.

In Canada, VDRs or S-VDRs are not mandatory for passenger vessels on domestic voyages such as the *Queen of the North*.

In this instance, an exploratory dive was conducted by BC Ferries shortly after the occurrence by a manned submersible capable of recovering a fixed VDR capsule, should the vessel have been so equipped.

1.12 Steering-Mode Selector Switch

The *Queen of the North* was in refit from January 2006 until 02 March 2006. Its steering system was modified, and the following items were modernized:

- the steering wheel at the aft steering station
- the steering-mode selector switch at the aft station

The new steering-mode selector switch, albeit a newer model, was for all intents and purposes physically the same as the original switch. However, the logic and the manner in which the steering system functioned were altered with the installation of the new steering-mode selector switch.

In situations where a replaced system is physically similar to the original system, but where changes have been made to the underlying logic of the system, usability issues may emerge. As a result of negative transfer,[36] significant training can be required to overcome the automatic

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35 VDRs are also required on certain passenger vessels constructed before July 2002 and certain ships other than passenger ships constructed on or after July 2002. In addition, cargo ships constructed before July 2002 are subject to a phased-in requirement beginning in 2006 and ending in 2010.

36 The interference of previous learning in the process of learning something new.

response associated with the original system logic. This can be particularly important in times of stress, where the original automatic response is evoked because of the physical similarity between the original system and the new system.

Throughout the refit, the C/O of the A watch had remained with the vessel. When the new steering-mode selector switch was installed, a procedure was developed for its use. The procedure and information on the functional characteristics of the new steering-mode selector switch were posted on a laminated sheet immediately aft of the steering wheel at the aft steering station. All deck crew of the A watch were familiarized with the operation of the new switch. The posted procedure did not highlight the fact that the rear steering station was no longer the "primary" station.

At the time of the handover, the C/O of the A watch informed the C/O of the B watch of the replaced switch and advised him of the instructions posted behind the aft steering station. Not all crew (including QM1) of the B watch were familiar with the changes in operation, nor with the rationale for the new system and procedure. The B watch's unfamiliarity with the changes in steering system functionality following the installation of the new steering-mode selector switch was demonstrated by the fact that, subsequent to the accident, various B watch deck crew provided investigators with four different explanations as to the interaction between the forward and aft steering station switches and which specific functions were available at various switch settings.

Following the change in watches, a number of crew members of the B watch challenged the new operational procedure. The master, in discussion with the crew and after testing the steering-mode selector switches en route, decided to use the steering selector system differently than the previous watch, and in a manner analogous to the original system. The B watch wanted the forward wheel to be active when the QM was at the forward station, and it was not active in the A watch system.

In developing their procedures, both the A watch and the B watch were attempting to maintain elements of the operation of the original steering system. However, the procedures for the original system and the procedures used by the A and B watches differed.

	A Watch	B Watch
Original Procedure	QM moves the switch at the aft station from FWD to AFT	
Procedure After Change	Aft station switch pre-set to AFT OOW moves the switch at the forward station from AUTO to WHEEL	Aft station switch pre-set to FWD QM moves the switch at the aft station from FWD to AFT OOW moves the switch at the forward station from AUTO to WHEEL

Table 1. Procedural differences for switching from autopilot to aft steering station

In the original system and the B watch system, the QM would normally only be required to operate the steering-mode selector switch at the aft steering station.

1.13 Lifesaving Equipment

The vessel's lifesaving equipment included a pair of 57-person motorized lifeboats suspended under gravity davits fitted port and starboard on Deck 7, as well as 30 25-person davit-launched "valise"–type inflatable liferafts stowed port and starboard on Deck 7. The liferafts were launched by four sets of single-arm davits also located on Deck 7, two on the port side and two on the starboard side. There were also 21 lifebuoys, 3 VHF radios for survival craft, 96 children's lifejackets, and 955 adult lifejackets. A six-person motorized rescue boat, capable of being launched by a single davit arm, was carried forward on the port side of Deck 7.

The vessel's inflatable liferafts were not equipped with automatic release devices or arranged to float free in the event of sinking, nor were they required to be. Under Part I of the *Lifesaving Equipment Regulations,* non-Convention vessels that were registered in Canada or whose keel was laid before 28 April 1996[37] are not required to have float-free liferafts.

[37] 1986 for SOLAS–compliant vessels.

1.14 Damage Stability

1.14.1 Damage Stability and Subdivision Concepts

"Damage stability" is a vessel's ability to remain afloat without capsizing during and after flooding, depending on the degree of subdivision. "Subdivision" refers to the partitioning of a vessel's internal volume below the bulkhead deck (in this case Deck 3) into main watertight compartments by bulkheads—thereby limiting water ingress (flooding) following hull damage.

The degree of subdivision makes a significant difference in a vessel's survivability. A one-compartment subdivision means a vessel will survive (that is, will remain afloat without capsizing) if one main compartment is flooded. (Note: This implies that the watertight bulkheads remain intact.) A two-compartment subdivision means a vessel will survive if any two adjacent main compartments are flooded.[38]

1.14.2 International Standards

The standards on subdivision and stability for vessels engaged on international voyages are set out in the SOLAS Convention.[39]

The 1960 SOLAS Convention had minimal damage stability requirements. In 1990, major amendments for new passenger vessels enhanced safety by defining standards of residual damage stability (see Appendix C).

In 1992 and 1995, the damage stability requirements of the 1990 SOLAS Convention were extended to existing ro-ro passenger vessels, albeit in accordance with a phase-in schedule. Also in 1995, special requirements were introduced for ro-ro passenger vessels carrying 400 persons or more. These were applicable to all new Convention vessels, with a phase-in schedule applied for existing Convention vessels. In order to phase out those that had been built to a one-compartment subdivision standard, a vessel's damage stability was required to meet the 1990 SOLAS Convention to a two-compartment standard.[40]

Other similar requirements were adopted in the SOLAS Convention for new non–ro-ro passenger vessels built after 01 July 2002.

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38 This implies that any one main transverse watertight bulkhead may be damaged, and two adjacent main compartments breached.

39 SOLAS Convention, Chapter II-1, Part B. The Convention specifies minimum safety standards for the construction, equipment, and operation of vessels engaged on international voyages.

40 The new damage stability requirements of the SOLAS Convention were brought forward following the *Herald of Free Enterprise* and *Estonia* disasters, which happened in March 1987 and September 1994, respectively.

1.14.3 Canadian Standards

The standards on subdivision and damage stability for Canadian vessels engaged on domestic voyages are mainly set out in the *Hull Construction Regulations*, which are based on the 1960 SOLAS Convention.

In 1989, TC began to examine how the new 1990 SOLAS Convention's international damage stability standards could serve as a basis for TC's ongoing review of Canadian regulations and standards for passenger vessels.

In April 1990, recognizing that Canadian regulations for passenger vessels operating on international voyages did not incorporate the latest international standards, TC adopted new ones to enhance safety.[41] In June 1991, similar standards were adopted, with the same intent, for passenger vessels operating domestically.[42] Both standards were based on the 1990 SOLAS Convention, but their residual damage stability requirements were applicable only to new vessels.

Owing to resistance from the industry, TC, in consultation with the Canadian Ferry Operators Association (CFOA), decided not to apply the damage stability provisions of the document *Ship Safety Passenger Ship Operations and Damaged Stability Standards (Non-Convention Ships)* (TP 10943) to existing Canadian vessels (that is, those built before 1991).[43]

Full compliance with TP 10943, however, is mandatory for those existing vessels entering into Canadian operation since 1991, although there are phase-in dates for compliance similar to the SOLAS Convention.[44]

TC has amended TP 10943 based on risk assessment and on risk factors such as area of operation, number of people on board, age of the vessel.[45] These amendments came into force on 01 October 2007 and apply damage stability requirements based on the SOLAS Convention to all domestic vessels (new or existing) of more than 15 gross tons or those carrying more than 12 passengers.[46] There is a compliance schedule for existing vessels. The compliance schedule of

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41 Transport Canada, *Ship Safety Passenger Ship Operations and Damaged Stability Standards (Convention Ships)*, TP 10405.

42 Transport Canada, *Ship Safety Passenger Ship Operations and Damaged Stability Standards (Non-Convention Ships)*, TP 10943, 1991.

43 The CFOA counts among its membership almost all major ferry operators in Canada.

44 The intent is to phase in the updated standards over a five-year period, depending on the area of operation, the age, and a vessel's size. Typically, newer vessels will have a longer phase-in period.

45 Transport Canada, *Passenger Vessel Operations and Damaged Stability Standards (Non-Convention Vessels)*, TP 10943, Second Edition, October 2007.

46 According to the preamble of the amended TP 10943, its damage stability requirements are to be applied in advance of updating the *Hull Construction Regulations*.

TP 10943 differs from that in the SOLAS Convention, in that the former allows a longer phase-in time for existing vessels. Where an existing vessel is not compliant with these standards, a risk-based methodology might also be used to demonstrate an equivalent level of safety on a route-specific basis.

1.14.4 Damage Stability of the Vessel

The *Queen of the North* was originally built in 1969 to the 1960 SOLAS Convention, for short international voyages, as a two-compartment subdivision vessel with a draught of 4.75 m.

An inclining experiment was first carried out on the vessel in 1969, and then again after modifications in 1980—at which point, due to its greater deadweight, increased operating draught, and reduced reserve buoyancy, it was reclassified as a one-compartment vessel with a draught of 5.25 m. More modifications were made in 1999, the vessel was re-inclined, and an intact/damage stability booklet based on this was approved in 2001.[47]

In the 2001 approval, the vessel's damage stability was assessed against the requirements of the *Hull Construction Regulations*, Schedule II, as a one-compartment subdivision vessel.

Although it was not required because the *Queen of the North* was a non-Convention vessel and thus operated under differing regulations, the 2001 approval also had the vessel's damage stability assessed as a one-compartment subdivision vessel against the 1990 SOLAS Convention criteria. The vessel was found compliant.

1.15 Relationship Between the Fourth Officer and the Quartermaster

Information provided to the investigation indicated that the 4/O and QM1 had a recurrent relationship that was brought to an end two weeks before the accident.

Both the 4/O and QM1 joined the vessel on March 15. Following an absence due to illness, QM1 returned to work on March 20, when the vessel was docked at Prince Rupert. On the evening of March 21, QM1 and the 4/O met and conversed in the crew's mess while other crew members were present. At approximately 2345, QM1 went on to the bridge for her turn at the helm. Minutes later, the 4/O replaced the 2/O as OOW. This was their first shift alone on watch together since the end of the relationship.

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47 One of the modifications made in 1999 was the addition of two sets of flood-control doors on the main car deck as a result of the investigation into the sinking of the *Estonia* in September 1994.

1.16 Crew Work/Rest History

During the 72-hour period preceding the occurrence, the 4/O maintained a regular sleep/wake pattern and only worked night shifts. Although working night shifts is known to influence circadian rhythms and increase fatigue, this likely had a small effect on the 4/O because he was somewhat adjusted to working at night and sleeping during the day, having joined the vessel seven days earlier.

Having joined the vessel on March 15, QM1 went home on sick leave on March 17. During her illness, she slept mostly at night. Having awoken at 0600 on March 20, she rejoined the vessel at approximately 1800 and immediately began working a 12-hour night shift. She experienced restless sleep during the day before the occurrence. The change from sleeping during the night to sleeping during the day, together with the restless sleep, increased the risk of QM1 being fatigued.[48]

1.17 Personnel Certification and Experience

The senior master started his sea career in 1962. Although not on board at the time of the occurrence, he was responsible for overall safe operation of the *Queen of the North*. He served on Royal Canadian Navy vessels and tug boats, before joining BC Ferries as a deckhand. After obtaining a master's certificate in 1975, he worked as a relief master on various ferries. In 1999, he was appointed as senior master on the *Queen of the North*.

The master's previous experience included eight years with the CCG, three of them in command of SAR vessels. He joined BC Ferries as a deckhand in 1987. Since 1990, he has worked as a master and C/O on both the *Queen of Prince Rupert* and the *Queen of the North*. He was appointed an exempt master in February 2006.[49]

The 2/O's regular position is a deckhand, and he has served in that capacity for about 25 years. He obtained his watchkeeping mate, ship certificate in 1997 and has been relieving as third officer (3/O) and 4/O since 1998. He obtained his first mate, intermediate voyage certificate in 2001 and has since substituted as a 2/O.

Before joining BC Ferries as a deckhand in 1990, the 4/O worked on board fishing vessels; he acquired his fishing master, Class III certificate of competency in 1981. The 4/O's regular position with BC Ferries is as a deckhand. He obtained his watchkeeping mate certificate and Simulated Electronic Navigation (SEN-I) training in 1995. He was cleared to work as an officer in 1995, and has been relieving as 3/O and 4/O on both North Coast run vessels since 1998. In 2002, he was issued a certificate of competency to serve in the capacity of an officer in charge of a navigational watch for near coastal voyages, which was endorsed pursuant to the International Convention on Standards of Training, Certification and Watchkeeping for

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48 D.I. Tepas and T.H. Monk, "Work Schedules," G. Salvendy (Ed.), *Handbook of Human Factors*, New York: John Wiley & Sons, 1987, pp. 819-843.

49 An "exempt" employee does not belong to the union.

Seafarers, 1978, as amended in 1995 (STCW Convention). During 2004 and 2005, he worked as a deck officer for a total of 67 and 119 days, respectively, and worked 126 days of 169 days in the previous 12 months (from March 2005 to March 2006) as a deck officer.

QM1 was issued a Marine Emergency Duties (MED) certificate in January 2005. She was familiarized and cleared to work as a deckhand on board the *Queen of Prince Rupert* and the *Queen of the North* in March and April 2005 respectively, as per BC Ferries standards and clearance protocol. The period of May to October 2005 was spent working on board the *Queen of Prince Rupert* and performing all the general duties as well as the steering and lookout duties of a deckhand. Having sailed with the crew of the *Queen of Prince Rupert* for the trip into refit on 03 March 2006, QM1 was then called on 15 March 2006 to work on the *Queen of the North*.

QM1 was one of three quartermasters[50] who did not possess a bridge watchman certificate and who could therefore not be included as part of the minimum deck watch required by the *Crewing Regulations* without supervision by another appropriately certified person.[51]

1.18 BC Ferries Employment Policies

Provisions within the contractual agreement between BC Ferries and the BC Ferry & Marine Workers' Union (BCFMWU) create a situation where all non-exempt[52] new employees, whether ratings (unlicensed) or officers (licensed), are hired as casual employees. Employment opportunities may be found at the terminal, or on board vessels in the following departments: catering, deck (as deckhands, deck officers), and engine (as engine-room ratings, engineers).

As BC Ferries encourages casual employees to work within different job classifications, employees may, if there is a need and the employee is found suitable, request to be familiarized in a different job classification than that for which they were hired. An employee hired in the terminal may be familiarized in the catering department, in the deck department, or in the engine room (and vice versa). This policy is intended to allow both the employer and the employee an opportunity to maximize employment (employee utilization) during slow months. Once cleared, an employee can move between classifications as and when there is a demand for work.

A new employee begins to accrue service seniority from the first day of work, and thereafter continues to accrue seniority regardless of whether the employee works in a calendar year. Employees on leave of absence (except in very limited circumstances) or approved for non-availability of more than 30 days will have their service seniority adjusted for the period of time they are away.

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50 There were eight quartermasters on board the *Queen of the North*.

51 *Canada Shipping Act*, *Crewing Regulations*, Section 40. Note that these regulations were repealed on 01 July 2007. Similar provisions may be found in Section 216 of the new *Marine Personnel Regulations* of the *Canada Shipping Act, 2001*.

52 A "non-exempt" employee belongs to the union.

Job vacancies are filled according to seniority from the appropriate seniority list: unlicensed or licensed classifications. The employee with the most seniority fills the vacancy, provided he or she meets all the job posting qualifications. In the case of licensed employees, they must also hold the appropriate TC–issued certificate of competency.

When employees are unavailable to work a shift due to leave, illness, etc., casual or regular employees are substituted, starting with the most senior qualified employee available.

The contractual agreement specifies seniority as the sole qualifying factor for awarding permanent jobs (that is, regular status, as opposed to casual) within the various classifications. Under this system, it is possible for a regular employee to compete for, and win, a job ahead of a casual employee who may have extensive job-specific knowledge/experience in a certain classification.

The same process applies for licensed employees. Under the terms of the collective bargaining contract, service seniority is the qualifying factor for a regular/casual employee to acquire his/her first licensed regular job. Although an arbitration awarded the company the option of promoting employees based on the suitability of the candidate as determined by interview and the employee's personnel file, this "suitability" criterion was not uniformly applied, with preference still being given to seniority to avoid grievance conflicts.

1.18.1 Familiarization and Clearance Procedures

According to BC Ferries *Fleet Regulations*, all masters, officers, and crew members must first be assessed before being afforded the opportunity to familiarize, after which they must be familiarized with safety procedures and equipment before being assigned a position on board a vessel. They must also be instructed in the safe operating procedures for any equipment to be used in the course of assigned duties, after which—and before taking up duty—they must be cleared by BC Ferries to sail. The familiarization process is carried out under the guidance of an employee's supervisor, who subsequently authorizes the clearance to work.

Clearance procedures may vary by department with respect to vessel type, position, and duration to maintain the clearance. For example, in order to maintain clearances, the *Fleet Regulations* indicate that:

- deckhands substituting in deck officer positions must serve in the higher position for 10 days on an operational vessel in each six-month period,

- deckhands must work a minimum of one day a year in order to maintain clearance on a given class of vessel.

1.19 BC Ferries Crew Training

According to the *Crewing Regulations,* a ship's owner is responsible for ensuring that written instructions are set out and followed so as to ensure that the ship's complement is properly familiarized. The master must also ensure that the ship's complement is trained in and carries out the policies and procedures.[53]

Consistent with the International Safety Management Code (ISM Code), "the corporation must employ suitably qualified people on board and in the office. Employees must receive written instructions on how to carry out their duties. Training must be delivered if and when necessary"[54] to meet job-specific requirements. In keeping with this statement, BC Ferries has a documented system to provide and record employee training.

The senior master for each route and the master of each vessel are responsible for ensuring that crew members are appropriately qualified for duty.

Although BC Ferries offers training in areas including bridge resource management (BRM), ECS, and passenger control, this training was not consistently provided in all regions. None of the deck officers on board the vessel at the time of the occurrence had received formal ECS training.

1.20 Bridge Watch Procedures and Practices

The conduct of a vessel by watchkeeping personnel is governed by the *International Regulations for Preventing Collisions at Sea* (*Collision Regulations*) and Parts 2, 3, and 3-1 of Section A-VIII/2 of the STCW Convention.

The *Collision Regulations* address the need for vessels to maintain a proper lookout at all times, by all available means, as well as maintaining a safe speed appropriate to the prevailing circumstances. The STCW Convention also addresses the maintenance of a proper lookout and provides guidance on watch composition, performing a navigational watch, the effective use of all navigational equipment at the disposal of the OOW, and ensuring that the vessel follows the planned course.

While entering Wright Sound, the *Queen of the North* experienced conditions of restricted visibility that required a third person on the bridge *in addition to* the OOW and the QM. In this case, as QM1 was not certified, when the 2/O left the bridge, another person, who was certified, was required to be assigned to the watch.[55]

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53 *Crewing Regulations*, subsections 21.1 (1) and (2).

54 BC Ferries Guide on the IMO's ISM Code (March 1996).

55 *Crewing Regulations*, Section 40.

1.21 Navigation Practices on the Queen of the North

The vessel was operated on a "12 hour on, 12 hour off" shift pattern, with the 0600 to 1800 shift assigned to the C/O and 3/O, and the 1800 to 0600 shift to the 2/O and 4/O, respectively. Four deckhands were assigned to each shift, and each took an hourly turn as lookout/helmsperson in the wheelhouse, with the remainder of each shift spent on routine deckhand duties elsewhere.

As the ferry had been on a regular run, a routine had evolved for the watches. After the master handed over the conduct of the vessel to the OOW, it was not unusual for one officer to leave the bridge. The two officers would relieve each other throughout the watch. They would both be on the bridge when the vessel was in an area where it was required to be on standby. Otherwise, no specific criterion was used to determine when the senior of the two would be on the bridge, and no measures were in place to ensure adherence to the minimum deck watch requirements of the *Crewing Regulations*. The officer not on the bridge would carry a hand-held VHF radio.

The passage across Wright Sound from Sainty Point to Nelly Point was not considered to be an area requiring standby. It features relatively open water with few hazards, and consists of an approximate 27-minute period which crews frequently view as an opportunity to take a meal break—particularly given the upcoming intense period of navigation.

The radars and the ECS were the main equipment used to navigate the vessel. The company maintained a route-specific manual, which contained information for each route on which vessels operated. For the *Queen of the North*, routing information was entered into the ECS. It was not routine practice to plot positions on the chart while the vessel was on a regular run.

1.22 Responsibilities of the Senior Master and Master

As described in BC Ferries *Fleet Regulations*, the senior master is "accountable for the safe, efficient and economical operation of a vessel for the purpose of transporting passengers and vehicles in accordance with all regulatory requirements." Besides serving as and assuming all authorities and responsibilities as master, the duties and responsibilities may be described as follows:

- responsible for coordinating and administering a comprehensive vessel safety program with emphasis on training and standardization;
- liaise with other masters on the same route or class of vessel toward establishing the composition of vessel staffing to allow leave to be taken without compromising the cohesiveness of bridge teams;
- participate in the appointment and promotional process for licensed and unlicensed personnel;
- initiate and maintain operational standing order and directives after consultation with the vessel's other masters; and

- responsible for the delivery and crewing of the vessel to and from refit, including monitoring the progress of the deck department refit items.

The responsibilities outlined in the job position profile, the effective date of which was 01 June 2005, also included:

- responsibility for overall management of the vessel and its employees;
- managing and leading the shipboard management team;
- establishing and maintaining a professional work environment by, among other things, implementing employee training programs in all phases of vessel operations, ensuring crew members are familiar with policies and procedures, regularly conducting emergency drills in passenger safety and control, and ensuring compliance with internal and external regulations and legislation.

In addition to having the overall responsibility for the safety of the vessel, the master's responsibilities included:

- ensuring safe practices in vessel operations and that employee work practices meet workplace health and safety standards;
- regularly conducting emergency drills in passenger safety and control;
- implementing employee training programs in all phases of vessel operation, ensuring crew members are familiar with policies and procedures;
- monitoring and ensuring compliance with internal and external regulations and legislation;
- ensuring timely and effective communication among employees across watches and departments; and
- ensuring that all written policies and procedures are kept current and that route performance records for the vessel's operation are in accordance with regulatory, certification, and audit requirements.

1.23 Passenger and Traffic Manifests

Before the vessel departed Prince Rupert, BC Ferries had a record of the number of passengers on board the *Queen of the North*, but not all their names. When a customer made a reservation, they needed only to provide one name and the number of people travelling. This reservation name might not match the passenger's name; it could be a company name, or it could be the name of a relative whose details are already within the reservation system.

Information from the reservation system was used to generate a passenger manifest containing reservation name or group name, the number of vehicle passengers, the number of foot passengers, and the number/type of vehicles aboard the vessel. This manifest was provided by the terminal agents to the ferry before sailing.

The traffic manifest was provided to the 4/O for loading purposes. This was different from the passenger manifest, and contained the number of vehicles but not the number of vehicle passengers. No head count was taken of the passengers as they boarded.

There is no mandatory requirement for domestic ferries to collect passenger information. In 1999, following TSB investigations and international passenger ferry accidents, TC recommended that all persons on board passenger ferries should be counted and that details of persons who have declared a need for special care or assistance in emergency situations should be recorded and communicated to the master before departure.[56]

1.24 Safety Management System

Although not required, BC Ferries had voluntarily elected to develop a Safety Management System (SMS) for its fleet to meet ISM Code requirements. The purpose of the ISM Code is to provide an international standard for the safe management and operation of ships, to prevent injury or loss of life, and to prevent pollution.

BC Ferries was issued an initial Document of Compliance for shore-side aspects of the SMS on 24 September 1997. The *Queen of the North* was first issued a Safety Management Certificate on 18 August 1999. At the time of the occurrence, the ferry held a Safety Management Certificate issued by Lloyd's Register on 27 July 2004. The certificate, which was valid until 17 August 2009, was subject to an external intermediate verification[57] of the vessel's SMS between the second and third anniversaries—sometime between July 2006 and July 2007—to ensure compliance with the ISM Code. The Document of Compliance may be cancelled upon an external auditor issuing major non-compliance notices. However, it was reported that, because BC Ferries had voluntarily adopted the ISM Code, notices that would have been warranted might not be issued by the external auditor.

Internal audits were carried out annually on board the *Queen of the North*. Typically, an internal audit was performed by a team of two auditors (three for vessels with a catering department); it addressed each of the first 13 sections of the ISM Code, and took up to 12 hours to complete. The audit also considered applicable regulatory requirements as well as corporate policy and procedures, as per Section 12.01 of the BC Ferries *Fleet Regulations*. The scope of each audit did

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56 Transport Canada, Ship Safety Bulletin 16/1999, *Information on Passengers*, 07 December 1999.

57 This is an independent examination conducted by the government of the state whose flag the ship is entitled to fly, or an organization recognized by the government of the state—such as a ship classification society—to determine whether the company continues to operate its SMS in accordance with the requirements of the ISM Code. The BC Ferries SMS is audited by the classification society of Lloyd's Register.

not necessarily address all of the elements within a section of the ISM Code. Rather, the scope for each audit was based on a number of factors including previous audit reports and corrective action requests.

An audit schedule covering all of the sites (for example, terminals, offices, vessels) was drawn up for the calendar year. Internal audit plans were prepared in advance. When the site was a vessel, each of the vessel's departments—deck, engineering and, if provided, passenger services—would be audited, and it was not uncommon for the audits of these departments to be conducted individually at different times of the year and while the vessel was underway. Vessels were informed in advance when the audit would be conducted. At the opening meeting on the day of the audit, the methods for conducting the audit were explained to the vessel's senior officers.

These internal audits were originally carried out using a checklist, but this was found ineffective—it limited the flexibility of the audit, and knowledge about the items on the checklist became so widespread as to make it ineffective.

Internal audits are now carried out by conducting interviews with shipboard personnel and by walking throughout the vessel and making observations, in addition to random sampling and the routine verification of specific items. The most recent audit before the occurrence was carried out by BC Ferries on 12 August 2005. It was reported that audit plans identifying those elements of the 13 sections of the ISM Code to be examined and the questions to be asked were developed in advance of conducting annual internal audits on board the *Queen of the North.* However, upon the completion of the audit, these plans were retained only for four to five months. At the time of the occurrence, the audit plan for the 2005 internal audit had been discarded.

In accordance with the ISM Code, BC Ferries established quarterly management reviews to evaluate and review its SMS. Any findings of an SMS audit, including trends and issues of concern, are presented at these management reviews.

When BC Ferries first developed its SMS, four full-time auditors were employed to conduct audits throughout the fleet, shore offices, and terminals. In the fiscal year ending 31 March 2006, two full-time auditors and, when required, contractors, conducted 257 SMS audits, of which 56 were conducted on board BC Ferries ferries. During the previous fiscal year ending 31 March 2005, 243 audits were conducted, of which 92 were conducted on board BC Ferries ferries, with 449 requests issued for corrective action.

In addition to the audits, BC Ferries *Fleet Regulations* required that a complete review of the shipboard SMS and the vessel-specific manual be undertaken annually, under the direction of the senior master. This was done, and no shortcomings were recorded. Furthermore, an agenda item for the monthly shipboard management meetings included a review of the SMS.

1.24.1 Emergency Preparedness

In order to comply with the ISM Code, BC Ferries established procedures for identifying and responding to emergency situations. The *Emergency Management and Response Manual* outlined corporate strategy for emergency management, as well as policies for organizing and activating

its response. Vessel-specific manuals contained the procedures for on-site responses to vessel emergencies and emergency procedures checklists were developed.[58] Furthermore, the BC Ferries *Fleet Regulations* required that contingency plans be developed for all identified potential emergency situations—including abandoning ship—and that a schedule of drills and exercises be established for each plan.[59] At the time of the occurrence, the *Queen of the North* had abandon-ship procedures in the vessel-specific manual, but these did not address the various situations that may be associated with an evacuation. Such situations include identifying and locating missing passengers, and directing passengers from assembly stations to embarkation stations.

Pursuant to the *Canada Shipping Act*, Section 111 of the *Life Saving Equipment Regulations* requires every passenger vessel to have an evacuation plan that provides for the complement to be safely evacuated from the vessel within 30 minutes of the abandon-ship signal. BC Ferries had sought clarification from TC with regard to what was required to satisfy the requirement, but without success. An amendment to Section 111 was published in the *Canada Gazette*, Part II, Volume 140, No. 22, on 01 November 2006, which clarified the requirement to have an evacuation procedure rather than a diagrammatic plan.

In January 2004, a BC Ferries team prepared an internal, draft version of an evacuation analysis for the *Queen of the North*, taking into consideration calculations to determine if the lifesaving equipment on board could be launched, and the vessel evacuated within 30 minutes—not including the time to muster. The stated purpose of the analysis was to assist the master in formulating the muster list functions and evacuation plan for the vessel. One of the recommendations included in the draft analysis was the development of a comprehensive evacuation plan.

BC Ferries was in the process of developing evacuation plans for its vessels. Although it has been a regulatory requirement since 1996, it was not until TC inspected the *Queen of the North* in early March 2006 that the requirement to have an evacuation plan/procedure was singled out. An SI 7 notice was issued to that effect on 02 March 2006.

1.25 Cannabis Use on the Queen of the North

It was determined that some crew members in safety-critical positions were casual users of cannabis and that they had previously smoked the drug aboard the vessel and while in port. There is no information to suggest that the 4/O or QM1 were under the influence of alcohol or illegal drugs at the time of the occurrence. Toxicological tests were not performed.

BC Ferries has a no-tolerance policy with respect to alcohol and drugs aboard ship. For live-aboard vessels, such as the *Queen of the North*, crew members are not permitted to consume nor have in their possession alcohol or any other mood-altering substance, which would render them unfit for duty. This prohibition is considered to include all hours on or off duty/watch,

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58 These include a muster list with assigned crew responsibilities, emergency response instructions in *Fleet Regulations*, lifesaving equipment plan, vessel-specific manual, crew familiarization booklet, and the emergency operation procedures.

59 BC Ferries *Fleet Regulations*, Section 8.02, Contingency Plans and Drills.

from the time an employee joins the ship until release for rest days.[60] In addition to the policy, an employee assistance program is available to provide counselling and assist BC Ferries employees with alcohol and drug dependencies.

BC Ferries provides information concerning the alcohol and drug policy to crew through several information packages as well as when members first join a vessel. BC Ferries also educates staff about alcohol and drug use. In addition, line managers and supervisors are provided with guidance on substance misuse and prevention and how to deal with problems related to alcohol and drug use. The BC Ferries employee assistance program offers confidential counselling for alcohol and drug abuse. However, the TSB investigation revealed that *Queen of the North* crew members who were regularly using cannabis showed insufficient awareness of its impact on fitness for duty.

BC Ferries also has a Voluntary Individual Safety Observation Reporting System (VISORS) for employees to report directly on operational safety issues or concerns. However, there is a reluctance to report safety concerns as employees are required to sign their name on the form.[61] Furthermore, the investigation revealed that not all senior crew members aboard the *Queen of the North* consistently took action to ensure the company's no-tolerance policy was strictly adhered to.

1.25.1 Effects of Cannabis on Performance

A large number of studies have shown that cannabis use can lead to significant impairment of a wide range of human performance characteristics.[62, 63] Although these studies have mainly focused on car driver and aviation pilot performance, the types of impairment are also clearly important to the variety of tasks required for the safe operation of vessels.

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60 BC Ferries, *Come Sail With Us*, (G) General Policy: Alcohol/Drugs, pp. 62-63.

61 G.L. Morfitt, *Safety and B.C. Ferries: A Review of Operational Safety at British Columbia Ferry Services, Inc.*, January 2007, p. 33.

62 Australian Transportation Safety Board, *Accidents and Incidents Involving Alcohol and Drugs in Australian Civil Aviation, 01 January 1975 to 31 March 2006*, Aviation Safety Research and Analysis Report: B2006/0169.

63 A.M. Smiley, "Marijuana: on Road and Driving Simulator Studies," H. Kalant, W. Corrigal, W. Hall, R. Smart (eds.), *The Health Effects of Cannabis*, Toronto: Addiction Research Foundation, 1999, pp. 173-191.

For example, cannabis use can impair psychomotor performance, memory, attention, and coordination.[64] Cannabis use has also been shown to affect the ability to quickly react to complex or unexpected scenarios.[65]

The impairment due to a single dose of cannabis is greatest during the initial high,[66] after which the impairment reduces, but can last 24 hours. Although cannabis users are commonly aware of the initial period of impairment, they are not normally aware of the longer-term effects.[67, 68]

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64 Australian Transportation Safety Board, *Accidents and Incidents Involving Alcohol and Drugs in Australian Civil Aviation, 01 January 1975 to 31 March 2006*, Aviation Safety Research and Analysis Report: B2006/0169.

65 A.M. Smiley, "Marijuana: on Road and Driving Simulator Studies," H. Kalant, W. Corrigal, W. Hall, R. Smart (eds.), *The Health Effects of Cannabis*, Toronto: Addiction Research Foundation, 1999, pp. 173-191.

66 *Guidelines for the Accident Investigator in the Interpretation of Positive THC (Cannabinoids) Results*, produced by Dr. Vern Davis for the Transportation Safety Board of Canada, 2001.

67 V. Leirer, J. Yesavage, and D. Morrow, "Marijuana Carry-Over Effects on Aircraft Pilot Performance," *Aviation, Space, and Environmental Medicine*, March 1991, pp. 221-227.

68 A.M. Smiley, "Marijuana: on Road and Driving Simulator Studies," H. Kalant, W. Corrigal, W. Hall, R. Smart (eds.), *The Health Effects of Cannabis*, Toronto: Addiction Research Foundation, 1999, pp. 173-191.

2.0 Analysis

2.1 Overview

When the ferry reported to MCTS at 0002:34, it was approximately 1.3 nm away from the course-alteration point. Some 3.5 minutes later, having reached that point, the vessel then proceeded on its original course for approximately 14 minutes before striking Gil Island at 0021:20. This analysis will address the sequence of events in three stages: the missed course change, the passage toward Gil Island, and the striking sequence.

2.1.1 Missed Course Change

When undertaking routine tasks, it is possible for a distraction to cause a sequential step to be missed and for persons in such circumstances to believe that the missed step and those that follow have in fact been accomplished.[69]

In this instance, between the time the 4/O announced to MCTS that the vessel was approaching Sainty Point and the time the course change should have been made (3.5 minutes), the OOW's routine sequence of making a course change was interrupted by several events that were taking place simultaneously, including:

- the 4/O and QM1 were engaged in a conversation of a personal nature;
- the vessel was encountering a rapidly moving squall, causing reduced visibility; and
- a visual alarm indicating a loss of target.

In dealing with the immediate requirement to identify the position of the lost target, combined with the effects of entering the squall, the 4/O was likely distracted at some point between logging the radio communication and carrying out the course change. As a result, he believed he had called for and verified the course alteration.

In addition, the ECS display was dimmed and the audible alarms had been deactivated, thereby negating any warning that may have been provided by the waypoint alarm. As a result of these combined factors, the vessel continued past Sainty Point and into Wright Sound without changing course.

2.1.2 Passage Toward Gil Island

Typically, the passage through Wright Sound from Sainty Point to the next course change at Point Cumming is about 27 minutes of travel across deep, open water with few hazards. Crews normally consider that part of the voyage to be less difficult, particularly compared with the upcoming, more complex legs of the Inside Passage. It was in anticipation of transiting Wright Sound that the 2/O took a lunch break, leaving the 4/O and QM1 alone on the bridge.

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[69] J. Reason, *Human Error*, New York: Cambridge Press, 1990.

Having entered the less difficult portion of the voyage through Wright Sound and believing he had made the course alteration at Sainty Point, the 4/O did not monitor the vessel's progress and failed to determine that the vessel was on an improper course.

The setup of the navigational equipment hampered effective monitoring, including:

- The brightness on the ECS monitor had been turned down such that the display could not be read.
- The ECS cross-track alarm, which would have alerted the crew to any substantial deviation, was turned off.
- The navigation-danger alarm on the ECS, which could have indicated the close proximity of Gil Island, was unavailable because a raster chart was loaded.
- Alarms available with other electronic navigational equipment (for example, radars) were not set up or enabled.

As well, a number of basic principles of safe navigation[70] were not observed by the bridge team:

- verifying the course after Sainty Point;
- reducing speed when the vessel encountered an area of reduced visibility;
- calling the senior OOW or the master to the bridge when visibility became reduced and the radar target (*Lone Star*) was lost;
- maintaining an effective lookout;
- posting a dedicated lookout during a time of restricted visibility;
- communicating with the target vessel;
- locating and identifying the navigational lights at Point Cumming, Cape Farewell, and Sainty Point;
- monitoring the vessel's progress visually, via radar and with the ECS;
- frequent plotting to determine the vessel's position; and
- maintaining appropriate bridge team composition.

Many of these practices would have assisted in keeping the vessel on course or provided the cues necessary to determine that the vessel was not on course.

The TSB examined a number of plausible scenarios. In the absence of objective data, such as from a VDR, the investigation was unable to explain why the 4/O and QM1 did not follow basic watchkeeping practices so as to keep the vessel on course—nor why the 4/O failed to detect the vessel's improper course for up to 14 minutes.

The TSB rejects the suggestion that QM1 was alone on the bridge in the time leading up to the grounding. The preponderance of evidence leads to the conclusion that the 4/O and QM1 were both on the bridge throughout this period.

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70 Parts 2, 3, and 3-1 of Section A-VIII/2 of the STCW Code.

2.1.3 *Striking Sequence*

When an individual's mental model of a situation differs from the actual, there is a period where contradictory information is rejected, followed by one where it is recognized that the mental model is incorrect and the individual or crew will need to work to reconcile the new information to form a more accurate picture. It is often only when very salient contradictory information is presented that they can realign their mental model.[71]

It is not known exactly when the 4/O began to be aware that the vessel was off course. However, approximately one minute before the striking, something prompted the 4/O to approach the window, and to move between there and the radar before subsequently ordering a course alteration to 109°, which would bring the vessel to a course for Point Cumming. As QM1 stood up and moved to alter course, both crew members saw trees ahead. The 4/O, now at the aft steering station, then gave the order to switch to hand-steering. This order was not complied with because QM1 was unfamiliar with the switch at the forward station.

Analysis of the DGPS data recorded by the ECS data logs indicates that, during the final 30 seconds before the striking, the vessel's straight-line course changed by about six degrees to port. It could not be determined whether this course change resulted from the action of the QM1 at the autopilot or if the 4/O made the switch to manual steering and applied moderate helm. Interaction forces between the hull and the steep sides of the island may also have influenced the vessel's motion in those final seconds. Regardless, there is no indication that aggressive evasive action was taken, and indeed any action taken by the crew was too little too late to prevent the vessel from striking Gil Island.

2.2 *Familiarity with the Steering System*

The procedure used by the B watch to change from autopilot to hand-steering (wheel) required QM1 to move from the forward to the aft station and stand by the wheel while the 4/O operated the switch at the forward station. A similar procedure was followed when switching from hand-steering to autopilot. This was the limit of QM1's experience with the steering changeover. In this instance, when the 4/O went to the aft steering station and ordered QM1 to switch to hand-steering at the forward station, QM1 was unfamiliar with the switch at that station and was unable to comply.

Unfamiliarity with an essential piece of equipment increases the risk to the vessel, its passengers, and crew.

2.3 *On Board Navigational Practices and Safety*

As shipboard personnel move from vessel to vessel, and as the BC Ferries crewing arrangements allow regular and casual crews to move between watches, consistency in route-wide fleet operations and adherence to the basic, accepted principles of navigation safety are essential to ensure safe ferry operation throughout the fleet.

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[71] R.S. Nickerson, "Confirmation Bias: A Ubiquitous Phenomenon in Many Guises," *Review of General Psychology,* 2, 1988, pp. 175-220.

On board the *Queen of the North*, the working environment on the bridge was less than formal, and accepted principles of navigation safety were not consistently or rigorously applied. As such, unsafe navigation practices persisted that, in this occurrence, contributed to the loss of situational awareness by the bridge team.

2.3.1 Bridge Watch Composition

A review of the bridge watchkeeping practices on board the *Queen of the North* identified the following areas of concern:

- Full consideration was not given to the maintenance of an adequate bridge complement at critical locations and times, and in poor weather conditions.

- Notwithstanding that two officers were assigned to each 12-hour shift, it was not unusual to have only one officer on the bridge—even during major course alterations, and, occasionally, during periods of adverse weather and visibility.

- The selection and composition of the bridge watch did not take into full consideration the experience of the bridge team. For instance, the C/O and 3/O stood the 0600 to 1800 watch (during predominantly daylight hours), while the 2/O and 4/O stood the 1800 to 0600 watch (during hours of darkness).

- The officers took their breaks such that the 2/O was on watch with an experienced QM, leaving the more junior 4/O on watch with a less experienced and uncertified QM during hours of darkness.

- QM1, who did not hold an appropriate certificate, was allowed to stand watch without being supervised by an appropriately certified person (other than the OOW).

- A third person was not called to the bridge when the vessel encountered restricted visibility around the time that the course alteration at Sainty Point should have been made.

2.3.2 Crewing Regulations – Interpretation

At the time of the occurrence, the minimum composition of the deck or bridge watch on the *Queen of the North* was defined by sections 39 through 41 of the *Crewing Regulations* of the *Canada Shipping Act*. In 2007, these regulations were superseded by the *Marine Personnel Regulations*, issued under the authority of the *Canada Shipping Act, 2001*, with sections 213 through 216 specifically applicable.

The language of the *Crewing Regulations* has led to differing interpretations. Nonetheless, a plain language reading leads to the conclusion that the minimum bridge watch required by the *Crewing Regulations* in the context of the *Queen of the North* at the time of the occurrence was intended to be as follows:

- a qualified person in charge of the watch (the OOW); and
- an additional person who holds one of an efficient deckhand certificate, an able seaman certificate, or a bridge watchman certificate.

Whenever the use of the automatic steering system was not appropriate—for example, when prompt helm action might be required due to encountering situations such as restricted visibility—then a second additional person was required. Under these circumstances, only one of either the additional person or the second additional person must hold one of the aforementioned certificates. The other does not, provided that he or she is assigned to the deck watch as a rating under training for the purpose of obtaining a certificate.

Therefore, regardless of whether the *Queen of the North* was in restricted visibility, the uncertified QM should have been supervised by either the second of the two officers on the bridge or, in the absence of the second of the two officers, by a qualified QM.

The TSB is of the opinion that the absence of a third (and appropriately certified) person on the bridge at the time of the missed course change, and through to the time of the striking, reduced the defences in place, thereby increasing the possibility that the error would go undetected.

2.4 Watertight Doors

The subdivision of passenger vessel hulls into watertight compartments is a fundamental principle of design intended to improve survivability should a vessel sustain damage below the waterline. While it is generally accepted that the operations of the ship may require doorways to be fitted in some of these bulkheads, these doors must be of special watertight construction and must remain closed in order to realize the benefits of the watertight subdivisions. On the *Queen of the North*, at the time of the occurrence, as per regular practice, several watertight doors were open.

As a result of the striking, at least three main compartments were damaged below the waterline, and flooding progressed rapidly and extensively. Although it was reported that the watertight doors were closed shortly after the striking—and this was relayed to Prince Rupert Traffic approximately 16 minutes later—one door remained blocked open by debris.

The full extent of damage, and therefore the potential to control the flooding, could not be determined with accuracy. By not ensuring that the integrity of subdivision measures, such as watertight bulkheads and doors, was maintained at all times while the vessel was in operation, the potential to slow down or stem the progressive flooding of the vessel was not realized. Any delay in ensuring that all watertight doors are closed can contribute to progressive flooding into compartments other than those initially damaged.

2.5 Navigation Equipment Alarm Features

Analysis of the information obtained from the recovered ECS indicates that the system was functioning within its set parameters. However, the lack of policies and procedures to manage the configuration of the system meant that important safety features (alarms) that could have alerted the crew had been either deactivated or silenced. Additionally, the display had been

dimmed in response to the overly bright monitor and raster charts. As such, the possibility of receiving a visual warning was also negated. Furthermore, alarm features available with other electronic navigation equipment were not set up or enabled.

The navigation equipment, therefore, was not set up to take full advantage of the available safety features and, as a result, the warnings that could have been provided with respect to the developing dangerous situation were not provided.

2.6 Voyage Data Recorders

The purpose of a VDR/S-VDR is to create and maintain a secure, retrievable record of information indicating the position, movement, physical status, and command and control of a vessel for the period covering the most recent 12 hours of operation.[72] Objective data—voice data in particular—are invaluable to investigators and operators in seeking to understand the sequence of events and identify operational problems and human factors.

The presence of a VDR/S-VDR on board provides a unique, cost-effective opportunity to accurately record for future analysis information pertaining to a vessel and crew's performance, including understanding and adherence to procedures. As a result, VDR/S-VDR data provide an effective source of information for auditing of ISM Code compliance between scheduled audits. VDR/S-VDR data may also be used proactively within an ongoing program of incident analysis with a goal of constant safety improvement and a reduction of accidents on board vessels.

Accident investigation agencies benefit from more efficient, timely, and accurate collection, assimilation, and analysis of information with corresponding benefits of a shortened investigation process and more timely communication of safety deficiencies and accident reports to stakeholders and the public. In this instance, the lack of a VDR/S-VDR on board the *Queen of the North* prolonged the investigation by several months while a dive was planned and executed to recover the on-board ECS system. Although the recovery was successful, the data retrieved were limited in comparison to those that would have been provided by a VDR/S-VDR—in particular audio recording of bridge conversations.

Despite the significant safety benefits to the company, investigators, and the travelling public, there is no current requirement for VDR or S-VDRs on non–SOLAS vessels—depriving accident investigators of a fundamental source of information and the domestic industry of a proven and valuable tool to continually enhance and improve performance and safety.

Furthermore, the limited availability of objective data, combined with contradictory witness statements, resulted in a protracted investigation and the use of investigation techniques that would have been unnecessary had a VDR/S-VDR been installed and recovered.

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72 B. Dawe (Rutter Technologies) in a presentation to the International Symposium on Vehicle Recorders in Arlington, Virginia, United States, in 1999.

2.7 Liferafts

When a vessel sinks rapidly, it is critical that lifesaving equipment be deployed, either by the crew, or automatically as the vessel submerges. This is particularly important when a vessel may not be expected to stay afloat for long after sustaining extensive damage from collision, grounding, or capsizing.

Such was the case on 28 September 1994 when the Estonian–registered passenger ro-ro ferry *Estonia* suffered a bow door failure while en route in the Baltic Sea, capsized, and sank within 35 minutes with the loss of 852 passengers and crew. The vessel carried inflatable liferafts, equipped with hydrostatic release mechanisms. While the rapid sinking prevented the orderly deployment of lifesaving equipment and abandonment of the ship by passengers and crew, once the vessel sank, the liferafts deployed automatically and were available for some survivors in the water.

As the *Queen of the North* sank, the liferafts that had not been launched by the crew did not automatically deploy, nor were they required to do so. Although large domestic passenger vessels built in or imported into Canada after 1996 are required to have inflatable liferafts equipped with float-free devices, existing passenger vessels are not required to be so equipped. As a consequence, passengers and crew travelling on older vessels may not be afforded an equivalent level of safety in comparison to newer vessels operating on the same route with similar risks, and may therefore be placed at risk in the event of the vessel sinking rapidly.

2.8 Damage Stability and Regulatory Concerns

Passenger ferries play a significant role in the Canadian transportation network. In 2006, over 44 million passengers and 16 million vehicles travelled by ship in Canada.[73] BC Ferries alone carries more passengers each year than the combined ferries of the four nations operating on the English Channel.[74]

In all, 113 passenger vessels above 500 gross tons are operating in Canada. About 50 of these vessels carry more than 400 persons. Although most of them operate in domestic rather than international trade, there is an equal (if not greater) risk of damage due to collisions and groundings.

As noted earlier, the *Queen of the North* was operating domestically as a one-compartment vessel, and at the time of the occurrence, was not required to meet the damage stability requirements of the 1990 SOLAS Convention. International standards require that a similar vessel engaged on international voyages must meet the 1990 SOLAS Convention standards in October 1998 for one-compartment subdivision, and in October 2008, for two-compartment subdivision, or else would have to reduce the number of persons carried to less than 400.

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73 Canadian Ferry Operators Association, 2006 Annual Report.

74 W.D. Molyneux, National Research Council Canada, *Safety Initiatives from the SNAME Ad Hoc Ro Ro Safety Panel*, IR-1996-11.

According to the compliance schedule of the amended TP 10943, the *Queen of the North* would have had to meet the damage stability requirements equivalent to those of the 1990 SOLAS Convention not later than the first periodical survey (that is, annual survey) after October 2010 for one-compartment subdivision, and after October 2013 for two-compartment subdivision, or else would have had to reduce the number of persons carried to less than 400. However, the *Hull Construction Regulations* have not yet been amended to make TP 10943 mandatory.

In this instance, given the extensive breach of watertight integrity, the additional damage stability requirement would not have ensured the survivability of the vessel. Nonetheless, under the current Canadian regulatory regime, older passenger vessels operating in Canada are not held to the same level of damage stability protection as those plying internationally or to new/substantially renovated vessels operating in Canada, potentially placing the passengers at risk.

2.9 Accounting for Passengers and Crew

The clearing of passenger and crew cabins during an emergency does not, by itself, ensure full accounting for all passengers and crew—this would assume that all persons always remain in their cabins. In this occurrence, the port passenger cabins on Deck 7, where the cabin to which the two missing passengers were assigned was located, were reportedly cleared.

In an emergency, as time is of the essence, any delay in determining if passengers or crew are missing has the potential to place lives at risk. It is therefore essential that measures be put into place to account for everyone during an emergency. At the very least, this requires that an accurate head count be performed once the complement has been mustered.

Although head counts of those boarding the survival craft were made, in at least one case, the crew member performing the count was distracted and the count was not accurate. There were no roll calls before proceeding with abandonment, nor were head counts made while the crew prepared and cleared away the survival craft. This lack of an accurate head count of passengers and crew before abandoning the vessel precluded a focused search for missing persons at that time.

2.9.1 Passenger Manifest

There was confusion when attempts were made to reconcile information on the manifest with that obtained after the abandonment. This was the result of insufficient and inaccurate information obtained from the way BC Ferries generated passenger manifests.

In an emergency where abandoning ship is the only recourse, accurate passenger information is vital to both the abandonment and SAR operations. A detailed passenger and crew information system can identify missing people, their infirmities (if any), and where they may be on board the vessel.

The International Maritime Organization (IMO) has established requirements for a minimum amount of passenger information to be collected,[75] and these requirements apply to all Convention passenger vessels constructed on or after 01 July 1998. The benefits of such a system were demonstrated in 2000 when, during a fire aboard the passenger vessel *Nieuw Amsterdam*, a roll call successfully helped the crew identify and find two missing passengers.[76]

In 1993, the TSB issued a recommendation regarding passenger information,[77] and in 1999, TC published guidelines regarding passenger counts on ferries.[78] In a 2003 occurrence involving the ferry *Joseph and Clara Smallwood*,[79] the TSB again highlighted the need for accurate passenger information on board vessels so that roll-call methodology can be used to identify, account for, and locate missing passengers.

While it is recognized that the scope of passenger information collected may necessarily vary depending on the type of operation,[80] the adoption of a mandatory requirement for collecting passenger information would help ensure that crews have the information they need during an emergency.

2.10 Emergency Preparedness

The combination of freely moving passengers in an unfamiliar environment for relatively short periods of passage time poses unique challenges for ferry operators in the management of emergencies, particularly with respect to passenger safety. Given the significance of preparation for abandonment and the identified shortcomings in this occurrence, this section focuses on the issues of on-board planning, procedures and crew's familiarity with them, and crew performance.

2.10.1 Planning

In an emergency situation, decisions are often made in a stressful environment involving heavy task loads, and where errors may result in significant consequences. Without a sufficiently detailed plan in place, difficult decisions are inevitably made based on an individual's past experience and his or her current understanding of the present risk. Given the risks associated

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75 SOLAS Convention, Regulation III/27, Information on Passengers. Information includes the name and gender of all persons on board, and whether he or she is an adult, child, or infant.

76 National Transportation Safety Board, Fire on Board the Netherlands–registered Passenger Ship *Nieuw Amsterdam*, Glacier Bay, Alaska, 23 May 2000, report No. MBR-01/01, NTIS No. PB2001-916402.

77 TSB Marine Investigation Report M90M4025, Recommendation M93–04.

78 Transport Canada, Ship Safety Bulletin 16/1999, *Information on Passengers*, 07 December 1999.

79 TSB Marine Investigation Report M03N0050.

80 Shorter voyages and turn-around times, for example, may preclude collecting detailed passenger information.

with decision making in emergency situations, contingency planning is therefore the cornerstone of emergency preparedness, providing the necessary framework for evaluating risk and considering risk-mitigation options. Ship evacuation is one such contingency plan.

BC Ferries was in the process of developing evacuation plans/procedures for its vessels; a detailed plan for the *Queen of the North,* however, had not been completed. Documentation available to the crew did not provide sufficient detailed information about passenger-control duties during abandonment.

2.10.2 Training

It is imperative that crew members have adequate training so as to respond to emergency situations and carry out assigned emergency duties. On vessels where large numbers of passengers may be aboard, those responsible for passenger safety require knowledge of crowd-management techniques as well as a basic understanding of crisis management and human behaviour in emergencies. There are several places in which BC Ferries documents its guidelines for crowd control. However, given the criticality of this issue for passenger safety, specific training is required in addition to the provision of written information. Only one crew member, who was assigned passenger-control duties, had received this training.[81]

The TSB, concerned by the lack of knowledge and skills for effectively managing passengers during emergencies, has previously issued two Marine Safety Advisories[82] and has also recommended to TC that officers and crew members who are responsible for passenger safety receive formal training in crowd control and relevant emergency procedures (M93-07).[83]

A more recent investigation[84] determined that the current TC requirements for crew training in crowd management, crisis management, and human behaviour in emergencies were not adequate to ensure that crew on all passenger vessels who are responsible for passenger safety are provided with adequate training in these areas.

At that time, TC indicated that proposed Marine Personnel Regulations[85] would mandate training in passenger safety management for officers and crew members with responsibilities for passenger safety. The TSB, however, noted that the new requirements would not include

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81 BC Ferries internal training.

82 TSB Marine Safety Advisories (MSA) 18/92 and 24/92, and TSB reports M92W1022 and M92L3011, respectively.

83 TSB Marine Investigation Report M90M4053.

84 TSB Marine Investigation Report M03N0050.

85 The *Marine Personnel Regulations* entered into force 01 July 2007; there has been no change in the above-noted scope of application for the passenger safety management training requirement.

training for crew of smaller vessels (500 gross tons or less) or for vessels engaged on voyages in sheltered waters, regardless of size. The TSB reiterated in a safety concern[86] that persons aboard such vessels will continue to be at risk.

2.10.3 Exercises and Drills

In addition to formal training, regular drills are essential to prepare crews for potential emergency situations—increasing confidence and efficiency should such situations arise. Drills also help evaluate preparedness and address identified shortcomings. On large passenger vessels, it is critical that emergency drills simulate the challenges of managing large numbers of people.

Although conducted regularly as required, drills on the *Queen of the North* were considered mundane and typically involved mustering the fire party, mustering crew members at embarkation stations, and launching a lifeboat. The abandonment process was included in both the boat and fire drills, and no separate exercises were conducted for abandonment even during annual regulatory safety certificate endorsement. Additionally, there is no requirement for separate drills involving the mustering and control of passengers.

Moreover, the boat and fire drills did not effectively simulate mustering and/or control of passenger movement and so did not provide an opportunity to assess the adequacy of procedures or of crew skill levels. These exercises did not fully address the challenges associated with managing large numbers of people (for instance, no means were provided to record head counts). Additionally, as the vessel did not have a completed evacuation plan, the master and the crew had to rely on their own experience to set up the drills, without the benefit or guidance of official advance planning.

The lack of a completed evacuation plan/procedure, in addition to inadequate passenger safety training/drills, left some crew members ill-prepared to handle some aspects of the abandonment, thereby placing passengers at risk.

2.10.4 Evacuation Procedures

In this occurrence, the crew was able to evacuate 57 of 59 passengers in the 30 minutes between the time of the striking and the time senior crew members entered the last survival craft, including both the mustering and clearing away duties. However, with this crewing level, the vessel was certified to carry up to 474 passengers. Given the short timeframe available for the preparatory phase of abandonment, the presence of 474 passengers would have posed additional challenges, compounding the difficulties experienced in the mustering, accounting, and abandonment phases.

In a rapidly developing emergency situation and in the absence of a comprehensive evacuation plan on board, masters have to rely on experience and their perception of the emergency to make decisions and deal with the situation. Given that such experience is rare and given that people respond to emergencies in different ways, a comprehensive evacuation plan is

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86 TSB Marine Investigation Report M03N0050.

paramount to better prepare the crew for emergencies in the interest of passenger, crew, and vessel safety. Such an approach would positively influence the outcome of evacuation and further passenger safety.

Current TC regulations require that every passenger ship have procedures for the safe evacuation of the complement within 30 minutes after the abandon-ship signal is given.[87] Although this requirement has been in force since 1996, TC has not established guidelines for operators to develop such procedures, nor has TC established criteria for the inspectors to evaluate/accept these procedures. Furthermore, no criteria are applied to the earlier (preparatory) phase of evacuation—muster and clear away[88]—which on a large passenger vessel is a critical element of the abandonment process.

Although TC reviews a new vessel's capability to abandon when initially certified, the focus is on the hardware—that is, quantity and location of equipment provided for this purpose. Likewise, while TC inspectors regularly review fire and boat drills, the main focus is placed on the operation of abandonment devices and survival craft. As such, performance of the wide range of actions necessary to manage passengers during abandonment and the corresponding number of crew required to do so successfully are not practically assessed.

TC does not currently provide operators of passenger vessels with guidance on how to prepare evacuation procedures, nor are performance measures stipulated for the mustering and clear-away phases of evacuation. Consequently, there is no means to objectively test the overall adequacy of an evacuation plan.

2.10.5 Passenger Vessel Abandonment and Technology

The evacuation of passenger vessels poses unique challenges, in which passengers and crew have to respond cooperatively for safe, effective, and rapid abandonment under trying circumstances. This creates communication and behavioural challenges, requiring crews to be efficient in the preparatory phase of carrying out an orderly abandonment.

It is well recognized that a ship's survivability—and therefore the time available—is a key factor in passenger vessel evacuation. The IMO's approach to large passenger vessel safety has, as a guiding principle, the premise that more emphasis should be placed on the prevention of a casualty from occurring, and that future passenger vessels should be designed for improved survivability so that, in the event of a casualty, persons can stay safely on board as the ship proceeds to port. In other words, evacuation should be avoided if at all possible.

However, the need for vessel evacuation can never be fully avoided. Furthermore, the need to muster passengers to safe areas of the ship will be necessary in a variety of emergency situations. The benefits of effective crew training and drills in accomplishing these tasks are well recognized and addressed by the regulatory regime.

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87 *Canada Shipping Act, Life Saving Equipment Regulations*, Part III, Operational Requirements and Equipment Standards, Evacuation Procedures.

88 Clearing away is the preparation of survival craft for launch, normally carried out after crew members are sent to boat stations and before the final abandonment order is given.

While the benefits of technology to assist in preparing the vessel for abandonment have been recognized, they have yet to be fully realized/implemented.[89] As a result, there are relatively few practical applications of research and technology on board that directly affect the preparatory phase of the evacuation process such as clearing the ship, accounting for passengers, controlling and guiding the movement of passengers, and communicating with passengers. Until technology is introduced into the preparation for abandonment phase, this stage will continue to be a weak link in the abandonment process—to the detriment of passenger and crew safety.

2.11 Crew Training and Familiarization

2.11.1 Familiarization with New Equipment

In replacing the aft steering-mode selector switch, the functionality of the overall steering selector system was altered. This change created a usability problem for the crew. Although the shift (A watch) that took the vessel out of refit was made familiar with this change in functionality, the subsequent shift (B watch) was not fully briefed. Furthermore, instead of following the procedures developed by the previous shift, the new shift determined its own preferred method of operation. As personnel can move between shifts, the lack of standardized procedures may lead to confusion, thus compromising safety.

As BC Ferries did not make a thorough risk/training needs analysis following changes made to the vessel's steering-mode selector switch, some crew members were not fully aware of how to operate this equipment once the ferry returned to operation following refit. This had the potential to compromise the safety of passengers, crew, vessel, and the environment.

2.11.2 Familiarization and Clearance for Assigned Duties

BC Ferries employees are encouraged to move from department to department when positions become available. The contractual agreement between BC Ferries and the employees' union requires the company to fill vacant positions based on the seniority of the candidate as long as any basic qualifications, such as certification, are fulfilled. A new employee begins to accrue service seniority from the first day of work, and thereafter continues to accrue seniority regardless of whether the employee works in a calendar year. An employee on a leave of absence (except in very limited circumstances) or approved for non-availability of more than 30 days will have his or her service seniority adjusted for the period of time he or she is away. The contract therefore creates a situation where employees, particularly casual employees, may experience prolonged absences from their positions, and only require re-familiarization and clearance if that absence is more than one year long.

By establishing a benchmark of one year's absence before requiring re-familiarization, the system does not take into consideration an individual's ability to retain skills and information over long periods, nor does it consider that some individuals may not be comfortable speaking

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[89] One such technology in use in the oil industry is the personnel on board monitor, which keeps track of the personnel on board an installation by means of a badge that is worn.

up if they feel they need additional training. The risk is that some employees, although maintaining clearance in accordance with the one-year rule, may not be fully competent to perform the duties expected of them.

2.11.3 Training and Continued Proficiency

It is important that personnel skills be upgraded to keep pace with technological and operational changes. In this instance, the 4/O had received no formal ECS training and had not—despite advances in radar technology—had SEN refresher training, neither was this required by regulations.

Furthermore, the 4/O had been issued a certificate of competency as a watchkeeper that had been endorsed by the STCW Convention. The STCW Convention, Section A-VIII/2, states that the "officer in charge of the navigational watch shall have a full knowledge of the location and operation of all safety and navigational equipment on board the ship."

In the absence of regulatory or industry-wide standards for ensuring that officers have received up-to-date training appropriate to the equipment they use, some mariners may lack the skills required to operate modern bridge equipment—jeopardizing the safety of the passengers, crew, vessel, and the environment.

2.12 Quality of Safety Management System Audits and Reviews

An effective SMS enables ship operators to anticipate and address safety shortcomings/deficiencies with the objective of improving on-board safety and reducing risk. SMS audits and management reviews are carried out to verify that a company's SMS not only meets these objectives, but that it is being effectively implemented. It provides for safe operating practices, and assures that safeguards against all identified risks have been established. Operators must ensure that the quality of audits and management reviews is such that performance measurement is accurate. Accordingly, operators must also have proper procedures and records to show that the auditing and reviews carried out were adequate.

A review of available audit records dating from 1998, in addition to the quarterly management reviews, revealed that several key non-conformities[90] relating to the *Queen of the North* had not been identified by internal or external audits. These included:

- deck officers not being provided with appropriate training to operate the electronic navigation equipment;

- BC Ferries certification requirements not being complied with (the certification requirements for several deck officer positions under BC Ferries employment policy exceeded those of TC. There were cases where, although an officer met the minimum TC certification requirement, the higher BC Ferries requirement was not being met);

90 Non-conformity means the non-fulfillment of a specific requirement of the ISM Code.

- deckhands, who were expected to perform the duties of a quartermaster, not always being qualified in accordance with the BC Ferries *Fleet Regulations*;

- watertight doors being left open in contravention of Canadian regulations and a TC Board of Steamship Inspection decision;

- no vessel-specific contingency plan or procedures being in place for responding to the various potential emergency situations associated with an evacuation;

- a less than formal working environment on the bridge; and

- an inconsistent application of accepted principles of navigation safety.

Additionally, senior management was advised in an August 2004 quarterly management review that there was an increase in the number of crew members assigned to vessels without being fully trained or cleared as required by the *Fleet Regulations*. The report indicated that part of that increase may have been attributed to the introduction of a new human resource management system while maintaining the previous system. The Operations Safety Log indicated instances where there was no documentary information of crew members having valid certificates/tests. However, there were no subsequent audit records relating to the *Queen of the North* identifying that deckhands continued to act as members of the deck watch (bridge team) without appropriate training or certification.

Taken together, this is an indication that the quality of these internal and external SMS audits was less than thorough.

Although internal audit records noted those instances where a non-conformity or an observation[91] was raised, there was no recorded information to identify those activities that were audited and found to be in accordance with requirements. Moreover, the audit plans were only retained for four to five months. This lack of audit history precluded internal auditors from effectively planning future audits, based on past results.

Previous TSB investigations have also identified shortcomings with the BC Ferries SMS. In the investigation into the 2002 malfunction of the automatic steering control system on board the ferry *Bowen Queen*,[92] the TSB found that the SMS of BC Ferries vessels did not require repairs to all critical equipment to be documented. In the investigation into the 2003 engine-room fire on board the ferry *Queen of Surrey*,[93] the TSB found that shortcomings in the monitoring, tracking, and correcting of safety deficiencies indicated inadequacies in the performance of the vessel's SMS.

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91 An observation is defined as a statement of fact made during an audit, which if not addressed, may lead to a non-conformity.

92 TSB Marine Investigation Report M02W0061.

93 TSB Marine Investigation Report M03W0073.

In 1996, BC Ferries employed four full-time auditors to conduct SMS audits throughout the fleet, as well as in its shore offices and terminals. In the fiscal year ending 31 March 2006, there were only two full-time auditors and, when required, contractors were hired. While additional auditing resources may have been required to verify initial compliance and effectiveness of the SMS, the thoroughness of subsequent audits—so as to ensure continued compliance and effectiveness—is equally important. As per BC Ferries *Fleet Regulations*, Section 12.1, all 35 vessels[94] and the approximately 150 sites were to be internally audited annually. During the 2005-2006 fiscal year, BC Ferries conducted 257 audits, of which 56 were conducted on board vessels, with 694 requests issued for corrective action. During the previous fiscal year, there were 243 audits, of which 92 were conducted on board vessels, with 449 requests issued for corrective action. While recognizing that it is difficult to objectively evaluate the effect of the audit team's workload upon the thoroughness of their past audits, it nonetheless cannot be ruled out as a contributing factor to the failure of the audits to identify significant non-conformities.

The continuity and thoroughness of safety audits, both internal and external, and thus the effectiveness of the measurement of the safety performance of the organization have been ineffective in identifying safety deficiencies on board BC Ferries vessels. Conditions contributing to this situation include the lack of audit history records and the heavy workload demand upon the audit team.

2.13 Alcohol and Drug Use on Board Vessels

Any impairment of employees who perform safety-critical tasks in the transportation industry is a risk to safety—whether due to impairment while on duty, or during off-duty periods if required to carry out emergency functions. Senior crew and management play an important role in ensuring that crew members conduct their duties in a safe and efficient manner and that their performance is not impaired by alcohol and drugs. However, on board the *Queen of the North*, some crew members regularly smoked cannabis between shifts, and not all senior crew members consistently took action to ensure that the company's no-tolerance policy was strictly adhered to.

Effective action to address the use of alcohol and drugs by employees usually involves a combination of measures including clear policies, an employee assistance program, education, reporting systems, enhanced supervision, and methods to detect impairment and the associated risks to safety. Some of these measures were in place at BC Ferries. For example, through enhanced supervision and enforcement of BC Ferries zero-tolerance policy with respect to alcohol and drugs, 5 terminations, 10 suspensions, and 8 letters of reprimand have been issued since 2004.

Given the documented effects on performance, the use of alcohol and drugs by crews of vessels presents an undue risk to the safety of passengers and the environment. Actions taken by BC Ferries regarding this issue were not adequate to ensure that this risk was addressed.

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94 In 2005.

3.0 Conclusions

3.1 Findings as to Causes and Contributing Factors

1. The fourth officer (4/O) did not order the required course change at the Sainty Point waypoint.

2. Various distractions likely contributed to the 4/O's failure to order the course change. Furthermore, believing that the course change had been made, the next course change was not expected for approximately 27 minutes.

3. For the 14 minutes after the missed course change, the 4/O did not adhere to sound watchkeeping practices and failed to detect the vessel's improper course.

4. When the 4/O became aware that the vessel was off course, the action taken was too little too late to prevent the vessel from striking Gil Island.

5. The navigation equipment was not set up to take full advantage of the available safety features and was therefore ineffective in providing a warning of the developing dangerous situation.

6. The composition of the bridge watch lacked an appropriately certified third person. This reduced the defences and made it more likely that the missed course change would go undetected.

7. The working environment on the bridge of the *Queen of the North* was less than formal, and the accepted principles of navigation safety were not consistently or rigorously applied. Unsafe navigation practices persisted which, in this occurrence, contributed to the loss of situational awareness by the bridge team.

8. No accurate head count of passengers and crew was taken before abandoning the vessel, thus precluding a focused search for missing persons at that time.

3.2 Findings as to Risk

1. In an emergency where abandoning ship is the only recourse, accurate passenger information is vital to both the abandonment and search and rescue (SAR) operations. In the absence of a mandatory requirement for collecting passenger information, the ability for ships' crews and SAR authorities to verify that all passengers are accounted for is compromised.

2. As a result of the practice of operating with some watertight doors open, the potential to slow down or stem the progressive flooding was not realized, thereby placing the vessel, its passengers, and crew at undue risk.

3. The lack of a completed evacuation plan/procedure, in addition to inadequate passenger safety training and drills, left some crew members of the *Queen of the North* under-prepared to handle the abandonment, thereby placing passengers at risk.

4. The overall adequacy of passenger vessel evacuation procedures is not fully assessed by Transport Canada, neither at the time of initial certification nor throughout the life of the vessel, increasing the risk to passengers in the event of an emergency.

5. British Columbia Ferry Services Inc. (BC Ferries) crew members were not fully familiarized with new safety-critical equipment installed during refit, and the company's training/familiarization program does not take into consideration an individual's ability to retain skills over a long period of time. As such, BC Ferries does not ensure that all employees are fully competent to perform the duties expected of them, thereby placing the vessel, its passengers, and crew at risk.

6. In the absence of regulatory or industry-wide standards for ensuring that officers have received up-to-date training appropriate to the equipment they use, some mariners may lack the skills required to operate modern bridge equipment—jeopardizing the safety of the vessel, passengers, or the environment.

7. Internal and external International Safety Management Code (ISM Code) safety audits have been ineffective in identifying significant safety deficiencies on board BC Ferries vessels. This indicates that measurement of the organization's safety performance has been inadequate, undermining the objectives of the safety management system.

8. Canadian regulations regarding the stowage of inflatable liferafts and damage stability of passenger vessels apply lower standards to older vessels even though these are exposed to similar risks. As such, passengers on older vessels are not afforded an equivalent level of safety in the event damage to the hull is sustained below the waterline.

9. The lack of a requirement for voyage data recorders (VDRs) or simplified VDRs (S-VDRs) on non-Convention vessels deprives the domestic maritime industry of a proven and valuable tool that can improve safety.

10. Action taken by BC Ferries was not adequate to fully address the risk to safety of the public and the environment posed by crews whose performance had been impaired by the use of alcohol and drugs.

3.3 Other Findings

1. The rapid response of the residents of Hartley Bay assisted in early recovery of survivors**.**

2. The application of research and technology to the preparatory phase of the ship evacuation process has yet to be fully realized in the passenger vessel industry.

3. Both the 4/O and the quartermaster (QM1) remained on the bridge when the second officer (2/O) took his break.

4. The change from sleeping during the night to sleeping during the day, together with the restless sleep, likely increased the risk of QM1 being fatigued.

5. The lack of a VDR/S-VDR installed on board the vessel resulted in a more complex and protracted investigation.

6. Although the two missing persons had been allocated a cabin on the aft port side of Deck 7, the investigation could not determine where on board the vessel they were at the time of the striking.

4.0 Safety Action

4.1 Action Taken

4.1.1 BC Ferries Passenger Manifest

Following the sinking of the *Queen of the North*, British Columbia Ferry Services Inc. (BC Ferries) updated the passenger reservation system for its northern fleet to create a manifest containing all passengers' names. At the terminal, all passengers are issued a boarding number, which is collected upon boarding, tallied, and then cross-checked against the names on the manifest maintained ashore.

4.1.2 Guidelines for Passenger Manifest

In August 2006, the TSB sent Marine Safety Advisory (MSA) 09/06 to Transport Canada (TC) concerning the adequacy of current guidelines for creating passenger manifests to ensure that sufficient information is available about passengers travelling on Canadian ferries.

In response, TC indicated that it will review current guidelines for creating passenger manifests with an eye to ensuring that sufficient information is available about the numbers, identity, and (as necessary) possible locations of all passengers travelling on Canadian ferries. TC has contacted the Canadian Ferry Operators Association and the Canadian Passenger Vessel Association, providing them with a copy of the MSA so as to solicit their comments.

On 02 August 2007, TC issued Ship Safety Bulletin (SSB) 06/2007, recommending that owners and masters have readily available information on all persons on board that will be of assistance during emergency situations and search and rescue (SAR) operations. The recommendation was made in anticipation of TC adopting the International Convention for the Safety of Life at Sea (SOLAS Convention) with regard to information on passengers[95] with the following additional details:

1. All persons on board all passenger ships shall be counted prior to departure. The number shall be recorded and shall be readily available to the master.

2. Details of persons who have declared a need for special care or assistance in emergency situations shall be recorded and communicated to the master prior to departure.

3. In addition, the names and gender of all persons on board, distinguishing between adults, children, and infants, shall be recorded for search and rescue purposes:

    - on Unlimited Voyages (formerly Foreign Voyages) or Near Coastal Voyages Class I (formerly Home Trade Voyages Class I or II);

95 SOLAS Convention, Chapter III, Regulation 27.

- on voyages longer than 12 hours;

- on overnight voyages or voyages on which there is at least one assigned berth.

4. The information required by paragraphs 1, 2, and 3 shall be kept ashore and made readily available to the master and to search and rescue services when needed.

4.1.3 Crew Familiarization of Equipment

In May 2006, the TSB sent MSA 07/06 to BC Ferries indicating that not all bridge team members were sufficiently familiar with on-board equipment, controls, and their functions.

In response, BC Ferries indicated that it has implemented additional procedures to ensure that bridge officers and quartermasters are familiarized with new equipment. Furthermore, BC Ferries has contracted a review of bridge and engine-room procedures, and an evaluation of its practices.

4.1.4 Passenger Safety Management Training

In response to the Board's Safety Concern dealing with passenger safety management training,[96] TC indicated that it will adopt Regulations V/2 and V/3 of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended in 1995 (STCW Convention), which address training in crowd management, for Canadian non-Convention passenger vessels. With the coming into force of the *Marine Personnel Regulations* in 2007, passenger safety management training is required by 07 November 2011 for crews on domestic roll-on/roll-off (ro-ro) ferries over 500 gross tons that are tasked with any of the following:

- assisting passengers in emergency situations;
- providing service to passengers; and
- assisting embarking and disembarking passengers.

4.1.5 BC Ferries Divisional Inquiry

BC Ferries conducted an internal Divisional Inquiry to determine the cause and circumstance of the occurrence, and to make safety recommendations that could be applied, if necessary, to the BC Ferries fleet to educate and to prevent the recurrence of a similar occurrence. A Divisional Inquiry panel, which included representatives from both management and the union, was convened. The inquiry concluded that the deck watch of the *Queen of the North* failed to maintain a proper lookout, failed to make the required or any course changes at Sainty Point, and that the vessel proceeded straight on an incorrect course for four nautical miles over 14 minutes until striking Gil Island. The inquiry also made 31 recommendations regarding equipment, bridge team, procedures, and evacuation. As of December 2007, BC Ferries stated that it had addressed 21 of the recommendations, and that the remaining recommendations would be acted upon.

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96 TSB Marine Investigation Report M03N0050.

Subsequent to the release of the report of the Divisional Inquiry, new information was provided to BC Ferries, and the panel was reconvened. Two BC Ferries employees provided sworn statements that they had heard QM1 (quartermaster) say, in the context of the striking, that she was alone. It is noted that, although the Divisional Inquiry panel found the statements to be credible, there was one dissenting opinion. Also, further analysis by BC Ferries found that the impact marks on the shoreline of Gil Island were consistent with a straight-line extension of a track line from Grenville Channel to the impact marks. As a result, BC Ferries issued an addendum to its Divisional Inquiry, though the original findings were unchanged.

4.1.6 Review of Operational Safety at BC Ferries

On 22 January 2007, BC Ferries released an independent review that it had commissioned on its safety policies, procedures, and practices.[97] The safety review concluded that, overall, BC Ferries is operating a safe coastal ferry transportation system. The review also made 41 recommendations on issues such as safety management system and audits, crewing and training in operational safety, bridge resource management, crowd management and control, the familiarization process, and emergency drills. In response, BC Ferries states that it is committed to working with the BC Ferry & Marine Workers' Union (BCFMWU) to implement all of these, 16 of which have been addressed to date.

To this end, BC Ferries and the BCFMWU have initiated a new safety program, SailSafe, which allows employees to suggest improvements and highlight safety concerns. A 41-member team met in January 2008 to evaluate documented concerns and create a plan of action.

4.1.7 Cannabis Use in the BC Ferries Northern Fleet

In November 2006, *Come Sail With Us* booklets were developed and presented to all union employees. These booklets included BC Ferries policy on alcohol and drugs.

In March 2007, the Terminal Operations Supervisory Skills Training Program was commenced. This included information on supervisors' responsibilities, as well as information on recognizing substance abuse and appropriate actions to take.

In October 2007, the TSB issued a Board Safety Concern to BC Ferries regarding the use of cannabis by some crew members on the *Queen of the North*. The Safety Concern states that, given the documented effects on performance and the risk to passengers and the environment, the TSB considers the use of cannabis by crews of vessels to be an unsafe condition—one that could lead to a serious accident. The Safety Concern further states that BC Ferries should determine whether cannabis is in use by crews of other vessels or whether it was isolated to the *Queen of the North*, and that this determination should include a review of the effectiveness of the company's policy on alcohol and drugs. The TSB requested that BC Ferries address the issue without delay and report back on measures taken to ensure that the public and the environment are not placed at risk by crews whose performance has been impaired.

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97 G.L. Morfitt, *Safety and B.C. Ferries: A Review of Operational Safety at British Columbia Ferry Services, Inc.*, January 2007.

In October 2007, BC Ferries issued a memorandum to all staff emphasizing the no-tolerance policy and, as of 12 December 2007, a total of 104 BC Ferries northern route employees had attended information sessions regarding substance abuse.

Employers in the transportation industry have developed programs for the management of alcohol and drug misuse, in compliance with the *Canadian Human Rights Act* and the Canadian Human Rights Commission Policy on Alcohol and Drug Testing.[98, 99]

In February 2008, BC Ferries advised the TSB of its new Policy and Commitment to Employee Wellness and Substance Abuse. This wide-ranging policy includes the requirement that employees report any behaviour or conduct that is contrary to this policy to either a supervisor with whom an employee is comfortable making disclosure, or confidentially via a Web site, e-mail, or telephone call. It also includes provision for mandatory testing for alcohol, drugs, and medications where "reasonable cause" exists.

The policy states "Employees in Safety Sensitive Positions shall not consume any mood altering substance(s) within **8 hours** of reporting to work." The TSB Safety Concern states, however, that the impairment due to a single dose of cannabis may last 24 hours.

On balance, the TSB believes that the effective implementation of this new policy will substantially reduce or eliminate the safety deficiency highlighted in its Safety Concern.

4.1.8 Location of Crew Accommodation

Subsequent to the occurrence, BC Ferries required that the crew of the *Queen of Prince Rupert* be placed in accommodations above the waterline.

4.1.9 Installation of Voyage Data Recorders

Subsequent to the occurrence, BC Ferries voluntarily installed simplified voyage data recorders (S-VDRs) on 14 vessels and stated that it expects the remaining 18 vessels to be similarly equipped by mid-2008.

As part of the *Canada Shipping Act, 2001* regulatory reform project, TC commissioned a study to conduct a cost-benefit analysis of potential regulatory requirements for voyage data recorders (VDRs)/S-VDRs for Canadian non-Convention vessels. The study is expected to be completed in the spring of 2008.

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98 June 2002.

99 For example, the east coast ferry operator Marine Atlantic has an alcohol and drug policy that includes a wide range of approaches, including several situations where testing is permitted.

4.1.10 Inflatable Liferafts

On 02 August 2007, TC issued SSB 07/2007 entitled *Inflatable Liferafts and Rescue Platforms, Storage and Proper Access*. This document urged owners and operators to stow liferafts in such a manner as to float free automatically if the vessel sinks. This SSB also urged owners/operators that, even if liferafts are carried voluntarily, these should float free.

4.1.11 Audit Plans

BC Ferries audit plans are now retained for 12 months, or until the next audit plan is prepared and the previous audit plan is used in preparation of the new audit plan.

4.1.12 Bridge Watch Composition

On 13 February 2008, the TSB sent MSA 03/08 to TC regarding the interpretation of the *Marine Personnel Regulations*. In this MSA, the TSB suggested that TC may wish to carry out a review of the existing minimum deck watch requirements with a view to simplifying the language so as to enhance understanding, compliance, and overall safety.

4.2 Action Required

Passenger ferries play a significant role in the Canadian transportation network. In 2006, over 44 million passengers and 16 million vehicles travelled by ship in Canada.[100] In all, 113 passenger vessels above 500 gross tons operate in Canada, and some 50 of these vessels carry more than 400 persons.

Most Canadian ferries operate wholly in domestic trade where, taking into account route characteristics and traffic levels, there is an equal (if not greater) risk of damage due to collisions and groundings than there is internationally. Domestic ferries nonetheless operate under a different regulatory regime, which in many instances is less stringent.

International shipping is subject, through flag-state enabling legislation, to international norms negotiated within the International Maritime Organization (IMO) and set out in the relevant conventions, including the SOLAS Convention. Domestic shipping is not subject to these conventions, and the flag state has the option of regulating industry separately or adopting the international conventions to cover domestic shipping—with or without modification to suit perceived local circumstances. Vessels subject to the IMO conventions are frequently referred to as Convention vessels; those that are not are referred to as non-Convention vessels.

Much of the cross-border traffic handled by sea between Canada and the United States is carried by vessels that also trade domestically within their respective countries. Although vessels of one country may traverse the other country's waters during the course of a domestic voyage, it is accepted practice that such vessels are not required to meet the conventions applicable to ships engaged in international trade; rather, they must meet the requirements of their own flag state.

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100 Canadian Ferry Operators Association, 2006 Annual Report.

The TSB is of the opinion that all large passenger vessels should adhere to the same safety standards, regardless of domestic or international operation, and that, in general, the rules set out in the various conventions should apply to all large passenger vessels operating in Canada. A number of the recommendations and safety concerns that follow should be considered in the context of this basic principle.

4.2.1 Accounting for Passengers

The accounting for passengers includes collecting information concerning passenger numbers and identities, maintaining that information in a form readily accessible on the vessel and ashore, ensuring that all passengers are accounted for during an abandonment, and effective use of the information in any subsequent SAR operation.

During and following the abandonment of the *Queen of the North*, those responsible for ensuring that all passengers had been accounted for had difficulties establishing the total count, reconciling that count against the recorded information, and identifying those who were missing.

In MSA 09/06 issued 10 August 2006, the TSB advised TC that it may wish to review the adequacy of guidelines for creating passenger manifests, so as to ensure that sufficient information is available about the number, identity, and, as necessary, the possible location of all passengers on board Canadian ferries.

On 02 August 2007, TC issued SSB 06/2007, recommending that owners and masters have readily available information on all persons on board that will be of assistance during emergency situations and SAR operations.

In addition, BC Ferries implemented a new procedure for establishing passenger manifests on the northern routes to ensure that the passengers on board the vessels are accurately reflected in the passenger manifest maintained ashore.

The TSB recognizes the safety value of TC's and BC Ferries' actions to enhance the information collected and recorded for the purpose of accounting for passengers. However, the scope of the safety action does not include near coastal voyages, Class II, and so covers less than one-third of Canadian ferry passenger journeys. For instance, BC Ferries' action does not extend to its southern routes and, although there are logistical and business barriers to collecting this information in the busy period preceding the loading of a large passenger vessel, the risk to safety remains.

Further, the scope of the action is limited to collecting and documenting passenger information and does not extend to the other critical aspects of accounting for passengers—counting and locating passengers aboard the vessel, and subsequently carrying out SAR operations. Although the Canadian Coast Guard has developed draft procedures and tools for accounting for rescued passengers,[101] these have not yet been implemented. Other aspects of accounting for passengers, such as the means to efficiently and accurately perform counts of large numbers of passengers

[101] Canadian Coast Guard, Casualty Tracking (CASTRACK) System.

before abandonment, have not been identified. It is important that an integrated set of tools and procedures be developed to support the accounting for passengers by all groups involved in the management of their safety, from embarkation to arrival and throughout all activities undertaken during an emergency.

The Board believes that a tailored approach is required, not just for each operator or route but for each individual vessel—one that addresses both the potential risks of a particular voyage and the most appropriate means of addressing them.

The Board, therefore, recommends that:

> The Department of Transport, in conjunction with the Canadian Ferry Operators Association and the Canadian Coast Guard, develop, through a risk-based approach, a framework that ferry operators can use to develop effective passenger accounting for each vessel and route.
>
> M08-01

4.2.2 Preparation Before Abandoning a Vessel

During abandonment, it is essential that all passengers be accounted for and that they board survival craft in an organized, efficient manner. Crew members must therefore be familiar with mustering and crowd-control procedures, as well as passenger-counting methods and measures to reconcile any discrepancies in those counts.

A number of other distinct challenges must also be addressed, including:

- High passenger-to-crew ratios
- Dealing with passengers in several different languages
- Passengers requiring assistance (for example, hearing, sight, mobility)
- Congestion
- Identifying and locating missing passengers

Following a May 2003 occurrence involving the ro-ro passenger ferry *Joseph and Clara Smallwood* (Marine Investigation Report M03N0050), a TSB investigation revealed a number of safety deficiencies related to emergency duties performance and training. A performance analysis indicated that crew members did not possess the knowledge or skills to adequately perform their emergency duties, and the TSB subsequently expressed its concern about the adequacy of passenger safety management training. Although crew members in that occurrence met regulatory requirements, additional training in crowd management, crisis management, and human behaviour would have better prepared them to respond. They had not received such training, nor had such on-board drills been conducted.

Canadian regulations require passenger vessels to have a procedure for safe evacuation of the complement within 30 minutes of an abandon-ship signal. There is no requirement to carry out a drill involving crowd-control duties before evacuation. Although some ferry operators have voluntarily conducted full-scale abandonment exercises, these do not involve crowd control.[102]

Under the new *Marine Personnel Regulations*, which came into force on 01 July 2007, crew members assigned to assist passengers in an emergency must have a passenger safety management certificate or endorsement.[103] However, due to the number of employees that some ship owners will be required to train, domestic passenger vessels have been granted a phase-in period, which will end 07 November 2011.

Although passenger safety management courses based on the provisions of the STCW Code are offered, these involve, for the most part, classroom instruction only. As this alone is not enough, regular exercises and drills need to be conducted so that crews are confident and prepared to carry out their emergency duties.

On the *Queen of the North*, boat and fire drills were to be conducted at intervals of not more that two weeks.[104] These were limited to crew members mustering at their designated emergency stations, followed by the deployment and operation of lifeboats. The drills did not include the full range of skills necessary to muster and control large numbers of passengers.

In this occurrence, crew members on the *Queen of the North* evacuated 57 of 59 passengers in the 30 minutes between the striking and the time senior crew members entered the last survival craft. With such a crewing level, however, the vessel was certified to carry up to 474 passengers—a significantly larger number that, given the short timeframe available for the preparatory phase of abandonment, would have compounded the mustering, accounting, and abandonment difficulties identified in this occurrence. Crew training and experience is therefore paramount for passenger safety on vessels, especially where there are high passenger-to-crew ratios.

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102 The SAREX 2006 "Ship-to-Shore" exercise was held on 15 October 2006 to evaluate inter-agency response to a major marine disaster on the British Columbia coast. The exercise included the evacuation of 200 volunteers from the BC Ferries vessel *Queen of Nanaimo*. The exercise was designed to improve inter-agency communications and operations during a large-scale emergency operation.

103 Applies only to vessels more than 500 gross tons carrying more than 12 passengers and engaged on a voyage other than sheltered waters.

104 *Boat and Fire Drill and Means of Exit Regulations*.

When crews are faced with an actual emergency, the response of those who have received training and practice is more automatic and requires less interpretation and decision making. Failure to reinforce this training with practice and evaluation reduces the benefit of the original training. Given the risks associated with improperly coordinated preparations for evacuating large number of passengers, the Board therefore recommends that:

> The Department of Transport establish criteria, including the requirement for realistic exercises, against which operators of passenger vessels can evaluate the preparedness of their crews to effectively manage passengers during an emergency.
>
> M08-02

4.2.3 Carriage of Voyage Data Recorders

The *Queen of the North* was not equipped with a VDR or S-VDR, as this was not a requirement for passenger vessels engaged on domestic voyages.

Although the electronic chart system (ECS) provided some information concerning the vessel's movements before the striking, unlike a VDR, it was incapable of recording bridge voice data. Information gathered about the activities of the bridge team was in conflict with information derived from the ECS. The lack of a VDR resulted in a more complex and protracted investigation.

The purpose of a VDR is to create and maintain a secure, retrievable record of information indicating the position, movement, physical status, and command and control of a vessel. Objective data—voice data in particular—are invaluable to investigators and operators seeking to understand the sequence of events leading up to an accident.

Although the aviation industry has enjoyed the benefits of flight data recorders for 50 years and cockpit voice recorders for 43 years, the maritime industry's experience with VDRs is in its infancy—though the proven benefits from their carriage are already evident. These include the proactive analysis of information stored in VDRs for constant improvement within a company safety management system, and benefits to accident investigators in the form of early and objective identification and communication of safety deficiencies.

It should be noted that, under the *Canadian Transportation Accident Investigation and Safety Board Act*, "on-board recordings" are privileged information.[105]

In the *Coast Guard and Maritime Transportation Act* of 2006, Congress directed the United States Coast Guard to conduct a study of the carriage of VDRs by passenger vessels carrying more than 399 passengers. The vessels that this study involves are ferries of at least 100 gross tons, providing transportation only between places that are not more than 300 miles apart, and carrying more than 399 passengers.

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105 *Canadian Transportation Accident Investigation and Safety Board Act*, Section 28.

Despite the significant safety benefits to operators, accident investigators, and hence the travelling public, there is no requirement for the carriage of VDRs on non-Convention vessels, thereby depriving the industry of a proven and valuable tool for improving safety.

The Board, therefore, recommends that:

> The Department of Transport extend the requirement for the carriage of voyage data recorders/simplified voyage data recorders to large passenger vessels over 500 gross tonnage and all other commercial vessels on an equivalent basis to those trading internationally.
>
> M08-03

4.3 Safety Concerns

4.3.1 Watertight Doors

The role of watertight doors is to maintain the integrity of the watertight bulkheads and the benefits of watertight subdivision.

The *Hull Construction Regulations* require that all watertight doors be kept closed during navigation except when necessarily opened for the working of the ship. As currently written, these regulations leave room for interpretation with regard to the terms "necessary" and "working of the ship." The SOLAS Convention, however, provides clear and specific instruction as to when these watertight doors may be opened.

On the *Queen of the North* at the time of the occurrence, as per regular practice for over 25 years, several watertight doors were open.

Over the last 30 years, the sinking of at least five vessels in Canada has been attributed to watertight doors being left open. TC has subsequently issued three SSBs, reinforcing the importance of keeping these doors closed.[106] The TSB has also issued a recommendation promoting awareness of this issue's serious consequences.[107] The practice, however, persists, and this has been addressed by MSA 02/08.

The Board is therefore concerned that some Canadian operators continue to operate their vessels with watertight doors open, thereby placing vessels, passengers, crews, and the environment at undue risk.

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106 SSBs 03/78, 01/85, and 16/92.

107 TSB Recommendation M92-04 following the sinking of the *Northern Osprey*, TSB Marine Investigation Report M90M4020.

4.3.2 Damage Stability

The damage stability requirements applicable for Canadian domestic vessels are mainly set out in the *Hull Construction Regulations*. Recognizing that the present Canadian regulations for passenger vessels do not incorporate the latest international requirements, TC has adopted the amended TP 10943. Although it is TC's intent to apply these standards in advance of updating the *Hull Construction Regulations*, these regulations are still in force, and their provisions are less stringent.

The revision of the *Hull Construction Regulations* is part of phase 2 of the *Canada Shipping Act, 2001* regulatory reform project. Information provided by TC indicates that it is too early in the reform process to adequately predict the timelines for publication of the new regulations in the *Canada Gazette.* The proposed amendments to these regulations are expected to be presented for consultation with the stakeholders in 2009 and 2010.

The TSB recognizes TC's effort since 1990 to enhance damage stability requirements and improve the survivability of passenger vessels by adopting the amended standards. However, until the *Hull Construction Regulations* make the application of the amended TP 10943 mandatory to all passenger vessels operating in Canada, the Board is concerned that passengers and crews on older vessels will not be afforded an equivalent level of safety compared to those plying internationally. Moreover, because the new standards have a longer phase-in time than the SOLAS Convention, the same concern applies to existing vessels until such time as they meet the standards.

4.3.3 Auditing Voluntary Adopted Safety Management Systems

The objectives of the International Safety Management Code (ISM Code) are to prevent human injury, loss of life, and damage to the environment. Although most vessel operators in Canada are not required to comply, several have done so voluntarily.

The goal of a safety management system (SMS) is to permit participants to detect and prevent unsafe practices and conditions before an accident occurs rather than having others identify safety shortcomings afterward. It is therefore important that, when any non-conformity is reported, appropriate corrective action be taken in a timely manner.

In this occurrence, internal and external audits failed to identify a number of shortcomings. It was also reported that external audits did not always apply the same standards regarding compliance. Major non-conformities, for example, which would have otherwise been cited, may not have been issued because the ISM Code had been adopted voluntarily. Therefore, less emphasis may have been placed on taking corrective action—effectively defeating the objectives of both the ISM Code and an effective SMS.

In Canada, TC has delegated five classification societies[108] to perform ISM Code audits on Convention vessels. TC also monitors, via audits, the activities of these classification societies. However, TC's monitoring, auditing, and overview is for mandatory systems only: TC does *not* monitor the application of the ISM Code where it has been voluntarily adopted.

The Board is concerned that this lack of consistent application compromises the objectives of the ISM Code. Moreover, the Board believes that, with the large numbers of passengers that may be carried at any one time on a passenger vessel, quality audits are essential in being able to identify deficiencies requiring corrective action. The Board, therefore, will monitor the situation.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 30 January 2008.

Visit the Transportation Safety Board's Web site (www.tsb.gc.ca) for information about the Transportation Safety Board and its products and services. There you will also find links to other safety organizations and related sites.

[108] Lloyd's Register, American Bureau of Shipping, Bureau Veritas, Germanischer Lloyd and det Norske Veritas.

Appendix A – Sketch of the Area

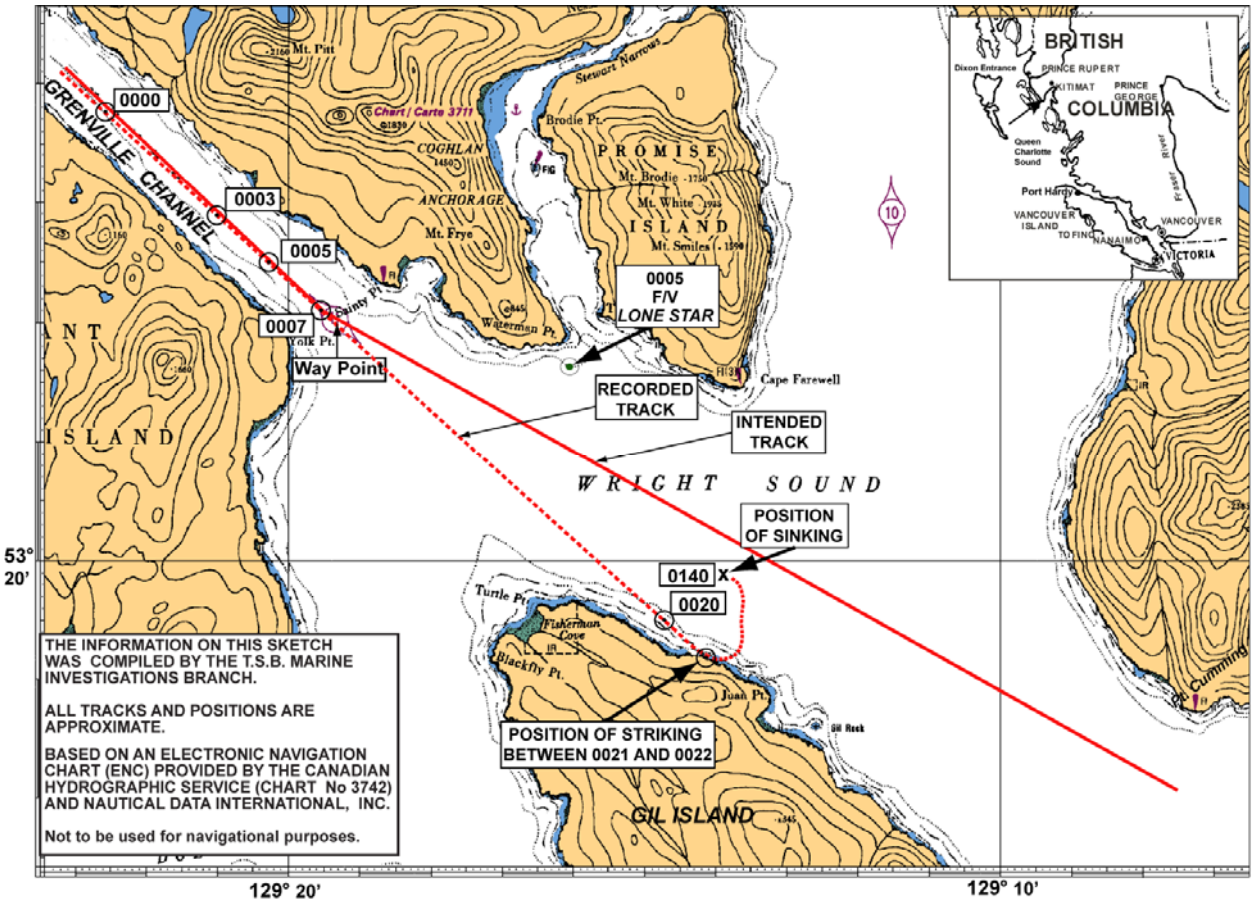

Figure 3. Track of the *Queen of the North*

Appendix B – Electronic Chart System Recording of the Vessel's Track (Based on Digital Global Positioning System Data)

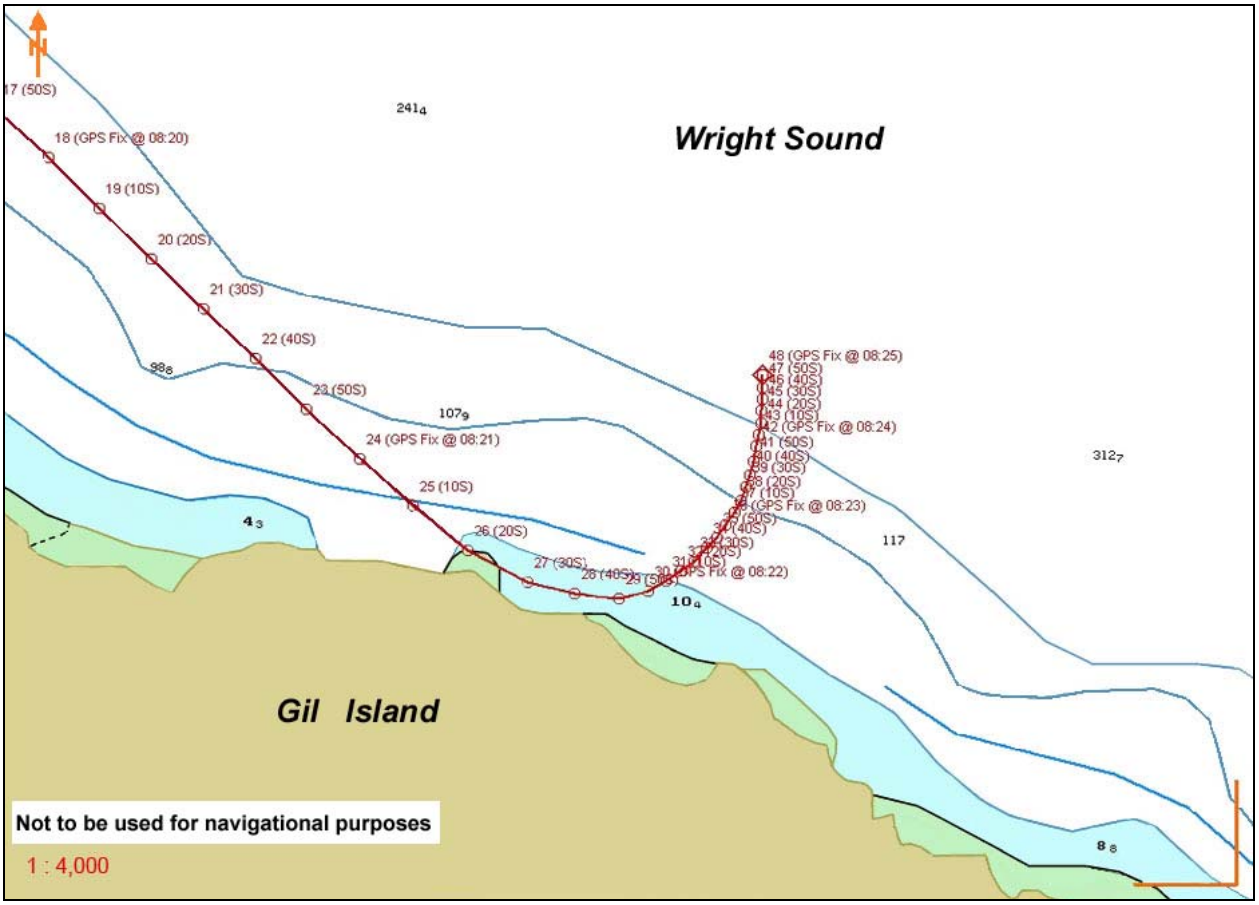

Figure 4. Course as it would have appeared on a vector chart

The above graphic shows the track of the *Queen of the North* as it would have appeared on a vector chart, which, while not available at the time of the accident, clearly shows the vessel's course both across Wright Sound before and after the striking. The fixes in the electronic chart system data log were updated every minute for the following: date, time, latitude, longitude, heading, course over ground, and speed over ground. Ten-second positions of latitude and longitude depict the vessel's track moments after the striking.

Appendix C – Major Amendments to the SOLAS Convention

Damage Stability Requirements for Roll-on/Roll-off Passenger Vessels

REFERED TO AS AMENDMENT	SUBJECT OF THE AMENDMENTS
1990 SOLAS	New standards on residual damage stability applicable for vessels built on or after 29 April 1990 (new vessels) in order to provide survivability following damage (Chapter II-1, Regulation 8).
1994 SOLAS or 1992 amendments	Most vessels built before 29 April 1990 (existing ships) to comply with the 1990 SOLAS, in accordance with a phase-in schedule from 1994 to 2005, depending on a vessel's survivability characteristics.
1995 SOLAS	All existing vessels to comply with the 1990 SOLAS, in accordance with a phase-in schedule from 1998 to 2005, depending on a vessel's survivability characteristics (Chapter II-1, Regulation 8-1). Vessels carrying 400 persons or more must comply with the 1990 SOLAS, as a two-compartment subdivision vessel, if: • built on or after 01 July 1997; or • built before 01 July 1997, in accordance with a phase-in schedule from 1998 to 2010, depending on the vessel's survivability characteristics, number of persons carried, and vessel's age (Chapter II-1, Regulation 8-2).

Appendix D – Glossary

AIS	automated identification system
B.C.	British Columbia
BC Ferries	British Columbia Ferry Services Inc.
BCFMWU	BC Ferry & Marine Workers' Union
BRM	bridge resource management
CCG	Canadian Coast Guard
CCGS	Canadian Coast Guard ship
CFOA	Canadian Ferry Operators Association
cm	centimetres
CMCC	Canadian Mission Control Centre
C/O	chief officer
COG	course over ground
DGPS	differential global positioning system
DSC	digital selective calling
ECDIS	electronic chart display and information system
ECS	electronic chart system
EPIRB	emergency position-indicating radio beacon
GPS	global positioning system
IMO	International Maritime Organization
ISM Code	International Safety Management Code (International Management Code for the Safe Operation of Ships and for Pollution Prevention)
JRCC	Joint Rescue Coordination Centre
km	kilometres
kW	kilowatts
m	metres
mm	millimetres
MCTS	Marine Communications and Traffic Services
MED	Marine Emergency Duties
MSA	Marine Safety Advisory
N	north
nm	nautical miles
OOW	officer of the watch
OSC	on-scene coordinator
QM	quartermaster
ro-ro	roll-on/roll-off
ROV	remote operating vehicle
SAR	search and rescue
SEN	Simulated Electronic Navigation
SI	Ship Inspection Notice
SIC	Ship Inspection Certificate
SMS	Safety Management System
SOLAS Convention	International Convention for the Safety of Life at Sea
SSB	Ship Safety Bulletin
STCW Convention	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended in 1995
S-VDR	simplified voyage data recorder

T	true
TC	Transport Canada
TP	technical publication
TSB	Transportation Safety Board of Canada
VDR	voyage data recorder
VHF	very high frequency
VISORS	Voluntary Individual Safety Observation Reporting System
W	west
W/T	watertight
XTE	cross-track error (alarm)
°	degrees
°C	degrees Celsius
'	minutes
2/O	second officer
3/O	third officer
4/O	fourth officer