MARINE INVESTIGATION REPORT
M99L0098

GROUNDING

PASSENGER VESSEL *NORWEGIAN SKY*
OFF ÎLE ROUGE, ST. LAWRENCE RIVER, QUEBEC
24 SEPTEMBER 1999

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

Marine Investigation Report

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Report Number M99L0098

Synopsis

The passenger vessel *Norwegian Sky* was on a voyage from Québec, Quebec, to Halifax, Nova Scotia. The trip included a cruise of the Saguenay River. On its return to the mouth of the Saguenay, at about 1130 local time, whales were observed in the St. Lawrence River. To prolong the whale-watching activity, the vessel was turned around but ran aground on the Bancs de l'île Rouge (Rouge Island Banks) before completing its manoeuvre. The vessel sustained substantial damage, but pollution was deemed minor. No injuries resulted from this occurrence.

Ce rapport est également disponible en français.

Table of Contents

Figures

1.0 Factual Information

1.1 Particulars of the Vessel

	Norwegian Sky			
Official Number	731038			
Port of Registry	Nassau, Bahamas			
Flag	Bahamas			
Type	Passenger Vessel			
Gross tonnage[1]	77 104			
Length[2]	258.57 m			
Draught	Forward:	8.07 m	Aft:	8.09 m
Cargo	None			
Crew	787 persons			
Passengers	1923 passengers, 2 pilots, 1 naturalist			
Built	1999, Bremerhaven, Germany			
Propulsion	2 diesel-electric engines, developing 30 000 kW			
Owners	Norwegian Cruise Line, Florida, USA			

1.1.1 Description of the Norwegian Sky

The *Norwegian Sky* is a 12-deck, 39 000-tonne displacement passenger vessel that entered service in Dover, United Kingdom, on 09 August 1999. The vessel was on its maiden voyage to North America.

The accommodation has a 2400-passenger and 750–crew member capacity. Life-saving appliances include, but are not limited to, lifeboats that can accommodate 2400 persons and liferafts that can accommodate 1600 persons.

Six diesel-electric generators, producing 50 700 kW, supply energy to the hotel and propulsion systems. Two stern and three bow thrusters enable the vessel to move sideways when the vessel's forward speed does not exceed seven knots. Under way, two controllable-pitch propellers and two semi-balanced articulated flap rudders give exceptional vessel manoeuvrability at a service speed of 20 knots.

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1 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 (SI) of units.

2 See the glossary in Appendix C for all abbreviations.

1.2 History of the Voyage

At 0030 eastern daylight time[3], on 24 September 1999, the *Norwegian Sky* departed Québec, bound for Halifax, with 2712 persons on board, including 1923 passengers, and two Laurentian Pilotage Authority (LPA) pilots. Norwegian Cruise Line estimates that there were some 50 different nationalities aboard and that the average age of the passengers was 63 years. The ratio of passengers to crew members was 2.4:1. The pilots estimated their arrival at Les Escoumins pilot station at about 1300.

The vessel sailed down the St. Lawrence River until it reached the entrance of the Saguenay River. The staff captain and pilot No. 1 were relieved by the master and pilot No. 2, respectively. At 0700, off Tadoussac, a naturalist boarded the vessel to act as a guide for the passengers during a scenic tour of the Saguenay River and whale-watching. The vessel returned to the St. Lawrence River.

At 0855, the vessel reached Baie Éternité and speed was reduced to approximately six knots to turn around off Cap Trinité. After reporting to Marine Communications and Traffic Services (MCTS) Les Escoumins in Baie Éternité, the pilot confirmed to the master that there would be sufficient time for passengers to observe whales at the mouth of the fjord. The return voyage to the St. Lawrence River was uneventful.

At 1107, the pilot reported to MCTS Les Escoumins that the vessel had reached the Pointe Noire / Tadoussac ferry crossing and that the passengers were about to begin whale-watching, before proceeding to the pilot station. The pilot noticed that excursion boats had grouped downriver from Île Rouge and, according to the voyage plan, intended to join them. Visibility was good, with fair skies; winds were light and the seas calm. Under the supervision of the officer of the watch (OOW), a cadet plotted positions on the chart approximately every five minutes.

Using the Pointe Noire range, the pilot conducted the vessel down the buoyed channel. At about 1120, near buoy S3, helm orders were given to steer a course of 115°G (the gyrocompass error was negligible) for buoy K55. The pilot adjusted the radar variable-range marker to two nautical miles (nm) and asked the master to gradually reduce the vessel's speed. The master moved the speed levers and oversaw progress of the vessel by visual observation. Near the Bancs de l'île Rouge (Rouge Island Banks), at about 1133, the pilot noticed that the target of Haut-fond Prince (Prince Shoal) light was nearing the variable-range marker and that whales were now grouped downriver of buoy K55. Consequently, he ordered the helmsman to turn the helm 20° to port to head toward Les Escoumins pilot station. At about 1141, the vessel settled on a course of approximately 030°T, heading toward the pilot station. At approximately 1148, the pilot realized that the whales were now abaft the port beam and, therefore, ordered 20° port helm (See Appendix A).

Because some passengers had not seen the whales, a discussion took place on the bridge between the master, the pilot and the cruise director; it was decided that the vessel would remain a little longer in the area. During this discussion, the vessel had continued to fall off to port.

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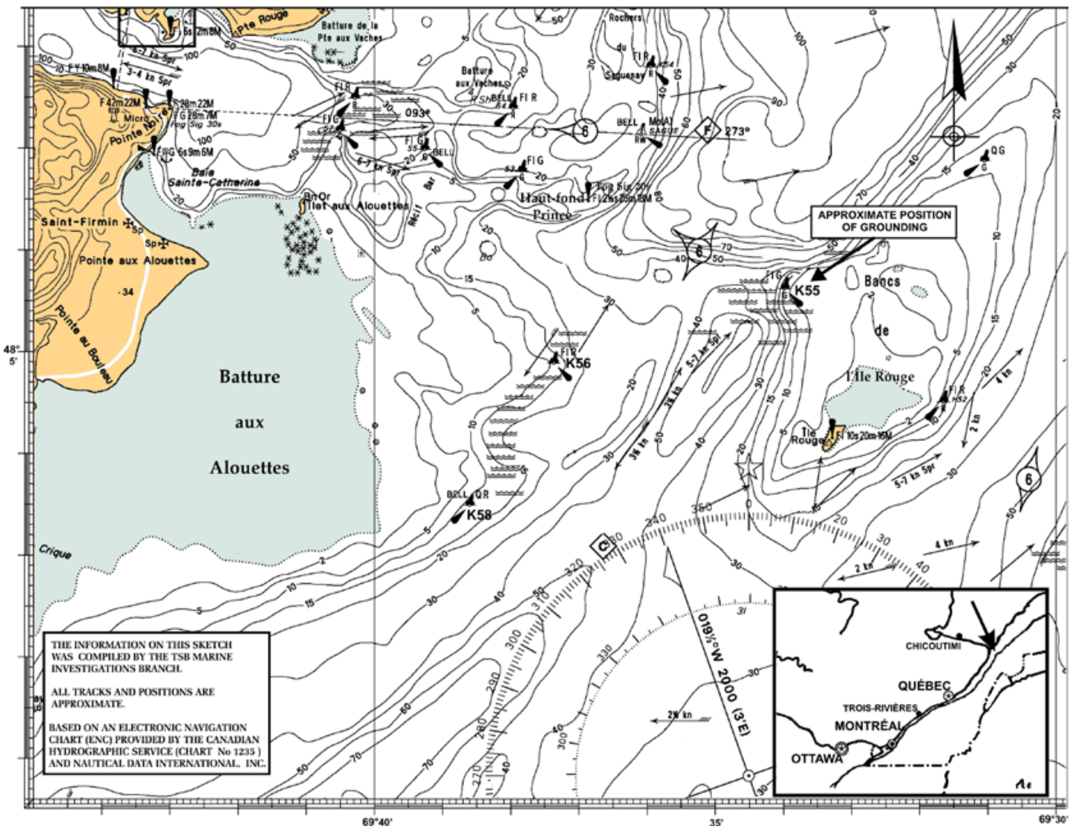
[3] All times are eastern daylight time (Coordinated Universal Time minus four hours) unless otherwise stated.



At 1154, the vessel was now headed toward the Saguenay River, stemming the tide and no longer making way. The master and the pilot agreed that there was sufficient time to turn the vessel round and still be on schedule at the pilot station. Since whales were now off the port quarter, the pilot decided to turn the vessel to port.

At 1156, the pitch of the propellers was increased and the vessel started to swing to port. There was no commercial traffic that could impede the *Norwegian Sky*'s passage in the area. The cadet continued to plot the vessel's position, while the pilot monitored the radar with the same variable-range marker setting.

At 1158, the vessel's heading continued to fall off to port and was now heading toward buoy K55. At 1200, the helm was turned to midship, and the propeller pitch setting was reduced from approximately half to one third. After plotting the noon position, the cadet informed the master that the vessel was nearing the shoal near buoy K55. When the master expressed concern that the vessel was coming too close to the shoal, the pilot assured the master that the situation was under control.

The pilot believed the vessel to be some four cables downriver of buoy K55 and the flood tide to be setting 210°T at some two to three knots. At 1202, the master increased the pitch on the starboard propeller from 31% to 48%, and the rate of turn to port gradually increased.

At 1203, the pilot asked the master to increase speed and ordered the helm hard-a-port. The master advised him that hard-over helm would swing the stern out and that less helm action was recommended. As a result, an exchange took place concerning the helm and the speed but the helm was kept at hard-a-port.

By 1204, with the heading about 076°G and decreasing, the rate of turn had increased to 47.1° per minute. The vessel's stern made bottom contact with the shoal. The vessel slowed and the stern came to rest on the Bancs de l'île Rouge. At 1206, the vessel was aground, listing 5.2° to port, heading 074°G, in position 48°05.8' N, 069°33.5' W. The electronic chart system (ECS) showed a speed of zero knots at 1206.52 (See Appendix B).

1.2.1 Events Following the Grounding

Emergency procedures were initiated before the vessel fully came to rest. At 1205, the 8–12 OOW activated controls to close the watertight doors and splash doors.[4] The staff captain and the chief officer, who felt the impact, rushed to the bridge to assist the master. At 1207, following the master's orders, the 12–4 OOW broadcast the emergency call, code delta[5] "D", on the public announcement system. At 1208, the general alarm was sounded on the ship's whistle. Then, on

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[4] A splash door is similar in construction to a watertight door but only retards the flow of water from one compartment to another.

[5] *Code delta* is the company's code to indicate to the crew a "damage stability" emergency procedure.

the public announcement system, the master ordered passengers to go to their assembly stations and crew to provide assistance. Meanwhile, the pilot reported the grounding to MCTS Les Escoumins.

Navigation personnel followed the Norwegian Cruise Line Contingency and Crisis Plan. The port and starboard lifeboats were reported ready for embarkation at 1219 and 1228, respectively. Tank and void space soundings were taken. An ingress of water was found in three compartments. At 1242, the master apprised MCTS Les Escoumins of the situation and was advised that tug assistance had been sought. The Canadian Coast Guard Ship (CCGS) *Isle Rouge* was requested to push on the starboard quarter to counteract the force exerted by the flood tide.

After determining that it was safe to refloat the vessel on the rising tide, ballast was redistributed. With the assistance of the tug *Techno Venture* and the CCGS *Isle Rouge*, the *Norwegian Sky* was refloated, some three hours after grounding, at 1515.

At approximately 1240 on 25 September, the *Norwegian Sky* weighed anchor, bound for dry dock at the port of Québec.

1.3 Search and Rescue Operations

1.3.1 Marine Rescue Sub-Centre Operations

After reporting the grounding to MCTS Les Escoumins, the Marine Rescue Sub-Centre (MRSC) set in motion its search and rescue (SAR) operations at 1208. The CCGS *Isle Rouge* was promptly tasked and arrived on scene. Depth soundings were taken in the area of the grounding. The *Norwegian Sky*'s starboard side was firmly aground. At 1237, the two Pointe Noire / Tadoussac ferries and the three Les Escoumins pilot boats were placed on standby in case passengers were to be evacuated. At 1242, the master appraised MCTS Les Escoumins of the situation and was advised that tug assistance had been sought.

A total of two Canadian Coast Guard (CCG) surface craft, three aircraft, two ferries, one commercial vessel, one tug, two service boats, and seven excursion boats were placed on standby for a rescue operation.

Once the vessel was refloated, the crew informed the MRSC in Québec that evacuation was no longer necessary. At 1541, the standby rescue craft were stood down. Subsequently, the *Norwegian Sky* proceeded across the river and anchored off Île aux Basques anchorage. The CCGS *Tracy* was tasked and stood by the passenger vessel during damage assessment.

1.3.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	-	-	-	-
Missing	-	-	-	-
Serious	-	-	-	-
Minor/None	787	1923	2	2712
Total	787	1923	2	2712

1.4 Damage to the Environment

Two perforated fuel oil tanks had been emptied before the grounding. Nevertheless, at 1635, approximately one hour after refloating the vessel, the pollution patrol aircraft GC 300 observed pollution. The quantity released was deemed minor.

1.5 Bridge Team Certification and Experience

1.5.1 Navigation Personnel

The manufacturer of the vessel's integrated navigation system (INS) had classroom and simulator training available to purchasers. Some cruise lines, including Norwegian Cruise Line, had sent its complement of officers to attend an awareness training session. There are no procedures to determine the proficiency of officers who operate the automated navigation system.

The master held a Master Mariner Certificate of Competency issued by the Bahamas in 1997, and a Master Deck Officer Class 1 Certificate of Competency issued by Norway in 1971. He had some 41 years' sea service, which included serving as master since 1972. He had taken command of the *Norwegian Sky* on 01 July 1999. As part of his continued proficiency training, in 1999 he had taken an INS course that included an overview of electronic chart system (ECS) equipment.[6]

The first officer (the 8–12 OOW who had remained on duty after the end of his watch until the time of the occurrence) held a Deck Officer Class 4 Certificate of Competency issued by Norway in 1995 and an equivalent certificate issued by the Bahamas in 1997. He had some 8 years' sea service and, in 1998, had begun serving as OOW. As part of his continued proficiency training, in 1999, he took an INS course that included an overview of ECS equipment.

The quartermaster on duty held a Deck Watch Navigation Certificate of Competency issued by the Philippines in 1998. He had some three years' sea service, some of which was acquired on board the passenger vessel *Norway*.

The cadet on duty had attended a maritime academy. He had acquired experience since 1998 on fishing vessels and ferries.

1.5.2 Pilot on Duty

The pilot on duty at the time of the occurrence held a First Mate Home Trade Certificate of Competency issued by Canada in 1962. He also held a Class A Pilot Licence issued by the LPA in 1975. He had some 41 years' service, of which some 32 years was acquired as a licensed pilot.

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[6] INS training enables an incumbent to better understand how different navigation systems work and interact with each other.

As part of his continued proficiency training, in 1987 and in 1994, he received ship-handling training in France. However, the pilot had not acquired ship-handling expertise for vessels like the *Norwegian Sky*. It was not until 1996 that the training facility, where the pilot attended his training, added a model ship fitted with a flap-rudder reproducing ship-handling characteristics similar to the *Norwegian Sky*. Under the pilotage services contract between the LPA and the Corporation des pilotes du Bas Saint-Laurent,[7] Class A pilots are required to acquire ship-handling training at an LPA-approved training centre, and adhere to a continued proficiency training program.

1.6 Weather, Current, and Geographical Information

1.6.1 Weather

Visibility was clear, with partly cloudy skies and northwest winds at some 13 knots. The air temperature was 15°C. The SAR vessel CCGS *Isle Rouge* recorded a water temperature of 5°C.

1.6.2 Current

Tidal information for the area at the mouth of the Saguenay River on the St. Lawrence River is contained in the *Canadian Tide and Current Tables*, volume 3. Tidal differences are referenced to the port of Pointe-au-Père and the secondary port of Île Verte. On 24 September 2002, low water was predicted at 0904, with a height of 0.7 m above chart datum, and high water at 1505, with a height of 3.7 m above chart datum. The current was flooding at the time of the occurrence.

According to the Fisheries and Oceans Canada publication, *Atlas of Tidal Currents*, two to three hours before high tide at Pointe-au-Père, the current vector on the northern edge of the Bancs de l'île Rouge indicates a speed of one knot and a direction of approximately 180°T. Those parameters are based on average weather conditions. Nevertheless, when the water level reading recorded by the Rimouski-Est tide gauge was extrapolated to Tadoussac, it was found to be 0.36 m above the tide prediction. Researchers at the Maurice-Lamontagne Institute (Marine Sciences Research Centre) indicated that this water level increase might have augmented the intensity of the tide off the Bancs de l'île Rouge.

1.6.3 Geographical Information

The Saguenay–St. Lawrence Marine Park is committed to the protection and development of marine resources and covers the northern half of the St. Lawrence estuary. It stretches from Les Escoumins wharf to Gros Cap à l'Aigle.[8]

From May to October each year, there is a large concentration of cetaceans in the area, especially between Grandes Bergeronnes and Tadoussac. Whale-watching is not always carried out in the same zones, because whales migrate to different feeding zones in the park. Three zones have been identified as having a greater concentration of marine mammals: Zone No. 1, off Île Rouge; Zone No. 2, off Pointe à la Carriole; and Zone No. 3, off Grandes Bergeronnes.

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7 The Québec–Les Escoumins Pilot Corporation.

8 Canadian Hydrographic Service, *Sailing Directions: St. Lawrence River / Île Verte to Québec*, 1999 (ATL111E).

To harmonize all marine mammal-watching activities in accordance with existing regulations, government departments and industry developed a code of ethics to set rules of conduct that apply to all commercial and recreational air- and water-borne craft. The code limits how closely the mammals may be approached.

The Bancs de l'île Rouge form an extensive shoal area lying in the middle of the St. Lawrence River. This obstruction divides the river into two channels: north and south. Île Rouge, with an elevation of 5.2 m, is the summit of the banks of the same name. The low and sandy island has a lighthouse, two towers, and a few buildings. The approximate layout of the west and northwest banks off Île Rouge lie respectively along position lines 190°-010° and 240°-060°. Aids to navigation were not reported out of position in the Île Rouge sector. Buoys K55 and K51 indicate, respectively, the northwest and northeast extremities of the Bancs de l'île Rouge. Pointe Noire leading lights serve as a guide to vessels proceeding in the channel at the mouth of the Saguenay River.

1.7 Vessel Information

1.7.1 Certification

The *Norwegian Sky* was crewed, certified, and equipped in accordance with existing regulations. Although the complement of Norwegian officers and international service staff exceeded the 750-person complement capacity, the total number of persons aboard did not exceed the vessel's overall capacity of 3150 persons.

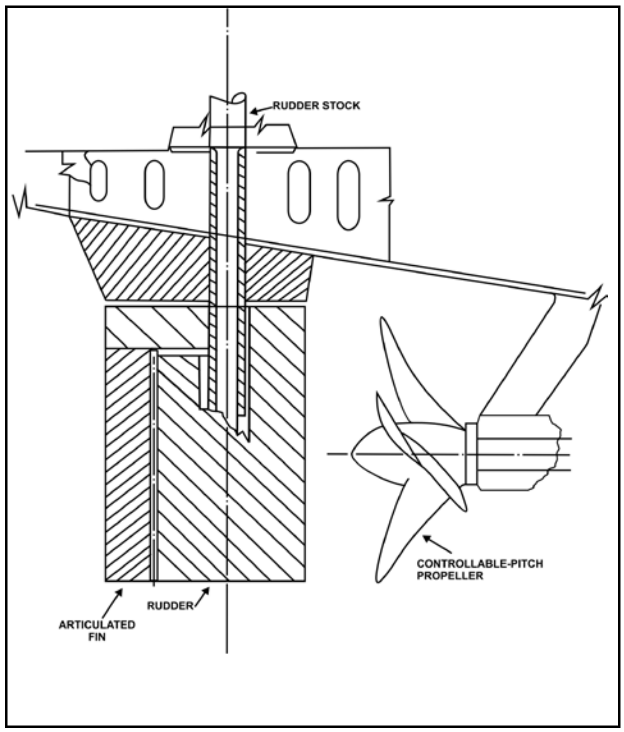
1.7.2 Damage

While aground, an ingress of water was discovered in the afterpeak and in two double-bottom fuel oil tanks located midships. The starboard propeller was reported non-operational. After refloating the vessel, an underwater survey revealed damage to the starboard rudder and bottom plating. As a result, classification society and Transport Canada inspectors determined that the vessel had to be repaired before it could continue its voyage.

At the dry dock in the port of Québec, the vessel was observed to have sustained extensive damage to the starboard rudder, both propellers, stern thruster No. 1, and the shell plating and adjacent internal structures. The starboard propeller hub was found to have sheared into two parts, and a void space in the bulbous bow section was also holed.

All damaged parts were replaced, and shell plating that sustained indentations more than 10 mm deep was cropped and renewed to restore the vessel to its original condition. As a result, the Certificate of Class remained valid without restrictions.

1.7.3 Rudders Fitted with an Articulated Flap



Unlike the steering and propulsion system of a conventional vessel, which has a single rudder and a single propeller, the *Norwegian Sky* is equipped with a twin-rudder and twin-propeller system. To further enhance manoeuvrability of the vessel, the rudders are Becker design, semi-balanced, underhung units that incorporate a vertical, articulated flap in the after part of the rudder. When the helm is put over, the main rudder can be set at any angle up to 35°(at sea) or 45°(in harbour). As the main rudder rotates, the flap automatically articulates in the same direction, thereby increasing the maximum rudder angle.

1.7.4 Ship Handling

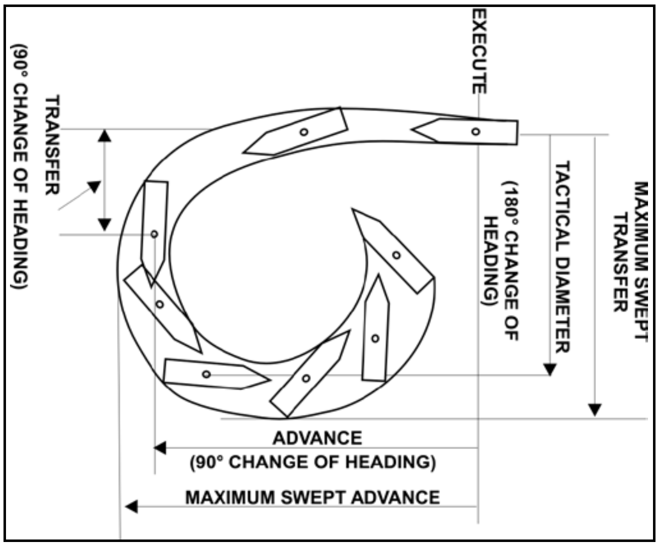
When the pilots boarded the vessel, they were handed an extract of the *Deck Procedures Manual,* which included details of the ship and its propulsion, a navigation equipment checklist, the departure draught, and tidal information. The manual did not contain helm procedures for proceeding at speed in a restricted waterway.

The turning circle of a ship is described by four numerical measures: advance (90°), transfer (90°), tactical diameter (180°), and diameter of turning (360°).[9] Although these parameters may offer suitable measures to use in developing criteria and standards for different ships, they give

9 The initial course followed by a vessel is 000°.

little information on how much space a ship requires. The swept path is most useful for ship handlers when estimating potential clearance with waterways, other vessels, and obstructions. The maximum swept advance and swept transfer are greater than the ordinary advance and transfer.[10]

A pilot card was posted on the after bulkhead of the wheelhouse, behind the central integrated bridge system (IBS) workstations. The card indicated the use of hard-over helm at 35° and 45° for sea and harbour applications, respectively, and showed a swept-path diagram. However, the information was limited to the turning circle data and did not contain swept advance and transfer data with corresponding helm angles.



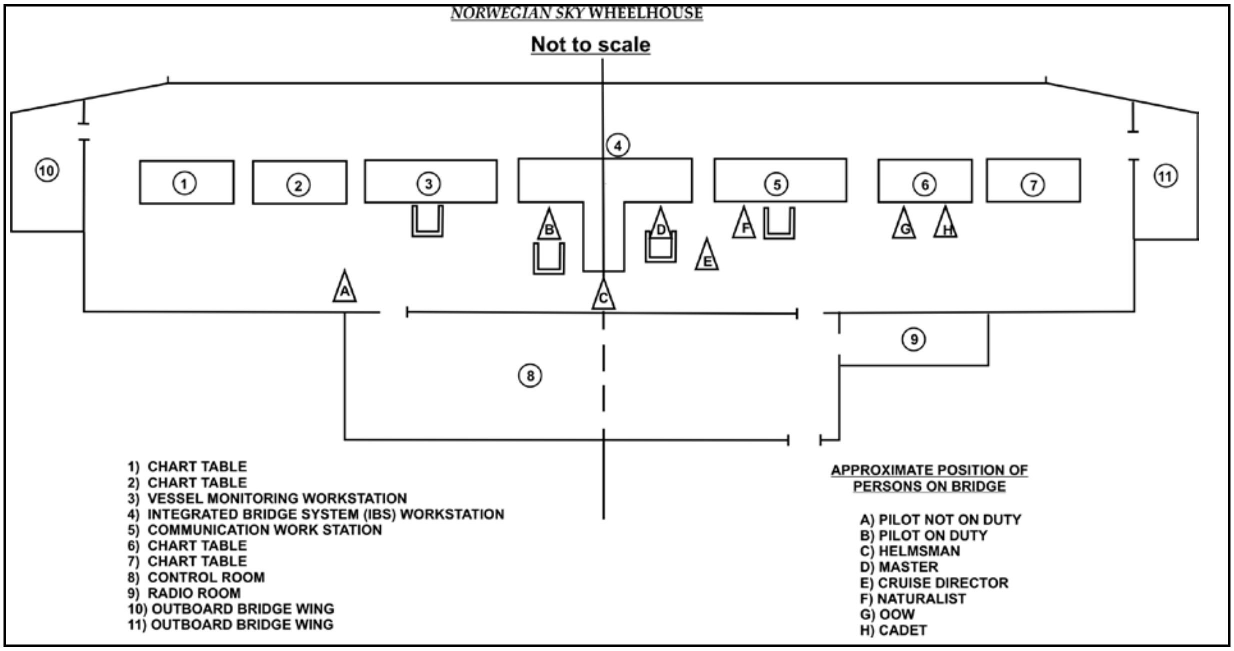
Based on their experience, acquired during sea trials of the *Norwegian Sky*, navigation personnel advised the pilots that 20° helm action was equivalent to hard-over helm and that 1° or 2° was sufficient helm action for most course alterations. Moreover, the master discouraged the use of hard-over helm.

1.8 Bridge Layout and Navigation Equipment

1.8.1 Visibility from the Bridge

Like most modern cruise liners, the *Norwegian Sky*'s wheelhouse is forward of the accommodation but a few decks below the uppermost deck. The navigation bridge is on the tenth deck above the waterline, at an elevation of 34.7 m. Panoramic windows give exceptional forward visibility but, from the central navigation workstation, the field of vision abaft the beam is limited.

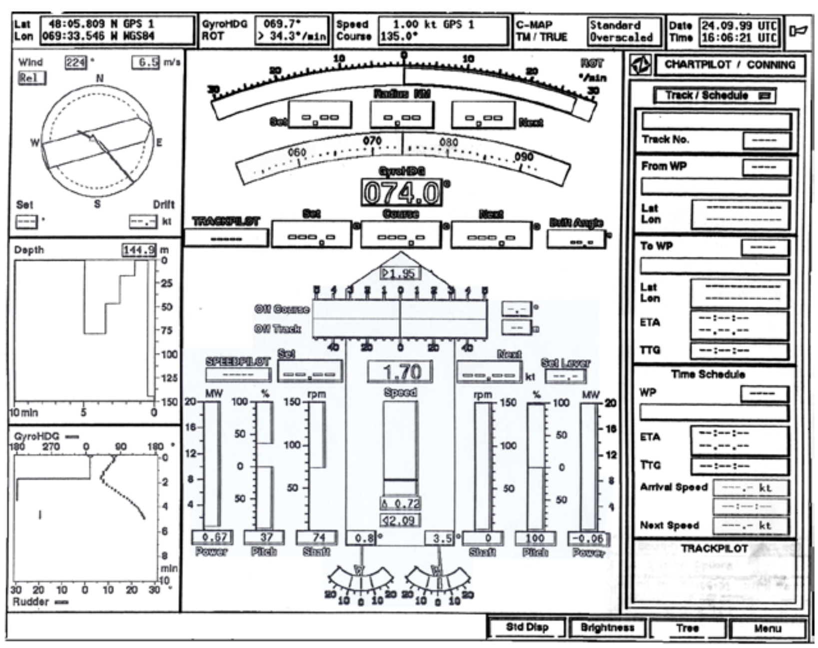
[10] Thomas G. Knierim, "Maneuvring Information for the Pilot/Navigator: Its Source, Value, and Limitations," in *Marine Technology*, vol. 31, 02 April 1994, 123-144.



1.8.2 Integrated Bridge System

On the bridge, on each side of the central navigation and manoeuvring workstation, is a communication workstation and a vessel monitoring workstation. On each side, outboard of these consoles is a chart table, and outboard again are the bridge wings.

ISO Standard 8468 covers ship bridge design and layout. An IBS enables the master and the pilot to monitor a radar and an ECS screen at the central navigation console.



The master and the pilot occupied, respectively, the starboard and the port station at the IBS central workstation. For the most part, the master sat and the pilot stood. The OOW and the cadet used the inner starboard chart table for paper chart-plotting. The workstations are designed as an IBS unit.

1.8.3 Integrated Navigation System

The central workstation display includes a radar and an ECS screen at each of the two work positions. Between these four screens is a conning information screen, with mimic presentation of all important conning, manoeuvring, and navigation information. Main engine controls are found on the centre counter between the two work positions.

The INS enables a full range of navigation planning, steering, and collision-avoidance procedures to be carried out while also displaying own-ship reference to a geographical representation.

The vessel's NACOS[11] INS includes:

- three radar sets fitted with automatic radar-plotting aid capabilities,
- speedpilot and speed log control units,[12]
- a helm autopilot,
- two gyrocompasses,
- a depth sounder and graph,
- a direction finder,
- a Loran C,
- a global marine distress and safety system (GMDSS), including INMARSAT B and C communication equipment,

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[11] Atlas NACOS (NAvigation and COmmand System).

[12] The Speedpilot is a component that sets automatically the speed according to a predefined ETA or alternately to maintain a constant speed. The speed log system has a display and control unit, and measures the speed over ground and/or through the water in both longitudinal and transverse directions.

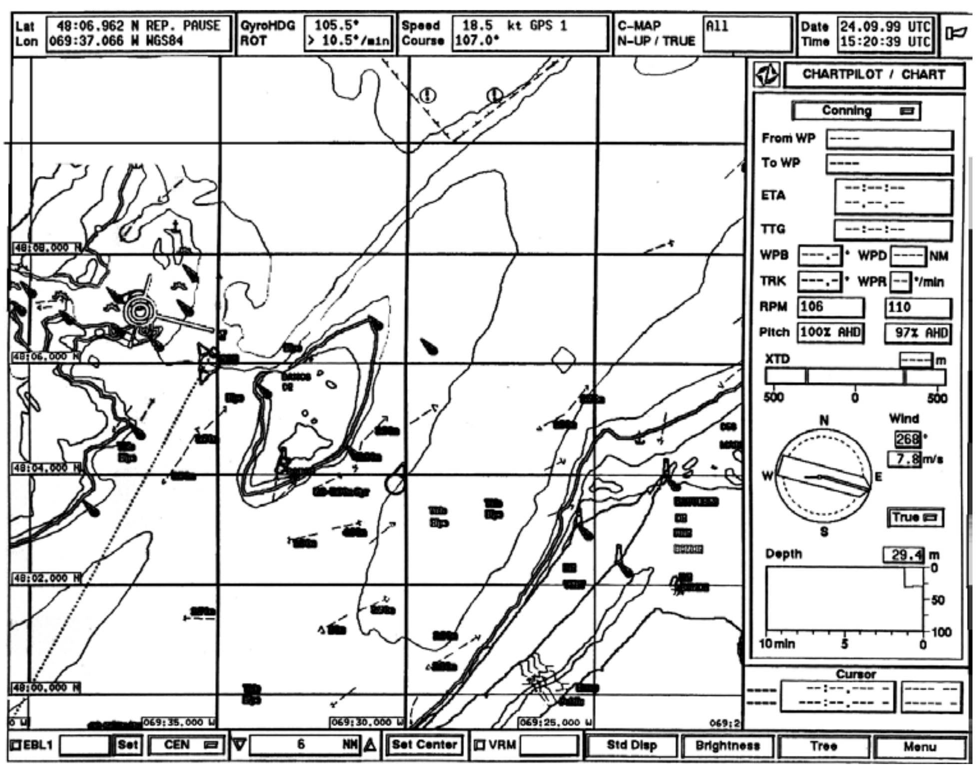
- an ECS linked to a differential global positioning system (DGPS)[13],
- monitors, linked to the INS, at the navigation console, the bridge wings, and the operations room abaft the wheelhouse.

Gyrocompass error was deemed negligible. No equipment malfunction was reported.

Abaft the wheelhouse are a control room and a radio room. Among other equipment in the control room are an automatic stability calculator linked to compartment and tank level sensors, various alarms systems, and an integrated video system.

1.8.4 Electronic Chart System

The ECS on board was an ECDIS nautical planning and consulting station.[14] This system enables the navigator to define and select a number of inclusion and exclusion zones, in which the computer will initiate automatic specific target tracking on the vector chart while defining channel limits and reducing operator workload. Important video and audio alarm signals can be selected to indicate if the vessel leaves these predetermined parameters. These alarms are easily recognized, even if the navigator is some distance away from the display. The radar image can be superimposed onto the ECS display.



1.8.5 Radars

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[13] At the time of the occurrence, the signal of the global positioning system was found to give optimum performance by not selecting the differential mode option.

[14] The system was pending Electronic Chart Display and Information System (ECDIS) type approval.

In addition to providing standard radar functions, each work station monitor is linked through the integrated radar display system. The pilots found that some buoys were difficult to detect on radar. Variable-range marker error was deemed negligible.

1.9 Bridge Resource Management

The essence of bridge resource management (BRM) is effective utilization of all available human and physical resources to ensure safe operation. BRM addresses the management of attention, operational tasks, stress, attitudes, and risk. Optimizing the management of these elements has a direct effect on factors critical to the successful outcome of any operation.

1.9.1 Managing the Bridge Team

Two interdependent teams were working on the bridge at the time of the occurrence. The helmsman worked closely with the pilot, who conducted the vessel under the master's supervision. The OOW and the cadet determined the vessel's position by chart work and updated the master. The chief officer, who was the most proficient user of ECS on board, was not on duty at the time of the occurrence. At 1156, after agreeing to extend the period of whale- watching, the bridge team did not alter its method of seeking and sharing navigational information.

The pilots alternated their shifts while on board. Pilot No. 1 had conduct of the vessel upon departure at 0030 until 0655, and pilot No. 2 from 0655 until the occurrence. Pilot No. 1 had returned to the wheelhouse at the time of the grounding, but he did not assist the pilot (No. 2) on duty. During assignments on cruise liners, pilots take turns conducting the vessel. There is no procedure or contract requirement that calls for both pilots to be on active duty during whale-watching. In this region, the requirement for two pilots to conduct a vessel simultaneously is found only on tankers of 40 000 tonnes deadweight or more.

1.9.2 Managing the Navigation Equipment

Each member of the bridge team had access to an IBS workstation and, as such, to the INS. Only navigation personnel used the integrated radar system; the pilot used a radar display that was independent of the integrated system used by the crew.

The OOW and the cadet continued to follow on-board navigation practice, which called for frequent manual plotting to determine the vessel's position. The last position was plotted on the chart at 1200. The pilot's primary source of information was the radar using a "north-up" presentation. Targeting the Haut-fond Prince lighthouse as a radar cue, the variable-range marker set at 2 nm indicated the safe distance off the Bancs de l'île Rouge which are 2.1 nm from Haut-fond Prince. Neither navigation personnel nor the pilot applied the parallel indexing technique, using electronic bearing lines to assess the vessel's movement and position.

The ECS was in operation for all bridge team members to use, but the team only glanced at the monitors. The system was equipped with the most recent electronic navigation vector charts issued by the distributor, CMAP, in 1999. The pilots did, temporarily, overlay the radar presentation on the ECS presentation but found discrepancies in shoreline features and reverted back to single radar presentation using "north-up" presentation. Although standards have been developed for the ECDIS , carriage of this equipment was (and still is) not mandatory. Training standards for use of the equipment have also been developed, but training is not readily available.

The DGPS receiver was set on the global positioning system (GPS) mode because navigation personnel found the positioning to be sufficiently accurate. The instrument on board is designed to select GPS by default unless specifically programmed to select DGPS mode. Navigation personnel were not aware of the high level of precision offered by DGPS reception in the area.

1.10 Communication

1.10.1 Ongoing Discussions

Throughout the voyage, there had been ongoing discussions between pilot No. 1 and the staff captain and between pilot No. 2 and the master about navigation of the vessel. The senior staff shared with the two pilots their sea trial experience concerning the steering characteristics of the vessel. No communication, however, occurred between the pilot, the OOW, and the cadet.

1.10.2 Communication on the Decisions Taken

During the voyage, navigation personnel were required to take action on several shipboard operations. Several times, this action required an exchange of information with the pilots on board, who had local expertise. Some of the key decisions made before the grounding were:

- At the beginning of the voyage, senior staff and the pilots agreed to carry out a whale-watching activity.
- At approximately 1153, the cruise director requested that time allocated to whale-watching be prolonged. It was decided to prolong this activity and not to proceed toward the pilot station.
- At approximately 1201, after being informed by the cadet that the vessel was nearing Île Rouge, the master communicated his concern to the pilot. Given the response of the pilot, the master took for granted that all was under control and the turnaround manoeuvre was continued.
- According to the navigation personnel, at approximately 1203, the pilot ordered the helmsman to put the wheel hard-a-port. The master advised otherwise. The pilot repeated the order, and it was carried out.

1.11 Whale-Watching

In the LPA district between Québec and Les Escoumins, Class A pilots are assigned the conduct of approximately 100 vessels per year, but few assignments are related to a large passenger vessel. In 1999, 17 passenger vessels made 55 transits between the port of Québec and Les

Escoumins pilot station. In this pilotage district, a minimum of two licensed pilots is required on board passenger vessels longer than 100 m. A Class A pilot will thus be assigned an average of two such vessels per year.

Passenger vessels in the St. Lawrence River often undertake some whale-watching. Out of 16 assignments the naturalist carried out in 1999, 14 resulted in whale-watching. It is a featured attraction, normally lasting about one hour. Reportedly, few of these result in a turnaround manoeuvre to prolong the activity. This type of activity has taken place for the past 20 years and has increased, with the flourishing passenger vessel industry, in the past 10 years. Since 1980, the international cruise liner industry has increased at an annual rate of 4.7 per cent on the St. Lawrence River.[15]

The pilots discussed the voyage schedule with the crew. As requested by the navigation personnel, they planned to engage in whale-watching before proceeding toward the pilot station, but the plan did not include a turnaround manoeuvre. Whale-watching, with its requirement to manoeuvre, is at the master's discretion.

The core activity of the Corporation des pilotes du Bas Saint-Laurent (the pilot corporation) is to provide a pilotage service and administration of revenues. The LPA is responsible for the safe operation of pilotage in its jurisdiction, continued proficiency training, and pilotage duties. Neither the LPA nor the pilot corporation had specifically addressed whale-watching before the occurrence. As such, visual and radar marks had not been planned or identified prior by the pilots for this type of manoeuvre.

1.12 Double Pilotage

In December 1991, the LPA published its proposal to impose double pilotage on passenger ships in districts 1 and 2 of its region. Objections to the proposal by Canadian shipowners led to a September 1992 memorandum of understanding between the LPA and the Canadian Shipowners Association (CSA) whereby, among other topics, the question of double pilotage would be examined by appointed officials. In 1992, LPA/CSA concluded that double pilotage for passenger vessels should be adopted and, in 1993, the LPA set the requirement in place.

Paragraph 35 of the LPA regulations stipulates that, for District 2, two pilots are to be assigned to the following vessels:

- ships that are likely to be under way for more than 11 consecutive hours in that district;
- ships of 74 999 tons deadweight or more;
- tankers of 40 000 tonnes deadweight or more;
- passenger ships longer than 100 m; and
- ships during winter navigation.

For long assignments (more than 11 consecutive hours), each pilot will work a mutually agreed duration and will then be relieved by the other pilot. For large deadweight vessels, tankers, and passenger vessels, each pilot works alternately for most of the voyage, and a team approach is adopted for passage of hazardous, higher-risk areas. However, there are no written guidelines or work procedures that specify when or where two pilots should work as a team. Although passenger vessel assignments are rarely more than 11 consecutive hours, pilots on these vessels work alternately and do not usually adopt a team approach for hazardous areas.

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[15] Nicolas Tremblay, *Ces palaces venus d'ailleurs*, Entreprendre, 1997.

In August 1998, the Minister of Transport requested that the Canadian Transportation Agency (CTA) carry out a comprehensive examination of pilotage matters to further safety, efficiency, and viability of the Canadian pilotage system. A review was undertaken, and its 21 recommendations were published in September 1999. According to the review panel, there was no indication that the 1992 examination had performed a risk-based analysis to substantiate its conclusions concerning two pilots for passenger vessels.

2.0 Analysis

The marine industry continues to be concerned with problems involving the effectiveness of bridge teams in pilotage waters. The International Maritime Organization (IMO) put forward measures that will lead to higher training standards and greater safety. One such measure was BRM training and implementation. Occurrences involving vessels operating in pilotage waters continue to draw the attention of the Board. The analysis of what happened in this occurrence, and why, is presented within the framework of group dynamics, issues related to shipboard navigational operations, technological advance, and pilotage.

2.1 Group Dynamics

The *Norwegian Sky* is equipped with state-of-the-art navigation equipment. From the start of the voyage, an ongoing exchange of information was established among the navigation personnel and between senior staff and the pilots. Centralized bridge functions of the IBS on board the *Norwegian Sky* were conducive to this open and ongoing information exchange.

The excellent rapport between navigation personnel and the pilots during the voyage downriver pointed to a good working atmosphere. During their voyage briefing, the pilots were informed by senior staff that they wished to carry out whale-watching, at the discretion of the master. All agreed that it was feasible, given the fact that cruise liners regularly carry out whale-watching activities on the St. Lawrence River. A good example was the use of limited helm off Cap Trinité. Given the characteristics of the rudder, the master advised the pilot to use a small angle of helm to execute the turn before heading back down the Saguenay River. The pilot readily accepted the recommendation.

The open exchange of information continued when the cruise director requested that the period of whale-watching be extended. The decision to execute the manoeuvre was made jointly by the master and the pilot, based on the facts that it would not interfere with the vessel's schedule and that it would lead to passenger satisfaction. At this point, information was shared among key decision makers, but it was limited to the schedule of the vessel. In so doing, one of the key elements essential for making this decision—that the turn could be completed safely—remained unaddressed.

During the turnaround manoeuvre, the pilot transmitted orders to the helmsman and, unless specifically advised by the pilot to select a vessel speed, the master controlled engine speed and pitch levers. There appears to have been an implied agreement between the master and the pilot as to their respective actions. However, contrary to normal bridge practice, engine movements executed by the master were not communicated to the bridge team. Consequently, communication on the bridge was incomplete: all pertinent information that could affect navigation was not shared.

When the cadet informed the master that the vessel was nearing the banks off Île Rouge, the information raised concern among team members. The master shared this concern with the pilot, who assured the master that all was under control. However, the exchange of information was elementary, and conflict resolution mechanisms were not used.

The pilot concentrated his attention on navigating by radar. Throughout this tense period, the pilot does not remember having a detailed conversation with the master. Such being the case, the pilot more likely acknowledged the request of the master without giving it the importance required and turned a deaf ear to the information concerning the manoeuvring characteristics transmitted to him.

The pilot took it upon himself to assess the situation and complete the turn, based on his assessment. Although he could not confirm the exact position of the vessel relative to the banks, the pilot insisted on maintaining hard-a-port helm. When the pilot elected not to take the advice of the master, who knew the ship's handling characteristics best, the master did not countermand the pilot's order of hard-a-port helm.

The good group dynamics that were present during the routine voyage down river gradually degraded after the vessel deviated from its planned route. Reduction in the team's cohesiveness coincided with the development of a rapidly deteriorating situation.

Technical skills acquired by bridge team members could have efficiently complemented each other. The pilot had gained local knowledge through a long career on the river. Navigation personnel had acquired a good understanding of the ship's handling characteristics during sea trials and had attended an INS awareness course on working with and operating the navigation equipment.

With increasing use of INS in an IBS environment, sufficient training and experience is necessary to take full advantage of this new technology. It takes time to effectively apply such technology on vessels. Until training to provide an adequate level of proficiency is in place, full participation from all team members on ships may be difficult to attain.

By law, pilots are technical advisors to a ship's personnel in most maritime countries, although ship's personnel generally consider pilots to be in total control of the vessel. As a result, a bridge team hierarchy can develop where the pilot is perceived to have greater authority than the master, who is, in fact, in command of the vessel. Historically, pilots have not shared navigational or manoeuvring information with ship's personnel, nor have they been accustomed to receiving advice from the ship's complement. These factors tend to degrade team cohesiveness and undermine the concept of BRM. Therefore, when the pilot insisted on using hard-over helm, navigation personnel (who were accustomed to executing the orders of the pilot) readily acquiesced and elected to follow the order.

Formalized BRM is being implemented successfully on ships. Training focuses on bridge team-building and communication. During normal operations, the bridge team applying BRM is dynamic: navigation officers and pilots share the work and provide checks and balances. However, training of navigation officers and pilots is usually conducted separately. As a result, bridge teams may not function as effectively when in the presence of a pilot, and a pilot may experience difficulties integrating with the bridge team. The effect of this lack of integration may not manifest itself until times of increased stress, such as during an emergency situation.

The ability of this team to work together was not put to the test until the cadet brought to the attention of the master the fact that the vessel was rapidly approaching the shoal—the start of a developing emergency situation. As the situation deteriorated, the team acquiesced to the pilot, breaking down the team's cohesiveness and effectively converting the team to a single-person operation. Recognizing this shortcoming, some marine training institutions engage the services of a pilot to better simulate reality and highlight the dynamics or interaction in the relationship between a pilot and a ship's navigation personnel.

2.2 Shipboard Navigational Operations

2.2.1 Factors Influencing Decision Making

Passenger vessels commonly extend whale-watching activities. However, this change often involves some level of improvisation on the part of the bridge team, and improvisation increases risk.

At approximately 1153, when the request was made to extend whale-watching activities, the weather was clear. The St. Lawrence River is very wide at the mouth of the Saguenay River, giving rise to a false perspective of a large manoeuvring space. The north shore was visible some five nm away, and Île Rouge and the Haut-fond Prince lighthouse were more than 2 nm off. These distances, together with the vessel's exceptional manoeuvring capabilities, might have provided a false sense of security to the bridge team and could account for the minimal planning of the manoeuvre. Although the shoal water between the vessel and Île Rouge was close (approximately six cables) when the decision was made to extend whale-watching, there was sufficient room for the turnaround manoeuvre to be completed safely.

Positioned north of the Bancs de l'île Rouge at 1153, the *Norwegian Sky* was barely making way as it lay across the southerly setting flood tide. At a drift speed of two knots, the current would drive the vessel ashore in about 18 minutes. Because the vessel was about to turn in the same direction as the current, the effect of the current was amplified. In situations where there is an increased risk, the navigation team must rely on close monitoring of the vessel's progress using all available means.

2.2.2 Limitations of the Navigation Practices Used

The pilot initially observed the radar target of Haut-fond Prince light on the inside edge of the two nm range ring. This cue permitted the vessel to clear the western edge of the Bancs de l'île Rouge at buoy K55. The selected method had only a one-dimension accuracy because it did not provide information as to the vessel's drift on the north-south axis. The ECS revealed that the vessel did progress southwardly beyond the two nm limit and, eventually, southeast onto the shoal. The OOW and the cadet, who plotted the vessel's position by radar, placed their last noon position some 3.8 cables off the northwest edge of the Bancs de l'île Rouge. Although valuable under normal circumstances, position plotting provides historical information only. Because the vessel did not maintain a constant heading throughout the manoeuvre, this technique did not allow for an accurate projection of the vessel's position beyond 1200.

The master used visual observation as a primary source of information. Since the Pointe Noire beacons could not be seen at noon from the central workstation, buoys K51 and K55 became the most prominent navigation aids forward of the beam. As the imaginary line between the two buoys got closer, the limit of approach to the shoal became more difficult to visualize and thus determine. At this time, the pilot estimated the vessel to be four cables downriver of buoy K55. The vessel, however, was only some 2.5 cables off the buoy. In other words, the pilot underestimated the manoeuvring room required to carry out the contemplated turnaround manoeuvre using helm only. By deviating from the normal route, the pilots were no longer using their usual courses to navigate. Notwithstanding the fact that they had a thorough knowledge of the marine topography of the St. Lawrence river, they no longer had the same level of preplanned cues essential to orient themselves and to maintain an equivalent level of security as that required on the normal route.

2.2.3 Technological Changes

The marine industry is undergoing an evolution in automation similar to other transportation industries. New technology affects not only bridge equipment and layout but also shipboard operation. For navigation to be conducted safely, the sheer volume and diversity of information on a bridge must be effectively managed. Automation, adequately designed and used by properly trained personnel, has the potential to improve operational efficiency and safety.[16]

2.2.4 Radar Techniques

Although manual position plotting is an adequate means to maintain situational awareness when navigating in coastal waters, it does not offer real-time position information when proceeding in a restricted waterway. No matter how frequent or how fast the plotting is carried out, collated information will be historical. Using this method, a vessel's progress can only be estimated, particularly when the vessel is constantly changing heading.

Various techniques that could have provided a better appreciation of the vessel's movement were available to the bridge team, including the use of true motion and parallel indexing techniques. These techniques provide real-time position of the vessel in relation to identified hazards depicted on the radar screen and could have been used to complement conventional position plotting. For example, electronic bearing lines could have indicated a safe distance off the Bancs de l'île Rouge. In restricted waterways, where prompt and effective action is essential to address the dynamic nature of navigation, use of advanced radar techniques would enhance the navigator's ability to better maintain situational awareness.

2.2.5 Effective Use of Resources

The *Norwegian Sky* had proceeded efficiently and safely toward the pilot station while the pilots put into practice the voyage plan they had learned and perfected throughout their careers. Deterioration in the cohesiveness of the team coincided with the rapidly developing emergency as the vessel deviated from the plan.

When the master expressed concern to the pilot that the vessel was coming close to the shoal, he deduced that the situation was under control. Further, when the pilot ordered hard-a-port helm and an increase in engine speed, the master cautioned the pilot that hard-over helm would swing the vessel's stern further toward the shoal. However, the pilot insisted on hard-over helm. By now, the focus had shifted to the use of helm only, and other options, such as going astern on the starboard engine and/or using thrusters, were not used to extricate the vessel from the situation. Because ECS and radar were not used to advantage, decision-making team members were deprived of complete, real-time information that was essential to make an informed decision in a rapidly developing situation.

In summary, the bridge team did not use all available means to accurately determine the vessel's position and/or did not use information at its disposal to accurately assess the developing situation or the success of the manoeuvre. As a last-minute change from routine, the manoeuvre was improvised. Good watchkeeping practices (properly monitoring and cross-checking the progress of the vessel) were not adhered to, and situational awareness in the final stages of the manoeuvre was lost.

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[16] "Integrating Computers into Navigation Control," *International Maritime Technology,* December 1994.

2.2.6 Lack of INS Experience

To meet the functional requirements of modern navigation equipment, IBS and INS have been introduced to the maritime industry to respectively offer a centralized access to sources of navigation information and an interface between navigation components. New technology is developing rapidly but has not spread throughout the industry. As a result, bridge teams have limited experience on these systems and do not make optimal use of them.

Because navigation personnel had received INS training, they used the network radar system to share information. Position plotting carried out at the communication workstation could be observed by the master at the central workstation. The INS was also designed to allow a team member to work independently from the rest of the team. Because the workstations were equipped with two monitors, one could be used for radar and the other could represent the overlay. This would have permitted the pilot and the master to observe both presentations.

The interface between different navigation components made it possible to compare radar information with the ECS. However, the chart provider used non-official data to produce the electronic navigation chart (ENC) which was at variance with the CHS official chart data. Consequently, the radar presentation could not precisely match the ECS presentation of shoreline features. Nonetheless, when one was overlaid on the other, the position of the vessel relative to geographical information would have enhanced the pilot's and the master's ability to maintain situational awareness. In this occurrence, only the radar was used and the integrated radar system was not used to advantage.

The level of ECS monitoring and the level of INS use point to poor management of resources. There is a need to establish procedures or conventions to effectively monitor all automated navigation equipment. Connecting navigation equipment to a network will eventually facilitate teamwork among bridge team members, including pilots, particularly when all team members have acquired sufficient knowledge and experience to use the network system.

2.3Effectiveness of INS Training

IMO working committees have highlighted the close relationship between INS and IBS and have emphasized the need to examine this relationship thoroughly when considering development of new performance standards.

The crew and the pilot had received BRM training. Furthermore, the pilot had attended simulated electronic navigation (SEN) II training and, the master, an equivalent course. In this instance, neither the pilot nor the master elected to use the parallel indexing technique, generally used to monitor the vessel's progress in confined waters, to advantage. At the time of the investigation, training standards for ECDIS were being developed. Training received by the ship's navigation personnel was an overview of the ECDIS. Further, only one of the certificated officers on board (the chief officer, who was not on the bridge) had acquired an acceptable level of ECS proficiency.

The bridge layout and the navigation network system were conducive to good BRM practices. IBS fosters a close working relationship and teamwork. It also improves efficiency and coordination between all members of the bridge team, including the pilot. However, until all team members have acquired sufficient knowledge and experience, the full benefit of a network system cannot be achieved. BRM training is now offered to crews and pilots, but it is essential that new technology form an integral part of such training, for pilots or for ships' navigation officers.

2.4 Vessel Manoeuvrability

In recent years, a number of cruise liners were built with high manoeuvrability. The *Norwegian Sky* is no exception. The turning manoeuvre off Cap Trinité, using small angles of helm, gave the pilot an opportunity to appraise the exceptional steering characteristics of this vessel. Although the *Norwegian Sky* is considered highly manoeuvrable, it generates a substantial swept path when it turns. The greater the speed or helm angle, the greater the swept path. This non-traditional ship-handling characteristic is, in part, attributable to the number of rudders and the special design of the articulated flap rudder. As a precautionary measure, the pilots were warned verbally by the navigation personnel against the use of excessive helm.

At 35° of helm, propeller thrust is diverted laterally, thereby creating an athwartships thrust similar to a thruster. This attribute may be very useful when manoeuvring in harbours but hazardous once the vessel has left its berth and proceeded down the river. When under way in a restricted waterway, there is no defence mechanism in place to prevent the application of excessive helm and no audio alarm to warn the navigator of excessive helm use, nor are there secondary measures (such as a warning placard or a cautionary note in the *Deck Procedures Manual* or pilot card).

2.5 Pilot Planning

2.5.1 Ship Handling

The pilot deemed the vessel to have the fastest rate of turn he had ever witnessed. This rate might have influenced the pilot to place greater emphasis on accomplishing the turn using helm and to downplay the sweep/thrust effect. This emphasis is reflected in the pilot insisting on hard-a-port helm.

The pilot had attended a ship-handling training centre for experienced pilots on two occasions, but the simulation courses attended did not include practice with a model ship equipped with a rudder fitted with a flap. Training fosters familiarity with procedures, reduces the time required to analyze emergency situations, and improves the coordination required to take evasive action.

Although the pilot received an explanation of the vessel's ship-handling characteristics, his experience with the *Norwegian Sky* was limited to the duration of his assignment. On conventional vessels, hard-over helm is used to derive maximum turning effect. Because the pilot was not accustomed to handling vessels fitted with flap rudders, the sweep/thrust effect of hard-over helm might not have been a predominant factor in the pilot's consideration. Under pressure to conduct the emergency manoeuvre, the pilot reverted to ordering hard-over helm.

In 1996, the training facility used by the pilots of the Corporation added a model ship equipped with a flap rudder to its fleet to simulate vessels, such as the *Norwegian Sky*. Given that safe handling of a vessel in emergency situations depends on the pilot's ability to respond, it is essential that simulation training reflect as much realism as possible, such as the visual environment and the characteristics of vessels they are required to handle. To mitigate this void in training, some pilotage authorities provide hands-on training, in a non-threatening environment, to help pilots that are required to handle such vessels better appreciate special ship-handling characteristics.

2.5.2 Dual Active Duty and Safety

Statistics reveal that pilots are seldom required to conduct large passenger vessels. The requirement to extend whale-watching is even less frequent. Given that whale-watching is not always carried out in the same zone of the marine park and under the same conditions, preparation of a detailed voyage plan to turn these large vessels around in a predetermined area is not practical. Consequently, turning a vessel around in restricted waters, such as the marine park, must be planned at short notice and executed with precision.

A pilot has to consider a number of factors to minimize risks before undertaking special manoeuvres near shoal waters. Because a detailed, pre-determined plan is not practical, good seamanship practices would dictate that a list of manoeuvring considerations should form part of a pilot's general passage plan for the area. This list would facilitate decision making and help in the development of specific plans at short notice.

The potential risk of an accident for vessels engaged in whale-watching in restricted waters is higher than for vessels making normal transits of the area. The practice of two pilots sharing the workload and their expertise in restricted waterways can mitigate the risk by early recognition of danger. In this instance, the request to conduct an additional turn was not fully considered. Workload sharing by the second pilot would have permitted the bridge team to better assess the risk and to maintain situational awareness. Input from the second pilot would have presented the bridge team an opportunity to consider other appropriate measures: initially prior to commencing the turn and subsequently, as the turn progressed. Such an approach is consistent with the philosophy of using a team approach to eliminate single-point failure. In the event that an emergency situation develops, their combined expertise may help extricate the vessel from a dangerous situation. Nevertheless, the two pilots alternated shifts such that only one pilot was on duty at a time while the vessel was carrying out manoeuvres in the vicinity of the banks. This effectively negated the benefits associated with the carriage requirement for two pilots.

Currently, there are no guidelines to help pilots determine when two pilots should be on duty. This permits pilots to use various criteria that need not necessarily take into consideration all elements essential to assess risk as reflected in this occurrence. The provision of guidelines will help ensure:

- a level of service appropriate to the assessed risk;

- uniform application of the two-pilot carriage requirement to meet the safety objective of the *Laurentian Pilotage Regulations* which recognize the need to eliminate single-point failure.

In essence, such a operational system will help ensure that:

- pilots have identified safe parameters before operations involving higher-than-normal risk are undertaken; and
- that additional risks associated with the dynamic nature of pilotage can be identified in a timely manner to permit appropriate response to mitigate these risks.

3.0 Conclusions

3.1 Findings as to Causes and Contributing Factors

1. The manoeuvre to turn the vessel around to prolong whale-watching was improvised and not part of the vessel's voyage plan. This change from routine was not effectively planned or managed.

2. The bridge team did not optimize the use of navigation equipment at their disposal to determine the approach limit to the banks to avert grounding.

3. The pilot did not accept advice from the master, who was knowledgeable in the vessel's manoeuvring characteristics. As a result, the vessel's stern moved rapidly toward the banks (experienced sweep/thrust).

4. The master did not countermand the pilot's order of hard-a-port helm.

3.2 Findings as to Risk

1. Formalized training in an integrated bridge system environment is not mandatory. As a result, bridge teams may not make optimal use of the system.

2. Because bridge resource management training varies among institutions around the world, with pilots and ships' officers often trained separately, the dynamics or interaction in the relationship between pilots and ships' officers can break down during emergency situations.

3. Less-than-complete communication by the bridge team members resulted in navigation decisions based on scanty or incomplete information and increased risk of accidents.

4. Carriage of an electronic chart display and information system is not mandatory on board vessels. As such, the quality and accessibility of training is inconsistent. As a result, a bridge team may not effectively make use of this situational awareness tool.

5. There was no mechanism (physical or other), audio alarm, or secondary measure (such as a warning placard) to prevent or warn against the application of hard-over helm.

6. The current practice of having one pilot on duty on vessels where two pilots are warranted and available, effectively negates the safety benefit of a team approach to eliminate single-point failure.

7. The training facility used by the pilots of the Corporation des pilotes du bas Saint-Laurent did not provide, at the time the pilot undertook his training, models ships simulating non-traditional ship-handling characteristics, such as those produced by the *Norwegian Sky*'s articulated flap rudders.

8. The pilot had not received hands-on training on similar vessels in a non-threatening environment, which could have lead to a better appreciation of non-traditional ship-handling characteristics.

3.3 Other Findings

1. It took 21 minutes for 787 crew members to muster 1923 passengers and prepare 16 lifeboats.

2. The prompt and efficient response to the exposed risk can be attributed, in part, to the training and the safety culture put in place by Norwegian Cruise Line.

3. Contingency measures for the major search-and-rescue operation proved well organized.

4.0 Safety Action

4.1 Action Taken

4.1.1 Review of the Pilotage Issues

In 1999, a Review Panel of the Canadian Transportation Agency (CTA) made a number of recommendations to the Minister of Transport on outstanding pilotage issues. With respect to double pilotage, the Review panel recommended that the Laurentian Pilotage Authority (LPA) be required to carry out a risk-based assessment by mid-2001. Further, they recommended the LPA be required to report the results of the risk-based assessment to the Minister of Transport and make the necessary regulatory amendments.

The Corporation des pilotes du bas Saint-Laurent forwarded a report/study on double pilotage to the LPA to be used as a reference document in risk-based analysis.

Transport Canada has recently made funding available to conduct the risk analysis recommended by the CTA.

4.1.2 Canadian Coast Guard

The Rescue, Safety and Environmental Response Division of the Canadian Coast Guard's (CCG) Marine Programs Branch has initiated a public awareness program addressed to all waterfront townships in the Laurentian region. The program consists of informing local authorities that search and rescue (SAR) will require their immediate support when a passenger vessel is disabled and requires passengers to disembark.

The CCG contingency plan was revised to:

- improve liaison between the public and waterfront township authorities;
- centralize the command centre;
- redefine parameters for passengers evacuation to facilitate crowd control and passenger mobility;
- develop a media strategy to cope with an evacuation operation; and
- improve the means of communication with a vessel requiring assistance to be able to react readily to unforeseen events.

4.1.3 Norwegian Cruise Line

Norwegian Cruise Line developed and implemented a comprehensive set of bridge procedures which are part of the company's Safety and Environmental Management System. The procedures are compiled in the Navigation Standards Manual address shipboard navigational operations and provide guidance, directives and recommendations to the bridge team.

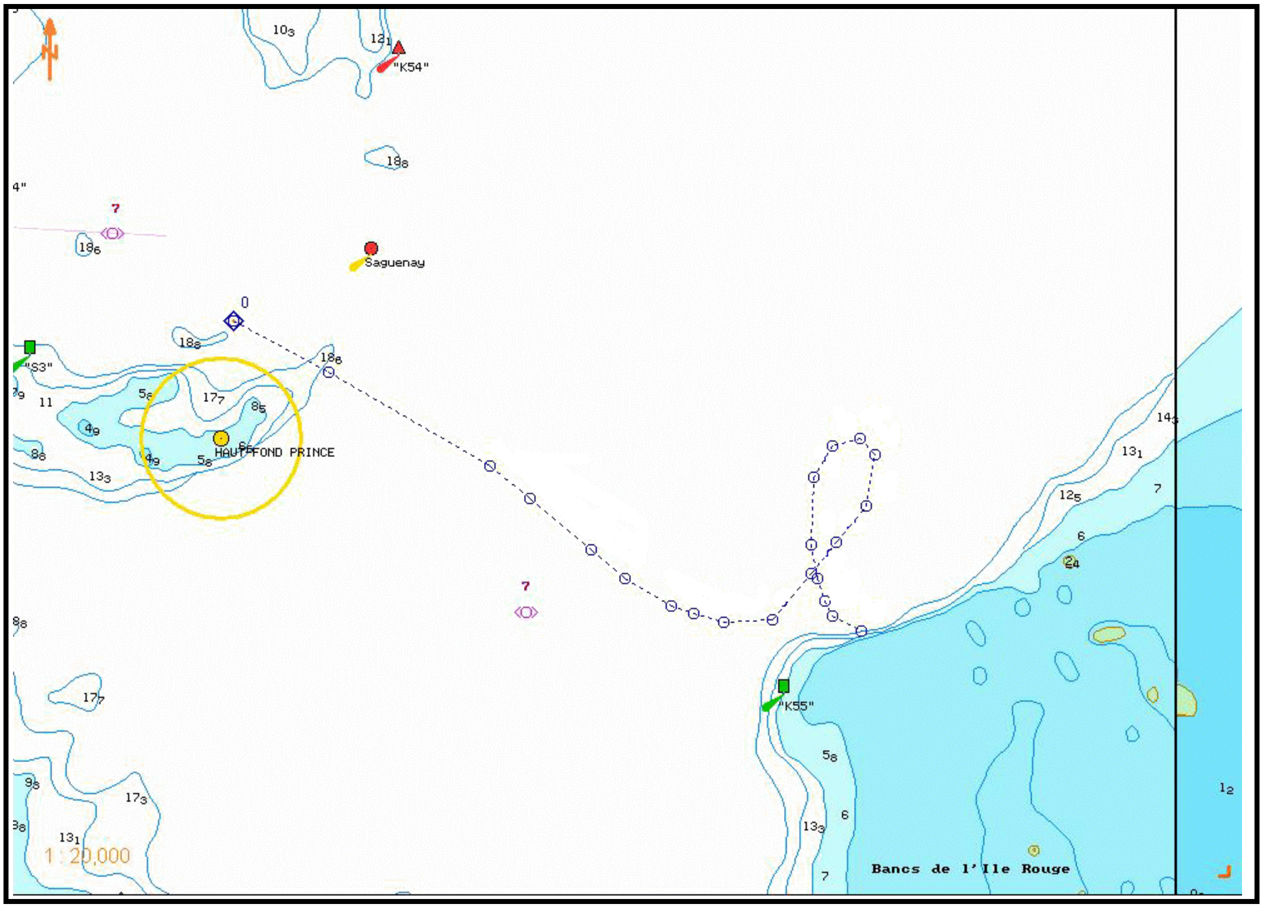
The following is a brief description of the safety issues addressed in this report and dealt with by the company further to the occurrence :

Training	Bridge officers will be trained in Integrated Bridge Systems and complete a comprehensive nine-day Skill Development and Crew Resource Management simulator course. The officers will also undergo a marine profile psychological evaluation test. A Bridge Officer Familiarization checklist will be completed by all new officers and by all returning officers in the event of their absence from the vessel for a period greater than three months.
Electronic Navigation	Given the use of advanced computerized onboard navigation systems, all navigation team members must be fully cognizant of the multiple functions and capabilities of the Integrated Bridge System and respective aids to navigation. Officers on watch shall be responsible for the close monitoring of all electronic equipment and, especially in confined waters, use the parallel indexing technique with the controlled turns technique.
Navigation Team	There will be two navigation officers simultaneously on duty during the bridge watch; the senior officer (OOW) and his assistant will be called the navigator and the co-navigator respectively. Furthermore, the master will ensure based on the workload that the composition of the navigation team is adequate and that resources are added prior to the workload increase. The workload may be dependent on the navigable waters, the traffic density and the prevailing weather conditions.
Task Verification	A challenge and verification task process has been implemented for normal, critical and emergency bridge procedures. The closed loop communication flow will eliminate errors by instituting a two person check.
Voyage Plan	A comprehensive plan to reduce risk of collision and grounding must be developed by the navigation officer under the direction of the master. If unforseen circumstances necessitate changes to the voyage and passage plan, the changes will be executed in accordance with the guidelines and only after being discussed and agreed by the bridge team. For vessels with Electronic Chart Systems and Integrated Bridge Systems, the track lines will be designed and plotted and include the limits of navigation, i.e. the grounding line.
Navigation with Pilot	In preparation for the transit with the pilot, the navigation team will initiate a constructive dialogue with the pilot involving all aspects of navigation during the passage. The ongoing dialogue must be clearly understood and agreed by all bridge team members. The navigation personnel will be familiar with the voyage plan, maintain a high situational awareness and anticipate the correct helm and engine orders.

This report concludes the TSB's investigation into this occurrence. Consequently, the Board authorized the release of this report on 19 August 2003.

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

Appendix A: Track of the Norwegian Sky



Appendix B: Photographs

Photos on this page by permission of the Department of Fisheries and Oceans.

Appendix C: Glossary

alarm	an announcement, by audible and/or visual means, of a condition or an abnormal situation requiring attention
Bancs de l'île Rouge	Rouge Island Banks
bridge team	navigation personnel and the pilot on the bridge
BRM	bridge resource management
CCG	Canadian Coast Guard
CCGS	Canadian Coast Guard Ship
CSA	Canadian Shipowners Association
CTA	Canadian Transportation Agency
DGPS	differential global positioning system
ECDIS	electronic chart display and information system (when the system has received a type approval certification)
ECS	electronic chart system
field of vision	angular size of a scene that can be observed from a position
FMBS	full mission bridge simulator
G	gyrocompass (degree)
GPS	global positioning system
haut-fond Prince	Prince Shoal
IBS	integrated bridge system (a combination of systems that are interconnected to allow centralized access to sensor information or command/control from workstations)
île Rouge	Rouge Island
INS	integrated navigation system (supports safety of navigation by evaluating inputs from several independent and different sensors, combining them to provide information giving timely warning of potential dangers and degradation of integrity of this information)
IMO	International Maritime Organization
INMARSAT	International Maritime Satellite Communication System
ISO	International Organization for Standardization
kW	kilowatt
LORAN	Long Range Hyperbolic Aid to Navigation System
LPA	Laurentian Pilotage Authority
m	metre
MCTS	Marine Communications and Traffic Services
MRSC	Marine Rescue Sub-Centre
navigation personnel	ship's complement on the bridge (excluding the pilot)
OOW	officer-of-the-watch
SAR	search and rescue
senior staff	captain and staff captain
TSB	Transportation Safety Board of Canada
VHF	very high frequency
workstation	the combination of all job-related items (including the console and all its devices, equipment and furniture) to fulfil certain tasks
°	degree
°G	degree of the gyrocompass
°T	degree true

'   minute