Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

Marine Transportation Safety Investigation Report M20P0110

STRIKING

Roll-on/roll-off passenger ferry *Spirit of Vancouver Island*
Tsawwassen, British Columbia
18 April 2020

Description of the vessel

The *Spirit of Vancouver Island* (Figure 1) is a single-ended roll-on/roll-off passenger ferry of 167.5 m in length, owned and operated by British Columbia Ferry Services Inc. (BC Ferries). The vessel was built in 1993 and can carry a maximum of 2100 people and 400 vehicles.[1] The propulsion plant consists of 4 diesel/natural gas engines with a combined capacity of 16 000 kW. The engines drive 2 inward-turning shafts via reduction gearboxes, developing a maximum speed of approximately 21 knots. The shafts are fitted with controllable-pitch propellers. The vessel has 2 bow thrusters with a combined capacity of 1540 kW and 2 articulated Becker rudders.

Figure 1. *Spirit of Vancouver Island* (Source: BC Ferries)

[1] The maximum capacity of people includes both passengers and crew, and the maximum capacity of vehicles is based on 20-foot auto equivalents.

Canada

The wheelhouse is located at the fore of the vessel and is fitted with navigation equipment and machinery controls. The forecastle has 2 windlasses that control the vessel's 2 anchors. The anchors can be released manually from the forecastle or remotely from the wheelhouse. The vessel operates under a voluntary safety management system (SMS), which is audited internally by BC Ferries and externally by a classification society.

Between October 2018 and February 2019, the vessel underwent a mid-life upgrade at a shipyard in Poland. The upgrades involved

- conversion of the vessel's propulsion plant to run on dual fuel (liquefied natural gas [LNG] and marine diesel oil), which included replacement of the engines and installation of a new LNG fuel system;
- renewal of propulsion equipment components that included the rudders, steering system, bow thrusters, propellers, and gearboxes; and
- installation of a new machinery control system, navigation system, internal communication system, and safety evacuation systems.

History of the voyage

On 18 April 2020, at 1501,[2] the *Spirit of Vancouver Island* departed Swartz Bay, British Columbia (BC), for Tsawwassen, BC. This was the first of 2 crossings for the vessel that day on its reduced sailing schedule[3] due to the COVID-19 pandemic. After exiting Active Pass, the bridge team contacted the Tsawwassen Terminal and the vessel was assigned to berth 3, the only suitable vacant berth at the time.[4] To allow more time for the vessel to offload its current load at Tsawwassen and then embark the full load of vehicles waiting for the return crossing, its speed was increased to 21 knots after exiting Active Pass. The reduced number of daily sailings between Tsawwassen and Swartz Bay had increased the amount of time required for loading and unloading. This increased time was due to a higher than normal number of drop-trailers per sailing and passenger walkway restrictions in force at the time.[5] On the previous day, the crew had experienced a situation where the vessel had departed Tsawwassen 9 minutes late despite having arrived on time. The *Spirit of Vancouver Island* was scheduled to depart berth 3 at 1700, allowing 15 minutes before the scheduled 1715 arrival of the next ferry to use berth 3.

At 1616, as the *Spirit of Vancouver Island* was approximately 3 nautical miles (NM) off the outer dolphin,[6] the bridge team notified the master and commenced the pre-arrival checklist. At this time, a deckhand went to the forecastle deck to stand by the anchors. The master arrived on the bridge at 1620 and took control of the vessel. The chief officer assumed the role of co-navigator. At 1622, after briefing the bridge team, the master began reducing the vessel's speed for arrival. At this time,

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2 All times are Pacific Daylight Time (Coordinated Universal Time minus 7 hours).

3 The vessel completes 4 crossings a day on its regular schedule.

4 Berths 4 and 5 were occupied by moored vessels at the time.

5 Walk-on passengers were required to embark and disembark from the main car deck instead of using the overhead walkway.

6 A dolphin is a structure that typically consists of a number of piles driven into the seabed or riverbed, and connected above the water level to provide a platform or fixing point.

the vessel was approximately 1 NM off the outer dolphin. The tide was ebbing and the bridge team anticipated that the vessel would set[7] to the southeast. The winds were from the southeast at 8 to 10 knots.

To counteract the effects of the wind and tide, the vessel approached by steering on[8] berth 5, which was located to the left side of berth 3. The master subsequently ordered the helmsman to adjust the course to starboard and steer on the end of the *Spirit of British Columbia*, which was moored at berth 4. The master then ordered the helmsman to adjust the course to starboard again and steer down the middle of berth 3.

At 1624, the vessel was approximately 0.25 NM from the outer dolphin, which is the command decision point (CDP)[9] for Spirit class vessels approaching Tsawwassen. At the CDP, the master must make the decision whether to proceed with or abort the planned manoeuvre. With all machinery components operating satisfactorily, the master continued with the approach. Soon after, the master observed that the vessel was setting in the opposite direction to that expected.[10] To counteract this, the master ordered the helmsman to adjust the course further to starboard and steer at a point halfway down the wall of berth 3. A few seconds later, the master applied astern pitch to the starboard engine, while the port engine was maintained on ahead pitch. The speed of the vessel at the time was 13.9 knots. At 1625, the astern pitch on the starboard engine was increased to 70% and subsequently to 90%.

Figure 2. Damage to the vessel (circled) (Source: BC Ferries, with TSB annotations)

During the approach, the chief officer called out the vessel's speed for the master twice and noted that the *Spirit of British Columbia* was resting against the wing wall to its port side, which indicated a northwesterly set in the vicinity of the terminal.[11]

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7 The set is the difference between the course made good and the course steered due to external forces such as wind and current on the vessel.

8 To steer on a shoreside feature, such as a berth or moored vessel, navigators maintain a course that is in line with that feature.

9 The *Spirit of Vancouver Island*'s vessel-specific manual defines a CDP as a position in a voyage where the master "must consider all critical factors and verify that all critical systems necessary for berthing, unberthing, or critical navigational passage are working satisfactorily and have been confirmed as such on the appropriate checklist" (British Columbia Ferry Services Inc., *M.V. Spirit of Vancouver Island Vessel Specific Manual*, Chapter 7.1.4 Bridge Procedures, 07.01.04.020 Passage Plans, p. 4).

10 Track data for the *Spirit of Vancouver Island* indicates that the vessel started setting to the northwest when it was approximately 0.5 NM off the outer dolphin.

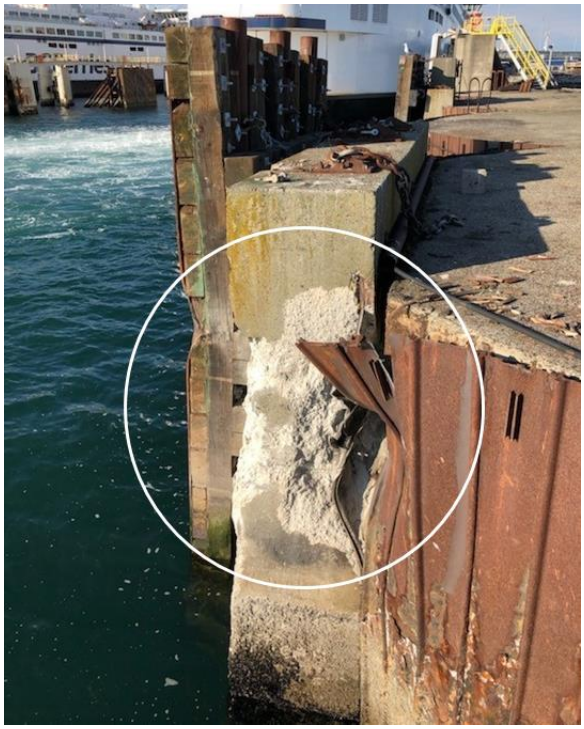
11 At the Tsawwassen Ferry Terminal, it is possible to obtain an indication of the set by assessing the side to which a berthed vessel in the terminal is resting.

With the speed at 9 to 10 knots, the master ordered the helmsman to steer hard to port to control the bow. The vessel did not respond to the helm order, even after the ahead thrust on the port engine was increased, and the vessel continued moving forward towards the wall of berth 3. At 1625:25, the master applied full astern on both engines and put the thrusters full to port in an attempt to avoid striking the wall. The vessel passed the outer dolphin at a speed of approximately 6.2 knots. At 1626:10, the chief officer was instructed to let go the port anchor. The chief officer pressed the remote release button and, approximately 4 seconds later, reported that the port anchor was not releasing. He was subsequently instructed to release both anchors. He pressed the remote release buttons for both anchors, but neither anchor released.[12]

At 1626:32, the vessel struck the concrete abutment on the wall of berth 3 at a speed of approximately 5.4 knots. The master stopped the engines and thrusters, and the crew conducted a damage assessment. Although no warning was broadcast to notify passengers about the impending striking, no injuries were reported immediately following the occurrence; the next day, 2 crew members and 1 passenger reported minor injuries.

The vessel sustained damage to the deck plate, rubbing strake, and the forepeak tank above the waterline (Figure 2). The concrete abutment of the berth wall was also damaged (Figure 3). The vessel docked at berth 3 at 1637. Vehicles on the upper car deck and foot passengers offloaded at 1802, and the remaining vehicles on the main car deck offloaded at 2058.

Figure 3. Damage to the concrete abutment (circled) (Source: BC Ferries, with TSB annotations)

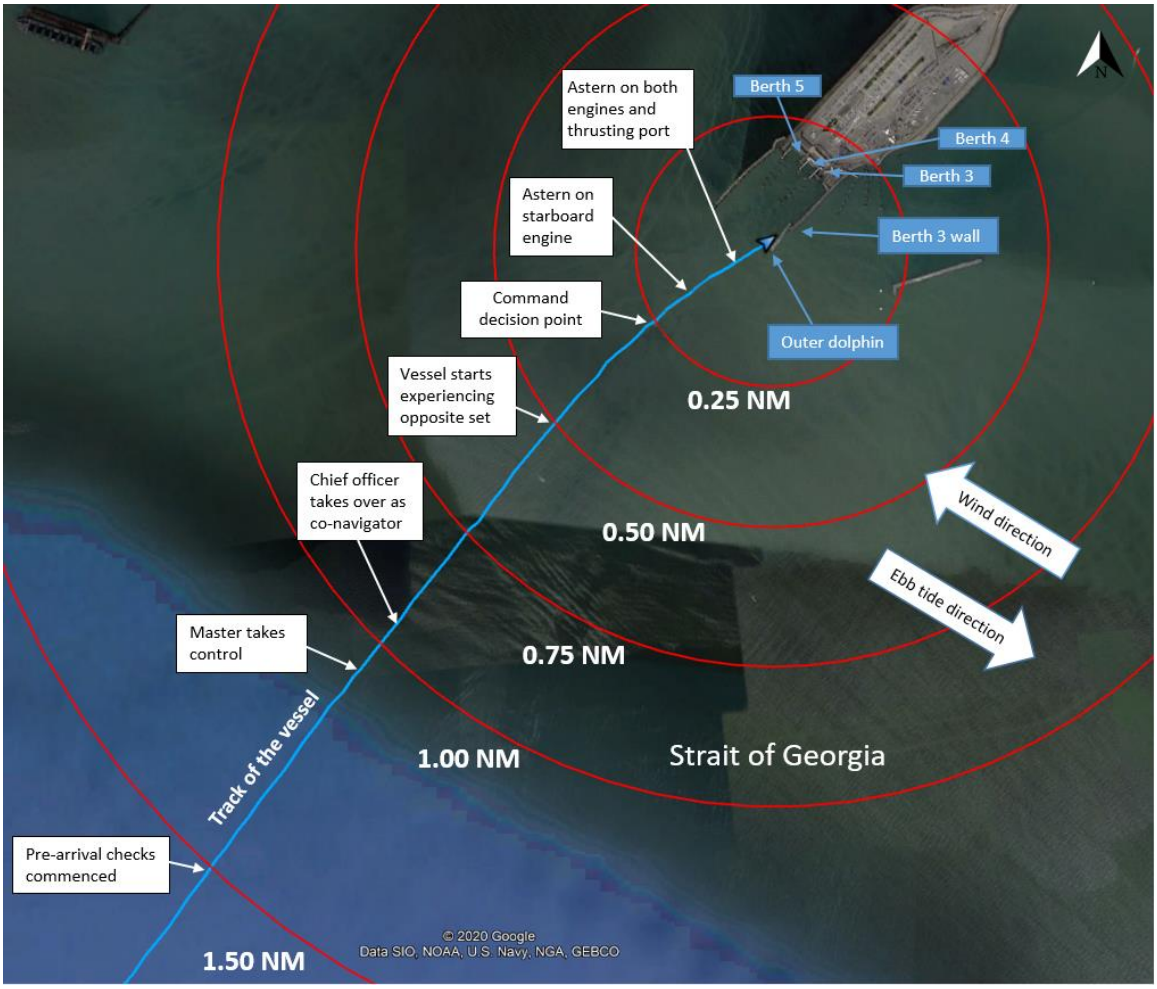


Approach speed guidance

Each vessel within the BC Ferries fleet maintains a vessel-specific manual (VSM) that forms part of the company's SMS. The VSM is updated at regular intervals by the senior master for the vessel, establishing guidelines and instructions for safe, efficient vessel operation in compliance with company policies and procedures. The intent of the VSM is to provide specific instruction, through the use of checklists, etc., for the execution of unique and/or critical shipboard operations. The passage plan section of the VSM contained a voyage checklist as well as best practice guidance for speed and propeller thrust in order to maintain consistency across watches. On the day of the occurrence, the vessel's speed and propeller pitch settings during the approach to the berth were higher than what was recommended in the VSM (Figure 4).

[12] After the occurrence, it was determined that the port anchor had released approximately 6 inches.

Figure 4. Vessel's speed and pitch (both actual and recommended) on approach to the berth (Source: Google Earth, with TSB annotations)



Distance off	Recommended speed (knots)	Recommended pitch	Actual speed (knots)	Actual pitch
1.5 NM	N/A	80%	20.6	90%
1.0 NM	N/A	40%	20.4	90%
0.75 NM	15.0	N/A	19.9	85%
0.5 NM	12.0	20%	18.0	62%
0.25 NM	9.0	Astern	13.8	40%
Outer dolphin	N/A	N/A	6.2	Full astern

Although the VSM in effect at the time of the occurrence did not specify a speed limit for the *Spirit of Vancouver Island* when transiting the outer dolphin, the general practice was to transit at a speed not greater than 6 knots. The guidance in the VSM had been revised following the vessel's mid-life upgrade to take into consideration the changes to the machinery and propulsion systems.

Currents

The currents in the Strait of Georgia set to the southeast during the ebb tide and to the northwest during the flood tide. High water at Tsawwassen on the day of the occurrence was predicted at 1541. The tide was ebbing just before the striking, which occurred at or just before peak ebb current.

At the TSB's request, the Ocean Modeling and Predictions Section at the Institute of Ocean Sciences, which is part of Fisheries and Oceans Canada, created a model[13] to simulate the direction of the currents at the time of the occurrence and examine the possibility of a current reversal,[14] which could have caused the vessel to set in a direction opposite to that which was expected. Current reversals have been known to occur in the vicinity of the terminal and can differ between tidal cycles.[15]

Figure 5. Model predictions for direction and speed of current (top graph) and model predictions for height of tide (bottom graph) (Source: Ocean Modeling and Predictions Section, Institute of Ocean Sciences)

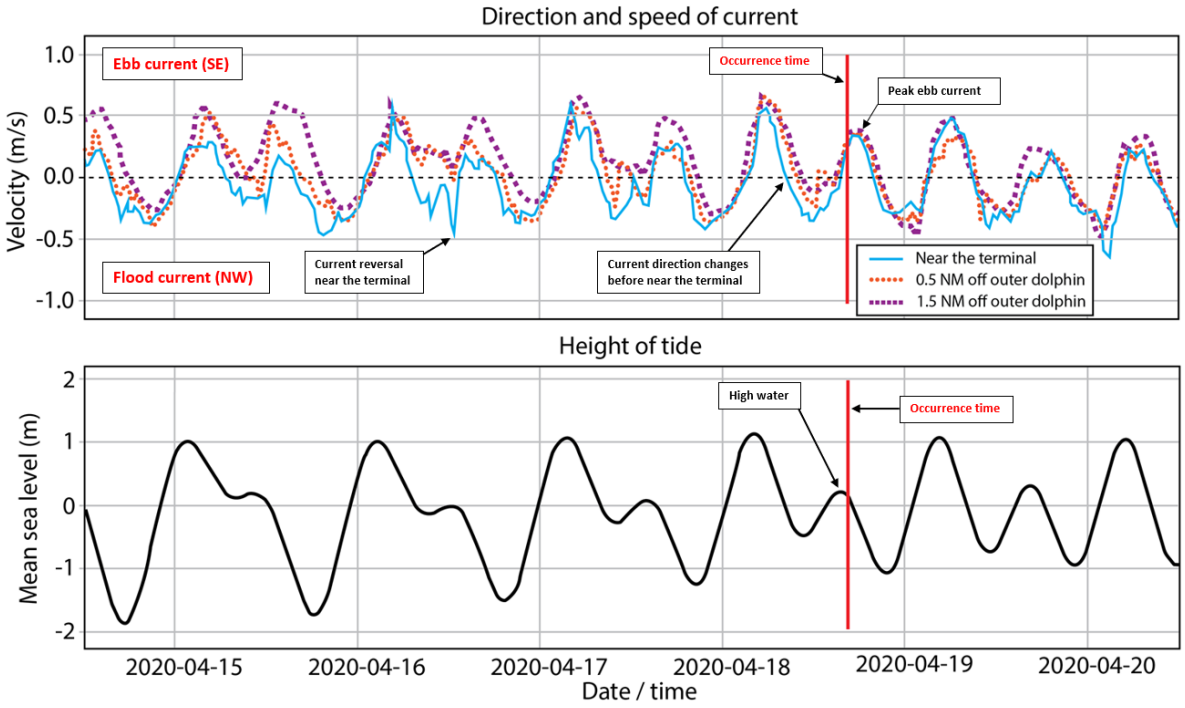


Figure 5 shows the model's recreations of the direction and speed of the currents (top graph) in correlation with the height of the tide (bottom graph), leading up to the occurrence time. The model showed unexceptional currents at the time of the occurrence; according to the model, the current was at peak ebb and, with currents near the terminal (solid line, top graph) similar to those further out in

[13] The model used to simulate the currents is a three-dimensional stratified ocean model known as NEMO (https://www.nemo-ocean.eu/). The model has a horizontal resolution of approximately 150 m and a vertical resolution varying from 1 m near the surface to 27 m in deep layers, with a total of 40 layers. Fresh water discharge from the Fraser River, based on observations at Hope, BC, is included in the model.

[14] A current reversal happens when the direction of currents in the vicinity of the berth is opposite to the direction of currents mid-channel.

[15] The model indicated that on 16 April 2020, 2 days before the occurrence, a substantial reversal of currents occurred, with a peak at about 1300.

the channel, there was no current reversal. The current near the terminal generally changes from ebb to flood slightly before the currents farther away (dotted line and line of squares, top graph), but this occurs as the currents are approaching zero (slack tide), not immediately after peak ebb.

Anchor release during emergencies

The anchors on the *Spirit of Vancouver Island* can be released remotely from the wheelhouse (Figure 6). This capability is particularly useful during emergencies, as it allows the anchors to be released quickly without having to manually operate the windlasses.

The process to release an anchor remotely involves 2 steps. First, the CHAIN STOPPER UP button, which raises the chain stopper that secures the anchor while at sea, needs to be pressed. Second, the ANCHOR RELEASE button needs to be pressed and held until the anchor releases and the required amount of chain pays out.[16] There is a delay of 4 to 6 seconds before the anchor starts to deploy, during which the anchor brake is remotely disengaging. At the time of the occurrence, there were no labels or instructions on the control panel to notify operators of this delay.

Figure 6. Remote release controls for the anchors (Source: BC Ferries, with TSB annotations)

On the day of the occurrence, the chain stoppers for both anchors had been raised remotely as part of the pre-arrival checks. In the final moments before the striking, the master instructed the chief officer to release the port anchor and, when it did not release, to release both anchors. The investigation could not determine how long the release buttons were pressed or why the anchors did not release. When tested by the crew after the occurrence, the remote anchor release for each anchor worked successfully. Subsequent testing of the anchors on 05 May 2020 identified an issue with overtightening of the anchor brakes, which may affect their operation. The senior master issued a directive[17] providing instructions to crew about securing the anchor brakes after operation.

[16] Digital displays above the release buttons indicate the amount of chain paid out in metres.

[17] Senior Master's Directive SMD 002 dated 05 May 2020.

TSB Watchlist

The Watchlist identifies the key safety issues that need to be addressed to make Canada's transportation system even safer. Safety management is one of these issues. In the marine sector, TSB investigations have found that, even when formal processes are present, they are often not effective in identifying hazards or reducing the risks.

The *Spirit of Vancouver Island*'s SMS was certified and audited by an approved authority. However, the investigation identified gaps in the effectiveness of safety management related to the guidance provided to crews regarding recommended vessel speeds and critical vessel operations (in this case, releasing an anchor), which was not well documented or understood by the crew.

Safety action taken

Following the occurrence, BC Ferries completed a site investigation report and the following safety actions were taken:

- A 2-hour review session with the bridge team was held that included
  - a review of the incident;
  - a review of the site investigation report, including root causes and recommendations;
  - a re-creation of the incident in the simulator and a review of the stages of the incident and lessons learned; and
  - a discussion of the findings as well as personal and institutional lessons learned from the incident.
- The anchor documentation and training manual were updated to clarify the anchor release method and all crews have been practicing proper stowage of the anchors on board Spirit-class vessels.
- The VSM was updated to include the major factors of a CDP in accordance with the fleet operations manual. Bridge teams have performed drills that address vessel speed and the elements of a CDP involving all bridge team members.
- Instructions on the remote release of the anchors were posted.

Safety messages

It is essential that bridge teams adhere to recommended speeds and guidance set out in a vessel's SMS. Higher speeds, particularly during docking, can reduce the time available to respond to any changes in environmental factors and result in a loss of control over a vessel's movements.

Clearly posted operating instructions, such as for the remote release of anchors, are essential to increase the likelihood that critical safety equipment will be operated successfully in emergency situations.

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 27 January 2021. It was officially released on 11 February 2021.

Visit the Transportation Safety Board of Canada's website (www.tsb.gc.ca) for information about the TSB and its products and services. You will also find the Watchlist, which identifies the key safety issues that need to be addressed to make Canada's transportation system even safer. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.

ABOUT THIS INVESTIGATION REPORT

This report is the result of an investigation into a class 4 occurrence. For more information, see the Policy on Occurrence Classification at www.tsb.gc.ca

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