Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

MARINE TRANSPORTATION SAFETY INVESTIGATION REPORT M18A0454

DOWNFLOODING AND SINKING

Fishing vessel *Atlantic Sapphire*
Georges Bank, Nova Scotia
13 December 2018

Canada

ABOUT THIS INVESTIGATION REPORT

This report is the result of an investigation into a class 3 occurrence. For more information, see the Policy on Occurrence Classification at www.tsb.gc.ca

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.

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Citation

Transportation Safety Board of Canada, *Marine Transportation Safety Investigation Report* M18A0454 (released 24 February 2021).

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Marine transportation safety investigation report M18A0454

Cat. No. TU3-12/18-0454E-PDF
ISBN: 978-0-660-37262-4

This report is available on the website of the Transportation Safety Board of Canada at www.tsb.gc.ca

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Summary

On 13 December 2018, at approximately 2300 Atlantic Standard Time, the fishing vessel *Atlantic Sapphire* sank off Georges Bank, Nova Scotia. At the time, there were 3 crew members on board. The master broadcast a distress message and each crew member donned an immersion suit and evacuated into a life raft as the vessel sank. A nearby fishing vessel responded to the distress message and rescued the crew members from the life raft. Over 11 000 L of fuel on was on board when the vessel sank. There were no injuries and the vessel was a total loss.

1.0 FACTUAL INFORMATION

1.1 Particulars of the vessel

Table 1. Particulars of the vessel

Name of vessel	*Atlantic Sapphire*
International Maritime Organization number	8964953
Official / licence number	821664 / VRN 157272
Port of registry	St. John's, Newfoundland and Labrador
Flag	Canada
Type	Fishing, trawler
Gross tonnage	130.57
Length	18.68 m
Built	2000, T.W.L. Enterprises Limited
Propulsion	Diesel engine (459 kW) driving a single fixed-pitch propeller
Fuel capacity	14.62 long tons*

Crew	3
Cargo	Approximately 47 long tons of fish and ice
Registered owner and authorized representative	Nova's Finest Fisheries Inc., Middle West Pubnico, Nova Scotia

*One long ton is 1016.05 kg. Long tons are used throughout the report to reflect the units of measure in the vessel's stability booklet.

1.2 Description of the vessel

The *Atlantic Sapphire* was a fibreglass fishing trawler with a superstructure mostly forward of amidships (Figure 1). The superstructure was accessible through 2 watertight doors on the port side of the main deck.

Figure 1. Aerial view of the *Atlantic Sapphire* (Source: Fisheries and Oceans Canada, with TSB annotations)

1. Forward deck
2. Roll-dampening paravane
3. Freeing ports
4. Stern ramp
5. Net drum
6. Bridge
7. Trawl winch
8. Main deck

The bridge contained steering and propulsion controls, GPS (global positioning system), radar, an echo sounder, and a very high frequency digital selective calling (VHF-DSC) radiotelephone. The bridge also contained controls for the vessel's trawl winch and bilge

pumps, as well as the high water bilge alarms, which were both visual and audible. A float-free emergency position-indicating radio beacon (EPIRB) was mounted above the bridge on the exterior of the vessel's superstructure.

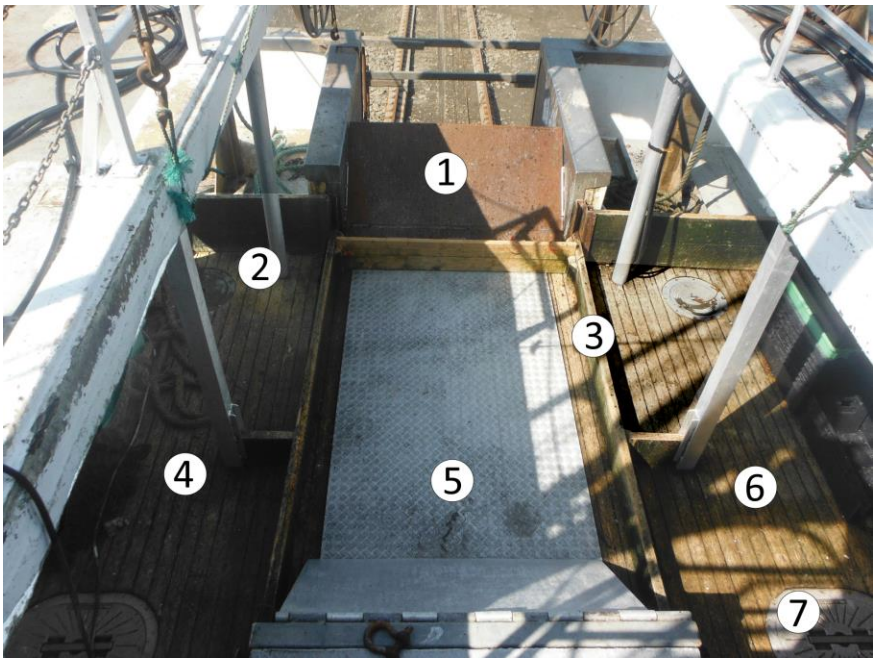
The deckhouse was below the bridge, and could be accessed by stairs leading down from the bridge or through a door from the main deck. The deckhouse also included a stairwell and escape hatch that led up from the engine room. Forward of the deckhouse and below the forward deck was the accommodations, which could be accessed through a door from the deckhouse or through an escape hatch in the forward deck. The forward deck was also accessible through a door on the port side of the bridge. A 6-person life raft was stored on the starboard side of the forward deck.

Aft of the bridge was the shelter deck, which was equipped with 2 trawl winches and a net drum. Roll-dampening paravanes were installed on either side of the deck.

The vessel also had a main deck with bulwarks and a stern ramp. The stern ramp had a steel gate that could be hydraulically raised and lowered (Figure 2). There were 6 freeing ports in the bulwarks around the main deck. The main deck could be divided into sections using pound boards[1] to facilitate sorting the fish on deck, as well as directing the fish into the desired hatches (Figure 2). The main deck had 1 non-watertight main hatch with a coaming that provided access to the fish hold via a ladder, as well as 8 other smaller flush watertight hatches that opened into the fish hold.

[1] Pound boards, also known as checkerboards, are 2 × 10-inch or 2 × 6-inch boards that can be stacked vertically on the main deck.

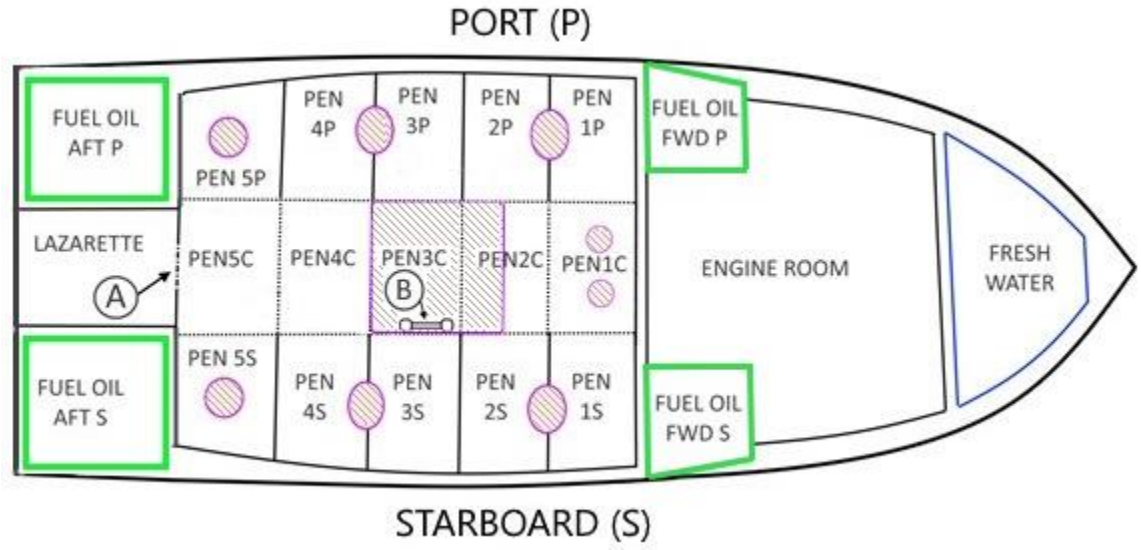
Figure 2. View of main deck, looking aft, with some pound boards in place (Source: Third party, with permission, with TSB annotations)



1. Hydraulic steel gate for stern ramp
2. Hatch for the fifth starboard pen
3. Pound board (single row)
4. Starboard section
5. Centre section
6. Port section
7. Hatch for the third and fourth port pens

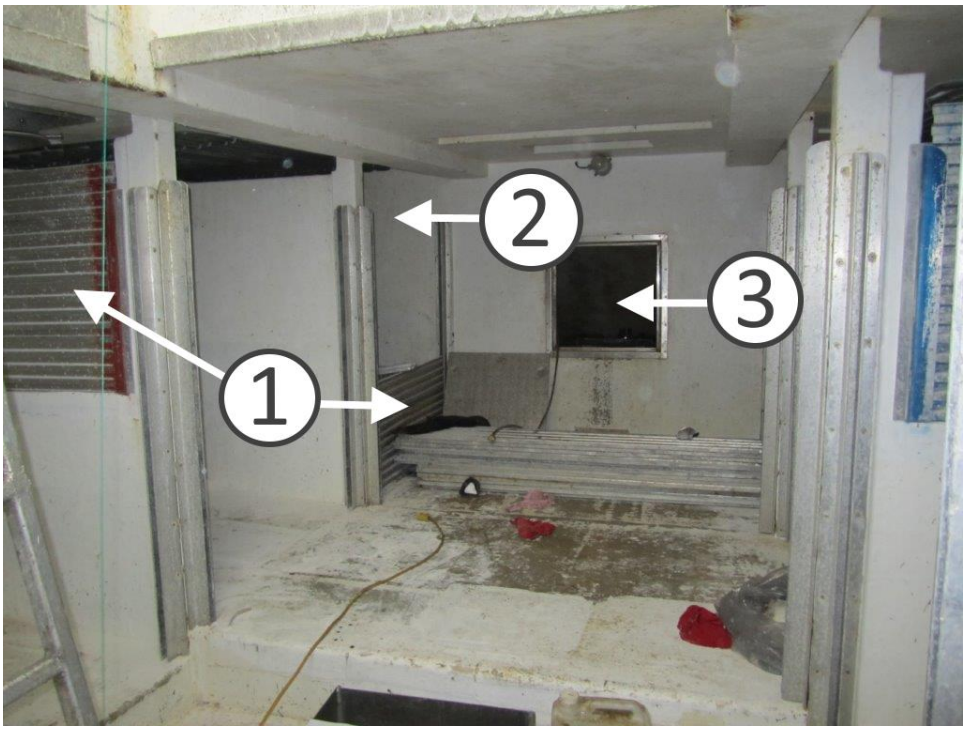
The fish hold was made up of permanent bulkheads and portable aluminum panels known as penboards. The penboards could slide into tracks affixed to the bulkheads in order to divide the fish hold into pens (Figure 3). The fish hold could be divided into a maximum of 15 pens: 5 each on the port, starboard, and centreline of the vessel. The penboards divided the catch and the ice but were not watertight.

Figure 3. Layout of the fish hold on the *Atlantic Sapphire*, showing the locations of the non-watertight access panel (A), the access ladder (B), the penboards (dotted lines), and hatches (circles between the pens) (Source: TSB)



The fish hold, steering gear compartment (lazarette), and engine room were all below the main deck, and each of these spaces had its own bilge pump and high water level alarm. The steering gear compartment could be accessed from the fish hold through an opening covered by a non-watertight panel in the centre of the aft bulkhead (Figure 4).

Figure 4. Fish hold, looking aft, showing access to the steering gear compartment (Source: Third party, with permission, with TSB annotations)



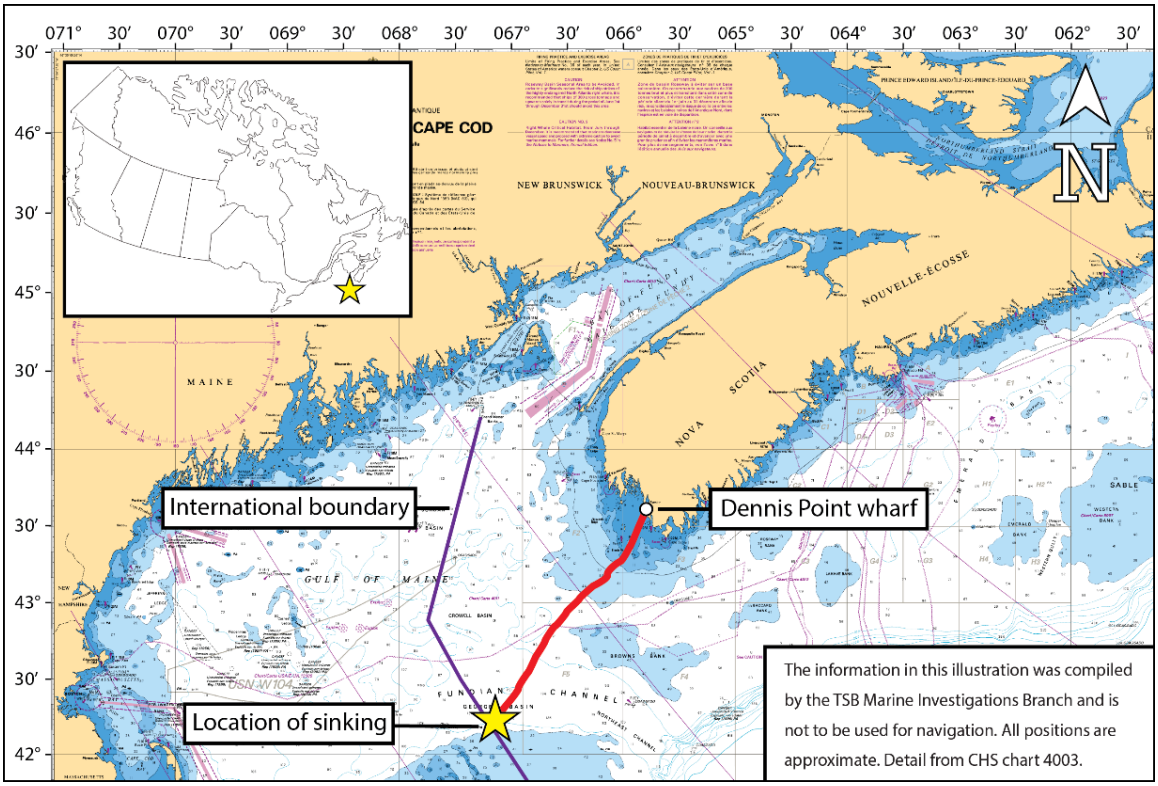
1. Penboards
2. Pen 5S

3. Non-watertight access to steering gear compartment

1.3 History of the voyage

On 12 December 2018, around 1800,[2] the *Atlantic Sapphire* departed Dennis Point wharf in Lower West Pubnico, Nova Scotia. The vessel was bound for Georges Bank, 105 nautical miles (NM) away, to trawl for haddock (Figure 5). The crew consisted of the master, a mate, and a deckhand. The vessel, loaded with 12 long tons of ice, arrived on the bank at 0700 on 13 December and began trawling.

Figure 5. Area of the occurrence (Source: Canadian Hydrographic Service with TSB annotations)



The crew towed the net multiple times throughout the day, fishing along the international boundary between Canada and the United States. Before the net was towed for the last time, the fish hold contained approximately 40 long tons of ice and fish, with fish loaded in all of the pens except pens 3P, 3C, 4C, and 5C. At about 2230, the crew brought the last tow of about 7 long tons of fish on board and planned to proceed to port once the catch was stowed. They emptied the catch onto the main deck and stored the empty net on the net drum before spreading the fish evenly over the main deck and putting the pound boards in place.

Around 2240, once the pound boards were in place, the mate began to load fish into pen 5S. The deckhand went to the fish hold and started shovelling ice from the centre pens into pen 5S, to keep the fish cool. The master left the bridge to help chop the ice stored in pen 3P

[2] All times in the report are Atlantic Standard Time (Coordinated Universal Time minus 4 hours).

and shovel it into the centre pens, toward pen 5S. At this time, the seas were calm and the wind was light. The vessel was drifting and rolling slightly with a 1° starboard list. There were 4 other vessels fishing in the area.

At approximately 2248, the mate was facing the vessel's port side, away from the open hatch, as he was preparing to load fish into pen 5P. By about 2250, the vessel's roll increased. With each roll, the vessel listed further to starboard, and seawater began to flow in surges onto the main deck and into the open hatch for pen 5S. The mate, on the main deck, informed the deckhand that the vessel was starting to sink. The deckhand relayed this information to the master. The master immediately proceeded to the bridge to assess the situation.

When the master arrived on the bridge, the fish hold high water alarm was sounding. At this point, water was no longer clearing off the deck and had covered the entire aft starboard quarter of the vessel. Once water began pouring through the open hatch into the fish hold, the deckhand went to the forward deck and stood by the life raft. The mate tried to load fish into a port pen to correct the list but, after a few minutes, went and joined the master on the bridge.

The master left the bridge, raised the paravane on the starboard side, and then returned to the helm. He turned the wheel hard to starboard and put the transmission in forward gear, then increased the throttle to try to counteract the starboard list. The vessel began turning to starboard but continued to list and sink lower in the water.

The master ordered the mate to retrieve the immersion suits from the accommodations. The mate left to do so but returned to the bridge after assessing the vessel's increasing list and the potential to become trapped in the accommodations. At approximately 2302, the master made a distress call on VHF radiotelephone channel 4[3] and received a response from a watchkeeper on an unidentified vessel. The fishing vessel *Angela O,* which was hauling up its trawl 2 NM away, also heard the distress call and prepared to proceed toward the *Atlantic Sapphire*. The master on the *Angela O* could see the lights of the *Atlantic Sapphire* and could identify the vessel on radar.

The master on the *Atlantic Sapphire* then went to the accommodations to retrieve the immersion suits. As he was returning to the bridge with the 3 immersion suits, he had to wade through water on the main deck that was about 1 m deep. Once back on the bridge, the master and mate donned the immersion suits. Once he donned his suit, the master realized that it was too large. However, at this point, the vessel was listed over 55° to starboard, and the master and mate had to climb out of the bridge through the port door to reach the forward deck, to avoid becoming trapped inside the bridge.

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3 Channel 4 is not an emergency channel but is commonly used by fish harvesters in that area.

The master and mate arrived on the forward deck with the other immersion suit for the deckhand. The deckhand tried to don the remaining immersion suit, but it was too small; only one of his arms could fit inside the suit, and he could not zip the suit up completely.

At 2309, the crew deployed the life raft. The vessel's generator and engine stalled and the vessel stopped. A minute later, the mate boarded the life raft. The master and deckhand became immersed in water as the vessel sank beneath their feet. A significant amount of water entered their immersion suits before they managed to board the life raft. The life raft's painter was pulled by the sinking vessel until it released and the life raft floated free.

The *Angela O* arrived on scene at 2325. After spotting the life raft's light, crew members on the *Angelo O* rescued the 3 crew members from the *Atlantic Sapphire*.

At 2329, Joint Rescue Coordination Centre in Halifax received a signal from the *Atlantic Sapphire*'s EPIRB. Search and rescue coordinators retrieved the vessel's registration information and tried to contact the vessel, the vessel owner, and other vessels in the search area. At 2349, the rescue centre received a phone call from the vessel owner and was informed that the *Atlantic Sapphire* had sunk, and that the crew was safely on board the *Angela O*.

1.4 Environmental conditions

On 13 December 2018, the winds were from the northwest at 10–15 knots. Between 1800 and 1900, visibility was reduced to less than 1 NM in snow. By 2300, the wind speed had reduced to 8.5 knots with gusts to 12 knots with clear visibility. The waves were 1 m from the east-northeast with a 10.7 second period.[4] The air temperature was 0 °C and the water temperature was 8.5 °C.[5] No weather warnings were in effect for the area at the time of the occurrence, and the vessel did not experience freezing spray.

1.5 Vessel certification and inspection

The *Atlantic Sapphire* was subject to the *Fishing Vessel Safety Regulations* (FVSR) and was required to undergo a periodic Transport Canada (TC) inspection for certification every 4 years. It had last been inspected on 16 September 2016 and had been issued an inspection certificate for Near Coastal, Class 1 voyages that stipulated that the vessel was to remain

4 A wave period is a measure of time that elapses between the formation of a wave and when it breaks.

5 Weather data obtained from nearby weather buoys and the ocean wave forecast for the Northwest Atlantic.

within 120 NM from shore.[6] The certificate was supplemented by a record of safety equipment[7] and a safe manning document.[8]

1.5.1 Safe manning document

A safe manning document specifies a vessel's minimum required complement, and the minimum certification requirements for each crew member, to safely navigate the vessel and respond to an emergency on its intended voyage. TC issues a safe manning document in accordance with the requirements of the *Marine Personnel Regulations* (MPR),[9] following an evaluation of the vessel and its intended voyage. The evaluation does not consider the number and qualifications of crew members required to safely carry out other vessel operations, such as fishing. A vessel's authorized representative (AR) must ensure that the requirements specified in the document are met.

The *Atlantic Sapphire*'s safe manning document indicated that, if the intended voyage was greater than 18 hours, the vessel required a minimum complement of 3 crew members. This included a master with a Fishing Master Third Class certification, a mate with a Fishing Master Fourth Class certification,[10] and 1 other crew member. On voyages that did not allow for overnight rest, a second certified person (in this case, the mate) was required to perform watch duties in addition to the master. The safe manning document also specified that the vessel needed to maintain a minimum of a 2-watch arrangement[11] and that all watchkeepers must have the Restricted Operator's Certificate - Maritime Commercial (ROC-MC). Finally, the document specified that all 3 crew members must have Marine Emergency Duties (MED) A1 training.

The *Atlantic Sapphire* operated with all 3 crew members performing watchkeeping duties alone on the bridge. It was common practice for the deckhand to act as a watchkeeper, although he did not hold a certificate or have the required ROC-MC training.

1.6 Personnel certification and experience

The master held a Fishing Master, Third Class certificate that was valid until 28 September 2022. He had completed both ROC-MC and MED A1 courses. He had more than 20 years of fishing experience and had been master on the *Atlantic Sapphire* since January 2018.

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6 Also described as a Limited Home Trade 2 voyage.

7 The record of safety equipment states that the *Atlantic Sapphire* was equipped in accordance with the requirements of the *Life Saving Equipment Regulations*.

8 The *Atlantic Sapphire* was issued a document entitled Minimum Safe Manning Document, under *Marine Personnel Regulations* paragraph 202(3)(b).

9 Transport Canada, SOR/2007-115, *Marine Personnel Regulations* (last amended 04 May 2019).

10 The Fishing Master Class 3 is a higher level of certification than the Fishing Master Class 4.

11 The vessel should have enough crew to maintain 2 watch teams to navigate 24 hours a day, 7 days a week.

The mate held a Fishing Master, Fourth Class certificate that was valid until 25 November 2019. He had completed both ROC-MC and MED A1 courses. He had 40 years of fishing experience and had started working on the *Atlantic Sapphire* in January 2018.

The deckhand had 40 years of seafaring experience. He had taken a MED course. The occurrence voyage was his fifth voyage as deckhand on the *Atlantic Sapphire*.

1.7 Safety procedures and drills

The FVSR require a fishing vessel's AR and master to establish written safety procedures and to familiarize persons on board with these procedures.[12] The safety procedures must cover:

- the location and use of all safety equipment;
- measures to maintain a vessel's watertightness and weathertightness to prevent flooding;
- measures for safe loading, stowage, and unloading of fish catches, baits, and consumables; and
- measures to prevent overloading the vessel.

The FVSR also specify that drills on the safety procedures shall be held to ensure crew members are proficient in carrying out the procedures, and that a record of each drill be kept for 7 years. The AR for the *Atlantic Sapphire* had created a safety book that included a pre-departure checklist, emergency procedures, a maintenance schedule, a safety equipment register, and the contact information and certification for each master and mate. The safety book did not contain any other operational instructions or assignment of duties. Safety drills were not carried out on the vessel.

1.8 Bridge watch procedures and practices

In Canada, the conduct of a vessel by watchkeeping personnel is governed by the *Canada Shipping Act, 2001*, primarily through the *Collision Regulations* and the *Marine Personnel Regulations* (MPR). The *Collision Regulations* address the need for vessels to maintain a proper lookout at all times, by all available means, as well as to maintain a safe speed appropriate to the prevailing circumstances.[13]

The MPR require the master of a vessel that is not securely anchored in port or securely moored to shore to ensure that a deck watch is maintained in accordance with parts 2, 3, and 3-1 of section A-VIII/2 of the *Seafarers' Training, Certification and Watchkeeping Code* adopted under the 1995 International Convention on Standards of Training, Certification and Watchkeeping for Seafarers.[14] The Code addresses maintaining a proper lookout and

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12 Transport Canada, *Fishing Vessel Safety Regulations* (last amended 17 May 2020), section 3.16(1).

13 Transport Canada, *Collision Regulations*, schedule 1, part A, rule 5, at https://laws-lois.justice.gc.ca/eng/regulations/c.r.c.,_c._1416/page-3.html#h-512872 (last accessed on 20 January 2021).

14 Transport Canada, SOR/2007-115, *Marine Personnel Regulations* (last amended 04 May 2019), section 213.

provides guidance on watch composition, performing a navigational watch, using all navigational equipment available to the officer of the watch, and ensuring that the vessel follows the planned course.

The MPR also indicate in paragraph 216(2)(b) that, on a vessel of at least 5 gross tonnage (GT), the deck watch, at a minimum, must include a person in charge of the deck watch and an additional person. However, the officer in charge of the navigational watch is allowed to be the sole lookout only during daylight and under certain conditions.[15]

Under the MPR, the *Atlantic Sapphire* was required to have 2 people on the bridge during hours of darkness. On the *Atlantic Sapphire*, it was the practice for the crew to maintain a 1-person bridge watch while the vessel was in transit (day or night). Once the vessel arrived at its fishing location, the master would remain on the bridge until relieved by a crew member in the late evening. On occasion, the master would leave the bridge to help the crew members with fishing operations.

1.9 Stability booklet

The *Atlantic Sapphire* carried a stability booklet that had been developed in 2013, and approved by TC. The stability booklet included 7 examples of stability conditions related to different vessel loading situations. One of the stability conditions described the vessel departing the fishing ground with a full load of fish and accompanying ice required to keep the fish cool (called the full load condition). The vessel's maximum load of fish and ice combined was 36.51 long tons (consisting of ⅔ groundfish and ⅓ ice). The stability booklet specified that, in full load condition, the fifth row of pens, pen 3C, and pen 4C were to be kept empty while the other pens were loaded to 90% capacity. The maximum load of fish and ice was calculated with 25% of the maximum amount of fuel and water remaining in the vessel's tanks. The stability booklet included a note that the fish hold was to be permanently marked to identify the point at which it was 90% full.

The stability booklet also identified the vessel's downflooding point as being the forward edge of the non-watertight main hatch, when all other hatches were closed and secured.

The Notes to Master and the Notes on Vessel Limitations from the stability booklet are illustrated in Appendix B.

The crew followed certain aspects of the guidance in the stability booklet, such as consuming fuel from the aft fuel tanks first, maintaining an even keel when loading the fish hold, using penboards, and loading the forward pens first. Other aspects of the guidance were not followed consistently; for example, the combined weight of fish and ice loaded into

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15 Paragraph 216(2)(b) of the MPR is clarified in Transport Canada's Ship Safety Bulletin 07/2017: Deck Watch Requirements for all Canadian & Foreign Vessels, Including Tug Boats Operating in Waters Under Canadian Jurisdiction (29 September 2017), at https://tc.canada.ca/en/marine-transportation/marine-safety/ship-safety-bulletins/deck-watch-requirements-all-canadian-foreign-vessels-including-tug-boats-operating-waters-under-canadian-jurisdiction-ssb-no-07-2017 (last accessed on 20 January 2021).

the fish hold frequently exceeded 36.51 long tons, and the fish hold was not permanently marked to indicate the point at which it was 90% full.

The AR did not provide any guidance or written operational procedures for the master with respect to loading, beyond having the stability booklet on board. The AR did not post a stability notice or caution the master about overloading when the vessel landed more fish than the maximum load stated in the stability booklet.

1.10 Post-occurrence stability analysis

The TSB contracted a naval architecture firm to conduct a post-occurrence stability analysis for the *Atlantic Sapphire* based on the vessel's lightship weight,[16] as indicated in the stability booklet, and the estimated load condition at the time of the occurrence.

The stability analysis determined that the vessel's estimated loaded condition at the time of the occurrence exceeded the full load condition in the stability booklet by almost 19 long tons (Table 2). One third of the excess weight was accounted for by unused fuel. In this loaded condition, the stability analysis determined that the angle of heel or roll required to immerse the vessel's starboard deck edge in water was approximately 5 °.

Table 2. Comparison of full load condition in stability booklet with the load condition at the time of the occurrence (Source: TSB)

Item	Maximum weight for full load condition, per stability booklet (long tons)	Weight at the time of the occurrence* (long tons)	Amount by which weight exceeded the maximum weight as per stability booklet (long tons)
Fish and ice in holds	36.51 (⅔ fish, ⅓ ice)	38.78	+2.27
Fish on deck	0	7.53	+7.53
Remaining ice in hold	0	0.79	+0.79
Freshwater	0.84	2.69	+1.85
Fuel	Aft 0 Forward 3.74	Aft 4.78 Forward 5.46	+6.5
Total amount	**41.09**	**60.03**	**+18.94**

*The values presented in this column are estimated based on reports of fullness of the fish pens and remaining ice, fuel, and water.

Further analysis by the TSB laboratory determined that sea conditions at the time of the occurrence caused the *Atlantic Sapphire,* with its estimated loaded condition, to roll with an average angle of heel of approximately 15 °, to a maximum angle of heel of 18 °. The analysis indicated that this angle of heel introduced by the sea conditions immersed the deck edge and the freeing ports. This immersion allowed water to collect on the aft-most corner of the starboard main deck, which added more weight and made the vessel more unstable

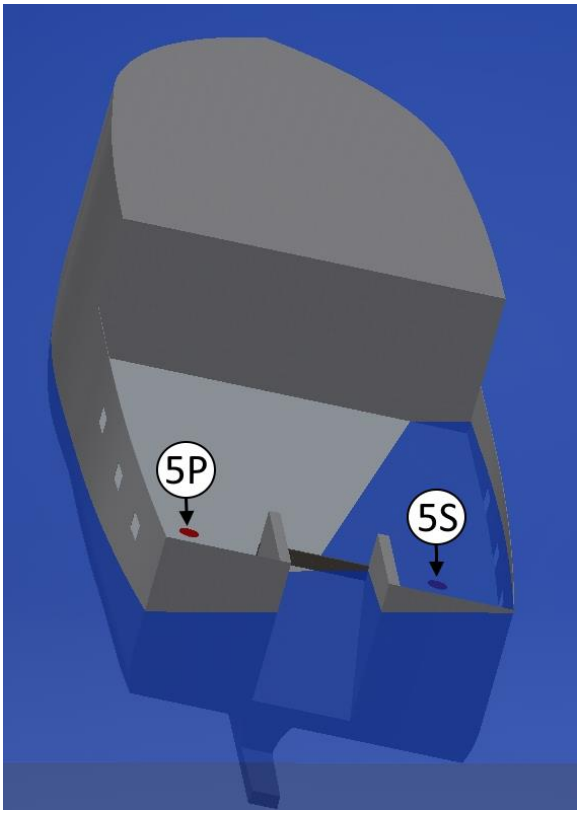
16 A vessel's lightship weight is the weight of the actual vessel, excluding any cargo, passengers, consumables, etc.

(Figure 6). The hatch for pen 5S was open for loading fish, which allowed the water on deck to downflood into the aft starboard-side corner of the fish hold.

1.11 Fishing practices on the *Atlantic Sapphire*

Practices for loading and storing fish on board the *Atlantic Sapphire* had evolved informally over time, and were not recorded as formal procedures in the vessel's safety book or other documentation.

Figure 6. Model of *Atlantic Sapphire* condition when fishing operations stopped. The dots indicate the location of the hatches over pens 5P and 5S (Source: TSB)



A typical fishing trip for haddock would begin with crew members loading ice and fuel before departure. Twelve long tons of ice would be loaded in the centre pens and pens 3S and 3P. The fuel tanks would be filled according to the anticipated trip length and fuel would be drawn from the aft fuel tanks first. The vessel would transit to the fishing grounds overnight and fishing would begin at sunrise the next day. The crew would fish continuously through the day and night until they caught the desired amount of fish, or until the weather conditions deteriorated to the point where they could no longer fish. Typically, the crew would try to catch as close to 100 000 pounds (44.6 long tons) of fish as possible, while planning a morning arrival to offload. The *Atlantic Sapphire*'s fishing licence allowed fishing throughout the year and the crew was paid by a percentage of the catch's monetary value.

When loading the catch, the forward-most pens were loaded first and the crew would fill the pens toward the stern as more fish were caught, while ensuring that the port and starboard pens were loaded evenly. As the ice melted and the fish settled, more fish would be added to the pens to maximize the space. The crew would estimate the total amount of fish on board at any given time based on estimates of the weight of each catch that was

hauled on board.[17] The total amount of fish to be caught and the method for loading the catch was based on the master's previous experience and knowledge; the master had determined the vessel's maximum load to be approximately 44.6 long tons and he was aware that the vessel had landed over 60 long tons of fish in the past.[18]

Between December 2018 and December 2019, the *Atlantic Sapphire* made 41 fishing trips. The average number of days per trip was 3.95, with the longest trip being 6 days. The occurrence voyage was the only voyage in the last year where the full load condition was met or exceeded within a single day of fishing.

The total amount of landed fish was weighed at the end of each trip. The amount of ice that remained in the hold after each trip was not weighed.[19] The average weight of landed fish per trip was 36 long tons, with the largest landing being 49.7 long tons. Figure 7 shows the total weights of landed fish, not including ice, for the *Atlantic Sapphire* between December 2017 and December 2018. The solid red line shows the maximum weight of fish and ice that the vessel can store in the hold per the stability booklet. The black dashed line shows the maximum weight of the fish, with ice being accounted for as ⅓ of the load. On 37 of the 41 trips, the total amount of landed fish exceeded the maximum weight of the fish in the stability booklet. On 23 of the 41 trips, the total amount of fish alone exceeded the maximum weight of fish and ice in the stability booklet.

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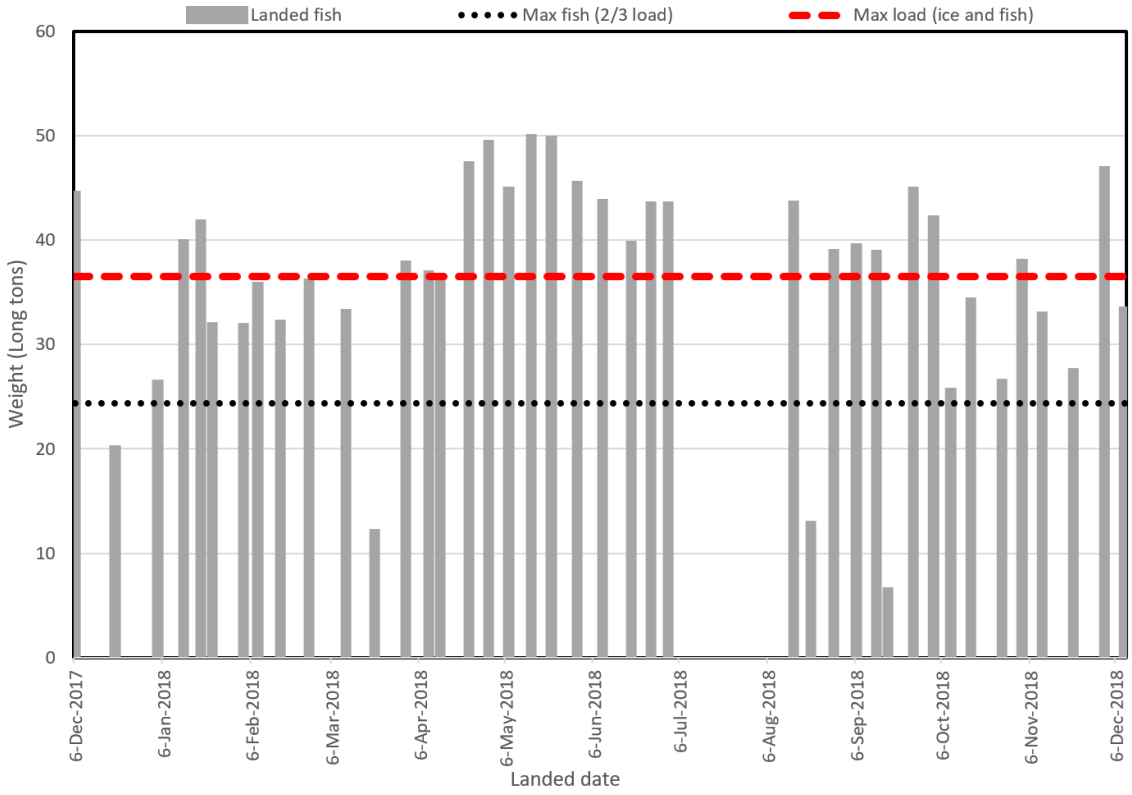
17 Throughout the preceding 12 months, the master's estimates, which were reported to a third-party monitor at the dock, were within 15% of the weighed value 97% of the time.

18 The vessel's stability booklet before 2013 had indicated a maximum loaded condition of 51.2 long tons of fish, and a previous owner had landed over 60 long tons of fish in the past. The vessel underwent modifications in 2013 that necessitated a new stability booklet, which indicated a lower maximum loaded condition of 36.51 long tons of fish. The vessel's landing history dating back to 2013 shows that the vessel was routinely loaded above its maximum loaded condition for fish.

19 The exact amount of ice remaining after each fishing trip cannot be determined because it depends on several factors, including ambient air temperature, surface water temperature, fish temperature, insulation around the fish pen, the amount of time the fish was on deck (sunlight), and the size of the pieces of ice around the fish.

Figure 7. Weight of fish landed* by the *Atlantic Sapphire* from December 2017 to December 2018 (Source: TSB)



* The additional weight of the ice on board that remained in the hold after the fish were landed is not shown on this figure.

1.12 Commercial fishing licensing

To commercially harvest any marine life in the tidal waters of Nova Scotia, a vessel's owner or AR must ensure that they have a licence to fish for the species they wish to catch.[20] Fisheries and Oceans Canada (DFO) is responsible for issuing licences for commercial fishing. DFO also maintains a database of information about commercial fishing in Canada, such as landing history.

The AR of the *Atlantic Sapphire* owned 5 groundfish licences. As a licence condition for the *Atlantic Sapphire,* the master was required to report catch information in the monitoring document[21] for that licence. A dockside monitor was also required to record the landed

20 Fisheries and Oceans Canada, SOR/86-21, *Atlantic Fishery Regulations*, *1985* (last amended 30 May 2018).

21 A monitoring document is a log that must be completed by the master that details the use of the fishing gear.

value of fish, and the vessel was required to participate in an at-sea observer program, and be fitted with a vessel monitoring system unit.[22] The information gathered as a licence condition was recorded and maintained by DFO.

1.13 Immersion suits

Marine immersion suits provide flotation to minimize the risk of drowning, and thermal protection to delay the onset of hypothermia. An immersion suit's effectiveness in preventing hypothermia depends on how well it fits the wearer to prevent the ingress of water. The FVSR require fishing vessels of not more than 24.4 m in length and up to 150 GT making certain voyages to carry an immersion suit of an appropriate size for each person on board.

At the time of the occurrence, the *Atlantic Sapphire* had 5 immersion suits on board, which were in the accommodations space. Four were adult universal-sized immersion suits and one was a jumbo-sized immersion suit. One crew member on the *Atlantic Sapphire* had identified his immersion suit by writing his name on it. Beyond this, there was no evidence of a method to ensure that a properly fitted suit was allocated to each crew member on a particular voyage. The pre-departure checklist included an item requiring the crew to check the number and size of lifejackets, but did not include a similar item for the immersion suits.

The Canadian General Standards Board requires immersion suits with a limited size range to be clearly identified to prevent inadvertent selection in an emergency.[23] The standard specifies that these suits, as well as their stowage bags, are to be permanently marked with the following words in characters at least 10 mm high:[24]

> WARNING
>
> THIS SUIT HAS A LIMITED SIZE RANGE AND IS NOT SUITABLE FOR UNCONTROLLED EMERGENCY DISTRIBUTION

The jumbo-sized immersion suit on board the *Atlantic Sapphire* was approved to the Canadian General Standards Board standard. It was kept in a stowage bag marked XXL (extra, extra large), but neither the suit nor the stowage bag displayed the warning quoted above.

1.14 Very high frequency digital selective calling radiotelephone

Fishing vessels over 8 m and of closed construction are required to be fitted with a VHF-DSC radiotelephone that can transmit an automatic distress message at the push of a button. If the VHF-DSC radiotelephone is installed, registered and programmed with a maritime

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22 A vessel monitoring system is a satellite-based position tracking system to monitor the movements of fishing vessels.

23 Canadian General Standards Board, *Immersion Suit Systems*, CAN/CGSB-65.16-2005 (Gatineau: 2005), section 8.5, p. 27.

24 Ibid.

mobile service identity, the distress message will automatically provide the vessel's identification information and the time of the message. If the VHF-DSC radiotelephone is integrated with the vessel's GPS, then the vessel's position will also be transmitted.

A VHF-DSC distress message is a digital transmission that has a greater range than a voice call via a VHF radiotelephone. The digital nature of the distress message also avoids the potential for broken or dropped voice transmissions. When a DSC distress message reaches another vessel in range, that vessel's VHF-DSC radiotelephone will automatically switch to channel 16 (the emergency channel) to increase the potential that the following voice distress message will be heard. The DSC distress message will also activate an audible alarm on vessels equipped with VHF-DSC and within range, to alert them of the distress message. The DSC distress message will continue to repeat automatically until it is cancelled by the initiating user or acknowledged by a receiver, which is normally a coast radio station (e.g., Marine Communications and Traffic Services).

The *Atlantic Sapphire* was fitted with a VHF-DSC radiotelephone that was registered, programmed, and integrated with the vessel's GPS. The button to send an automatic distress message was not pressed during the occurrence.

1.15 Commercial fishing safety oversight

Safety oversight of commercial fishing operations is a responsibility shared by individual masters and ARs, as well as federal and provincial regulators.

The *Canada Shipping Act, 2001* requires the master of a vessel to take all reasonable steps to ensure the safety of the vessel and of persons who are on board.[25] The Act also requires the AR to act with respect to all matters related to a vessel that are not otherwise assigned to any other person. Specifically, a vessel's AR is responsible for ensuring that the vessel and its machinery and equipment meet the regulations; developing procedures to safely operate the vessel and to deal with emergencies; and ensuring that vessel crew and passengers receive safety training.[26]

Furthermore, the FVSR indicate that the master and AR are both responsible for ensuring the regulations are followed.[27]

1.15.1 Federal regulators

Both TC and DFO have roles in federally regulating commercial fishing. While DFO is responsible for the management of fisheries to ensure the sustainability of the resource and an economically viable industry, it is not responsible for the safety of fish harvesters or fishing vessels. The safety of vessels, including fishing vessels, is the responsibility of TC,

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25 Government of Canada, *Canada Shipping Act, 2001* (last amended 20 July 2019), subsection 109(1).

26 Ibid., subsection 106(1).

27 Transport Canada, *Fishing Vessel Safety Regulations* (last amended 17 May 2020), section 3.02.

and accessibility of Canada's waterways is the responsibility of the Canadian Coast Guard, including marine search and rescue. However, many of their responsibilities are interconnected, and actions taken by an organization to fulfill its mandate may have an impact on another component of the fishery and affect the safety of fish harvesters.

In 2006, TC, DFO, and the Canadian Coast Guard signed a memorandum of understanding (MOU) to ensure collaboration on commercial fish harvesters' safety at sea. The MOU states that each participating organization must establish principles to promote a safety culture and consider the safety of commercial fish harvesters when creating or revising rules, regulations, policies, and plans that affect commercial fish harvesters.

The MOU also states that the organizations will meet as required to discuss fishing vessel safety issues, and that TC and DFO are to meet before the national Canadian Marine Advisory Council meeting. All participating organizations at the national and regional levels are to discuss safety issues through the advisory process, with decisions being reflected in the integrated fisheries management plans. Since January 2015, the majority of the meetings agreed upon in the MOU have been held.

DFO also signed a letter of agreement under the MOU, which permits the sharing of DFO data with TC for commercial fishing vessel safety purposes and other related activities, such as education, compliance monitoring, or investigations. DFO is currently collaborating with TC in the Pacific and Quebec regions as a pilot project to share vessel registration information to identify fishing vessels registered with DFO that are not duly registered with TC.

1.15.2 Province of Nova Scotia

The workplace safety of crews while they are engaged in the business of fishing is under provincial jurisdiction. The *Occupational Health and Safety Act* in Nova Scotia states that employees and owners share the responsibility for the health and safety of persons at the workplace. The provincial department responsible for occupational health and safety has a role in establishing and clarifying the responsibilities of the owner and employees, supporting them in carrying out their responsibilities, and intervening appropriately when those responsibilities are not carried out.[28]

According to the Nova Scotia *Labour Standards Code*,[29] fishing is considered an industrial undertaking. In Nova Scotia, there are provincial regulations that set out specific safety requirements and procedures for industries such as commercial diving, underground

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28 Province of Nova Scotia, *Occupational Health and Safety Act* (last amended 2017), section 2.

29 Province of Nova Scotia, *Labour Standards Code* (05 May 2020), section 66, https://www.canlii.org/en/ns/laws/stat/rsns-1989-c-246/latest/rsns-1989-c-246.html?searchUrlHash=AAAAAQAKZW1wbG95bWVudAAAAAAB (last accessed on 30 June 2020).

mining, pipeline transportation, rail transportation, and traffic control.[30] However, there are no provincial regulations or requirements specific to commercial fishing.

1.16 Fatigue

Fatigue is recognized as being pervasive throughout modern society, and this has important implications for safety-critical roles in the marine industry. Disruptions to sleep or sleeping patterns in personnel occupying safety-critical roles can reduce performance and increase the risk of incidents and accidents. Fatigue has been shown to slow reaction time, increase risk taking, and reduce a person's ability to solve complex problems. It more generally affects attention, vigilance, and general cognitive functioning.

Several factors are conducive to fatigue, including acute or chronic lack of sleep, effects of the body's circadian rhythms (particularly during night shifts), continuous wakefulness, and sleep disorders. Other factors that may influence a person's ability to obtain restorative sleep are individual factors (e.g., morningness/eveningness,[31] ability to nap), the nature of the work (e.g., high or low workload), and the individual's schedule type (e.g., split shifts[32]). Fatigue increases and performance deteriorates as work shifts increase in length. The risk of an accident becomes critical after 12 hours of constant work.[33]

Due to an individual's circadian rhythm,[34] rest periods taken during the daytime may be less restorative than those taken during the hours of darkness. For sleep to be restorative, it should occur at night for a period of at least 7, and up to 9, continuous hours[35,36] so that all

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30 These industries are regulated under the *Occupational Diving Regulations*, *Underground Mining Regulations*, *Pipeline Regulations, Railway Safety Regulations,* and the *Temporary Workplace Traffic Control Manual*.

31 Morningness/eveningness is the degree to which people prefer organizing their activity and sleep patterns toward the morning or evening. (Source: B.P. Hasler, J.J. Allen, D.A. Sbarra, et al.,"Morningness-eveningness and depression: preliminary evidence for the role of the behavioral activation system and positive affect," *Psychiatry Research*, Volume 176, Issues 2–3 (30 April 2010), pp. 166–173.)

32 Split shifts are those that consist of 2 or more distinct work periods.

33 J. R. Jepsen, Z. Zhao, C. Pekcan, et al., "Risk factors for fatigue in shipping, the consequences for seafarers' health and options for preventive intervention," *Maritime Psychology* (January 2017), pp. 127–150.

34 Circadian rhythms are the physiological functions, such as sleep/wake cycle, that cycle over a day.

35 M. Hirshkowitz, K. Whiton, S. M. Albert, et al., "National Sleep Foundation's sleep time duration recommendations: methodology and results summary," *Sleep Health: Journal of the National Sleep Foundation*, Vol. 1, Issue 1 (March 2015), pp. 40–43.

36 Fatigue-management programs, such as the U.S. Coast Guard's Crew Endurance Management System, have shown that at least 7 to 8 continuous hours of sleep is preferable.

stages of sleep[37] occur during each nightly sleep period. Likewise, due to an individual's circadian rhythm, overall performance and cognitive functioning are at their worst during the night. This can occur in the absence of fatigue;[38] that is, overall performance may be low during the circadian trough even if a person is not fatigued.

1.16.1 Fatigue in the fishing industry

In the fishing industry, crew members are typically compensated by sharing the value of the landed catch. Limiting the crew size on board a vessel to the smallest complement permitted by regulations maximizes each crew member's income. At the same time, having a smaller crew on board increases the risk of fatigue by requiring crew members to work longer, irregular hours across long periods of time, while providing them limited opportunities to obtain good quality, uninterrupted sleep.[39]

Meals, personal chores, crew shift changes, and unscheduled interruptions (such as fouled gear) prevent crew members from obtaining the necessary amount of sleep in the time available.[40]

1.16.2 Vessel manning and work–rest requirements

From a regulatory standpoint, fatigue in the marine industry in Canada is addressed through the MPR, which incorporate the requirements set out in the *Seafarers' Training, Certification and Watchkeeping Code*. The MPR require the following for the master and every crew member on fishing vessels over 100 GT[41] in Canadian waters on near coastal voyages:

- At least 6 consecutive hours of rest in every 24-hour period
- At least 16 hours of rest in every 48-hour period
- That not more than 18 hours, but not less than 6 hours, elapse between the end of a rest period and the beginning of the next rest period[42]

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37 Sleep consists of 3 non-REM (rapid eye movement) stages (N1, N2, and N3) and 1 REM stage. A typical sleep cycle will progress through 5 stages—N1-N2-N3-N2-REM—with 4 to 6 repeating cycles of approximately 90 minutes each.

38 T. Monk, S. Folkard, and A. A. I. Wedderburn, "Maintaining safety and high performance on shift work," *Applied Ergonomics*, Vol. 27 (1996), pp. 17–23.

39 TSB Marine Investigation Report M09Z0001 (Safety Issues Investigation into Fishing Safety in Canada) identifies both fatigue and the costs associated with safety as significant safety issues associated with fishing accidents.

40 I. Lazakis, R. E. Kurt, and O. Turan, "Contribution of human factors to fishing vessel accidents and near misses in the UK," *Journal of Shipping and Ocean Engineering*, Issue 4 (2014), pp. 245–261.

41 An advanced search in TC's vessel registration query system in March 2020 indicated there were 16 904 fishing vessels registered in Canada, 377 (2.23%) of which are over 100 GT.

42 Transport Canada, SOR/2007-115, *Marine Personnel Regulations* (last amended 04 May 2019), section 320.

Table 3 contains an example of a schedule that would meet the MPR requirements for a 3-person crew, on a vessel of over 100 GT, on a voyage that does not allow for overnight rest in port. This example accounts for a lookout at all times[43] and does not allow for any operations aside from navigation.

Table 3. Example of a 48-hour navigating schedule with 3 crew following the MPR rules (Source: TSB)

	Day 1			Day 2		
Role	**0000–0800**	**0800–1600**	**1600–2400**	**0000–0800**	**0800–1600**	**1600–2400**
Master	8-hour rest	Watchkeeping	Watchkeeping	8-hour rest	Watchkeeping	Watchkeeping
Mate	Watchkeeping	8-hour rest	Lookout	Watchkeeping	8-hour rest	Lookout
Crew	Lookout	Lookout	8-hour rest	Lookout	Lookout	8-hour rest

The Nova Scotia *Labour Standards Code* mandates a rest or eating break of at least half an hour for every 5 consecutive hours of work but does not mandate rest periods in terms of hours or days.

1.16.3 Work–rest schedule on the *Atlantic Sapphire*

In the 12 months before the occurrence, an average fishing trip for haddock on the *Atlantic Sapphire* included 12 hours of overnight transit to the fishing grounds, 4 days of continuous fishing, and an overnight transit back to port. While in transit, each crew member was expected to hold a 3- to 4-hour, 1-person watch. The schedule was timed so that the master would finish his 6- to 8-hour rest when the vessel arrived at its fishing location. The master would remain on the bridge until he needed to rest again, and the other crew members would work on deck, resting when they could during a tow or before the next tow.

Although crew members did not record their rest periods, the crew's typical work and rest patterns when fishing could be estimated using the vessel's monitoring document. On a previous fishing trip that took place from 05 to 09 December 2018, the vessel spent 3 consecutive days fishing. During the 80 hours of fishing, the longest possible rest period was 4 hours 39 minutes. The average tow was 3 hours 48 minutes, and the average time between tows was 54 minutes (Appendix A).

For the occurrence voyage, the master and crew members of the *Atlantic Sapphire* had anticipated to work 4 days and 3 nights, including the transit to Georges Bank and back. The crew's work hours for this trip started on 12 December 2018 at 1400, when the crew loaded the vessel with fuel and ice. The occurrence took place on the crew's second workday, after the crew had been fishing for 16 hours. One crew member had accumulated an additional 3 to 4 hours of consecutive duty time (19 to 20 hours total) as a bridge watchkeeper before fishing began that day. During this 16-hour period, the crew harvested about 33 long tons of fish; this amount is typically caught by this crew after 4 days of fishing.

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43 A daytime lookout would be required in restricted visibility; fog and precipitation are both common on Georges Bank.

1.17 Adaptations in the workplace

People rarely follow rules or instructions precisely, for reasons and in ways that make sense to them given their circumstances, knowledge, and goals.[44] Such adaptations can be defined as deliberate decisions to act against a rule or procedure. While policies and procedures are prescribed to set boundaries for safe operations, individuals and crews may push the boundaries to become more productive or obtain some other benefit. This can lead to adaptations of procedures that result in unsafe practices.[45] Without intervention, successful adaptations—in other words, those that do not result in an accident or incident—tend to be communicated among crew members. Such adaptations are unlikely to be recognized as deviations by those within the group using them. The adaptations become normal behaviour, and the associated risk becomes unlikely to be recognized.[46]

1.18 Safety Issues Investigation into Fishing Safety in Canada

In August 2009, the TSB undertook an in-depth safety issues investigation into fishing vessel safety in Canada. The Safety Issues Investigation into Fishing Safety in Canada[47] report was released in June 2012, and provided a national view of safety issues in the fishing industry, revealing a complex relationship and interdependency among these issues. The Board identified the following safety-significant issues requiring attention: stability, lifesaving appliances, fisheries resource management, the cost of safety, safety information, safe work practices, the regulatory approach to safety, fatigue, training,[48] and fishing industry statistics. These 10 issues form part of the context of commercial fishing work in Canada.

1.19 Previous recommendations

1.19.1 Stability

1.19.1.1 TSB Recommendation M94-33

While en route from Cap-aux-Meules, Magdalen Islands, Quebec, to Rivière-au-Renard, Quebec, the fishing vessel *Le Bout de Ligne* disappeared on 13 December 1990 with the loss of all hands. The most probable cause is that the vessel suddenly capsized in adverse weather conditions due to a loss of transverse stability.

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44 S. Dekker, *The Field Guide to Understanding 'Human Error'* (Ashgate Publishing, 2006).

45 J. Rasmussen, "Risk management in a dynamic society: a modeling problem," *Safety Science*, Vol. 27, Issue 2/3 (1997), p. 197.

46 S. Dekker, *Drift into Failure* (Ashgate Publishing, 2011), p. 111.

47 TSB Marine Investigation Report M09Z0001.

48 The Safety Issues Investigation into Fishing Safety in Canada report found that marine emergency duty training does not instill the importance of safety drills and that fish harvesters do not always conduct these drills.

The Board concluded its investigation and released report M90L3033 on 16 December 1994. The investigation found that most fish harvesters did not have formal training in vessel stability, and were unable to extrapolate the stability of their vessel under different conditions. Consequently, essential information was not being put to effective use. Therefore, the Board recommended that

> the Department of Transport establish guidelines for stability booklets so that the information they contain is presented in a simple, clear, and practical format for end-users.
>
> **TSB Recommendation M94-33**

Since the release of Recommendation M94-33, the TSB has followed up annually with TC on action to address the recommendation. TC has provided responses to indicate any action taken, and the TSB has assessed those responses. The history of these responses, as well as the TSB's latest assessment of TC's response (dated January 2019), is available on the TSB website.[49]

1.19.1.2 TSB Recommendation M16-02

On 05 September 2015, the fishing vessel *Caledonian*, with 4 crew members on board, capsized 20 NM west of Nootka Sound, British Columbia. Following the capsizing, the Canadian Coast Guard rescued 1 crew member and recovered the bodies of the master and the 2 other crew members.

The Board concluded its investigation and released report M15P0286 on 14 December 2016. The investigation found that crews on fishing vessels need adequate stability information to enable them to determine safe operating limits. Therefore, the Board recommended that

> the Department of Transport establish standards for all small fishing vessels that have had a stability assessment to ensure their stability information is adequate and readily available to the crew.
>
> **TSB Recommendation M16-02**

Since the release of Recommendation M16-02, the TSB has followed up annually with TC on action to address the recommendation. TC has provided responses to indicate any action taken, and the TSB has assessed those responses. The history of these responses, as well as the TSB's latest assessment of TC's response (dated January 2020), is available on the TSB website.[50]

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49 TSB Recommendation M94-33: Guidelines for small fishing vessel stability booklets, at https://www.tsb.gc.ca/eng/recommandations-recommendations/marine/1994/rec-m9433.html (last accessed on 15 September 2020).

50 TSB Recommendation M16-02: Adequate stability information for crews on small fishing vessels that have previously been assessed for stability, at https://www.tsb.gc.ca/eng/recommandations-recommendations/marine/2016/rec-m1602.html (last accessed on 25 January 2021).

1.19.2 Fatigue

1.19.2.1 TSB recommendations M18-01 and M18-02

On 13 October 2016, the articulated tug-barge composed of the tug *Nathan E. Stewart* and the tank barge *DBL 55* went aground approximately 10 NM west of Bella Bella, BC.

Following this occurrence, the Board concluded its investigation and released report M16P0378 on 31 May 2018. The investigation found that although fatigue is widely accepted as an unavoidable condition within the marine industry and is recognized as a contributing factor in many marine accidents, there is a general lack of awareness of the factors that cause fatigue. If watchkeepers understand those factors and the practical actions that can be taken to minimize their effects, it may significantly reduce the number of fatigue-related occurrences. The Board therefore recommended that

> the Department of Transport require that watchkeepers whose work and rest periods are regulated by the *Marine Personnel Regulations* receive practical fatigue education and awareness training in order to help identify and prevent the risks of fatigue
>
> **TSB Recommendation M18-01**

The investigation also found that implementing effective fatigue education and awareness for watchkeepers is just one step that will help the marine industry go beyond the regulations to mitigate the risk of fatigue. Implementing comprehensive fatigue management plans within the marine industry will bring it in line with approaches to fatigue management adopted by the rail and air transportation modes. The Board therefore also recommended that

> the Department of Transport require vessel owners whose watchkeepers' work and rest periods are regulated by the *Marine Personnel Regulations* to implement a comprehensive fatigue management plan tailored specifically for their operation, to reduce the risk of fatigue
>
> **TSB Recommendation M18-02**

Since the release of Recommendations M18-01 and M18-02, the TSB has followed up annually with TC on action to address the recommendation. TC has provided responses to indicate any action taken, and the TSB has assessed those responses. The history of these responses, as well as the TSB's latest assessment of TC's responses (dated January 2020), is available on the TSB website.[51,52]

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51 TSB Recommendation M18-01: Fatigue education and awareness training for watchkeepers, at https://www.tsb.gc.ca/eng/recommandations-recommendations/marine/2018/rec-m1801.html (last accessed on 25 January 2021).

52 TSB Recommendation M18-02: Fatigue management plans on vessels, at https://www.tsb.gc.ca/eng/recommandations-recommendations/marine/2018/rec-m1802.html (last accessed on 25 January 2021).

1.20 TSB Watchlist

The TSB Watchlist identifies the key safety issues that need to be addressed to make Canada's transportation system even safer.

Commercial fishing safety and fatigue are **Watchlist 2020 issues**. As this occurrence demonstrates, gaps remain with respect to vessel stability, adequate manning, emergency preparedness, and fatigue.

ACTIONS REQUIRED

Commercial fishing safety will remain on the Watchlist until there are sufficient indications that a sound safety culture has taken root throughout the industry and in fishing communities across the country, namely:

- Federal and provincial authorities coordinate regulatory oversight of commercial fisheries.
- TC, provincial workplace safety authorities, and harvester associations promote existing user-friendly guidelines on vessel stability designed to reduce unsafe practices.
- Spurred by the leadership of industry and safety advocates, there is marked and widespread evidence that harvesters are taking ownership of safety, specifically with respect to the use of stability guidelines, PFDs, immersion suits, emergency signalling devices, and safe work practices.

1.21 TSB laboratory reports

The TSB completed the following laboratory report in support of this investigation:

- LP071/2019 – Dynamic Stability Analysis, Fishing Vessel "ATLANTIC SAPPHIRE"

2.0 ANALYSIS

The investigation determined that the excess weight of the fish, ice, fuel, and freshwater on the *Atlantic Sapphire* compromised its stability. The analysis will focus on vessel stability, safe manning, emergency preparedness, fatigue, and oversight of commercial fishing vessel safety.

2.1 Factors leading to the sinking

Before bringing the final catch (approximately 7.53 long tons) on board, the *Atlantic Sapphire* already had more fish and ice (estimated at 38.78 long tons) in the hold than the maximum load specified in the stability booklet (36.51 long tons). This reduced both the vessel's freeboard and stability, making it more vulnerable to downflooding.

On the occurrence voyage, the crew caught a full load of fish in less time than on any other trip that year, so there was more fuel, freshwater, and ice on board than usual. The crew did not appreciate the risk to the vessel's stability created by this excess weight, and as a result, the crew did not take precautions against the risk of downflooding and capsizing.

With the final catch on board, the vessel's stability was further compromised; the rolling motion due to the sea condition was enough to immerse the deck edge and allow seawater onto the main deck. The water then downflooded into the fish hold through the open hatch.

The master left the bridge to help the crew load the final catch; consequently, when the main deck became awash, the situation was not recognized until the fish hold began to downflood. Progressive downflooding in the vessel compartments caused the vessel to list to starboard and the freeboard to decrease until the vessel sank.

2.2 Stability limits

Operating a vessel within its stability limits is critical to the safety of the vessel, the crew, and the environment. This is especially important for commercial fishing operations where varying amounts of weight are being brought on deck before being stored according to the stability booklet. The vessel's authorized representative (AR) must ensure that the master and crew clearly understand the vessel's stability limits and that the vessel is operated within these limits at all times.

The *Atlantic Sapphire*'s AR was aware of the results of the stability assessment conducted in 2013 and had provided the vessel's crew with a stability booklet. The AR did not, however, provide the crew with the required written operational procedures, permanently mark the fish hold at 90% capacity, or post a stability notice to help them conduct all vessel operations within the vessel's stability limits.

The crew had not been consulting the stability booklet consistently to determine safe loading conditions for at least 12 months prior to the occurrence trip, without any apparent impact on safety, indicating that an adaptation to the loading procedure had likely evolved over time. The AR had not been ensuring that the master complied with the vessel's stability booklet with respect to maximum load. Consequently, the risks associated with the loading

practices on the day of the occurrence, particularly given the extra fresh water and fuel on board, were not fully appreciated by the crew.

Based on his experience, the master informally assessed the vessel's maximum load (44.6 long tons) and believed the vessel was safe to operate. However, this load was greater than the maximum load defined in the stability booklet (36.51 long tons).

The stability booklet included an assumption that ⅓ of the ice load would remain at the end of a voyage, and stated that the maximum load for fish and ice was 36.51 long tons. On this basis, the vessel load had exceeded the maximum load defined in the stability booklet on 90% of its voyages in the 12 months leading up to the occurrence. During this period, the average weight of landed fish alone was approximately 36 long tons. This suggests that the vessel's maximum load for both fish and ice may have been interpreted as the vessel's maximum load for fish only, without accounting for the weight of ice.

The compensation for the master and crew was based on the amount of fish caught per trip. This system may have incentivised the crew of the *Atlantic Sapphire* to land large quantities of fish that exceeded the vessel's stability limits.

If a vessel is operated beyond its stability limits and oversight by the AR is not effectively executed, the vessel is at increased risk of sinking or capsizing.

2.3 Safe manning

A safe manning document specifies the minimum complement of certified crew members required to safely navigate a vessel on its intended voyage and to respond to an emergency. The minimum complement does not consider that additional crew may be required depending on the vessel's operations, such as fishing. Transport Canada (TC) expects that the AR will augment the crew for these other operations as required. This distinction may not necessarily be clear for ARs, who may perceive meeting the safe manning requirements to be sufficient for the safety of all vessel operations, and who may also perceive a commercial benefit from operating with a smaller crew.

The AR for the *Atlantic Sapphire* considered the number of crew members prescribed in the safe manning document to be the acceptable minimum required for all vessel operations, including navigation, emergencies, and fishing. However, the crew complement on the *Atlantic Sapphire* was such that the master could not configure a crew work–rest schedule that met both the requirements for fishing operations and the requirements for consecutive hours of rest in the *Marine Personnel Regulations* (MPR).

Table 4 shows the challenge of configuring a schedule for a crew of 3 on the occurrence voyage that met the MPR requirements with respect to hours of work and rest, accounted for a lookout during darkness, and also allowed opportunities for fishing. Table 4 demonstrates that when meeting the regulatory requirements with a crew of 3, the time remaining for fishing operations is minimal: about 3 hours with 2 crew on deck and another

3 hours with 1 crew on deck. Such a minimal amount of time allocated to fishing is not feasible in most operations.

Table 4. Example of a schedule for the *Atlantic Sapphire* that would meet *Marine Personnel Regulations* requirements while fishing in good visibility. The example date is 13 December 2020; sunrise is at 0746; sunset is at 1646. (Source: TSB)

	Master	Mate	Crew
0000–0400	Resting	Watchkeeping	Lookout
0400–0600	Watchkeeping	Lookout	Resting
0600–sunrise	Watchkeeping	Resting	Lookout
Sunrise–0800	Watchkeeping	Resting	Resting
0800–1200	Watchkeeping	Resting	Resting
1200–1400	Watchkeeping	Resting	Resting
1400–1600	Watchkeeping	Fishing	Fishing
1600–sunset	Watchkeeping	Fishing	Fishing
Sunset–2000	Watchkeeping	Lookout	Fishing
2000–0000	Resting	Watchkeeping	Lookout

Crewing a vessel without taking into account all of the vessel's operations can result in situations where crew members have unsustainable workloads or are fatigued. It may also lead crew members to make adaptations or take risks that they would not otherwise take, such as putting an unqualified crew member on watch, or leaving the bridge unattended to help crew members with fishing operations.

Unlike workplaces in other industries, there are no provincial regulations for fishing vessel operations, including a minimum crew complement. A safe manning document issued by TC, along with any relevant regulations, is the only guidance available to ARs to determine the number of crew required to safely operate a vessel.

Although the crew complement on the *Atlantic Sapphire* met the minimum requirements of the safe manning document for navigation, it did not meet the work–rest schedule required by the MPR when engaged in fishing operations. These circumstances may have led the crew to make procedural adaptations or take risks that they would not have otherwise taken.

If vessel manning is not based on both the safe manning document and the *Marine Personnel Regulations*' work–rest requirements, there is a risk that crew members will have

unsustainable workloads or be fatigued, causing them to deviate from safe operating practices.

2.4 Bridge watchkeeping

Maintaining a constant watch on the bridge helps avoid collisions and provides an overall vantage point from which to monitor the vessel's status. It is also important for the safety of the vessel to ensure that critical bridge systems, radios, and alarms are monitored at all times.

The *Atlantic Sapphire* was required to have 1 certified watchkeeper on the bridge at all times, and an additional person during periods of darkness. However, the vessel's crew complement did not allow for 2 watchkeepers during periods of darkness, and for adequate rest periods when fishing. Additionally, although the master remained on the bridge for most of his watch, on occasion, he would leave the bridge unattended to help with fishing operations.

In this occurrence, once the last tow was brought on board, the master left the bridge to go help chop ice in the fish hold. His goal was to save time and effort for the crew members so that they could start heading home after a long workday. Because the master was familiar with operating the *Atlantic Sapphire* and had never experienced adverse consequences with this vessel, he may have perceived the risk associated with leaving the bridge unattended as being low.

However, with no one on the bridge, none of the crew had a good vantage point from which to identify the vessel's list as it developed. The master and deckhand were below deck in the fish hold, and the mate was on the main deck facing toward the port side, away from the open hatch. From both of these positions, a list would be difficult to perceive until it became substantial. When the high level alarms for the bilges began to activate, there was no one on the bridge to receive the warning and activate the bilge pumps to begin pumping out water. The crew became aware of the developing emergency situation only when the mate perceived the rising water level, which reduced the time available to take action.

If a bridge watch is not maintained at all times, there is a risk that the crew may not have a good vantage point from which to observe the vessel's overall status and may miss critical information provided by bridge systems, radios, and alarms alerting them to an emergency.

2.5 Emergency preparedness

An emergency response is most effective when crew have emergency response procedures to guide them in carrying out critical steps and are familiarized with these procedures through regular emergency drills.

2.5.1 Emergency drills

In the 12 months preceding the occurrence, the master and crew on the *Atlantic Sapphire* had not performed emergency drills. Without drills, there was little opportunity for the crew to detect in advance the issues they would encounter with the sizing of immersion suits, and for the master to choose a method of distress alerting that would maximize the potential for a response.

Drills are discussed in the Marine Emergency Duties training that fish harvesters are required to take. However, the Safety Issues Investigation into Fishing Safety in Canada report found that this training does not instill the importance of safety drills and that fish harvesters do not always conduct drills, as was the case in this occurrence.

2.5.2 Distress alerting

In an emergency, there is often little time to send a distress alert and so it is important that mariners use the distress alerting method that maximizes the potential for a response.

In this occurrence, the master was successful in calling a local vessel on very high frequency (VHF) radiotelephone channel 4, which is not an emergency channel but one used frequently by fish harvesters. However, the likelihood of a distress call on a local channel being received is contingent upon other vessels monitoring that particular channel, and it may not consistently yield the same response.

The *Atlantic Sapphire*'s VHF radiotelephone was also fitted with digital selective calling (DSC), which can be activated at the press of a button. Marine Communications and Traffic Services monitor the DSC frequencies at all times and alert the appropriate rescue coordination centre; the centres will respond to any type of emergency. A DSC distress message also has other benefits, such as a greater range than voice transmissions; an alarm to alert other vessels that a distress message has been received; and an automatic repeat function so that the distress message continues to be transmitted until it is cancelled or acknowledged. All of these features help maximize the potential for a response.

The TSB has investigated many occurrences where not having available or using a DSC radiotelephone prevented timely alerting to other vessels or search and rescue authorities.[53]

If methods of distress alerting that maximize the potential for a response are not used during an emergency, there is a risk that the response may not be timely or adequate.

2.5.3 Donning of immersion suits

The effectiveness of an immersion suit in preventing hypothermia depends on how well it fits to limit loss of body heat and how effectively it prevents the ingress of water.

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[53] TSB marine transportation safety investigation reports M98N0001 (*Flare*), M05N0072 (*Melina & Keith II*), M09L0074 (*Le Marsouin I*), M15P0286 (*Caledonian*), and M16A0327 (*Pop's Pride*).

In this occurrence, the master and deckhand donned immersion suits that were more appropriately sized for the other person and there was not enough time for them to switch suits. As a result, cold water entered both of their suits, exposing them to the risk of hypothermia.

The company pre-departure checklist included a prompt for the crew to check the number and size of lifejackets on board, but did not have a similar prompt for the immersion suits. Without having conducted any emergency drills, the crew had little opportunity to identify before the occurrence the potential issue of donning an incorrectly sized suit. Although one of the immersion suits had been labelled by a crew member with his name, and another had been labelled with its size, there was no evidence of a company process to ensure that each crew member would don an appropriately sized suit during an emergency.

If there is no process to ensure that each crew member dons an appropriately sized immersion suit in an emergency, crew members may don ill-fitting suits, increasing the risk of hypothermia or drowning.

2.6 Fatigue

The investigation was unable to ascertain the crew's hours of work or rest for the days before the occurrence, because this information was not recorded. It was therefore not possible to perform a quantitative analysis of data. However, it was possible to perform qualitative analysis to establish the presence of fatigue. While fatigue was not a causal factor in this occurrence, it is likely that fatigue risk factors, such as acute fatigue, chronic sleep disruptions, and circadian rhythm desynchronization, were present in all of the crew members involved. In addition, one crew member was continuously awake for 19 to 20 of the 24 hours before the occurrence.

The Safety Issues Investigation into Fishing Safety in Canada report has identified fatigue as a significant safety issue with fishing accidents. Fatigue is widespread in commercial fishing due to the long hours, high levels of physical and mental exertion, increased workload from reduced crew size, unsafe operating procedures, and lack of awareness of fatigue and its effects.[54] Fish harvesters have confirmed that risk factors for fatigue, such as insufficient, fragmented sleep and variable work–rest schedules, are commonplace. Given the small complement, the watch schedule, and the demands of fishing operations on the *Atlantic Sapphire*, the crew would likely have experienced fatigue if the voyage had been longer, suggesting that the risks of fatigue persist in the Canadian commercial fishing industry.

If fishing crews work without adequate periods of rest, there is a risk of crews operating while fatigued, and making fatigue-related errors in the operation of the vessel.

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54 TSB Marine Transportation Safety Investigation Report M09Z0001 (Safety Issues Investigation into Fishing Safety in Canada).

2.7 Monitoring for overloading

Effective oversight of commercial fishing safety depends on the cooperation and coordination of a number of individuals and organizations, including the master, the AR, the province, and federal regulators.

At present, TC monitors overloading only at the time of an inspection or when prompted by a complaint. TC does not routinely access a vessel's historical landing data, which is available from Fisheries and Oceans Canada (DFO), to identify if the vessel has a history of overloading.

In the case of the *Atlantic Sapphire*, the vessel had been routinely overloaded for the past several years, dating back to 2013. Although the *Atlantic Sapphire* was inspected in 2016, there was no verification that the vessel's landing history was within the stability booklet's limitations. As a result, the vessel continued operating in the same manner until the time of the occurrence.

This occurrence identified a potential area of coordination where federal regulators could work together to improve fishing vessel safety regarding monitoring a vessel for overloading.

Given that DFO maintains data on vessels' landing history, and that DFO and TC have committed to working together to improve fishing vessel safety, there is an opportunity for TC to use DFO's landing data in its oversight of vessel stability.

2.8 Safety issues in the fishing industry

The Safety Issues Investigation into Fishing Safety in Canada report categorized actions impacting safety into 10 significant safety issues and found that there are complex relationships and interdependencies among them. It further analyzed these safety significant issues.[55] The following 8 safety significant issues were found to have a relationship to this occurrence:

2.8.1 Stability

Findings of the Safety Issues Investigation into Fishing Safety in Canada	Relationship to this occurrence
Fish harvesters generally do not understand or use information in stability booklets.	Despite a stability booklet being on board, the crew consistently caught more fish than was deemed safe according to the booklet.

[55] TSB Marine Transportation Safety Investigation Report M09Z0001 (Safety Issues Investigation into Fishing Safety in Canada).

2.8.2 Lifesaving appliances

Findings of the Safety Issues Investigation into Fishing Safety in Canada	Relationship to this occurrence
Fish harvesters feel that equipment that they are required to carry by regulation does not always meet their practical needs (e.g., the difficulty of using DSC radios).	The DSC distress alert button was not activated to provide all pertinent information about the distress situation to potential responders within seconds.
Fish harvesters do not always conduct drills, while some assume that training, certification, and experience guarantee quick reaction time in an emergency.	Drills had not been carried out on board the *Atlantic Sapphire* in the last year.
Fish harvesters often have difficulty donning immersion suits.	Before the abandonment, 2 crew members donned immersion suits that were the wrong size. During the abandonment, a significant amount of water entered their immersion suits.

2.8.3 Regulatory approach to safety

Findings of the Safety Issues Investigation into Fishing Safety in Canada	Relationship to this occurrence
Regulations and interim processes are implemented and enforced inconsistently.	The monitoring and enforcement of stability booklet limits is dependent on voluntary notification of overloading or the inspector being present during off-loading.

2.8.4 Training

Findings of the Safety Issues Investigation into Fishing Safety in Canada	Relationship to this occurrence
Fish harvesters generally conduct their business based on knowledge, skills, and attitude gained primarily through experience.	Practices for loading and storing fish on board the *Atlantic Sapphire* had evolved informally over time. The master based the maximum load on previous landings. The master also employed the informal practice of leaving the bridge unattended in this occurrence.
Fish harvesters assess and manage their risk based on experience.	The master had never experienced negative consequences with the informal practices of leaving the bridge unattended and overloading, and so he perceived the hazards associated with these unsafe work practices as low.

2.8.5 Cost of safety

Findings of the Safety Issues Investigation into Fishing Safety in Canada	Relationship to this occurrence
Fish harvesters may consider cost over effectiveness when hiring crew.	The compensation arrangement for the crew was not conducive to hiring additional crew members and the vessel was crewed with the minimum required by TC for navigating the vessel.

Fish harvesters see the likelihood of an accident as very low.	Shortcuts were taken to try to fish more efficiently, such as loading beyond what was identified in the stability booklet, using uncertified watchkeepers, and leaving the bridge unattended. Additionally, drills were not conducted because the vessel had not experienced emergencies previously and the likelihood of an accident was perceived as low.

2.8.6 Fatigue

Findings of the Safety Issues Investigation into Fishing Safety in Canada	Relationship to this occurrence
Fish harvesters reduce crew, adding to workload.	The master left the bridge unattended to help in the fish hold. Also, to allow some rest for the crew, the bridge watch was always a solo stand, often with uncertified crew. An assessment of the crewing required to navigate the vessel and conduct fishing operations has not been completed by any federal or provincial agency.

2.8.7 Safety information

Findings of the Safety Issues Investigation into Fishing Safety in Canada	Relationship to this occurrence
Safety information is not presented in a way that applies to fish harvesters' specific situations.	Operational procedures for fishing and watchkeeping had not been developed. A stability note was not provided.

2.8.8 Safe work practices

Findings of the Safety Issues Investigation into Fishing Safety in Canada	Relationship to this occurrence
Fish harvesters learn and reinforce their operating practices based on experience and exchanges with peers.	The maximum load for the *Atlantic Sapphire* was based on the catch history and not the stability booklet.
Fish harvesters change or eliminate some safe work practices to meet economic pressures.	Without official guidance on fishing work practices, and without recent accidents, the perceived risk of their unsafe work practices was low.

2.9 Interdependency of safety issues

The safety of fish harvesters is compromised by numerous issues, which are interconnected. The following safety issues share a complex relationship and were present in this occurrence:

- The regulator did not consistently enforce stability limits.
- DFO collected data on landed catches, but TC did not monitor this data with respect to vessel stability limits.
- Although lifesaving appliances were on board, the crew did not regularly practise using them.
- Safety training addressed the need to practise drills on board; however, drills were not regularly done.

- The cost of safety meant additional crew were not hired to conduct all operations safely, leading to fatigue for the crew.

Past attempts to address these safety issues on an issue-by-issue basis have not led to the intended result: a safer environment for fish harvesters. The Safety Issues Investigation into Fishing Safety in Canada report emphasized that, in order to obtain real and lasting improvement in fishing safety, change must address not just one of the safety issues involved in an accident, but all of them, recognizing that there is a complex relationship and interdependency among those issues. Removing a single unsafe condition may prevent an accident, but only slightly reduce the risk of others.

The safety of fish harvesters will be compromised until the complex relationship and interdependency among safety issues is recognized and addressed by the fishing community.

3.0 FINDINGS

3.1 Findings as to causes and contributing factors

These are conditions, acts or safety deficiencies that were found to have caused or contributed to this occurrence.

1. The authorized representative had not been ensuring that the master complied with the vessel's stability booklet with respect to maximum load.

2. Based on his experience, the master informally assessed the vessel's maximum load (44.6 long tons) and believed the vessel was safe to operate. However, this load was greater than the maximum load defined in the stability booklet (36.51 long tons).

3. Before bringing the final catch on board, the *Atlantic Sapphire* already had more fish and ice in the hold than the maximum load specified in the stability booklet. This reduced both the vessel's freeboard and stability, making it more vulnerable to downflooding.

4. On the occurrence voyage, the crew caught a full load of fish in less time than on any other trip that year, so there was more fuel, freshwater, and ice on board than usual. The crew did not appreciate the risk to the vessel's stability created by this excess weight, and as a result, the crew did not take precautions against the risk of downflooding and capsizing.

5. With the final catch on board, the vessel's stability was further compromised; the slight rolling motion due to the sea condition was enough to immerse the deck edge and allow seawater onto the main deck. The water then downflooded into the fish hold through the open hatch.

6. The master left the bridge to help the crew load the final catch; consequently, when the main deck became awash, the situation was not recognized until the fish hold began to downflood.

7. Progressive downflooding in the vessel compartments caused the vessel to list to starboard and the freeboard to decrease until the vessel sank.

3.2 Findings as to risk

These are conditions, unsafe acts or safety deficiencies that were found not to be a factor in this occurrence but could have adverse consequences in future occurrences.

1. If a vessel is operated beyond its stability limits and oversight by the authorized representative is not effectively executed, the vessel is at increased risk of sinking or capsizing.

2. If vessel manning is not based on both the safe manning document and the *Marine Personnel Regulations*' work–rest requirements, there is a risk that crew members will have unsustainable workloads or be fatigued, causing them to deviate from safe operating practices.

3. If a bridge watch is not maintained at all times, there is a risk that the crew may not have a good vantage point from which to observe the vessel's overall status and may miss critical information provided by bridge systems, radios, and alarms alerting them to an emergency.

4. If methods of distress alerting that maximize the potential for a response are not used during an emergency, there is a risk that the response may not be timely or adequate.

5. If there is no process to ensure that each crew member dons an appropriately sized immersion suit in an emergency, crew members may don ill-fitting suits, increasing the risk of hypothermia or drowning.

6. If fishing crews work without adequate periods of rest, there is a risk of crews operating while fatigued, and making fatigue-related errors in the operation of the vessel.

3.3 Other findings

These items could enhance safety, resolve an issue of controversy, or provide a data point for future safety studies.

1. Although the crew complement on the *Atlantic Sapphire* met the minimum requirements of the safe manning document for navigation, it did not meet the work–rest schedule required by the *Marine Personnel Regulations* when engaged in fishing operations.

2. It was common practice to use the uncertified crew member as a watchkeeper.

3. Given that Fisheries and Oceans Canada (DFO) maintains data on vessels' landing history, and that DFO and Transport Canada have committed to working together to improve fishing vessel safety, there is an opportunity for Transport Canada to use DFO's landing data in its oversight of vessel stability.

4. The safety of fish harvesters will be compromised until the complex interdependency among safety issues is recognized and addressed by the fishing community.

4.0 SAFETY ACTION

4.1 Safety action taken

The Board is not aware of any safety action taken following this occurrence.

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 16 December 2020. It was officially released on 24 February 2021.

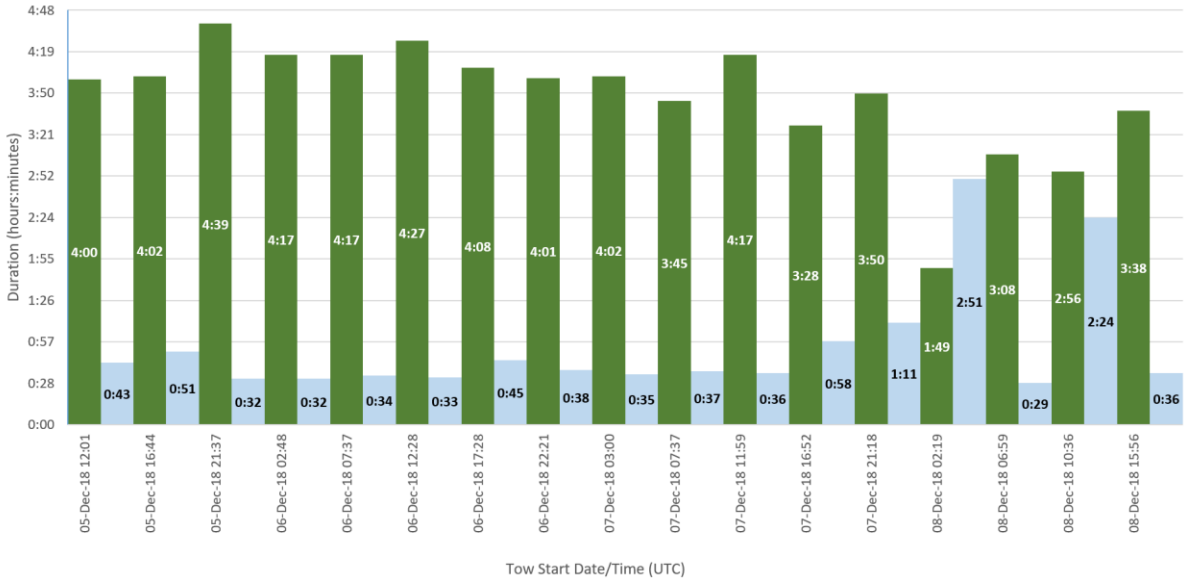
Visit the Transportation Safety Board of Canada's website (www.tsb.gc.ca) for information about the TSB and its products and services. You will also find the Watchlist, which identifies the key safety issues that need to be addressed to make Canada's transportation system even safer. In each case, the 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.

APPENDICES

Appendix A – Rest availability from fishing trip from 05 to 09 December 2018

For the fishing trip from 05 to 09 December 2018, the vessel fished for 3 consecutive days. During those 3 days, the longest period of rest possible was 4 hours 39 minutes, with an average tow time of 3 hours 49 minutes (Figure A1). This does not take into account the time required to complete deck duties, clean up, eat, and change before actually resting.

Figure A1. Time towing and time between tows for the *Atlantic Sapphire*'s trip with a 3-person crew on the fishing trip that ended on 09 December 2018 (Source: TSB, based on data provided by a third-party on-board monitoring company)



Appendix B – Guidance from the *Atlantic Sapphire*'s stability booklet

NOTES TO MASTER

1	**Purpose and Method**
A	To disclose the basis upon which the Naval Architect produced the Trim and Stability Booklet and to present operating conditions for the vessel that meet the Transport Canada Marine Safety (TCMS) criteria in the current Regulations; TP 7301, STAB 4, Stability for Small Fishing Vessels (SFV).
B	This booklet has been prepared for groundfish operations using a trawl when freezing spray and top side icing does not occur.
C	Flake ice becomes part of the groundfish mixture as the fish hold pounds are loaded.
D	Net drum, winches and warps are a part of lightship.
E	Drafts in all conditions have been referenced from the bottom of keel.
F	Using this Manual of Trim and Stability as a baseline this vessel may not be modified in any way that affects it stability characteristics without the approval of Transport Canada Marine Safety.
G	Before the vessel fishes species other than those listed in this booklet, stability conditions for such should be analyzed and submitted to Transport Canada Marine Safety for approval.
2	**Master's responsibilities**
A	The loading conditions in this booklet represent a stowage scheme which reflects the way the product is loaded in this vessel, as per discussions with the operator. It is the operator's responsibility to ensure that the stability conditions presented in the Stability Booklet submitted for approval accurately reflect the vessel's loading conditions and modes of operation. (TP 7301, STAB 4, Stability for small fishing vessels)
B	Where the actual loading scheme or product stowage rate varies from figures used in this booklet it is the masters responsibility to ensure that the vessel is safely loaded and in full compliance with stability standards.
C	Compliance with the stability criteria does not ensure immunity against capsizing, regardless of the circumstances, or absolve the Master from his responsibilities. The Master should therefore exercise prudence and good seamanship having regard to the season of the year, weather forecasts, navigational zones and should take appropriate action as to the speed and course warranted by prevailing circumstances.
D	Preparation for a voyage: Before a voyage commences, action should be taken to ensure that the cargo and equipment have been properly stowed and secured and closures in way of down flooding point have been closed and secured.
E	The master is to ensure that the vessel is maintained with an even heel in all conditions of loading the fish hold, installation of deck equipment and carriage of fishing gear and other equipment on deck.
3	**Loading Particulars**
A	*Loading:* During groundfish operations the fish hold is loaded forward to aft.
B	*Limitation:* This book was calculated with a maximum load of groundfish of 36.51 LT (2/3 groundfish, 1/3 ice) with the aft three pounds, FHOLD4.C and FHOLD 3.C kept void of fish at all times.
C	This book is prepared on the basis that groundfish is not carried on deck.
D	Fish hold arrangement: pound boards must be used at all times.
E	The master should use caution when loading the vessel as to not cause excessive trim by the stern.
4	**Consumable Particulars**
A	*Fuel Oil:* During groundfish operations the aft fuel tanks are consumed first,

	then forward fuel tanks.
B	*Lube Oil:* operation level is assumed in all conditions thus it has been included in absolute lightship.
C	*Hydraulic Oil:* operation level is assumed in all conditions thus it has been included in absolute lightship.
D	*Fresh Water:* it has been assumed that fresh water will be consumed from one tank at a level representative of the consumables in each condition.
5	**Downflooding**
A	*Description:* Point #1: Fwd Port/Starboard Corner of Fish Hold Hatch at VCP = 15.373 ft. from bottom of keel, LCP = 23.895 ft. forward of aft perpendicular, and TCP = 2.250 ft. port/starboard of centreline.
B	To reduce the risk of downflood while at sea, close and secure all openings (i.e. windows, doors, hatches, manholes etc.)
C	The wheelhouse is not included in the calculation of righting arm curves.
6	**Specific Gravity or unit weight**
A	Groundfish = 0.793
7	**Free Surface Effect**
A	Insuring that tanks are pressed full limits the effect of free surface.
B	Groundfish has no free surface.
8	**Ballast**
A	Vessel has permanent cement ballast which is fitted on the fish hold floor and in the fore peak. However, the amount and centers of permanent ballast is unknown.
B	Permanent ballast is included in lightship.
9	**Fishing Gear**
A	Groundfish Gear: Trawl doors, Net and General Fishing Gear.
B	A detailed list of fishing gear weights and centers for each fishery is located on page 23. The weights of fishing gear were provided by the vessel owner and shipyard.
10	**Software**
A	Due to this booklet being prepared by a computer software package, rounding errors may occur in some of the software printouts.
B	The weight and center of gravity used for the righting arms above include tank loads. However, the tank load centers were not allowed to shift with heel and trim changes. Rather, a constant Free Surface Moment was applied to artificially modify the centers of gravity.

NOTES ON VESSEL LIMITATIONS

1	**GROUNDFISH**
A	The maximum load is limited to 36.51LT (2/3 groundfish & 1/3 ice), with the aft three pounds, FHOLD4.C and FHOLD3.C kept void of fish at all times.
B	Vessel is not to be operated at times when freezing spray and topside icing can occur.

NOTE: "Full Load" identified in the appropriate condition sheets, represents a full load only to their limitation of the catch for that condition. For example: 1A, full load of groundfish is when the fish hold is 90% full with the noted pounds kept void.

NOTE: Master is to permanently mark the fish hold to identify fullness of catch, i.e. 90%.

Source: *Atlantic Sapphire* stability booklet