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

TRANSPORTATION SAFETY

REFLEXIONS

Issue 22 – July 2005

MARINE

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Canada

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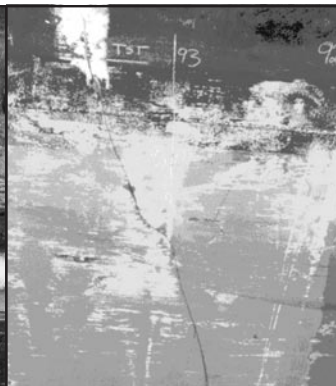

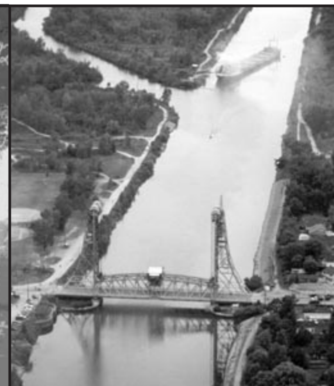

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Reflexions is a safety digest providing feedback to the transportation community on safety lessons learned, based on the circumstances of occurrences and the results of TSB investigations.

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Being Safety Conscious

Risk does not discriminate. Large bulk carriers, cruise ships, tankers, fishing vessels, tug boats and small passenger vessels are susceptible to it, whether at sea or in harbour. The Transportation Safety Board of Canada investigates a wide spectrum of marine occurrences each year; some result in tragedy, some do not, and some have international repercussions.

This issue of *Reflexions* offers an interesting cross-section. Each may stem from different circumstances, but all highlight the uniqueness and complex nature of an accident. Rarely is there one single event responsible for an occurrence. Instead, investigators must sift through a series of underlying causes and contributing factors.

This presents significant challenges for investigators. These challenges are compounded by the need to remain current with shipping and operational practices of all vessel types. As a result, it is more and more complex to identify and verify safety deficiencies in order to advance transportation safety.

The reductions in risk are no accident. They have resulted from actions taken by all partners, often based onthe results of our investigations. Reported marine accidents and vessel losses are at a 30-year low. However, this encouraging statistic does not diminish the importance of the findings of our investigations: personal injuries caused by accidents, for example, have not followed the same trend.

Lessons learned about what happened, why it happened and how we can avoid a recurrence will continue to offer critical insight and information for each and every one of us.

Risk may not discriminate, but we can avoid being its target. This starts by being safety conscious, and continues with a relentless commitment to minimize unsound policies and practices. We trust that the following pages will help readers appreciate the severity of what might happen and to reflect on the possible consequences.

Charles H. Simpson
Acting Chairperson

Lady Duck after recovery at the Hull Marina

The *Lady Duck*

What began as a land-sea cruise on the Ottawa River, Ontario, on 23 June 2002, ended with the sinking of the amphibious vehicle *Lady Duck*. Of the 12 people on board, 6 passengers, the driver, and the tour guide escaped from the vehicle and were recovered by private craft on the scene at the time of the sinking. Four passengers, trapped within the sunken vehicle, drowned. — Report No. M02C0030

The vehicle was based on the conversion of a Ford F-350 truck chassis. The original gasoline engine was used for on-road operation. A gasoline-powered Mercruiser inboard/outboard (I/O) at the rear was used for water-borne propulsion.

The bottom of the chassis was enclosed with welded and bolted steel plating and the sides were extended upward to enclose a buoyant structure. The original truck wheels and suspension were fitted outside the watertight hull. The effective breadth of the chassis was increased by the addition of extensions (sponsons) on each side. These sponsons were partially filled with rigid foam plastic to enhance transverse stability and buoyancy and to ensure appropriate forward and after trim when water-borne.

Passenger Cabin

A passenger boarding ramp, located at the rear left corner of the vehicle, hinged up to a steel sill and a flexible gasket to ensure the watertight boundary of the passenger deck. The ramp was lifted to the closed position by an electrically driven winch and secured with hasps on each side of the ramp.

Eleven single-passenger seats were arranged along the sides of the open passenger deck, with five on the port side and six on the starboard side. There were two seats in the vehicle cab: the left one for the driver and the right one for the tour guide. In the event of a full payload, the tour guide's seat acted as the 12th passenger seat; the guide would assume a standing or crouching position in the middle of the cabin aisle.

A fabric awning provided protection from inclement weather. Roll-down transparent weather screens were arranged on each side of the passenger area for additional protection.

Approved lifejackets were stowed in lockers under each of the passenger seats and, at the time of the occurrence, three children's lifejackets were located at the after end of the vehicle. Twelve additional adult-approved personal flotation devices (PFDs), located adjacent to the seats in the passenger area, were readily available.

A steel visor plate was fitted at the front of the forward engine compartment and was intended to prevent the entry of water at the front end of the vehicle when water-borne and under way.

Cruise

The *Lady Duck* started the amphibious tour—its second of the day—at about 1500. At the beginning of the tour, the guide briefed the passengers, in French and English, on safety procedures related to the on-land part of the tour. Before the vehicle entered the water at the Hull, Quebec, marina ramp at approximately 1540, the tour guide provided a safety briefing to the passengers for the water-borne portion of the tour.

The tour guide had no formal training or written instructions on suitable pre-departure safety briefings. Consequently, only incomplete verbal instructions were given, and passengers were not advised of the location and use of all safety equipment.

In addition, passengers did not receive a demonstration on how to correctly don their lifejackets. The size of a lifejacket or a PFD must be appropriate to the body size of the wearer to perform as designed. If the life-saving appliance is too large, too small, or incorrectly worn, the wearer can be at risk of sustaining personal injury and/or drowning. In this occurrence, the PFDs worn by two of the victims were too large for their body size.

Although passengers were informed that the rear exit and side windows were emergency exits, no instructions were given about what to do in the event of an abandonment. For example, passengers were not told how to open the windows if they were zipped closed. Passengers were not instructed to look around to determine their nearest exit and they were not cautioned that it may not be the same one used to enter the vehicle.

When the vehicle entered the water, the main bilge pumps were switched on to clear the hull of any shipped water. Because no water was seen to be discharging from the five drainage points near midships, the two emergency bilge pumps, located in the hull, slightly forward of the bilge wells, were also activated to discharge the accumulation of floodwater. Water was then seen discharging intermittently from outlets on both sides of the vehicle near midships.

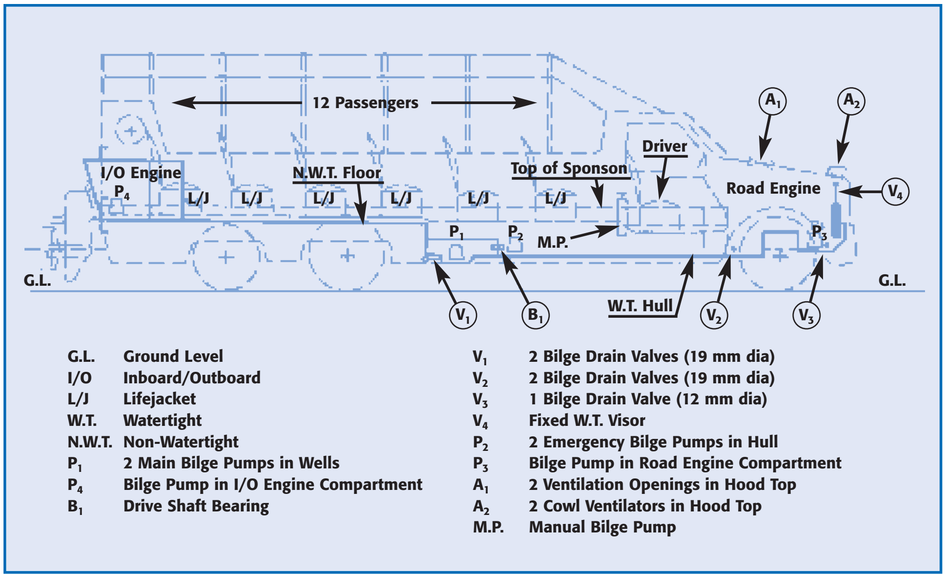
The weather was fine and clear with little wind. The river was relatively calm, with waves caused by wakes from boats and other watercraft in the tour area. On occasion, the vehicle encountered some waves that washed over the hood and up to the windshield. Some spray also came in through the opened windows in way of the driver and tour guide seats.

The tour guide had no formal training or written instructions on suitable pre-departure safety briefings.

Taking on Water

Toward the end of the tour, at about 1608, while returning to the Hull Marina at approximately 8 km/h, the driver noted that the front end of the vehicle was floating lower than normal and that water was being continuously discharged from both sides of the vehicle near midships. The driver then ordered the four foremost passengers and the tour guide to move to the back of the vehicle to try to decrease the forward trim.

The driver confirmed that the emergency bilge pumps were discharging water. However, the



Construction profile outline

The two main bilge pumps were inoperable.

combined discharge capacity of these two pumps did not stem the increasing ingress of water overflowing the forward visor and the vehicle trimmed progressively by the bow. These pumps were the only operational pumps whose discharges could be observed from the driver's position. The two main bilge pumps were inoperable.

The bilge pumps were not installed in accordance with manufacturer instructions. Specifically, the wiring connections to the pumps were not watertight or adequately secured, and the main pumps were over-fused. Debris in the impellers stalled the pumps and, as the fuses were too large, induced the failure of the pump motors. Of the six electrically driven bilge pumps, the two that were effectively operable did not stem the ingress of water.

The forward trim continued to increase and, realizing that the safety of the passengers was at risk, the driver instructed the tour guide to tell the passengers to don PFDs. At this time, he diverted the vehicle toward the nearest point on the Quebec shore. The driver then broadcast a MAYDAY on emergency channel 16, identifying the *Lady Duck*, giving its position and the number of passengers on board. However, the Canadian Coast Guard Marine Communications and Traffic Services (MCTS) do not provide marine very high frequency (VHF) coverage in the Ottawa area and bystanders with cellular telephones called 911.

At about 1610, the situation deteriorated rapidly as more floodwater accumulated in the forward end of the vehicle. The driver then called on the passengers to abandon the vehicle. The driver left the steering position, made his way aft and, with seven other persons, managed to get free of the sinking vehicle. The remaining four passengers became trapped under the fabric awning and sank with the vehicle in 8 m of water.

After ordering the evacuation, and as he was moving aft to help the passengers don their PFDs, the driver was swept out of one of the window exits. To evacuate, all other occupants turned to the rear exit that had been their entrance point.

Exit Bottleneck

The guide and one passenger, recognizing that there was a "bottleneck" at that exit, evacuated through the window exit beside the aftermost seat on the port side. Reportedly, the vehicle was almost vertical and the guide used the top of the awning to help pull out from under the water. The passenger also reported experiencing difficulty exiting through that side window.

***Lady Duck* approximately five minutes before sinking. Reproduced with permission.**

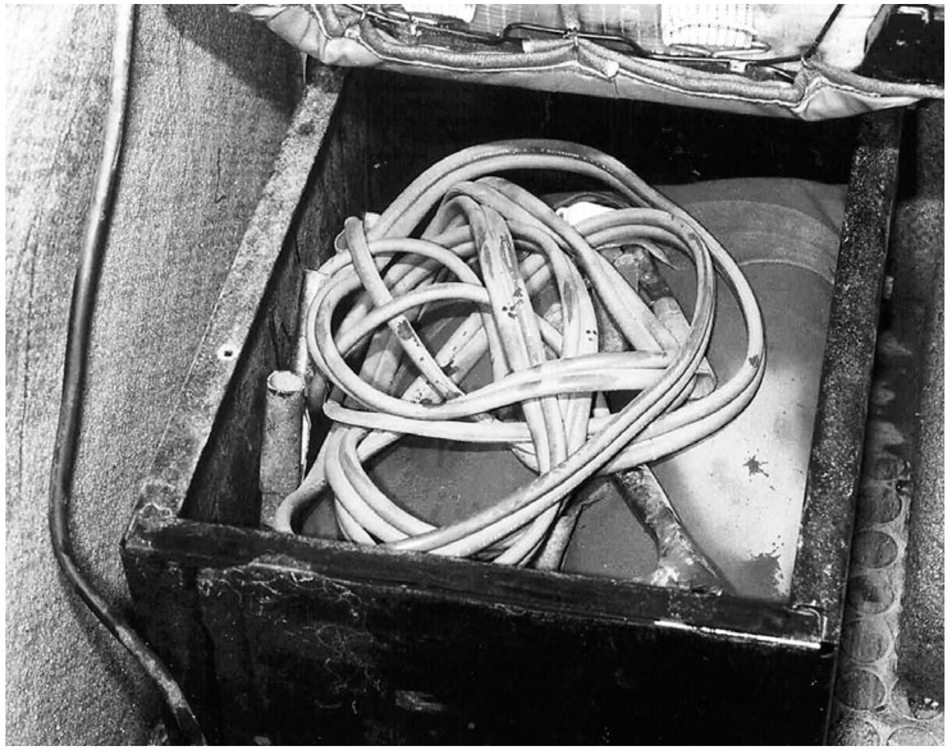
The passengers who exited through the rear exit encountered difficulties because of the need to climb up to the opening at the top of the raised boarding ramp and because of the small opening provided by that exit. Minor injuries were received when passing through the opening.

Of the six electrically driven bilge pumps, the two that were effectively operable did not stem the ingress of water.

Once passengers were at the top of the retractable stairs, there was no platform to step on to facilitate egress into the water. Passengers had to find a posture to jump without any support structure to aid them in that movement, while ensuring that they cleared the hazard presented by the exterior stairs and the I/O motor.

During the evacuation, one survivor held onto a PFD. Two others wore PFDs when they exited, neither of which was fastened. One of the survivors was given a lifejacket before exiting, but it was a child's lifejacket and was too small to allow the head to pass through. Another passenger, on surfacing, also used a child's lifejacket that was ineffective as a flotation device for that person. The driver and one of the passengers had not donned PFDs; the driver because he was swept overboard as he was moving to the rear of the vehicle, and the other person because he had moved to the rear of the vehicle at the driver's request and was no longer within reach of the PFD at his seat. The driver was able to link his arm around a floating PFD after he was ejected from the vehicle.

In order for the passengers to retrieve the lifejackets from their storage location beneath each passenger seat, it would have caused congestion in the narrow centre aisle. During vehicle inspection after the occurrence, removing a lifejacket without tearing it on the edges of the metal storage box was a challenge for investigators, let alone passengers who, in a time-critical situation, could have jeopardized the integrity of the jacket. Further, other items that were stored on top of the lifejackets would have presented a challenge to their quick removal.



Lifejacket under the seat with booster cables on top

No Formal Evacuation Policies

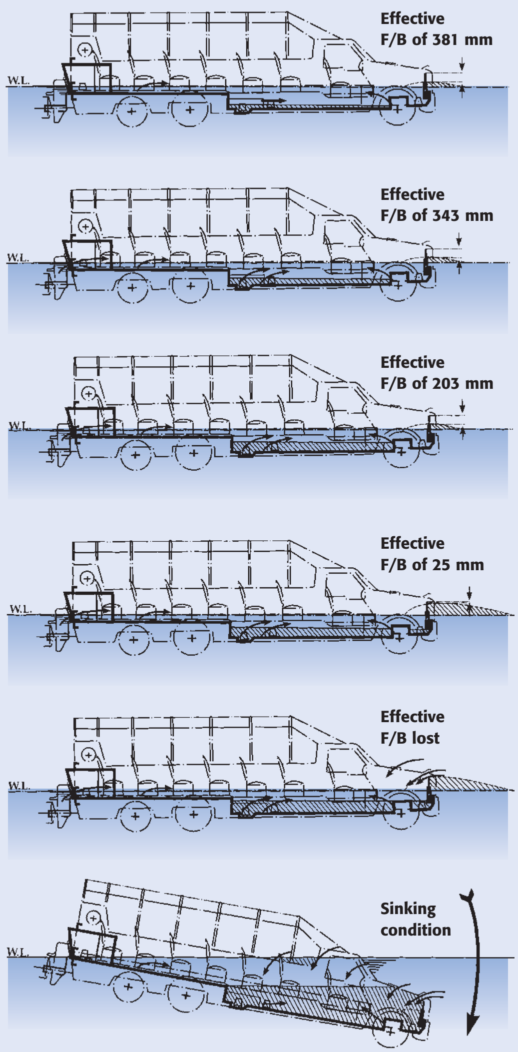
The company had no formal evacuation policies, procedures or training that addressed the possibility of a vehicle evacuation. Although the driver had received abandonment instructions, no specific training or drills were conducted on company vehicles, including the *Lady Duck*, to put that training into practice. Further, none of the tour guides received hands-on training on the safety equipment, including fire extinguishers, distress equipment and, in the case of the company's larger vehicles, the liferafts.

Although the side window exits were larger than the rear exit and were available as a means of escape, 11 of the occupants initially turned to the rear exit to evacuate. For a few, this may have been due to the driver's earlier request to move to the rear of the vehicle. The others may have been reacting in a manner that has been seen in other evacuations, where people tend to exit through their point of entry. Only two occupants recognized that there was a "bottleneck" there and chose a side window as their point of egress.

Post-Accident Tests

After the accident, the vehicle was the subject of structural, mechanical, pumping and other safety-related equipment inspections and tests. A series of speed, freeboard, trim, wave-making and flooding trials was also completed to determine the operational characteristics and physical condition of the *Lady Duck*. Review and analysis of these inspections, tests and trials showed that the safe operation of the vehicle was at risk due to the following:

- The condition of the vehicle meant that watertight integrity could not be maintained. Watertight integrity was compromised by fractures, the absence of effective watertight glands and seals, and water siphoning action through bilge piping.



Speed = 5 km/h; Forward F/B = 470 mm; Bow wave height = 89 mm; Aft trim = 254 mm. Hull and shaft bearing leakage starts to accumulate. Port and starboard main bilge pumps activated (port-side pump inoperative).

Speed = 5 km/h; Forward F/B = 432 mm; Bow wave height = 89 mm; Aft trim = 216 mm. Hull and shaft bearing leakage continues. Starboard main bilge pump is fouled with solid debris. Syphonic flooding starts. Both emergency bilge pumps activated.

Speed = 5 km/h; Forward F/B = 292 mm; Bow wave height = 89 mm; Aft trim = 38 mm. Hull, shaft bearing and syphonic flooding continue. Emergency bilge pumps continue in operation.

Vehicle returning to the marina. Speed = 8 km/h; Forward F/B = 292 mm; Bow wave height = 267 mm; Aft trim = 38 mm. Hull, shaft bearing and syphonic flooding continue. Bow wave starts to overflow visor and downflooding of forward end begins. Emergency bilge pumps continue in operation.

MAYDAY broadcast while the vehicle is headed for shore at approximately 8 km/h. Bow wave height = 267 mm. Hull, shaft bearing and syphonic flooding continue. Downflooding accumulates as bow wave overflows visor and enters cowl vents, hood sides and air vents. Forward trim increases as vehicle settles and reserve buoyancy is reduced (see photo on page 4).

Downflooding becomes general with a sudden increase in forward trim as reserve buoyancy is lost and vehicle sinks rapidly by the bow.

The most likely sequence of events

- When operating in calm water conditions, the *Lady Duck* was vulnerable to shipping water over the bow, because of low initial static forward freeboard and of proportional loss of effective forward freeboard due to the bow wave created by the speed of the vehicle.

- When operating in water disturbed by the wakes of other craft, the *Lady Duck* was highly vulnerable to shipping water when relatively moderate waves were encountered.

- The effective static forward freeboard in the loaded condition, when reduced by the progressive accumulation of floodwater in the hull, was insufficient to prevent the entry of water from bow waves generated at service speed.

- The non-watertight construction of the hood and the installation of 75 mm-diameter (3-inch) cowl ventilators at its forward end, after the completion of Transport Canada's inspection, allowed the ingress of water when the forward freeboard was reduced and waves were encountered.

- The design and construction of the vehicle were such that all bilge and floodwater initially accumulated in the forward half of the hull and caused a forward trimming moment and a reduction of effective forward freeboard. This reduction of forward freeboard made the vehicle more vulnerable to shipping water at speeds lower than when completely free of floodwater.

- Launching trials at the Hull Marina showed that, when the visor was submerged before the front of the vehicle became fully buoyant, water was shipped and accumulated in a well specifically served by the forward bilge pump. Malfunction of this pump would result in floodwater being retained on board, causing a reduction of the effective forward freeboard at the start of each water-borne tour.

In the event of pump malfunction or failure, any accumulation, including floodwater due to hull leakage, could not be detected by the driver. The combined weight of the shipped water and floodwater from drive shaft bearing leakage and bilge piping siphon effects would reduce the forward freeboard. This would render the vehicle more vulnerable to shipping water over the visor as speed was increased and its own bow wave and the wakes of other vessels were encountered.

Inadequate Regulations

The regulatory framework that applied to the *Lady Duck* did not adequately address the risk involved in the vehicle's operation. Although the *Lady Duck*, with a gross tonnage of less than 5 and carrying not more than 12 passengers, had a first inspection, it was not subject to construction requirements, did not require a qualified operator, and the company was not required to have a safety management structure in place. In contrast, when more than 12 passengers are carried, vessels are subject to additional requirements that address the hull, machinery, electrical systems, fire protection equipment, life-saving equipment, and stability, thus affording a greater level of passenger safety.

As a consequence, the effectiveness of the regulatory framework is compromised in that the complexity of regulations, standards, and programs that apply to small passenger vessels may not be readily understood by the owners, operators, and inspectors who must apply them. Furthermore, the current regulatory framework does not address all aspects of small passenger vessel operations. Consequently, vessels that may not be fully fit for their intended purpose may operate, placing passengers at risk.

Vehicle launched at 8 km/h, visor submerged by approximately 25 mm

The current regulatory framework does not address all aspects of small passenger vessel operations.

As a result of this investigation, action was taken to improve safety briefings, improve bilge pumping operations, establish life-saving equipment carriage requirements, address inconsistencies regarding lifejackets, require the carriage of radio equipment, and develop risk indices to help select vessels for random and targeted compliance monitoring inspections.

TSB Recommendations

Recognizing that the *International Safety Management Code for the Safe Operation of Ships and for Pollution Prevention* (ISM Code) may be beyond the scope of most small operators, a system tailored to the needs of small passenger vessels, which incorporates principles of effective safety management, would assist small vessel operators to help ensure that the company, the vessel, and its crew are fit for their intended purpose. Given the benefits associated with preventing accidents, and the need for a structured approach for operators to effectively manage the risks associated with their operation on an ongoing basis, the TSB recommended that:

The Department of Transport take steps to ensure that small passenger vessel enterprises must have a safety management system.

M04-01

The TSB acknowledged the initiatives by Transport Canada to reform the current regulatory framework to make it more streamlined, applicable, and effective. However, given the planned time frame of 2006 for completion of this reform, and the large number of small passenger vessels that have yet to be identified, the TSB recommended that:

The Department of Transport expedite the development of a regulatory framework that is easily understood and applicable to all small passenger vessels and their operation.

M04-02

Small passenger vessels are rarely of standardized design and, consequently, the arrangements for boarding, accommodating, and disembarking passengers vary greatly, particularly in vessels of novel construction such as the *Lady Duck*.

Transport Canada has standards for commercial passenger vehicles, such as buses, trains and aircraft, and, to a lesser extent, for small passenger vessels with a gross tonnage greater than 15 or carrying more than 12 passengers. However, there are no statutory requirements for small passenger vessels, such as the *Lady Duck*, to be ergonomically designed to afford passengers and crew the best possible opportunity to safely evacuate in the event of an emergency.

There are no statutory requirements for small passenger vessels, such as the *Lady Duck*, to be ergonomically designed to afford passengers and crew the best possible opportunity to safely evacuate in the event of an emergency.

The TSB is aware of proposed amendments to incorporate by reference the *Construction Standards for Small Vessels* (TP 1332). However, review indicates that small commercial vessels in excess of 6 m, such as the *Lady Duck*, are not required to incorporate sufficient inherent buoyancy to prevent sinking, and there are no provisions for the timely and unimpeded evacuation of passengers in the event of an emergency. The TSB, therefore, recommended that:

The Department of Transport ensure that small passenger vessels incorporate sufficient inherent buoyancy and/or other design features to permit safe, timely and unimpeded evacuation of passengers and crew in the event of an emergency.

M04-03

The National Search and Rescue Secretariat (NSS), an independent government agency reporting to the Minister of National Defence, has responsibility for promoting the national Search and Rescue (SAR) program. The program is a collection of SAR services provided by all agencies and individuals in Canada, regardless of the type of activity or jurisdiction.

Given NSS's leadership role to work directly with federal, provincial and local authorities, and other organizations, to develop and standardize the quality of SAR services, and mitigate risks associated with an improperly coordinated SAR system, the TSB recommended that:

The National Search and Rescue Secretariat, in collaboration with local authorities and organizations, promote the establishment of a system to monitor distress calls and to effectively coordinate Search and Rescue responses to vessel emergency situations on the Ottawa River between Ottawa and Carillon.

M04-04

REFLEXION

Whether cruising on a large passenger vessel in the Caribbean or a small vessel on a river or a lake, we should all be aware of safety requirements and keep a weather eye on the operational and environmental aspects involved.

A Lesson in Firefighting

On the afternoon of 17 March 2002, while it was stopped in ice and waiting for a change in the weather, a fire broke out in the bow of the large fishing vessel *Katsheshuk*. After an unsuccessful attempt at fighting the fire, the decision was made to abandon ship. Several days later, the tug *Atlantic Maple* took the vessel into tow and steamed towards St. John's, Newfoundland and Labrador. The tug and tow encountered adverse weather and were forced to seek refuge in Trinity Bay, Newfoundland and Labrador. When the weather finally moderated, the tow resumed. On the morning of 30 March 2002, while approximately six nautical miles northwest of Cape. St. Francis, Newfoundland and Labrador, the *Katsheshuk* listed and sank. — Report No. M02N0007

The fire was discovered when two crew members working on the deck saw smoke coming from door "G" in the trawl superstructure providing access to the lobby. One crew member immediately went to inform the officer of the watch (OOW) while the other entered the lower accommodation to warn the crew.

The OOW, on being informed of the situation, immediately activated the fire alarm, but it failed to sound. He was soon relieved by the master and proceeded to his muster station. The master then made an announcement on the public address system and activated the general alarm, which did sound. The master then contacted three vessels by very high frequency radio, the *Newfoundland Otter*, the *Arctic Endurance* and the *Ocean Pride*, which were fishing in the area, and informed them of the fire on board the *Katsheshuk* and requested their assistance. The master did not immediately inform the Canadian Coast Guard of the vessel's situation.

An initial inspection determined that the smoke was emanating from the bow area of the vessel and, as a precaution, the sliding watertight doors were remotely closed. While the master monitored the situation from the wheelhouse, in the 'tween deck accommodation three decks below, preparations were being made to locate and fight the fire.

Fighting the Fire

Two fire parties on the port and starboard sides of the vessel attempted to extinguish the fire internally but were unsuccessful. The first fire party lead opened door "D" and entered a small foyer where he was met by a wall of smoke. Upon opening either door "E" or "F" he was met with heat and flame. The second fire party lead made it to door "D" and when he opened it, he was met by a white flame that shot out over his head and hit the deckhead. Door "D" provided access to the compartment that housed the spurling pipes and door "F" provided access to the forward stores. This would suggest that the fire originated either in the compartment housing the spurling pipes or in the forward stores.

The housekeeping practices in the forward stores were poor. The supplies were stored on deck or on shelving and were not secured. As such, they were prone to being dislodged from their position due to the movement of the vessel in the 50-knot winds and 4 m swell. Further, materials stored in the locker included flammable material such as barbecue lighter fluid, chemicals and cleaning materials that have the potential to generate toxic fumes in enclosed places, and combustible materials such as paper products. All these materials provided a source of fuel to the fire. As the vessel ultimately sank, the cause of the fire could not be determined; however, it is highly likely that the fire originated in the stores compartment.

There was no indication that any fire hoses were ever run out, inspected and pressurized.

The crew then started to set up boundary cooling on the exterior of the vessel. To cool the deckhead of the forecastle storage locker, a fire hose was fed through the wheelhouse, onto the foredeck, and then lowered through a rope scuttle (an opening through which mooring ropes are passed) to the forward mooring station. Shortly after charging the line, a hose clamp securing the hose to the fitting let go, requiring the line to be shut down to reattach the clamp. A second fire hose was set up on the trawl deck and directed at the transverse bulkhead at the forward end of the trawl deck. Meanwhile, the master contacted other vessels in the area and requested additional firefighting equipment. Some hoses and self-contained breathing apparatuses (SCBAs) were transferred to the *Katsheshuk* from other vessels; however, the hose connections were incompatible and an adapter had to be made for one of the *Katsheshuk* hydrants.

Incomplete Fire Drills

Boat and fire drills carried out on a regular basis, in accordance with the regulations, familiarize the crew in dealing with emergency situations. In accordance with the intent of the *Boat and Fire Drill Regulations*, drills on board vessels like the *Katsheshuk* are to be carried out monthly, and the crew is to be familiarized and instructed with respect to the facilities of the vessel and their duties. Each crew member is to demonstrate such familiarity. Such drills include, *inter alia*, the running out, examination and pressurization of fire hoses, and examination of smoke helmets, breathing apparatus and associated firefighting equipment.

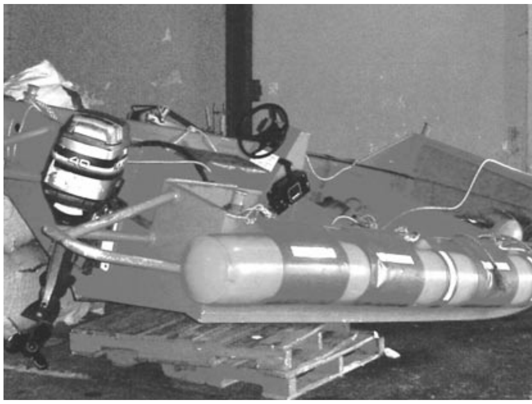
The vessel was a recent acquisition in late 2001 and boat and fire drills were carried out on a regular basis. However, due to the short period the crew was on board this vessel (three to four months), relatively few drills had been performed. However, in spite of regulatory requirements, there was no indication that any fire hoses were ever run out, inspected and pressurized.

In this instance, the fact that no mock scenarios were used during the fire drills meant that, when faced with a real life situation, the crew, although trained in Marine Emergency Duties, was not completely familiar/comfortable with the duties at hand. As a result, the crew was ill-prepared to put forward a cohesive and coordinated firefighting response.

The TSB is concerned that, despite efforts to improve the familiarity with equipment and competence of fishing vessel crew members in emergency situations, accidents like that on the *Katsheshuk* continue to put vessels and their crews at risk. The TSB will continue to monitor these issues and will determine whether further safety action is required.

Poorly Executed Response

The firefighting effort, while well intentioned, was ill-advised and poorly executed. A review of the Fire Drill Muster List indicated that the crew did not proceed to the designated emergency stations. Instead, crew members reacted to the emergency situation individually and took upon themselves different roles, leading to an uncoordinated response. This culminated in



The rescue boat

Between the time the fire was detected and the time a notification was made, almost 3 hours 40 minutes had elapsed.

neither of the fire party leads (port and starboard) being properly attired with SCBA and protective fireman's outfit to fight the fire and both had to retreat from the fire scene. In this instance, a fireman's outfit was at hand for use by the port fire hose party but none was readily available for the starboard party. The vessel was outfitted with two complete sets of SCBAs and fireman's outfit and one fireman's outfit was not available for use. The non-availability of one of the fireman's outfits may be attributable, in part, to personnel not adhering to the designated fire stations, culminating in it being moved to a different location during firefighting activity.

Roughly 45 minutes after the fire was discovered, the master decided to evacuate all non-essential personnel to the other fishing vessels in the area. An attempt was made to raise the vessel's rescue boat (RB) using the port davit, but the crew could not get it to operate. As a result, they used the cargo crane on the starboard side.

The crew evacuated using the vessel's own RB by boarding the RB on the forecastle deck and then being lowered to the water. After several lifts, it was decided to deploy the pilot ladder and have the crew climb down the ladder and board the RB from the *Katsheshuk* as well as boats dispatched from the nearby vessels. During the initial evacuation, 24 crew members were transferred to other vessels; two more crew members were evacuated a short time later.

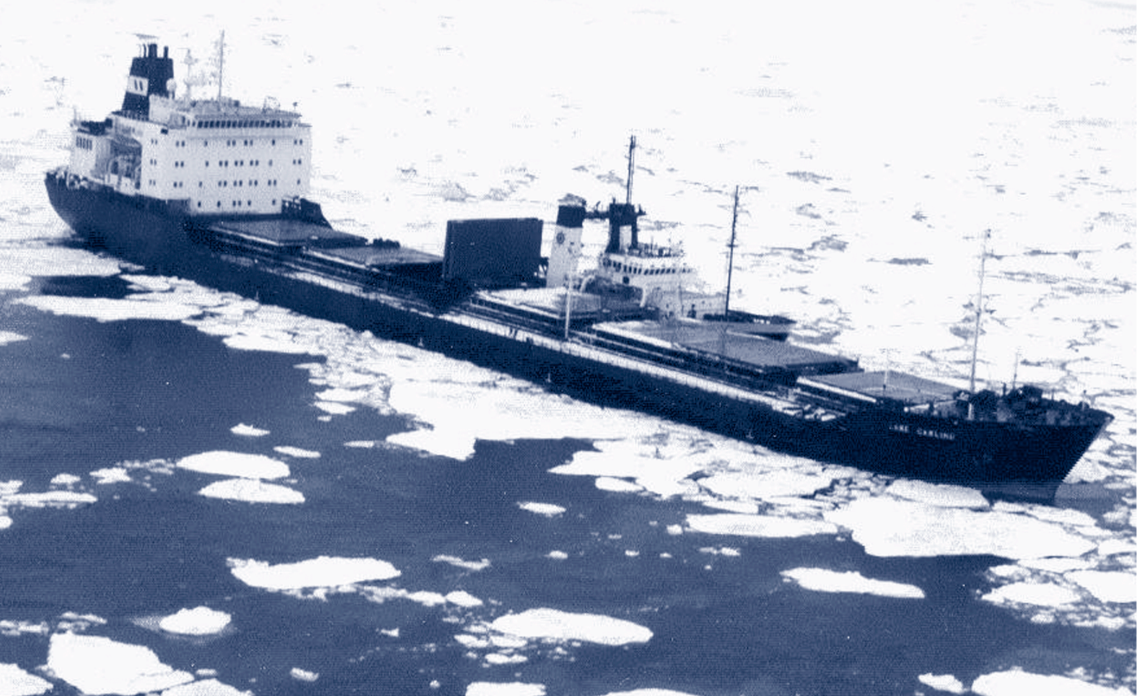
Eventually, the wheelhouse began to fill with smoke, and the decision was made by the master for the remaining crew members to leave the vessel.

Between the time the fire was detected at 1545, and the time an initial notification was made to Marine Communications and Traffic Services (MCTS), almost 3 hours 40 minutes had elapsed. The master indicated that he did not think it necessary to contact MCTS as there were three other vessels in the area. He was also very busy in the wheelhouse with his own emergency duties.

Given that the success of a Search and Rescue (SAR) mission is dependent on the prompt and efficient dispatch of SAR resources, it is essential that the authorities be notified as soon as an emergency situation arises. This permits the SAR authorities to identify, prepare and dispatch appropriate units and equipment in a timely manner in the event the situation escalates and/or SAR assistance is required/requested.

By not notifying SAR, the vessel as well as the shipboard personnel are placed in a vulnerable situation. In the event that the emergency is brought under control and assistance from the authorities is no longer required, the resources could then be stood down.

Post fire



The *Lake Carling* stopped in ice, 22 March 2002 (assisting tug, the *Ryan Leet*, seen on the port side)

The Toughness of Steel

On 18 March 2002, the bulk carrier *Lake Carling*, with 24 654 metric tons (mt) of iron ore pellets in hold numbers 1, 3 and 5, departed Sept-Îles, Quebec, bound for Point Lisas, Trinidad. According to the loading instrument, the greatest seagoing Still Water Bending Moments (SWBMs) were located at frame 85 in the No. 4 hold (90 per cent of approved maximum) and at frame 154 in the No. 2 hold (86 per cent of approved maximum). The next morning, during scheduled rounds, it was discovered that the No. 4 hold was taking on water. Further inspection revealed that a six-metre fracture had developed on the port side shell. Sea ice thwarted attempts to keep a collision mat in place to stem water ingress and the bilge pumps were unable to keep up. — Report No. M02L0021

The ship's position at this time was 48°16′48″ N and 061°21′30″ W, approximately 38 nautical miles north of the Îles de la Madeleine in the Gulf of St. Lawrence. Winds were from the north at 20 knots, air temperature was -6°C and water temperature was near 0°C. Sea state was not documented by the crew but, by all accounts, was unexceptional. Calculations and historical data support a wave height of between 1.5 and 2.5 m and a wave length of approximately 56 m.

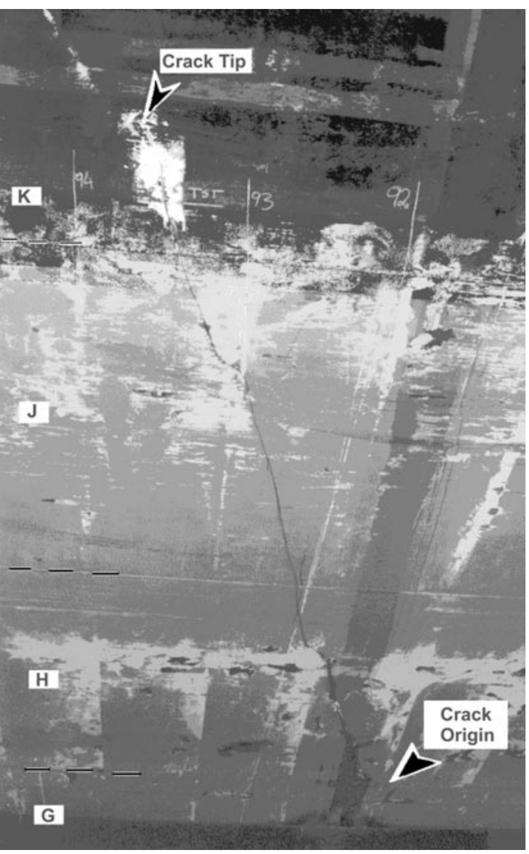
With assistance from a Canadian Coast Guard vessel and a salvage tug, temporary repairs were made and the *Lake Carling* eventually proceeded to Québec, Quebec, to undergo permanent repairs. On 28 March 2002, the vessel tied up at Québec and offloaded a portion of its cargo. Floating repairs were carried out according to Det Norske Veritas (DNV) classification specifications and, on 04 April 2002, the vessel was cleared to sail by port state inspectors and the DNV surveyor.

Side Shell Fracture

The principal fracture was on the port side frame at frame 91, extending upwards and forward from the toe of the weld at the base of the side shell frame. The fracture traversed frames 92 and 93 through the H and J strakes, terminating just short of frame 94 (K strake) in the No. 4 upper water ballast tank, which was empty at the time. The shell fracture divided at the juncture of the ballast tank sloping plate: one branch continuing for 45 cm on the ballast tank sloping plate at approximately 90° from the juncture point, and the other branch on the ship's side continuing up and forward for approximately 40 cm past the juncture point. Visual inspection and laboratory analysis indicates that the principal fracture originated at the base of frame 91 (at the toe of the weld). The fracture origin was located 1.3 m below the neutral axis of the vessel's midships section modulus.

Five similar crack manifestations were found in the No. 4 hold.

The principal fracture was the forward half of a crack manifestation that presented itself on either side of the base of the frame. Five similar crack manifestations were found in the No. 4 hold: on the port side, at frames 89 and 93, and on the starboard side, at frames 85, 91 and 96. All crack manifestations appeared to originate near the base of the frame at the toe of the weld, and giving rise to two cracks, one forward and one aft of the frame, each some 75 mm in length and generally in a characteristic "V" formation. All of these cracks were rusted and appeared to have been present for some time.



Principal fracture

In the No. 2 hold, four crack locations were also found: on the starboard side at frames 171 1/2 and 172 1/2, and on the port side at frames 144 and 145. In contrast to the cracks in No. 4 hold, all the cracks in No. 2 hold had been covered with superficial weld repairs. The weld repairs had penetrated only a few millimetres into the thickness of the hull plate. It was not determined when, or by whom, these repairs were undertaken, nor is there any record held by DNV of these cracks or the repairs. In contrast to the crack manifestations in No. 4 hold, not all these cracks were present both fore and aft of the frame, such as at frame 171 1/2, where the crack was only forward of the frame.

How the Cracks Started

Several sources could have been responsible for the cracks in the No. 4 hold. Deballasting in unprotected waters and/or an improper loading at Thunder Bay, Ontario, four months prior to the hull fracture before a voyage to Montréal, Quebec, are possible causes of the crack initiation. The loading printout (harbour condition) for this loading indicates an actual bending moment (BM) of 78 055 tonne-metres (t-m) occurring at frame 86. This is 79 per cent of the permissible harbour BM of 99 375 t-m, but 103 per cent of the seagoing limit of 75 900 t-m at this location. No loading instrument printout for the seagoing condition was available. The *Lake Carling* sailed from Thunder Bay in this condition, with draughts of 7.99 m forward and 8 m aft.

Frame 171 1/2, starboard

For the deballasting scenario, the SWBM imposed on the hull girder at frame 91 would have been 107 per cent of the approved maximum permissible. For the loading scenario, the SWBM at frame 86 was 103 per cent of the approved seagoing allowable limit. Being farthest from the neutral axis, stresses would have been experienced in the deck and bottom shell. However, the combination of all global and localized stresses would still have been significant at the bottom of the side shell frames. The vessel sailed in this condition for five days, from Thunder Bay to Montréal, in water close to 5°C. After leaving Montréal, the vessel encountered very heavy weather in the North Atlantic. Had small cracks developed due to improper loading and cold water conditions between Thunder Bay and Montréal, they could have grown under such dynamic loading.

The restrained nature of the welded connections at the lower ends of the side shell frames made this area susceptible to the retention of residual stresses. The coincidence of several stress concentration factors created the conditions necessary, when subjected to high stresses and cold ambient temperatures, to cause small cracks to form at the base of the side shell frames between frames 85 and 96 in the No. 4 hold. These factors are:

- the discontinuities caused by a scallop (cut-out) in the side frame;
- the proximity of the frames' lower ends to the shell plate seam (possibly exacerbated when the frames were renewed in the drydock at Gdansk, Poland, a year previously);
- the change in plate thickness at the shell plate seam weld; and
- the presence of residual stresses.

The extremely low fracture toughness of the side shell plate when exposed to temperatures near 0°C allowed the forward crack at frame 91 (port) to grow to failure at a load well below the ultimate tensile strength of the material.

The intervening four months of operation prior to the occurrence is a reasonable time frame in which these cracks could grow imperceptibly under the dynamic loading of the hull girder.

Lack of Specifications

The grade A steel used in the construction of the side shell of the *Lake Carling* was "within specifications" insofar as tensile strength is concerned, but as for minimum Charpy V-notch (CVN) impact test, no specifications actually exist. The extremely low fracture toughness of the side shell plate when exposed to temperatures near 0°C allowed the forward crack at frame 91 (port) to grow to failure at a load well below the ultimate tensile strength of the material. The length of the crack at the time it became critical was not determined, but calculations have shown it could have been as short as 10 cm.

Under the International Association of Classification Societies' (IACS) Unified Rules, grade A steel less than 50 mm thick (and grade B, 25 mm or less in thickness) does not have to demonstrate a minimum CVN. Under these rules, this steel can be used for a ship's side shell. Some testing has shown that the average CVN of grade A steel available worldwide is often quite high and the grain size relatively small. This, in effect, sets a *de facto* standard —ship owners, ship constructors, and classification societies all expect and depend upon grade A steel having a fracture toughness that is sufficient for all conditions. However, without actual standards, expectations are not always enough to ensure adequate fracture toughness and damage tolerance.

Although the relationship between CVN energy and fracture toughness is not necessarily straightforward, the system has been used with relative success by all the major classification societies for many years by providing a qualitative estimate of material toughness. There are, however, no requirements to use steel of a given CVN energy at low operating temperatures in way of the ship's sides (which are usually grade A steel). Nonetheless, cargo vessels may often trade in zones where ambient temperatures are close to, or below, 0°C and these low temperatures generally tend to reduce the ability of the steel to resist crack growth.

Without actual standards, expectations are not always enough to ensure adequate fracture toughness and damage tolerance.

A recent Lloyd's initiative to qualify the toughness of grade A steel may appear to be an improvement on existing standards; however, the required 27 Joules at 20°C is less than that demonstrated by the *Lake Carling*, and 20°C is certainly well above the temperature most vessels may expect to encounter at one time or another. Additionally, Lloyd's leaves it up to the manufacturer to report that the steel meets the requirement by way of "in house" checks. This measure, although well intentioned, is less a tool for quality control than it is an indication that the toughness of grade A steel has been and continues to be a cause for concern. It has been suggested that a fracture appearance transition temperature (FATT) below 0°C is necessary to ensure sufficient fracture toughness for ships' hulls. In the Lloyd's study of the fracture properties of grade A steel, 5 of 39 samples (nearly 13 per cent) demonstrated a FATT above 0°C, while another 4 samples (10 per cent) were at -6°C or above. For the *Lake Carling*, the FATT was determined to be 32°C. In other industries, such as electric power generation, risks due to brittle fracture are reduced by ensuring that operating pressures are only permitted at component temperatures approaching or exceeding the component's FATT.

A recent study found a significant variability in the fracture initiation toughness of grade A plates after a review of the available data. Other studies have found similar results and have advocated the use of a prescribed minimum toughness standard for all metals and welds used in ships' hulls. In fact, 40 Joules at -40°C has been the standard for Canadian ships of war for over 40 years, while 100 Joules at -20°C has also been suggested as a minimum to ensure adequate damage tolerance and protection against brittle fracture. In a major review of a vast amount of available literature concerning the fracture properties of grade A ship plate, it was concluded that "... the crack arrest ability of grade A plate is poor and probably inadequate for most ship applications." Nonetheless, it would appear that, notwithstanding the average high toughness and quality of most steels, some grade A and B steels that are not suitable in all conditions are still being produced and used in ships' hulls.

Risks Continue

All ships, especially bulk carriers, operating in cold waters and having their side shell of metal with characteristics similar to those of the *Lake Carling* are at risk. The damage tolerance could be less than adequate and cracks could remain unnoticed or discounted as insignificant, yet they would still pose a significant risk when exposed to low temperatures. Given the uncertainties and variability of fracture toughness for some grade A and B steels, it would appear that residual risks for unstable brittle fracture are still present in hulls constructed of these steels, especially when operating in colder climates.

The TSB is encouraged by the intention of the IACS to carry out critical crack length calculations. Based on the results of this analysis, the IACS will apparently consider whether to introduce a screening of the material properties of shell plating in way of the single skin areas of the cargo and machinery region in ships with ice strengthening. The TSB is also encouraged by the work of the International Marine Organization involving restrictions on alternate hold loading and its proposal for "Goal-based new ship construction standards."

The TSB is concerned, however, that, even if a standard is agreed upon, too low a standard would cause unwanted and unnecessary constraints with a questionable safety benefit. Furthermore, until such time that restrictions or regulations are put into effect, existing bulk carriers and their crews continue to be at risk.

Some grade A and B steels that are not suitable in all conditions are still being produced and used in ships' hulls.

Even vessels without ice strengthening are regularly called upon to trade in waters with sea temperatures at or near 0°C. By limiting any possible modifications of the IACS Unified Rule S6 (Use of steel grades for various hull members) to ice-strengthened vessels, other vessels will continue to be exposed to unacceptable residual risks.

REFLEXION

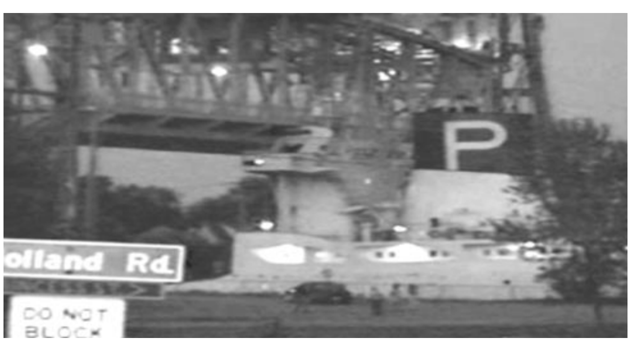
In any language, "grade A" would mean something that is top of the line. In the case of ship's steel, it is not necessarily so.

The bulk carrier *Windoc* (photograph provided by Boatnerd.com)

The Bridge and the *Windoc*

The bulk carrier *Windoc* was transiting the Welland Canal at Allanburg, Ontario, on 11 August 2001, when it was struck by Bridge 11's vertical lift span, which was lowered before the vessel had passed clear of the bridge structure. The vessel's wheelhouse and funnel were destroyed. The *Windoc* drifted downstream, caught fire, and grounded approximately 800 m from the bridge. — Report No. M01C0054

The wheelhouse team had observed the flashing amber approach light, located 925 m from the bridge on the west side of the canal, which indicated that the bridge operator was aware of the approaching vessel. The *Windoc*'s speed was reported to be approximately five knots. As the vessel neared the bridge, the signal lights on the bridge were flashing red and the lift span was being raised. When the vessel was approximately 0.75 to 0.5 nautical miles from the bridge, the signal lights changed to solid green and the lift span was in the fully raised position. With the *Windoc*'s centre line lined up with the bridge signal lights, the vessel proceeded under the bridge.



Bridge 11 striking vessel in way of wheelhouse front windows. Reproduced with permission.

The Lights Turned to Red

When the vessel was approximately halfway under the bridge, the third officer observed that the bridge signal lights were solid red and the lift span was descending. The master sounded a few blasts on the ship's whistle. Then, without identifying himself or the bridge in question, the master called the Traffic Control Centre (TCC) on very high frequency (VHF) radio about the lowering of the bridge. The master quickly stopped the engines and ordered an evacuation of the wheelhouse.

The bridge operator did not respond to either the VHF radio call or the ship's whistle blasts. It is unlikely that the operator could have heard the VHF radio transmission, given the noise level in the bridge control room when the bridge is in operation. However, given the proximity of the whistle to the bridge, and the high pitch and decibel level of the whistle, the operator should have been able to hear the ship's whistle. Residents upstream of the bridge reported coming out of their homes to investigate the reasons for the repeated whistle blasts.

The *Windoc* was clearly visible through the south windows of the control room when the operator began lowering the bridge.

Nevertheless, the bridge operator described having seen the stern of the vessel through the north windows of the control room where the door is located. If this were the case, the *Windoc* would have been clear of the bridge at the time the span was lowered. Analysis of the ship's position before and at the time of impact shows that the superstructure of the *Windoc* was clearly visible through the south windows of the control room when the operator began lowering the bridge.

Operator Impairment

Earlier that morning, the bridge operator took two Darvon-N pain relief tablets to relieve back pain, and consumed about two to four glasses of wine around lunch time. Between 1300 and 1400, he received a telephone call from a St. Lawrence Seaway Management Corporation (SLSMC) team leader, who asked the operator if he would work an overtime shift that evening on Bridge 11. The operator agreed. Reportedly, he did not consume any additional alcohol or take any medication after accepting to work the overtime shift.

On behalf of the TSB, the United States National Transportation Safety Board conducted an analysis of the bridge operator's speech and noted that intelligibility of the operator's speech deteriorated between the time he came on duty at 1830 on the day of the accident and the period immediately preceding the accident, which occurred at approximately 2054.

As revealed by the recorded communication, in the period surrounding the accident, the operator's confusion, slurred speech, impaired memory, and lack of appreciation for the seriousness of the event are consistent with substance and/or alcohol intoxication. Comments made by TCC controllers following their conversation with the bridge operator indicate that they might have entertained this possibility. Therefore, it is likely that the operator's performance was impaired while the bridge span was lowered onto the *Windoc*.

Following the collision, a fire broke out in way of the main engine casing and spread to the accommodation structure as the vessel drifted downbound from Bridge 11. The starboard anchor was dropped; however, the vessel's starboard bow struck the east bank of the canal. The *Windoc* then drifted to the west side of the canal and went aground.

Ineffective Firefighting

The arrival of the Thorold, Ontario, Fire Department on scene at 2105 was timely; however, crews were confronted with a situation for which conventional shore-based firefighting had not prepared them. Due to the watertight integrity of the accommodation structure, water applied to the vessel from the shore-side aerial ladder truck had little effect on the fire, beyond its use as peripheral boundary cooling. Once on

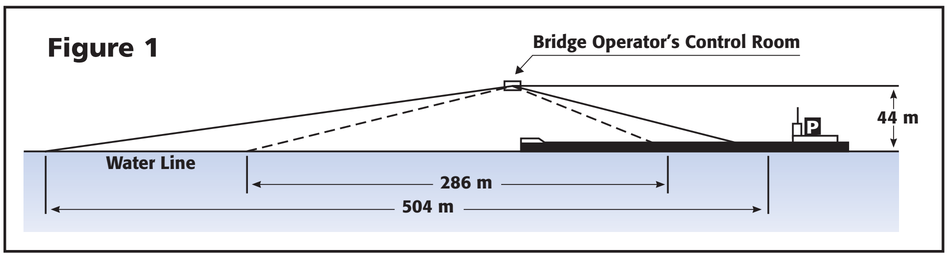


Diagram of a bridge operator's field of view when the bow of the vessel is under the operator's control room. Bridge is in the fully raised position.

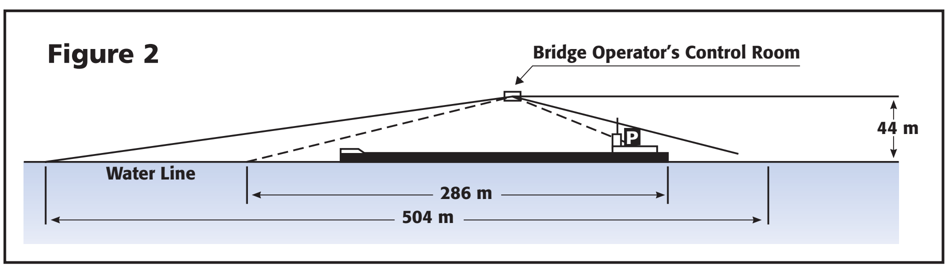


Diagram of a bridge operator's field of view when the vessel is amidships under the operator's control room. Bridge is in the fully raised position.

Legend for figures 1 and 2:

The area within the straight lines (i.e.—) represents the lower limit when the operator is seated at the control panel.

The area within the dotted lines (i.e.-----) represents the lower limit when the operator is standing at the control panel.

board, the shore-based firefighting team was reluctant to enter the burning accommodation. The team did not appreciate that the fire was partly contained by sealed dampers and watertight doors. Based on their training and experience, opening watertight doors to ventilate smoke from the vessel may have seemed an appropriate tactic; in fact, such actions allowed fresh air to reach the smouldering fire and superstructure. The fire department's lack of training and experience for fighting shipboard fires and the unavailability of equipment to access the vessel hindered firefighting response.

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The Thorold Fire Department, in which jurisdiction the accident occurred, was the only fire department in the canal area that did not have shipboard firefighting experience or training. Other than a request for boats, no assistance was requested of nearby, more experienced fire departments. As a result, available firefighting resources in the canal area were not effectively used to contain and extinguish the fire in time to prevent the vessel's accommodation from being destroyed.

Inadequate Contingency Plan

The SLSMC contingency plans in place for responding to vessel-related emergencies within the canal were inadequate and outdated. They were neither used at the time of the accident nor made available to personnel, some of whom were not aware of their existence.

In essence, SLSMC's overall response to the accident was conducted in an *ad hoc* manner, hampering coordination and deployment of response personnel and equipment.

Safety Action and Recommendations

The TSB acknowledged that the SLSMC has expressed positive intentions in response to safety deficiencies raised throughout the investigation. The SLSMC outlined a number of steps, including identifying safety-sensitive positions, drafting a new policy on alcohol and drug testing, and updating attendance and sick leave procedures. It increased the number of supervisory positions, and implemented new procedures for shift handover and communications between vessels and structures.

Given the limited opportunities under the *Canadian Human Rights Code* for the SLSMC to identify employees who may be experiencing personal problems that could affect their fitness for duty, it is determined that the SLSMC should review its supervision and monitoring with respect to fitness for duty to the full extent permissible under human rights legislation. The TSB therefore recommended that:

The St. Lawrence Seaway Management Corporation reassess and clearly identify safety-sensitive positions in their organization in which incapacity due to impairment could result in direct and significant risk of injury to the employee, others or the environment;

M02-01

and that:

The St. Lawrence Seaway Management Corporation establish programs and policies which are pro-active and promote early detection of impairment and safety risk of employees occupying safety-sensitive positions by management,

Aerial view of aft section of vessel with fire department vehicle on site (photograph by Harry Rosettani)

supervisors or peers and which promote an effective mechanism for remedial action.

M02-02

In response, the SLSMC said that it has a new Drug and Alcohol Abuse Policy, and that supervision of employees at isolated sites has been enhanced.

During the 1999-2000 navigation season, there were 3141 vessel transits through the Welland Canal, including petroleum and chemical product carriers. However, no major vessel-related emergency response exercise involving other agencies has been conducted within the canal. Given that the risks associated with an improperly coordinated response were higher than those associated with a fully coordinated response, the TSB therefore recommended that:

The St. Lawrence Seaway Management Corporation conduct, in collaboration with the other appropriate authorities and organizations, exercises to respond to vessel-related emergencies which may be encountered within the Seaway, including the Welland Canal, in order to evaluate the preparedness for responding to a major vessel-related emergency.

M02-03

The SLSMC said that two internal table-top exercises were conducted in each SLSMC region, the results of which were integrated into the contingency plan. Annual exercises were being conducted, and arrangements to conduct an inter-agency exercise were ongoing.

Transport Canada retains regulatory authority over the Seaway and is responsible to ensure that arrangements are in place for dealing with vessel-related emergencies. The TSB therefore recommended that:

The Department of Transport ensure that overall preparedness is appropriate for responding to vessel-related emergencies within the Seaway.

M02-04

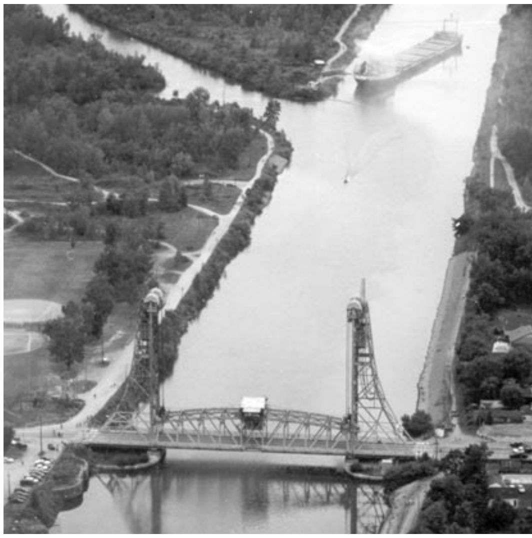
As a result, Transport Canada indicated that, following discussions with the SLMC, an amendment will be made to the *Management, Operation and Maintenance Agreement* that will require the SLMC to have in place an up-to-date emergency response plan. Exercises will be required annually and a validation of the plan will be conducted by an independent party every five years. A validation report will be sent to both Transport Canada and the SLMC.

The TSB was encouraged by the measures taken by the SLSMC towards correcting identified procedural and supervisory deficiencies. The TSB noted, however, that, in the absence of effective backup monitoring systems, the competence of the bridge operator continued to be the sole line of defence against the inadvertent lowering of the span onto a vessel. The TSB therefore recommended that:

The St. Lawrence Seaway Management Corporation ensure that physical and administrative defences are in place to ensure that Seaway bridges are prevented from coming into contact with transiting vessels.

M02-05

The SLSMC responded that two vessel detectors had been installed at Bridge 11 and were to be integrated into the operation of the bridge for the next navigation season. Similar detectors were to be installed at other Seaway bridges.



Aerial view looking north at the bridge and vessel after the striking (photograph by Harry Rosettani)

The TSB noted that the *Windoc*'s fire plan was stowed in the wheelhouse and was inaccessible because of the fire. The TSB was concerned that, without a requirement for such plans to be stored in a location outside the deckhouse on Canadian non-convention vessels, inaccessibility of the plans may continue to hinder the firefighting capability of municipal fire departments, thereby increasing the risk of personal injury and damage to property.

Examination of the sprinkler system on the *Windoc* indicated that the pipework had been secured to wooden structures. Once the fire destroyed the wooden components, the unsupported sprinkler pipework collapsed, rendering it unserviceable. The TSB was therefore concerned that such other older vessels may have retrofitted sprinkler systems attached to combustible internal structures, in a manner similar to the *Windoc*, and that exposure of such systems to fires may negate their effectiveness.

Photo of the *Avataq* in 1990 (provided by Transport Canada)

The Harsh Arctic

At approximately 2330 on 24 August 2000, the captain of the small fishing vessel *Avataq*, in Hudson Bay, in gale force winds, initiated a series of radio calls on citizen's band (CB) radio channel 14, advising a relative that the crew was on deck re-securing cargo that had come loose and that they expected to arrive in Arviat, Nunavut, at 0200 the next morning. Another radio call at 0030, 25 August 2000, indicated that the vessel was in a position 10 nautical miles south of Arviat, that the bilge pumps were not working properly, and that the vessel was taking on water. A final radio transmission was heard from the vessel at 0130 advising that the *Avataq* was taking water over the bow and stern and was sinking. Despite attempts from shore to contact the vessel, no further transmissions were heard. The vessel foundered, and all four crew members perished. — Report No. M00H0008

When communications could not be established with the *Avataq*, a group of residents proceeded south along the shoreline on all-terrain vehicles in an attempt to locate the vessel. At 0255, the searchers called the head of the local Emergency Measures Organization (EMO) in Arviat and informed him that the *Avataq* was missing and might have sunk.

No procedures were in place to ensure that the appropriate Rescue Coordination Centre (RCC) was notified. Nunavut Emergency Services (NES), when contacted at 0257, proceeded to assess whether the *Avataq* had indeed foundered and to identify local Search and Rescue (SAR) forces. A telephone call was made to the Canadian Coast Guard (CCG) in Iqaluit, Nunavut, seeking information on what vessels were in the vicinity of the occurrence. However, the nature of the emergency was not communicated to the CCG, which in turn did not inform RCC Trenton, Ontario, that the *Avataq* might have foundered. While local authorities may wish to react, an efficient SAR operation requires that the appropriate RCC be notified as soon as possible. Resources may then be dispatched expeditiously to the area. In this occurrence, although the Arviat EMO was informed of the distress by area residents at 0255 and immediately called NES Iqaluit, NES Iqaluit did not inform RCC Trenton until 2.5 hours later.

Emergency position-indicating radio beacons (EPIRBs), which operate on 406 MHz, provide an immediate distress signal and have become common; however, the *Avataq* was not equipped with one and was not required to be so equipped. Had the vessel carried a float-free EPIRB or had the emergency been immediately communicated to NES Iqaluit, RCC Trenton would have become aware sooner of the vessel's sinking. Given earlier notice, a Hercules aircraft that was operating north of the area—and that was re-tasked to search for the

At present, there are no statutory requirements for life-saving equipment to be carried on board small fishing vessels such as the *Avataq*.

Avataq—could have arrived on scene within the estimated survival time of those persons in the water who were wearing personal flotation device (PFD) coveralls. The two victims whose bodies were found died of hypothermia.

The *Avataq* was equipped with a four-person Beaufort liferaft secured by a pelican hook to a cradle on top of the wheelhouse. A hydrostatic release and deep chocks were not fitted to the liferaft, nor were they required to be so fitted. There is evidence that the *Avataq* foundered quickly and the crew had little time to don survival equipment and manually launch the liferaft. A liferaft sitting in deep chocks or equipped with a suitable release mechanism such as a hydrostatic release is likely to deploy and be available to the crew in the water. During the extensive air search, neither the liferaft nor its canister was spotted in the debris field, suggesting that they sank with the vessel.

Limited Survival Time

Once the crew members found themselves in the water of 8°C to 10°C without a liferaft, their survival time was limited in part by the amount of thermal protection they were wearing. Full immersion suits are not comfortable to work in; consequently, most small vessel operators are more familiar with and tend to use PFD coveralls, which provide protection against hypothermia for a shorter period of time than a full immersion suit.

At present, there are no statutory requirements for life-saving equipment such as liferafts, deep chocks or hydrostatic releases, and immersion suits to be carried on board small fishing vessels such as the *Avataq*. Given that operating conditions vary from location to location across Canada, safety equipment carriage standards, appropriate for vessels operating in southern Canada, do not provide protection for the crews of vessels operating in the isolated Arctic marine transportation environment.

Information provided by cargo consignors and gathered from the examination of salvaged cargo indicated that the *Avataq* was carrying an estimated 15 823 kg of cargo made up of 3727 kg of propane and 12 096 kg of building materials.

The precise on-board disposition of the cargo cannot be ascertained. In the past, the vessel had been loaded with steel pipe "space frames," wood construction materials, and large propane bottles stored on deck. Smaller propane bottles were stowed in the hold on either side of the engine room. On departure from the Port of Churchill, the vessel's freeboard was estimated to have been approximately 40 cm. To prevent water ingress onto the afterdeck, the scuppers were plugged with threaded barrel plugs. Because of the low freeboard, it was common practice for the crew to cover the afterdeck with a plastic tarpaulin attached to the gunwale to reduce the amount of water shipped.

Safety equipment carriage standards, appropriate for vessels operating in southern Canada, do not provide protection for the crews of vessels operating in the isolated Arctic marine transportation environment.

On one previous voyage, the *Avataq* nearly capsized after taking on a large angle of heel. In that instance, the cargo was lost overboard and the vessel righted itself. A small fishing vessel that is not engaged in fishing herring or capelin is not required by regulation to have approved stability information. However, at the time of the occurrence, the vessel was operating as a cargo carrier.

Meeting the Demand for Cargo

Although a well-established marine transportation system exists to facilitate the summer re-supply of Canada's northern territories, the system's complex scheduling is not always flexible enough to provide for the short-term needs of northern communities. As a result, a demand has developed for smaller vessels such as the *Avataq* that can operate on a more flexible schedule. Economically, it is more advantageous for a northern vessel operator to purchase an existing vessel in southern Canada than to construct a purpose-built vessel. Therefore, small fishing vessels such as the *Avataq*, which may be unsuitable to carry cargo, have become commonplace in the North.

Transport Canada Marine Safety (TCMS) does not maintain a resident surveyor in the Port of Churchill, nor would it be reasonable to expect it to do so. The *Canada Shipping Act*, however, does provide a statutory mechanism for the inspection of any vessel by a port warden or other competent person. In a small port such as Churchill, with relatively few ship movements, the identification of vessels loading cargo in an unsafe manner is not difficult, particularly if a trained and competent port warden is already present and directed to act as the eyes and ears of TCMS.

There was an awareness that the *Avataq* and other similar fishing vessels were engaged in the loading of cargo at the Port of Churchill for delivery to communities on the western shore of Hudson Bay since the vessel began operating out of Rankin Inlet in 1995. During this time, concerns for the safety of the vessel's loading practices had not been identified and passed on to the appropriate authorities. As a result, no assessment was made to determine whether the vessel's cargo was properly loaded or if it was seaworthy as a cargo vessel. Cargo vessels are required to have load-line markings and to have a stability book to assist the master in safely loading the vessel.

Untrained Crew

The use of small fishing vessels carrying heavy cargoes on offshore voyages has engendered new hazards for northern seafarers. Special technical skills and knowledge are required to ensure safe and efficient vessel operations. Although such knowledge can be acquired on the job, formal courses and training, coupled with seagoing experience, provide an enhanced awareness of safe operational practices. The crew of the *Avataq* had no such training, and without that guidance, the crew did not have the required knowledge of cargo loading, stability, and the deleterious effect of free-surface water to recognize the risks associated with operating the vessel under conditions that could be expected during the voyage.

Safety Action

After this occurrence, TCMS met with the Government of Nunavut and agreed to translate the *Ship Registration Guide* into Inuktitut.

Amendments to the *Life Saving Equipment Regulations* came into force on 14 March 2002 and require all vessels under 25 m that are equipped with liferafts to have provision for the liferafts to float free in the event of a sinking. TCMS issued *Ship Safety Bulletin* (SSB) 03/2001 recommending that all vessels, irrespective of their size, have float-free arrangements for liferafts. TCMS also proposed amendments to the *Life Saving Equipment Regulations* to require that liferafts be stowed in readily accessible locations. In the interim, SSB 07/2001 was issued

No assessment was made to determine whether the vessel's cargo was properly loaded or if it was seaworthy as a cargo vessel.

reminding vessel owners of the importance of having life-saving equipment visible and accessible. TCMS, with the assistance of industry groups, was also examining certification and training requirements for small commercial and fishing vessels, with a goal of designing mandatory operator training and qualifications.

Amendments to the *Ship Station (Radio) Regulations* and the *Ship Station (Radio) Technical Regulations* are being phased in over the next few years. As of 01 April 2002, small commercial vessels more than 8 m long (which includes the *Avataq*) operating more than 20 miles from shore are required to carry an EPIRB.

Since the occurrence, TCMS has reorganized the Prairie and Northern Region Branch and moved its headquarters to Winnipeg, Manitoba, from Ottawa, Ontario.

With the support of Department of National Defence Search and Rescue New Initiatives funding for three years, Marine Communications and Traffic Services (MCTS) Iqaluit implemented an Inuktitut-language marine radio safety service during the 2001 operating season. The service is based in Iqaluit and provides coverage 20 hours per day, 7 days per week, during July, August, and September. Regularly scheduled broadcasts focus on weather and tide information, as well as hazards to navigation. Although the system is intended to cover the waters of Frobisher Bay, the coverage area in fact extends beyond and in other directions as well. A listening watch is also kept on the medium-frequency "hunters" favoured by Inuit hunters and seafarers.

TSB Concerns

The TSB continues to be concerned that any shortcomings with the monitoring of small commercial vessels, particularly in remote areas, may result in vessels being used for carrying cargo beyond their capabilities. The *Avataq* had been operating as a cargo vessel for at least five years before this occurrence but was not inspected for this type of operation. As a result, neither an inspector nor the master had participated in an assessment of the capabilities of the vessel to carry cargo according to the applicable regulations. The determination of the appropriate operating parameters for this type of voyage was left to the knowledge and the experience of the crew. Because the master was uncertified, it would not be reasonable to expect that he possessed the skills required to determine whether he should have been operating the *Avataq* given the loaded condition and the area of operation. By not defining the operational parameters of the vessel and the capabilities of its crew through the certification process, a master's ability to assess risks is potentially compromised. The fact that the master may not perceive the risk in time to take corrective action increases the probability and the adverse consequences of an accident.

After this occurrence, personnel from key agencies involved in SAR operations in the Arctic and representatives of local authorities met to review mandates and to discuss procedures relating to SAR operations. It was agreed that RCC Trenton or RCC Halifax must be immediately notified of marine accidents.

At the time of the *Avataq* occurrence, there was a delay of 2.5 hours before NES Iqaluit informed RCC Trenton of the occurrence. This delay held up the tasking of a SAR Hercules that was already in the area and reduced the efficacy of the SAR response.

Given the continuing delays in notifying the appropriate RCC, the TSB is concerned that the agreements made between the key agencies have not been effectively implemented, resulting in a continued risk to seafarers and others in peril in the area. The TSB will continue to monitor and assess these types of occurrences with a view to determining the need for further safety action.

REFLEXION

Just because a vessel has operated without an accident for a certain period of time does not indicate that it is safe to continue to do so. Furthermore, in northern climates, the SAR organization should be rapidly informed as a prime priority.

Marine Occurrence Statistics

	2004	2003	1999–2003 Average
Total Marine Accidents	**490**	**547**	**536**
Shipping Accidents	**440**	**481**	**475**
Collision	12	24	19
Capsizing	18	11	10
Foundering/Sinking	17	30	33
Fire/Explosion	51	65	67
Grounding	108	118	126
Striking	81	76	78
Ice Damage	17	28	10
Propeller/Rudder/Structural Damage	37	39	34
Flooding	63	49	57
Other	36	41	40
Accidents Aboard Ship	**50**	**66**	**61**
Vessels Involved in Shipping Accidents	**469**	**527**	**518**
Cargo	21	18	25
Bulk Carrier/OBO	52	48	59
Tanker	7	16	13
Tug	32	34	34
Barge	34	31	31
Ferry	20	25	24
Passenger	28	41	25
Fishing	227	260	252
Service Vessel	25	27	26
Non-Commercial	10	14	16
Other	13	13	13
By Vessel Flag	**469**	**527**	**518**
Canadian (Non-Fishing)	193	216	201
Canadian (Fishing)	223	253	243
Foreign	53	58	74
Vessels Lost (By Gross Tonnage)	**21**	**38**	**41**
1600 grt and over	0	2	1
150 to 1599 grt	0	2	2
60 to 149 grt	4	8	6
15 to 59 grt	7	12	11
Less than 15 grt	3	12	16
Unknown Tonnage	7	2	5
Fatalities	**28**	**17**	**28**
Shipping Accidents	22	9	15
Accidents Aboard Ship	6	8	13
Injuries	**82**	**95**	**84**
Shipping Accidents	37	35	28
Accidents Aboard Ship	45	60	56
Reportable Incidents (Mandatory)	**246**	**223**	**212**
Close-quarters Situation	67	60	48
Engine/Rudder/Propeller	105	83	84
Cargo Trouble	1	3	4
Personal Incidents	9	14	8
Other	64	63	69

All five-year averages have been rounded.

Occurrence data do not include pleasure craft except when the latter are involved in an occurrence with a commercial vessel.

The majority of vessels listed under “unknown tonnage” are suspected of being less than 15 grt.

(2004 figures are preliminary as of 11 February 2005 and subject to change.)

Source: Transportation Safety Board of Canada

MARINE Occurrence *Summaries*

The following summaries highlight pertinent safety information from TSB reports on these investigations.

BILGE PUMP FAILURE LED TO FLOODING AND CAPSIZING

The log salvage vessel Bruce Brown *took on water and capsized when a makeshift bilge pump repair failed. The vessel took on water and capsized at Artevida Reef, Mamaspina Strait, British Columbia, sometime during the night of 11 June 2002. The vessel owner and his son were later found some distance from the tug; one had died from hypothermia and the other, from drowning. — Report No. M02W0089*

The bilge pump hose in the engine compartment parted where two lengths of hose of the same diameter had been joined with a metal connector. Examination of the connector revealed that, in place of a straight connector, a reducer had been used. One end of this reducer matched the 28.5 mm diameter of the rubber hose, while the other end was 25.4 mm in diameter. This smaller diameter had been built up to match the 28.5 mm inside diameter of the hose with plastic electrician tape. Two hose clamps had then been secured over each hose end at the reducer.

***Bruce Brown* in 1987**

The raw cooling water, its temperature raised by the heat from the engine, warmed the electrician tape and softened its adhesive. The wire reinforcing within the rubber hose limited the ability of the hose clamps to compress the hose against the reducer. The pressure of the cooling water, as supplied by the circulating pump, was sufficient to elongate the warmed adhesive until the connection failed and the hose parted.

Because the hose failure occurred during darkness, it is unlikely that the operator would have been able to observe that the cooling water discharge was now reduced to a single stream. The accumulation of water in the bilges would have served to trim the *Bruce Brown* by the stern. A vessel change of trim can often be detected when referenced to the horizon; however, this would be more difficult to detect during darkness.

Without corrective action, the vessel would capsize.

It was calculated that the bilge would have filled in 50 minutes. However, because of the low freeboard of the vessel, it can be estimated that the addition of approximately 1.8 metric tons of seawater would cause the stern to become submerged to the point where seawater would downflood into the vessel after well deck and eventually flow forward over the partial transverse bulkhead into the accommodation space. Without corrective action, the vessel would capsize. By calculation, this sequence would take approximately 25 minutes from the time of the hose failure.

Although both crew members were experienced, neither had received formal marine-related instruction, nor had either obtained a Transport Canada marine certificate. At the time of the accident, the crew of vessels with a gross tonnage under 15, not carrying passengers, did not require Transport Canada certification. The crew members had not taken two new Marine Emergency Duties (MED) courses, nor was there a requirement for such training.

Transport Canada was working with approved safety training providers and industry associations to enhance awareness among mariners about MED training, which is now required, and to make the training available in remote areas.

Mariners who had not yet had training available in their area of operation were required to demonstrate, before 30 July 2003, or within a reasonable period after the training became available in their area, that they had registered to take the appropriate MED course. Transport Canada will enforce the requirement without exception after 01 April 2007.

REFLEXION

If a system is worth repairing, it is worth repairing properly. The jury is still out on "jury-rigs."

OVERBOARD IN THE RAPIDS

Jet boating in the boiling rapids of the Niagara River below Niagara Falls can be an exhilarating experience. One trip turned out to be frightening for two passengers, who were swept overboard on 02 September 2001. The passengers were rescued within a few seconds and suffered only cuts and abrasions to their legs. — Report No. M01C0063

The *Saute Moutons 14* set out from Niagara-on-the-Lake, Ontario, at about 1730 that day with 43 passengers. Before departure, the passengers received a mandatory safety briefing, including a safety lecture and reference to posted signs highlighting the inherent risk of the activity. The pre-boarding briefing also included instruction of the importance of using the support bar to assist passengers to remain seated during the whitewater ride.

The trip was uneventful until 1814, when the trip from the Niagara Gorge Whirlpool near Devil's Hole began. Just before entering the Devil's Hole rapids, the passengers were asked if they wished to proceed sideways into the rapids. Proceeding sideways into the rapids means that the vessel encounters large waves at an oblique angle and side slips into the trough. The result of this is that the volume of water shipped into the starboard and port forward passenger seating areas is substantially increased.

Passenger water jet boats

As the trip progressed, an on-board video camera, operated by a crew member, recorded a deluge of water increasing in frequency and volume being shipped over the bow and windshield. The passengers were waist and chest deep in water. In addition, due to the constant spray, there was very little opportunity for the forward three or four rows of passengers to catch their breath.

About three-quarters of the way through the rapids, the passenger area remained full with water and the vessel approached a large trough and subsequent wave in quick succession. The vessel proceeded into the trough and wave with no let-up in speed. The forward section of the windshield of the *Saute Moutons 14* and the forward half of the passenger compartment disappeared from view, after having passed through the wave. These passengers were completely submerged for approximately four to five seconds beyond the wave before the forward half of the vessel rose to the surface.

The passengers were waist and chest deep in water.

Immediately before the occurrence, the time between wave encounters did not allow the vessel to evacuate the water and re-acquire its normal operating draught. Thus, when the vessel bow dipped down into the next wave trough, it did not rise with the next approaching wave but rather ploughed into it. The availability of the high engine horsepower (1620 HP) applied to the water jets allowed the operator to continue to move the vessel with the passenger compartment in a flooded condition. The manner in which the operator was manoeuvring the vessel for a brief moment before the occurrence indicates that he was not sufficiently cognizant or aware of the danger to which the passengers were exposed.

As the bow of the vessel was under water and rising to the surface, the outflow of water carried the outboard of the two passengers over the side. The inboard passenger attempted to keep the outboard passenger on board but was carried or pulled overboard. At this time, the operator had reduced power, which slowed the vessel and at the same time he noticed the second passenger going over the starboard side. Both were successfully recovered and taken to the dock for treatment.

Niagara Gorge Whirlpool Jet Boats Ltd. advised that, at the end of the 2001 season, the bailing ducts, which evacuate water from the passenger area, were expanded in size and re-designed. The previous design incorporated a 90-degree turn in the duct. The new design and larger construction allows the same volume of water to be evacuated in a straight line direction aft and thus shed water faster from the passenger area. The weight of the water exiting in the reconstructed tubes helps to raise the bow and drop the stern, further helping to trim the boat.

REFLEXION

The force and effect of moving water should never be underestimated.

FREE-FALLING ELEVATOR

> *The fishing vessel* Mersey Venture *was discharging a cargo of shrimp alongside the wharf in Stormont, Nova Scotia, on 14 August 2000. The forward hatch is equipped with a freight elevator. The vessel caught and processed its catch of shrimp, packing the shrimp in boxes in the fish hold. In order to reduce broken stowage and maximize earning capacity, boxes were shoved in all the hold spaces, including the elevator platform in the hoistway.*
>
> *The elevator hoistway was unloaded to the point where the elevator could be used to prepare pallets of boxes on the platform. After several lifts, the platform was again raised, with the stevedores also on the platform, for the ride to the factory deck level. At about 1220 local time, after two of the stevedores had stepped off, the elevator rope hoist gearbox failed, which caused the drum to freewheel and the platform to descend in a free-fall. Three of the four stevedores still on the platform received injuries consistent with elevator accidents, including shattered heels and broken bones. — Report No. M00M0083*

The investigation revealed that:

- Warning signs were ignored, safety devices were intentionally bypassed, employees were not adequately supervised, and unsafe practices were routinely accepted in the interests of expediency.

- The elevator rope guide had been removed, allowing the starboard load rope to overwrap itself, which caused the port load rope to go slack. This resulted in an inaccurate measurement of the load on the elevator and overstressing of the rope hoist.

- Secondary safety systems that were not disconnected were inoperative.

- There was no formal preventative maintenance program for the elevator in effect at the time of the occurrence.

- Routine repairs and modifications to the elevator were carried out by unqualified individuals.

- Repeated overstressing of the rope hoist resulted in failure of the gear cover, which caused the gears to de-mesh, the rope drum to freewheel and the elevator to fall.

- Periodic comprehensive inspection of the elevator would have revealed its poor condition.

Periodic comprehensive inspection of the elevator would have revealed its poor condition.

- Confusion surrounding the ownership of jurisdiction over the elevator, i.e. Transport Canada Marine Safety or the Nova Scotia Department of Labour Occupational Safety and Health, contributed to deficiencies in the frequency and comprehensiveness of its professional inspection.

Fishing vessel *Mersey Venture*

The elevator was repaired and tested and the owners issued safe working procedures for the equipment.

Many of these units are installed in jurisdictions outside the province. The Province of Nova Scotia has revised its *Elevators and Lifts Act* to include a design and installation standard for these types of lifts and a process for licensing these devices. The province also took enforcement action based on the *Occupational Health and Safety Act* and its associated regulations. Transport Canada is amending applicable regulations as part of its ongoing regulatory reform process.

REFLEXION

This was a freight elevator that should not have been used by personnel. The easy way up is not always the safest.

Investigations

The following is *preliminary* information on all occurrences under investigation by the TSB that were reported between 01 January 2004 and 31 December 2004. Final determination of events is subject to the TSB's full investigation of these occurrences.

DATE	LOCATION	VESSEL (S)	TYPE	GRT	EVENT	OCCURRENCE NO.
JANUARY 11	Horseshoe Bay, B.C.	*Queen of Surrey* *Charles H. Cates V*	Ferry Tug	6969 69	Striking	M04W0006
23	Between Campobello Island and Mace's Bay, N.B.	*Lo-Da-Kash*	Fishing	13	Missing	M04M0002
FEBRUARY 26	Queen Charlotte Sound, B.C.	*Hope Bay*	Fishing	—	Capsizing	M04W0034
MARCH 04	14 miles NNE of North Sydney, N.S.	*Caribou*	Ferry	27 213	Fire in boiler	M04M0013
APRIL 27	Port of Sorel, Que.	*Catherine-Legardeur*	Ferry	1348	Grounding	M04L0050
JUNE 17	10 M off Natashquan, Que.	*Persistence I*	Fishing	47	Taking on water	M04L0065
21	Magog River, Sherbrooke, Que.	Unknown	Small craft (unlicensed and unregistered)	—	Capsizing	M04L0066
JULY 10	St. Clair River, Michigan, U.S.	*Evans McKeil*	Tug	284	Grounding	M04F0016
24	Île de Grâce, Que.	*Horizon*	Container	19 872	Grounding	M04L0092
27	American Narrows, St. Lawrence River, U.S.	*Salvor* *KTC115*	Tug Barge	407 6430	Grounding	M04F0017

DATE	LOCATION	VESSEL (S)	TYPE	GRT	EVENT	OCCURRENCE NO.
AUGUST 11	Saint-Nicolas, St. Lawrence River, Que.	*Canada Senator* Unknown	Container Yacht	30 567 —	Collision	M04L0099
14	Bay of Quinte, Ont.	Unknown (runabout) *Elmer H* Unknown (barge)	Service Fishing Barge	— 3 —	Collision	M04C0043
15	Iroquois Lock, St. Lawrence Seaway, Ont.	*Federal Maas*	Bulk carrier	20 837	Striking	M04C0037
24	Île-aux-Coudres, Que.	*Famille Dufour II*	Passenger	465	Striking	M04L0105
SEPTEMBER 11	Near Amherstburg, Ont.	*Barge A397* *Karen Andrie*	Barge Tug	2928 433	Striking	M04C0044
19	Off Cape Bonavista, N.L.	*Ryan's Commander*	Fishing	129	Foundering and grounding	M04N0086
OCTOBER 29	Kyuquot Sound, B.C.	*Prospect Point*	Fishing	70	Capsizing	M04W0225
NOVEMBER 06	Georgia Strait, B.C.	*M.B.D. NO. 32* *Manson* *McKenzie*	Barge Tug Barge	409 44 505	Sinking	M04W0235
DECEMBER 10	Georgian Bay, Ont.	Unknown	Small craft (unlicensed and unregistered)	—	Capsizing	M04C0090

Final Reports

The following investigation reports were released between 01 January 2004 and 31 December 2004.
* See article or summary in this issue.

DATE	VESSEL(S)	EVENT	REPORT NO.
99-09-24	*Norwegian Sky*	Grounding	M99L0098
99-11-09	*Eternity* *Canmar Pride* *Alcor*	Grounding and near-collision	M99L0126
00-05-18	*Sunny Blossom*	Grounding	M00C0019
00-10-03	*Keta V*	Grounding	M00M0106
00-12-18	*Miller 201*	Striking	M00W0303
01-05-14	*Canadian Transfer*	Contact with bottom	M01C0019
01-06-15	*Rachel M* *Shannon Dawn*	Swamping and capsizing	M01C0029
01-08-22	*Adanac III* *PML 2501* *Coral Trader*	Striking	M01C0059
01-09-02	*Saute Moutons 14*	Persons overboard	M01C0063*
01-10-26	*Kella-Lee*	Foundering	M01W0253
02-03-17	*Katsheshuk*	Fire and sinking	M02N0007*
02-03-19	*Lake Carling*	Hull fracture	M02L0021*
02-04-21	*Progress*	Striking	M02C0011
02-05-15	Unknown (workboat)	Foundering	M02C0018
02-05-22	*Vaasaborg*	Grounding	M02L0039
02-06-11	*Bruce Brown*	Capsizing	M02W0089*
02-06-23	*Lady Duck*	Sinking	M02C0030*
02-07-08	*Fritzi-Ann*	Capsizing	M02W0102
02-07-16	*Kent*	Crew member lost overboard	M02L0061
03-04-15	*Emerald Star*	Grounding	M03C0016

TRANSPORTATION SAFETY
REFLEXIONS
MARINE

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