Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

MARINE INVESTIGATION REPORT

M12W0070

CAPSIZING WITH LOSS OF LIFE

FAST RESCUE CRAFT *LEWIS-MCPHEE*
SECHELT RAPIDS, BRITISH COLUMBIA
03 JUNE 2012

Canada

Marine Investigation Report

Capsizing with Loss of Life

Fast Rescue Craft *Lewis-McPhee*
Sechelt Rapids, British Columbia
03 June 2012

Report Number M12W0070

Summary

On 03 June 2012 at approximately 1130 Pacific Daylight Time, the Royal Canadian Marine Search and Rescue vessel *Lewis-McPhee*, with 4 crew members on board, capsized during exercises in Sechelt Rapids, British Columbia. Two of the crew members were recovered by another vessel; the remaining 2 crew members were later found dead under the capsized vessel.

Ce rapport est également disponible en français.

Factual Information

Particulars of the Vessel

Name of vessel	*Lewis-McPhee*
Licence number	C02055BC
Port of registry	Vancouver
Flag	Canada
Type	Rigid hull inflatable, model 733
Weight	1236 kg (not including engines and fuel)
Length [1]	7.2 m
Draught	Forward: 0.53 m Aft: 0.53 m
Built	1996 by Zodiac Hurricane
Propulsion	Twin 150 HP Yamaha outboard motors
Capacity	18 persons
Crew	4
Registered owner	Royal Canadian Marine Search and Rescue, British Columbia

Description of the Vessel

The *Lewis-McPhee* is a rigid-hull inflatable boat originally designed as a fast rescue craft (FRC). The vessel is operated by the Royal Canadian Marine Search and Rescue (RCM-SAR) [2] for use primarily as a search and rescue (SAR) vessel (Photo 1 and Appendix A).

The deep V-shaped hull of the *Lewis-McPhee* is made of fibreglass-reinforced plastic, as is the vessel's deck. The deck is further reinforced with a core of balsa-treated marine plywood. Positive flotation is provided by an inflatable collar which surrounds the perimeter of the hull. The inflatable collar is 600 mm in diameter and extends 630 mm aft of the engine bracket on both sides of the vessel. Self-draining scuppers are fitted on each side of the transom at deck level.

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1 Units of measurement in this report conform to International Maritime Organization Standards or, where there is no such standard, are expressed in the International System of Units.

2 The Royal Canadian Marine Search and Rescue was formerly known as the Canadian Coast Guard Auxiliary Pacific Region (CCGA-P). The name was changed in May 2012; however, some of the organization's documentation still refers to the CCGA-P.

Photo 1. RCM-SAR *Lewis-McPhee*

The vessel is fitted with a self-righting system that is mounted on an aluminum frame. A righting bag, which can be manually activated via a pull handle located on the transom, is housed on top of the frame. The radar dome and antennas for the very high frequency (VHF) radiotelephone and global positioning system (GPS) are located on a platform just aft of the righting bag.

The steering console, with a magnetic compass and various indicators for the 2 outboard motors, is positioned amidships. To the right of the console are throttle controls fitted with an engine kill switch and lanyard. Aft of the steering console is the operator's bench seat, below which 2 lead–acid batteries are located. Two navigation / communication (nav / com) stations (port and starboard) are located immediately aft of the operator's bench seat. Each nav / com station is fitted with a bench seat, radar / plotter, GPS, VHF radiotelephone and 2 hand-hold bars.

The vessel's propulsion is provided by twin Yamaha 150 HP 4-cycle outboard motors. Just forward of the motors is a roller for a towing line and towing post.

History of the Voyage

On 22 May 2012, the coxswains of the *Lewis-McPhee* and the *Ken Moore,* both from Unit 12 [3] of RCM-SAR, planned a navigation and towing exercise involving these 2 vessels for 03 June 2012 in Vanguard Bay, in Jervis Inlet, BC. This information was posted on the unit website and volunteers were requested to crew the *Lewis-McPhee.*

3 Unit 12 has 2 fast rescue craft, one based in Halfmoon Bay and the other in Porpoise Bay, BC.

At 1000 [4] on 03 June, the 3 RCM-SAR members who volunteered to crew the *Lewis-McPhee* arrived at the Porpoise Bay dock in Sechelt, BC, where the vessel was berthed. The vessel had been put into service just 1 day prior, following sea trials after a lengthy refit. The crew members were joined shortly afterwards by the coxswain of the vessel. Upon the coxswain's arrival, pre-departure checks were carried out. The pre-departure checks involved a visual verification of the following: inflatable collar, battery condition, fuel and oil levels, and the self-righting system components such as the air bag, the pressure in the compressed air cylinder, the self-righting frame, and the release cable.

The crew then discussed the itinerary for the exercise as well as the state of the tide and current in the Sechelt Rapids, which had to be transited in order to reach Jervis Inlet: the maximum ebb tide on 03 June at Sechelt Rapids was at 0940 with a current of 13.6 knots. [5]

At 1030, the *Lewis-McPhee* departed the dock with one of the crew members at the helm. The other 2 crew members were seated at the port and starboard nav / com stations and the coxswain was standing behind them. The coxswain and crew members were wearing personal protective equipment (PPE), which included marine anti-exposure suits and non-flotation mesh RCM-SAR crew vests. The coxswain radioed Comox Marine Communications and Traffic Services (MCTS) to inform them that 4 persons were on board and that the purpose of the voyage was an RCM-SAR exercise in Jervis Inlet. At 1100, the vessel arrived at the Sechelt Rapids (Appendix B). With the crew member still at the helm, the vessel proceeded through the west side of the rapids on the ebb tide. The crew member then stopped the vessel at approximately 1 cable north of the rapids.

At this point, the *Lewis-McPhee* was ahead of schedule for the meeting with the *Ken Moore*, so the coxswain advised the crew members that they would use the time to conduct station-keeping [6] exercises in the rapids.

At approximately 1106, one of the other crew members took over the helm, proceeded into the rapids, and began station-keeping south of Sechelt Islets. The other 2 crew members were seated at the port and starboard nav / com stations and the coxswain stood behind them. After several minutes of station-keeping, the crew member at the helm increased engine power, turned the vessel 180°, and proceeded out of the rapids.

Upon exiting the rapids around 1120, the coxswain took the helm in order to demonstrate station-keeping to another crew member. The 2 seated crew members remained at the port and starboard nav / com stations, while the crew member who had just left the helm was standing just behind the crew member seated at the port nav / com station. The coxswain increased power and manoeuvred the vessel into the rapids, maintained a SE heading facing Sechelt, and began station-keeping between Roland Point and the southwest extremity of Sechelt Islet using a reference point to starboard.

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4 All times are Pacific Daylight Time (Coordinated Universal Time [UTC] minus 7 hours) unless otherwise stated.

5 Canadian Hydrographic Service, *Tide and Current Tables*, Juan de Fuca Strait and Strait of Georgia, Vol. 5, 2012.

6 To maintain a vessel in a constant position relative to a fixed object ashore.

At 1130, a wave from the port side rolled the vessel over to starboard. The vessel continued to roll rapidly before capsizing at position 49°44.34’ N, 123°53.92’ W. Crew on board vessels that were in the area estimated the ebb current to be flowing at approximately 11 to 12 knots.

The coxswain and the crew member who had been standing on the port side were thrown clear of the vessel. Both experienced difficulty staying afloat in the turbulent water once they surfaced. The coxswain surfaced close to the overturned vessel and transmitted a Mayday with his hand-held radio on VHF channel 16. Comox MCTS received the call and alerted the Joint Rescue Coordination Centre (JRCC) in Victoria, which initiated an SAR response. The coxswain then climbed onto the vessel’s overturned hull near its stern and held on awaiting rescue. Meanwhile, the crew member who had been thrown clear surfaced close to the vessel and swam to it, but was unable to get a firm grip and was carried away from the vessel in the strong current. The 2 crew members that had been seated in the vessel prior to the capsizing were nowhere in sight. The vessel was carried by the current for approximately 20 minutes before it eventually settled in an eddy north of Sechelt Islet, where it began circling slowly in the current.

Two local work boats, the *Duke of Earl* and the *Devil Fish*, responded to the Mayday; they arrived on scene at 1139, and rescued the coxswain from the hull of the overturned vessel. Once on board the *Duke of Earl*, the coxswain, working with the operator, directed the search for the missing crew members. At 1142, the *Duke of Earl* recovered the crew member who had been carried away by the current. He was drifting approximately 700 m north of the location where the vessel had capsized (Appendix B). Once the crew member had boarded the *Duke of Earl*, the vessel then returned to the rapids to continue the search.

At approximately 1150, the *Duke of Earl* returned to the overturned vessel. When it reached the vessel, the rescued crew member jumped onto the overturned hull and tapped on it, listening for a response from underneath. No response was heard. The crew member then pulled the handle to activate the self-righting system. The force applied caused the handle to slip off the pull cable and the system did not activate. The coxswain attempted to activate the system by pulling on the cable with his bare hands and then with a pair of vice grips, but these attempts were also unsuccessful.

At 1215, an SAR Cormorant helicopter arrived on scene. At 1225, 2 SAR technicians (SAR techs) entered the water. One of the SAR techs dove underneath the overturned vessel and found the 2 missing crew members. The SAR tech assessed the 2 crew members for signs of life but found them to be unresponsive. One of the crew members was found with her mesh vest tangled around the towing post directly behind the nav/com station bench seats (Appendix A); the crew member’s legs were intertwined with those of the other crew member who was found beneath. There was an air pocket under the capsized vessel about 20 cm deep; it was constantly changing as the vessel pitched.

The SAR techs attempted to extricate the crew from under the vessel but were unable to because of the entanglement. The SAR techs then attempted to cut the crew member’s vest from the towing post in order to free the crew members, but they were unsuccessful.

It was then decided to tow the capsized vessel to the government dock at Egmont, less than a mile away, where a shore crane could be used to lift the vessel so that the crew members could be accessed. The *Devil Fish* started towing the vessel to Egmont. The *Duke of Earl* proceeded ahead to the government dock in Egmont to prepare a crane. At 1259, the crane on the Egmont government dock lifted the bow of the *Lewis-McPhee* clear of the water. The SAR techs then recovered the 2 crew members from beneath the vessel. Emergency Health Services were on scene and pronounced the crew members dead.

Royal Canadian Marine Search and Rescue

In Canada, marine search and rescue services are complemented by organizations such as the Canadian Coast Guard Auxiliary (CCGA). The CCGA is composed mainly of volunteers, such as commercial fish harvesters and pleasure boaters, who assist with search and rescue operations. [7] In addition, the CCGA relies on volunteers to operate community-owned vessels that are on stand-by 24 hours a day, 7 days a week. Each year, the CCGA responds to approximately 2000 marine SAR incidents. [8] The CCGA is divided into 5 regions that parallel the CCG regions. [9] Each Canadian Coast Guard (CCG) region coordinates with the CCGA on the availability of units, as well as training and planned exercises.

In May 2012, the CCGA-P region was rebranded as RCM-SAR, but continued to operate under the CCGA structure. The name was changed primarily to improve fundraising opportunities for the organization. [10] RCM-SAR receives federal and provincial funding, [11] and also carries out fundraising activities. Federal funding is for training, response to SAR incidents, and remuneration for administration staff. Funds raised provincially are used to purchase equipment.

RCM-SAR consists of over 1000 persons, and it maintains 41 SAR units and 5 SAR prevention stations along the Pacific coast of British Columbia. RCM-SAR's resources are placed, in consultation with the CCG, in locations along the coast where they are likely to be needed most. The Joint Rescue Coordination Centre (JRCC) in Victoria tasks RCM-SAR's resources to respond to SAR incidents as required. According to SAR records, there were a total of 2478 marine incidents in the Pacific Regional SAR zone in 2011, and RCM-SAR responded in 671 of those incidents. In 2012, there were a total of 2612 incidents; RCM-SAR responded in 594.

RCM-SAR's organizational structure includes a president, executive officer, SAR operations manager, training manager, and a vessel/equipment standards manager. Individual SAR units ordinarily include a station leader, training officer, coxswain, and duty crew. Recruitment and training of crew members is done by the individual RCM-SAR units, and recruits generally live

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7 Department of Fisheries and Oceans, *Departmental Performance Report 2011-12*, 03 May 2013, http://www.dfo-mpo.gc.ca/dpr-rmr/2011-12/SO3/so-rs-3.1.2-eng.html, last accessed on 5 August 2013.

8 "Canadian Coast Guard Auxiliary – Volunteer Marine Search and Rescue," 2013. http://ccga-gcac.ca/about-us/index.php, last accessed on 5 August 2013.

9 At the time of the occurrence, the CCG organizational structure was composed of the Pacific, Central & Arctic, Quebec, Maritimes, and Newfoundland regions. Since October 2012, the CCG has been made up of the Western, Central & Arctic and the Atlantic regions.

10 Since the name CCG was associated with a federal organization, the CCGA-P was finding it difficult to raise funds locally for its operations.

11 Federal funding is provided under a contribution agreement with the Department of Fisheries and Oceans. Provincial funding is provided by the BC Gaming Commission and Lottery Corporation.

within 15 minutes of their given unit. The duty crew and coxswain at each unit are tasked by the Joint Rescue Co-ordination Centre (JRCC) Victoria when they are needed to respond to a marine emergency.

Vessel History and Certification

The *Lewis-McPhee* was purchased directly from the manufacturer in 1996 by the Canadian Coast Guard (CCG). From 1996 until early 2010, the vessel was used by the CCG at various stations in BC. In early 2010, it was removed from service and stripped of its electronic equipment, propellers, and self-righting system, except for the aluminum self-righting frame. On 20 July 2010, the vessel was donated to the RCM-SAR to be used for SAR purposes at Unit 12.

On 05 September 2010, the vessel was sent to a local Vancouver Island boatyard to be refitted before entering into service. The refit included a new electronics package; an overhaul of the engine, which included new propellers; and the installation of a new self-righting system.

The vessel arrived at RCM-SAR Unit 12 on 12 November 2010, but could not be put into service until the vessel was fitted with SAR equipment. During sea trials performed by RCM-SAR, several hull defects were found that required repairs to the transom and to the bow stem around the beaching shoe to stop water ingress. These repairs were made by a local repair shop between 04 June 2011 and 07 September 2011. Following these repairs, the vessel continued to experience problems with the engines, which were original to the vessel. Eventually, 2 new Yamaha engines were installed on 09 March 2012. After a period of final adjustments, the vessel was put into service at Unit 12 on 02 June 2012.

Though the *Lewis-McPhee* is registered as a workboat, TC considers it a pleasure craft because it is operated for non-commercial purposes, and does not require it to undergo inspections. However, pleasure craft must meet the requirements of Part 2 of the *Small Vessel Regulations*; these deal with lifesaving appliances including visual signals, navigation equipment, safety equipment and firefighting equipment. The *Lewis-McPhee* met these requirements.

Fatalities/Injuries

The coxswain and surviving crew member both suffered mild hypothermia as a result of the capsizing. The coroner found that the cause of death of the other 2 crew members was drowning.

Damage to the Vessel

The vessel, which was subsequently recovered, sustained extensive water damage to the 2 outboard motors, control systems, and electronics. There was no apparent damage to the hull.

Personnel Certification and Experience

The coxswain on the *Lewis-McPhee* had the following certification and training as required by RCM-SAR for his duties: a Pleasure Craft Operator Card (PCOC), Restricted Radio Operator’s Certificate (ROC-M), Standard First Aid, and CCG Rigid Hull Inflatable Operator Training (RHIOT) certification. The coxswain also held a valid Small Vessel Operator’s Proficiency training certificate (SVOP), [12] obtained on 04 November 2008. The coxswain had almost 5 years of service and 363 hours of sea time with the RCM-SAR.

The surviving crew member held a valid SVOP, PCOC, ROC-M, and Standard First Aid; he had not taken the RHIOT course. The crew member had served RCM-SAR for 23 months, and had 142 hours of sea time.

One of the deceased crew members held a valid SVOP, PCOC, ROC-M, and Standard First Aid, but had not taken the RHIOT course. The crew member had served RCM-SAR for 14 months, and had 136 hours of sea time.

The other deceased crew member held a valid PCOC, and had not taken the RHIOT course. The crew member had served RCM-SAR for 4 months and had 23.5 hours of sea time.

All crew members had the required training and certification as per the RCM-SAR's Safety Management System (SMS). [13]

Environmental Conditions

On 03 June 2012, at 1100 hours, the Environment Canada weather station in Sechelt registered winds of 19 km/h from 150º T. Local weather was reported to be cloudy with intermittent rain and a temperature of 12.4°C. The water temperature was approximately 10°C.

Sechelt Rapids

Sechelt Rapids, known locally as the Skookumchuck Rapids, are located about 100 km north of Vancouver at the entrance of Sechelt Inlet, BC. The rapids extend over an area approximately 1000 m long and 500 m wide.

Volume 1 of the *British Columbia Coast Sailing Directions* cautions mariners about the Sechelt Rapids:

> Tidal streams within the rapids can attain 16 ½ knots on the flood and 16 knots on the ebb tides during large tides. Although the preferred time to transit Sechelt Rapids is at high water slack, it is also navigable at low tide slack water. Caution: It is hazardous for any vessel to attempt to navigate Sechelt Rapids except at or near slack water. Low-powered vessels, or those that answer the helm sluggishly, can find themselves spun about or set upon the west shore if attempting to abort passage through the rapids. [14]

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12 An SVOP is required under the *Marine Personnel Regulations* to operate vessel of up to 5 gross tonnage, with the exception of tugs.

13 CCGA-P Safety Management System, Section 3, "Training," Item 2.8, 4th ed., 15 October 2011.

14 Canadian Hydrographic Service, *Sailing Directions*, British Columbia Coast (South Portion), Vol. 1, 17th ed., page 205.

The strongest flood stream occurs to the southeast and west of Sechelt Islets. The strongest ebb stream occurs just west of the green light on Sechelt Islets (Photo 2), with a strong cross-channel set toward the west-northwest. A large back-eddy occurs to the north of the light, and whirlpools form close to the light. On 03 June 2012, the predicted time of maximum ebb current at Sechelt Rapids was 0940, at 13.6 knots. The next predicted time of slack water was 1414.

Photo 2. Green light marking southwest extremity of Sechelt Islets

Since 2003, there have been 3 instances of the JRCC being notified of overturned or capsized vessels in and near Sechelt Rapids. Two were overturned kayaks/jet boats, and one was a tug with 4 crew on board that was towing a barge.

Standing Wave Phenomenon

The Sechelt Rapids are well known for standing waves. [15] Standing waves are waves that maintain a constant position. They form when the internal energy of water, which is a function of velocity and depth, becomes greater than the force of gravity which is holding it down. Water can build internal energy if the flow increases very swiftly; if the depth of the water decreases quickly; or if the water is backed up by rocks/obstructions, as within rapids. When the water builds energy, but the flow is constrained (either by the sides of a channel or by rocks and other obstructions), this internal energy forces the water to rise upward. In these moments, the water actually flows uphill and forms a standing wave. [16]

Self-righting System

The *Lewis-McPhee* is equipped with a self-righting system, which was installed before the RCM-SAR put the vessel in service . The purpose of the self-righting system is to right the vessel after it capsizes so that the crew can return to the safety of the vessel. The system is composed of an air bag mounted on a self-righting frame and a compressed air cylinder. The system's handle is connected to the firing head of the air cylinder by a release cable. When the handle is pulled, a spring-loaded bayonet in the firing head pierces a puncture disc, allowing air to fill the righting bag. When the system is tested on land, the normal force required to activate the righting system is less than 50 lb.

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15 Burkard Baschek and David Farmer, "Energy Dissipation in Extreme Tidal Environments," http://www.burkard.baschek.info/research_extreme_tidal.html, last accessed on 7 August 2013.

16 Moody, Tom, "Rocks, rapids and the hydraulic jump," *The News* (Grand Canyon River Guides), 6(3)(Late Summer) 1993:19-23, last accessed at http://www.gcrg.org/bqr/6-3/hydraulic.htm on 7 August 2013.

The self-righting system is not intended to be used when personnel are trapped under the capsized vessel, as the righting action is very quick and the direction of the righting action is unpredictable. The CCGA-SAR crew manual [17] provides instructions for righting a capsized vessel.

As part of their weekly and pre-departure checklists, the crew members on duty visually inspect the self-righting system to ensure the presence of all components. However, because the system had been installed on board the *Lewis-McPhee* recently, the RCM-SAR did not test or activate it before putting it into service. Testing the system was not an RCM-SAR requirement. The vessel manufacturer's technical manual recommends weekly inspections of the system, as well as more comprehensive annual inspections that include inflation of the righting bag. The CCG conducted regular inspections and maintenance of the systems fitted on its vessels, and had been doing so on the *Lewis-McPhee* while they operated it.

The CCG released a Fleet Circular [18] in July 2008 that addressed issues with the operation and maintenance of the self-righting system. In particular, the circular identified problems associated with the handle originally installed by the manufacturer, which was found to rust at its fitting and fall free of its restraints as a result. Because neither the RCM-SAR nor the CCGA are on a CCG Fleet Circular distribution list they were not aware of this circular.

A post-occurrence inspection of the vessel's self-righting system by the TSB found the following:

- The plastic activation handle was missing.
- The steel pull-cable used to activate the self-righting mechanism was not manufacturer-approved, as it was not nylon-coated. [19]
- The pull cable, as configured, passed through numerous bends, contrary to the manufacturer's specifications.
- The force required to activate the system was 20 lb at the cylinder head and 100 lb at the pull handle.

During the investigation, the TSB also visited another RCM-SAR unit where one of the vessels was found to be fitted with an identical self-righting system, but the release cable was not manufacturer approved: recently replaced by the crew, the cable had been purchased at a local hardware store.

Training

The RCM-SAR's training policy and the requirements for training plans are outlined in the SMS. Training is delivered through centralized courses and at individual stations; it includes

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17 Canadian Coast Guard Auxiliary, *Canadian Coast Guard Auxiliary Search and Rescue Crew Manual*, 2nd ed., 2006. The RCM-SAR used this manual for training personnel on their vessels.

18 Canadian Coast Guard, FC-12-2008, "Self-Righting System Inspection and Maintenance."

19 Zodiac Hurricane 733 Technical Manual M-B-10050, 1998, p. 222.

classroom instruction prior to on-the-water exercises, [20] as well as the requisite Transport Canada–approved courses. At each unit, the station leader, training officer, and coxswain work together to develop individualized training plans, and are responsible for maintaining training records. [21]

Crew are divided into 5 levels within the RCM-SAR structure: juniors, new crew, crew, advanced crew, and coxswains. Before moving up to the next level, crew members must complete a predetermined number of training hours and specific courses. At the advanced crew level, members are trained and evaluated in station-keeping, boarding, and pacing. At the crew level, members receive classroom instruction and are evaluated on theoretical knowledge regarding emergency situations such as sinking, damage control, and capsizing. In this occurrence, the surviving crew member and one of the deceased were at the advanced crew level within the RCM-SAR training structure. The second deceased crew member was at the crew level. With the exception of the coxswain, the other crew members had limited training and experience in station-keeping.

Duty coxswains [22] are responsible for scheduling and setting up training for crew members within their unit, the complexity of which is based on the duty coxswains' own level of experience and that of the crew members assigned to them. To help plan the training, coxswains have access to the CCGA Search and Rescue Crew manual, the RHIOT manual, and the CCGA-P SAR Management System documentation. While the RCM-SAR's SMS specifies that "training should reflect emergencies that may happen to rescue vessels when out training or during a call", [23] the above-noted publications do not provide specific guidance on training procedures for escape from a capsized FRC, nor do they cover the risks of practising station-keeping in a strong current.

As part of their training, new crew may be familiarized with local risks and hazards. For coxswains, this familiarization is a requirement of the RCM-SAR's SMS. At some units, the known risks are communicated verbally, while at other units, these risks are documented. Prior to on-the-water training exercises, crew are provided with a pre-departure briefing, which may include an assessment of risks. The SMS provides guidelines with respect to passage planning and notes that passages undertaken by auxiliary vessels will be planned as far as possible in advance. [24] The SMS guidelines on marine operations also specify the importance of identifying

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20 On-the-water skills must comply with the SAR Crew Training Manual, as stated in the RCM-SAR's SMS.

21 The training records are occasionally reviewed for compliance by a member of the management team as part of their quarterly report on station readiness; the records for the crew members of the *Lewis-McPhee* were last reviewed on 27 April 2012.

22 The duty coxswain is on a 1-week rotation and is responsible for both the *Lewis-McPhee* and the *Ken Moore* and any call-outs during the week.

23 CCGA-P Safety Management System, Section 3, "Training," Item 2.6, 4th ed., 15 October 2011.

24 CCGA-P Safety Management System, Section 3, "Marine Operations," Item 8.1, 4th ed., 15 October 2011.

risky navigational areas (extensive shallows, clefts in rocky shorelines, and rip current) and states that “a strategy for dealing with them by crew cannot be over-emphasized.” [25]

In this occurrence, the coxswains of the *Lewis-McPhee* and *Ken Moore* had planned a navigation and towing exercise, and prior to the *Lewis-McPhee*’s departure, the crew discussed the conditions in the Sechelt Rapids. However, when the *Lewis-McPhee* arrived early for the exercise, the extra time was used to conduct station-keeping exercises without an assessment of the risks involved.

Escape Training and Dangers of FRC Capsizing

The physical and mental demands of escape from a capsized FRC are extremely challenging, and the greatest danger the crew of an FRC face is sudden capsizing and subsequent drowning. [26] An FRC capsize is dangerous for a number of reasons, including the following:

- The capsize often happens suddenly and unexpectedly, so crew members may not have a good handhold.
- Because the crew members are not restrained in the FRC, they may be thrown out of the vessel during the capsize.
- The sudden inrushing of water during a capsize may disorient the crew members.
- The crew members may be injured if they are thrown against parts of the FRC.
- The crew members may become disoriented once in the water due to inversion and submersion.
- The buoyancy of survival suits, lifejackets, and personal flotation devices (PFD) may prevent crew members from swimming in the desired direction or escaping from underneath a capsized FRC.

RHIOT courses are offered by the CCG and by private facilities within Canada, and teach boat handling, SAR, and leadership skills. The RHIOT course offered to RCM-SAR crew takes place over a 1-week period, and includes an in-water session for crew members to practise capsize reversal of an overturned FRC. The vessel is overturned without crew members inside and the exercise involves instructing the crew members to check for injuries and deploy a safety line. One crew member practises deploying a safety line by swimming it out the complete length of the vessel followed by the remaining crew members. The coxswain remains at the transom to activate the self-righting system.

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[25] Ibid.

[26] C. J. Brooks, “Disorientation in Helicopter Ditching and Rigid Inflatable Boat Capsizement: Training is Essential to Save Crews”, paper presented at RTO HFM Symposium on “Spatial Disorientation in Military Vehicles:Causes, Consequences and Cures”, held in La Coruña, Spain, 15–17 April 2002, published in NATO Research and Technology Organisation, “Spatial Disorientation in Military Vehicles: Causes, Consequences and Cures”, RTO Meeting Proceedings 86 (RTO-MP-086).

At the CCG, all crews required to operate an FRC must complete RHIOT training. For RCM-SAR, this training is a prerequisite in order to become a coxswain.

Personal Protective Equipment for FRC Crews

FRC operators wear personal protective equipment (PPE) to protect themselves in adverse environmental conditions and emergency situations. The type and style of PPE will depend on the conditions present and the operation being conducted. As part of their PPE, FRC operators often wear either a dry suit or a marine anti-exposure suit (Photo 3).

Photo 3. Marine anti-exposure suit

The RCM-SAR's SMS includes a section on protective clothing and equipment, which specifies that crew are required to wear a flotation suit, a floater jacket, or inherently buoyant lifejacket or PFD at all times while on board. Crew wearing a dry suit are required to wear a PFD as well.

A dry suit, when worn with thermal undergarments, thermally insulates the body. Dry suits are designed with watertight zippers and seals around the neck and hands to prevent water ingress, making them more suitable for use in cold water. The suit normally protects the whole body, with the exception of the head and the hands. However, dry suits can be uncomfortably hot in warm temperatures, and are typically more expensive and more complex to put on than other types of PPE. Dry suits do not provide buoyancy, so a PFD must be worn to provide the necessary flotation.

PFDs are available in various styles, and range from vests to full coverall-style suits, some of which are classified as marine anti-exposure suits. PFDs and marine anti-exposure suits are relatively inexpensive and simple to use. Marine anti-exposure suits thermally insulate the body by allowing small quantities of water into the suit; this water is then warmed by body heat. When properly sized, the close-fitting style prevents excessive heat loss, as water that enters the suit is prevented from escaping and being replaced with cold water. However, marine anti-exposure suits are limited in their ability to provide warmth by 2 factors: the wearer is still exposed to some amount of water, and the insulation is less effective than that of dry suits, as water in the suit draws body heat.

CCG crew members, when operating a FRC in response to a SAR incident, wear dry suits and personal flotation work vests. The crew members of the Royal National Lifeboat Institute (RNLI) in the United Kingdom wear dry suits with an inflatable lifejacket at all times when operating an FRC.

RCM-SAR provides crew members with a list of required PPE. All the PPE worn by the crew of the *Lewis-McPhee* was approved by RCM-SAR for their intended operations. At the time of the occurrence, the crew were wearing marine anti-exposure suits (certified as PFDs) that provided thermal and flotation protection. Three of the crew members were wearing the 2-piece suits

(Photo 3), and 1 was wearing the 1-piece suit. All of the crew members were wearing helmets, work boots, and non-flotation mesh crew vests.

RCM-SAR provides crew vests, which are used to carry additional equipment necessary for SAR operations. Standard items carried by crew members include survival gear such as a portable VHF radiotelephone, notepad, knife, pocket mask, and flashlight. When additional equipment is carried in the vest pockets, it may compromise flotation due to the additional weight of the items carried.

Dry suits are available to some units in the RCM-SAR but were not available to the crew at Unit 12.

Medical and Physical Fitness Standards

The purpose of a medical examination is to obtain a factual report of one's state of health and medical history and to indicate one's fitness for duty. In SAR operations, a health problem can endanger one's life, endanger the safe operation of the vessel, and put the rescue operation at risk.

RCM-SAR crew members are required to perform some physically demanding tasks during SAR operations. These tasks may include

- carrying heavy dewatering pumps;
- recovering persons in the water;
- helping to transport stretchers carrying persons;
- performing CPR for extended periods of time;
- moving around a vessel in rough weather and extreme sea conditions, which requires dexterity, a good sense of balance, and good coordination; and,
- holding onto and jumping onto disabled vessels in rough weather.

The RNLI, a volunteer lifeboat society in the United Kingdom that operates 330 lifeboats, requires new recruits to undergo an extensive medical examination and meet physical fitness standards. The medical standards include testing for blood disorders, cognitive and behavioral disorders, cardiovascular disorders, respiratory disorders, digestive disorders, and musculoskeletal disorders, among others. The RNLI also has medical standards for the abuse of alcohol and drugs. The Royal Netherlands Sea Rescue Institution (KNRM),[27] another mainly volunteer-based SAR organization, also has extensive medical standards and physical fitness requirements for volunteers working on its rescue vessels. Within the CCG, personnel carrying out SAR duties are required to have a seafarer's medical certificate, issued by Health Canada.

The RCM-SAR's minimum qualifications to join the organization are a criminal record check and a PCOC. There are currently no medical or physical fitness requirements. Medical certificates verifying physical fitness are required from crew members only before they attend a

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27 The Royal Netherlands Sea Rescue Institution is translated from its proper name: Koninklijke Nederlandse Redding Maatschappij.

RHIOT course, since the course is physically demanding. Although the 2 deceased crew members had not undergone physical fitness or medical examinations to join RCM-SAR, information obtained by the TSB with respect to each crew member's medical history revealed no issues that may have impeded their escape from the capsized vessel.

Vessel Maintenance

Each RCM-SAR unit is responsible for the maintenance of its vessels. The RCM-SAR training provided to Unit 12 covered maintenance of the safety-critical equipment on board its vessels. Training provided on the overall maintenance of the vessel is primarily focused on keeping track of major mechanical failures, performing routine engine maintenance, and carrying out filter changes and ignition maintenance. When maintenance of a more complex nature is required, the work is generally done by local marine contractors, and is paid for by donations collected by RCM-SAR. The work is not checked by RCM-SAR personnel.

The CCG operates a small fleet of rescue vessels similar in size to those of RCM-SAR and have qualified technicians on staff to provide maintenance or oversee maintenance that is contracted out.

A post-occurrence inspection of the *Lewis-McPhee* by the TSB identified the following:

- Two lead–acid batteries located in the steering console were not secured in place and were not fitted with spill-resistant caps.
- The recovery line on the vessel's aluminum protective frame was secured in such a way that it was positioned below the waterline when the vessel was overturned.
- A small perforation in the aft engine pod allowed ingress of water.
- There was an opening on the transom above the engine pod.
- There was a 2-cm crack on the self-righting frame on the port side.
- Screws used to clamp down the 3/8" aluminum cable conduit were in contact with the righting bag.
- The dome housing the radar scanner was fitted right alongside the righting bag on the self-righting frame, so that when the righting bag was inflated by the TSB it damaged the dome.

Analysis

Events Leading to the Capsizing

After departing the Porpoise Bay dock in Sechelt, BC, at 1030 for a planned exercise with the *Ken Moore*, the *Lewis-McPhee* travelled through the Sechelt Rapids. These rapids are hazardous for any vessel to navigate except at or near slack water. [28] The predicted time of maximum ebb tide at Sechelt Rapids was 0940 with a rate of current of 13.6 knots. Following the initial transit through the rapids, the *Lewis-McPhee* arrived early for the planned exercise. The coxswain decided to use the extra time to conduct a station-keeping exercise in the rapids. The object of this exercise was to give the crew an opportunity to practise station-keeping in the rapids during an ebb tide.

After 1 of the crew members successfully performed a station-keeping manoeuvre in the rapids, the coxswain took over the helm at approximately 1120, transited into the same area of the rapids, and began station-keeping. At this time, the current in the rapids would have been 11 knots. [29] To perform the station-keeping manoeuvre, the coxswain was observing an object ashore to the starboard side of the vessel. He was constantly adjusting the throttle in order to maintain position when a wave from port rolled the vessel over to starboard. The coxswain had no time to react as the vessel rapidly rolled over and capsized.

Although the investigation could not determine the exact cause of the capsizing, 2 possible scenarios may explain the circumstances that caused the vessel to roll to starboard:

A standing wave may have developed on the port side of the vessel and hit the vessel broadside. The swift tidal current flowing over the changing topography and the stepped-up rock formation off Roland Point (Appendix B) provide ideal conditions for the formation of a standing wave. The coxswain, who was station-keeping while using a reference point on the starboard beam, may not have seen this wave developing.

While station-keeping, the coxswain was using a combination of power and helm to keep the vessel in position. To ensure the vessel maintained this position, neither advancing nor falling astern, the coxswain used a fixed point ashore on the starboard beam while also maintaining a look-out ahead. Given the high rate of current, if the coxswain had allowed the vessel’s head to fall off to starboard, even by a few degrees, the current could quickly have pivoted the vessel, and exposed it broadside to the strong current, initiating the vessel’s roll to starboard.

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[28] Canadian Hydrographic Service, *Sailing Directions*, British Columbia Coast (South Portion), Vol. 1, 17th ed.

[29] Canadian Hydrographic Service, *Tide and Current Tables*, Juan de Fuca Strait and Strait of Georgia, Vol. 5, 2012.

Station-keeping

Station-keeping within the rapids in areas prone to exceptionally high current and standing waves is a high-risk exercise, and risks must be carefully analyzed when the exercise is planned, and the crew members prepared for the worst-case scenario.

In this occurrence, the decision to conduct station-keeping exercises was made ad hoc, without an advance plan or formal consideration of the risks involved because the vessel was ahead of time for the meeting with the *Ken Moore*. The current conditions within the Sechelt Rapids were high at 11 knots; the next predicted time of slack water was not until 1414. The sailing directions for the BC coast recommend that vessels transit the rapids only during slack water.

The location chosen by the coxswain for the station-keeping exercise was well known for its standing waves and strong currents, and was selected to help train the crew members to provide SAR aid to those trapped within the rapids. However, SAR statistics for the past 9 years do not indicate that there has been a need for this type of rescue in the rapids, because the swift water carries persons swept overboard downstream, as in this occurrence.

If high-risk training exercises are carried out without consideration of the need for training, proper planning and preparation, risks to crew members are increased.

Vessel Maintenance

For crew to respond efficiently and effectively during emergency situations, it is important that all safety-critical equipment and systems on board a vessel are periodically inspected and tested. If necessary, they must also be repaired as per the manufacturer's requirements and specifications.

The self-righting system on the *Lewis-McPhee* was installed by a contractor that used non-original equipment manufacturer (OEM) parts. Neither the contractor nor his staff were trained and certified by the manufacturer of the system, as recommended in the manufacturer's specifications. At the time of the occurrence, the self-righting system did not function as intended because the release cable had not been configured according to the manufacturer's specifications, and the cable itself was not manufacturer-approved. In areas where the cable within the protective sheathing passed over bends, the cable cut into the sheathing, resulting in undue friction between the cable and its protective sheathing.

The force necessary to activate the self-righting system via the pull handle was determined to be 20 lb at the cylinder head and 100 lb at the pull handle, beyond the 50 lb of force required under normal operational conditions, due to the use of a non-approved cable and its improper configuration. During the occurrence, the pull handle broke and the crew were unable to activate the system and right the vessel.

The crew within the unit had not received a great deal of RCM-SAR training on vessel maintenance, and therefore had limited knowledge about the maintenance of safety critical equipment on board their vessels, particularly the self-righting system. Without adequate knowledge and organizational oversight of vessel maintenance, there is a risk of essential safety equipment not operating as required during an emergency.

If repairs to vessels and their on-board systems are carried out in facilities that are not manufacturer-approved or by personnel who are not certified by the manufacturer, there is risk that a vessel may be put in service or operated with deficiencies.

Escape Training from an Overturned FRC

Effective training transfers knowledge and skills, and is important in keeping mariners safe. The real safety benefits from training come with regular practice of skills learned.

The physical and mental demands of escape from a capsized FRC are extremely challenging. At the crew level in RCM-SAR training, crew members receive classroom instruction on sinking, damage control, and capsizing. They are then examined on the information they have learned. Though training may not necessarily prevent capsizing, periodic exercises to practise escape and survival techniques during a capsizing may help to improve crew preparedness during such emergencies. The Rigid Hull Inflatable Operator Training (RHIOT) course provides exercises that allow crew members to practise a capsize reversal and righting the vessel. However, it is offered to RCM-SAR crew members only at the coxswain level, and does not deal with escape from an overturned vessel in either static or dynamic conditions.

Without practical training for emergency situations that may be encountered during regular duties, crew members may not be adequately prepared to deal with one should it occur.

RCM-SAR Personal Protective Equipment

Appropriate personal protective equipment (PPE) for crew members is essential to increasing the chances of their survival during an emergency at sea. Within RCM-SAR, standards for crew members' PPE are flexible, and crew members are responsible for purchasing some of their own PPE. As such, PPE differs from unit to unit, and is largely dependent on the financial situation of the unit. Some units can afford more expensive dry suits that are augmented with personal flotation work vests, whereas other units can offer crew members only marine anti-exposure work suits.

The coxswain and surviving crew member were found to be suffering from mild hypothermia when they were rescued. The marine anti-exposure suits they were wearing did not provide sufficient thermal protection, nor did they provide adequate buoyancy while the crew members were in the cold and turbulent waters of Sechelt Rapids.

Crew members who are not equipped with PPE appropriate for the conditions and elements may be at increased risk of hypothermia and drowning.

Medical and Fitness Standards

The job of a FRC crew member on a RCM-SAR vessel is very demanding, both physically and mentally, and requires crew members to respond to emergencies in all types of weather and sea conditions. For this reason, it is essential that active crew members be in good health and physically able to carry out their duties.

Medical and physical fitness standards are of even greater importance when a vessel is operating with a small crew complement, as is the case with most FRCs. In a situation where one or more of the crew members are incapacitated for reasons of medical or physical fitness, the operational responsibilities fall to the remaining crew members, making their tasks even more challenging. Consequently, an unfit crew member may not only jeopardize the safety of the rescue mission, but may also place the safety of the other crew members and the individuals that they are rescuing at risk.

RCM-SAR has neither a process nor standards for ensuring medical or physical fitness of crew members. This is not consistent with CCG and other volunteer organizations performing similar functions in other countries. Volunteer organizations such as the Royal National Lifeboat Institute (RNLI) and Royal Netherlands Sea Rescue Institution (KNRM), which operate similar lifeboat societies, have medical and physical fitness standards to ensure that volunteer personnel responding to incidents can do their jobs safely.

Although there is no information to indicate that the medical history and physical fitness of the deceased crew members contributed to their drowning, recruitment standards that include medical and fitness standards help ensure that crew members can do their jobs safely. Without medical and fitness standards, there is a risk that RCM-SAR may recruit crew members who are not fit for SAR duties.

Findings

Findings as to Causes and Contributing Factors

1. An ad hoc training exercise was being conducted at a time of high current in a hazardous area of the rapids without an advance plan or formal consideration of the risks involved.

2. While the exact cause of the vessel's capsize could not be determined, the vessel rolled to starboard, took on water, and capsized rapidly.

3. Two crew members trapped beneath the capsized vessel were unable to escape and drowned.

Findings as to Risk

1. Without practical training for emergency situations that may be encountered during their regular duties, crews may not be adequately proficient to deal with one when it occurs.

2. Without adequate knowledge and organizational oversight of vessel maintenance, there is a risk of essential safety equipment not operating as required during an emergency.

3. If repairs to vessels and their on-board systems are carried out in facilities that are not manufacturer-approved or by personnel who are not certified by the manufacturer, there is risk that a vessel may be put in service or operated with deficiencies.

4. Crew members who are not equipped with PPE appropriate for the conditions and elements may be at increased risk of hypothermia and drowning.

5. Without medical and fitness standards, there is a risk that RCM-SAR may recruit crew members who are not fit for SAR duties.

Safety Action

Safety Action Taken

On 03 June 2012, the Transportation Safety Board of Canada (TSB) issued the Marine Safety Information Letter (MSI) 03/12, advising the Royal Canadian Marine Search and Rescue (RCM-SAR) about the safety issue regarding the installation of the self-righting system on the *Lewis-McPhee*. A copy of the letter was also sent to the Department of Fisheries and Oceans, the Department of National Defense, the Royal Canadian Mounted Police, and the contractor that installed the self-righting system.

The letter briefly outlined the events of the occurrence and identified the crew's inability to activate the self-righting system due to the design of the system and the use of parts that were not manufacturer-approved. The letter also noted that RCM-SAR might wish to relay this information to other units to ensure that the self-righting systems on their rigid hull inflatable fast rescue crafts (FRC) was properly rigged and fitted with manufacturer-approved parts only.

On 03 July 2012, RCM-SAR issued a memo prohibiting training in the Skookumchuck Rapids and specifying that if RCM-SAR vessels are required to transit the rapids, these voyages should be limited to emergencies only, and the vessel should be under the conduct of certified Rigid Hull Inflatable Operator Training (RHIOT) coxswains.

On 09 August 2012, RCM-SAR issued a further memo requiring that:

- all units operating vessels with self-righting systems immediately initiate the service recommended by Zodiac Hurricane for their self-righting systems;
- all units operating vessels with self-righting systems have those systems recertified by an authorized and certified dealer/installer within the next 3 months, and preferably as soon as possible; and,
- all units with self-righting equipment provide a copy of the completed recertification to the management team of the Royal Canadian Marine Search and Rescue for them to forward to the TSB and insurers.

On 01 August 2012, Zodiac Hurricane issued a Technical Bulletin concerning the importance of inspection and maintenance of the righting system. On 10 September 2012, the contractor that installed the self-righting system on the *Lewis-McPhee* issued a new series of check, maintenance, and service guidelines for all aspects of the self-righting system.

In January 2013, Raven Rescue, a training provider, conducted its Swiftwater Motorized Boat Operator Course for RCM-SAR members, including 3 coxswains from Unit 12 (Halfmoon Bay) and 2 coxswains from Unit 61 (Pender Harbour). The training covered identification of hazards, man overboard, boat-based rescue, and general on-water safety. It also developed a sound working knowledge of the dynamics of swiftwater and water-related physiology.RCM-SAR training exercises are now subject to the following restrictions:

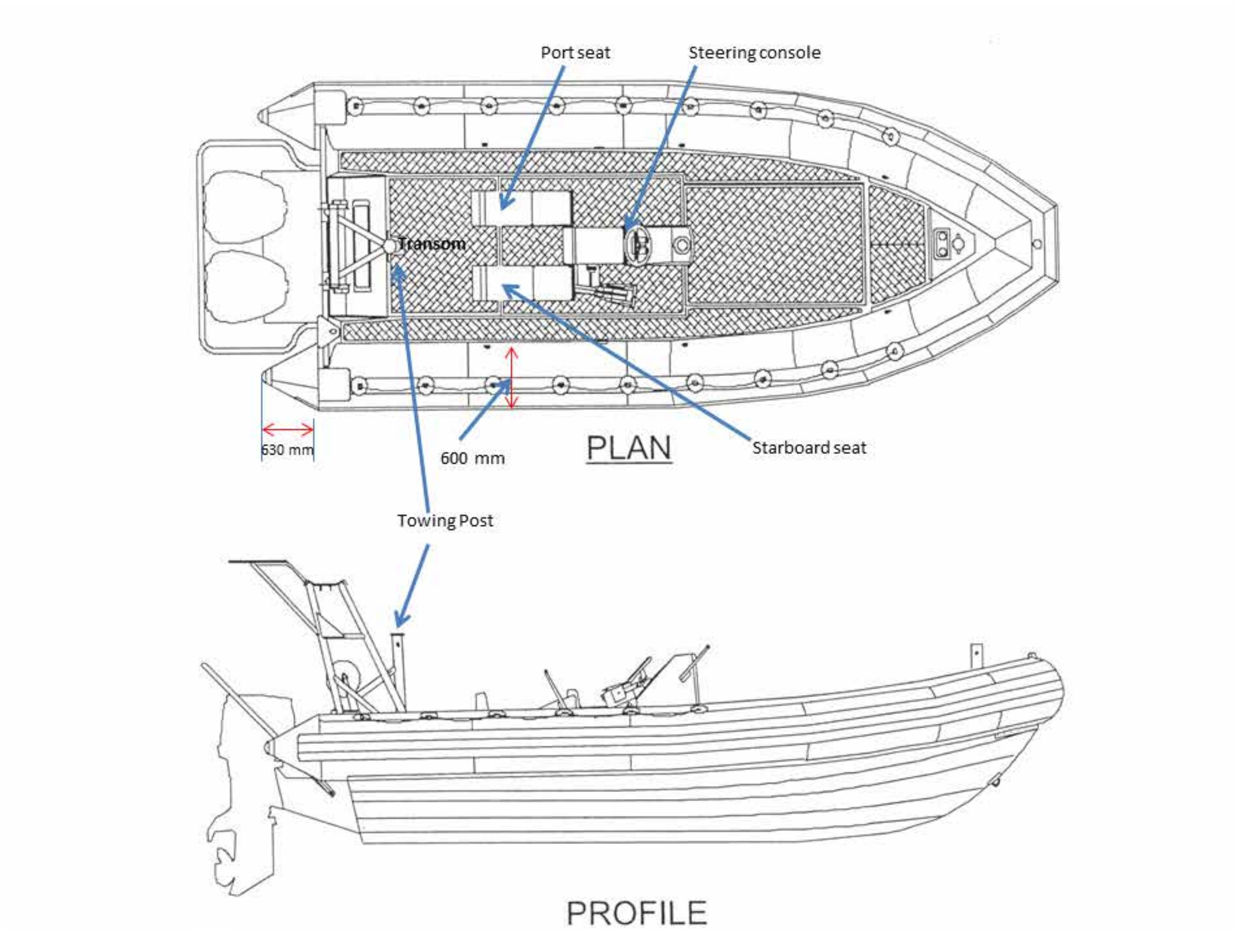
- Training to be conducted in safe passage routes as designated by RCM-SAR.
- Only certified Swiftwater Boat Operator Coxswains are authorized to be at the helm when transiting or training in the Skookumchuk Rapids.
- In order to operate in this area, all crew members onboard require the Swiftwater Motorized Boat Crew Training Course.
- Training is not authorized when currents exceed 10 knots during the ebb or flood tides
- A second RCM-SAR vessel with the appropriate Swiftwater training for all members onboard must be present for all training in the Skookumchuk Rapids.
- An exercise plan must be completed by both stations and approved by the station training officers before departure
- Station-keeping and vessel handling in the whirlpools are not permitted as this is a high-risk operation.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 17 July 2013. It was officially released on 14 August 2013.

Visit the Transportation Safety Board's website (www.bst-tsb.gc.ca) for information about the Transportation Safety Board and its products and services. You will also find the Watchlist, which identifies the transportation safety issues that pose the greatest risk to Canadians. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.

Appendices

Appendix A – General Arrangement of a Zodiac Hurricane 733



Zodiac Hurricane 733 plan and profile showing the location of the towing post.

Appendix B – Area of the Occurrence