Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

# MARINE INVESTIGATION REPORT M15P0286

## Capsizing and loss of life

Fishing vessel *Caledonian*
20 nm west of
Nootka Sound, British Columbia
05 September 2015

Canada

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Cat. No. TU3-7/15-0286E-PDF
ISBN 978-0-660-06844-2

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

*Le présent rapport est également disponible en français.*

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

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## *Summary*

On 05 September 2015, at approximately 1530 Pacific Daylight Time, the fishing vessel *Caledonian* capsized 20 nautical miles west of Nootka Sound, British Columbia. At the time, the vessel was trawling for hake with 4 crew members on board. Following the capsizing, the master and mate climbed onto the overturned hull and remained there for several hours. When the vessel eventually sank, the master and mate abandoned it, and the mate swam toward and boarded the life raft. The Canadian Coast Guard subsequently rescued the mate and recovered the bodies of the master and the 2 other crew members.


*Le présent rapport est également disponible en français*.

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# 1.0 Factual information

## 1.1 Particulars of the vessel

**Table 1. Particulars of the vessel**

| | |
|---|---|
| Name of vessel | *Caledonian* |
| International Maritime Organization number | 7366257 |
| Official/licence number | 348511/VRN 23277 |
| Port of registry | Vancouver, British Columbia |
| Flag | Canada |
| Type | Fishing, trawler |
| Gross tonnage | 259.92 |
| Length | 30.63 m |
| Built | 1974, Benson Brothers Shipbuilding Company (1960) Ltd. |
| Propulsion | Diesel engine (634 kW) driving a single variable-pitch propeller |
| Cargo | Approximately 244 tons[1] of hake[2] and seawater |
| Crew | 4 |
| Registered owner | Caledonian Holdings Inc., North Vancouver, British Columbia |

## 1.2 Description of the vessel

The *Caledonian* was a fishing vessel outfitted for trawling (Photo 1). It had a welded steel hull and a deckhouse located forward of amidships. The main deck comprised the forward superstructure, including the deckhouse, and the working deck. Below the main deck was the engine room (located forward), 6 fish holds (3 on each side), and 8 fuel tanks (4 on each side). There were also freshwater tanks located below the forward fish holds.

**Photo 1. *Caledonian* (Source: Eric Sorenson)**


At some point prior to 1998, the tank configuration was changed, and the fuel tanks in the engine room were converted to freshwater tanks. The 2 fuel tanks below the forward fish

1 In this report, "ton" refers to a short ton, which is equal to 2000 pounds.

2 Hake is the common name for Pacific whiting in British Columbia.

holds were no longer used, and the 2 fuel tanks below the centre fish holds were used to store fuel for the 2 fuel tanks at the stern, which were the only tanks used to supply the main engine with fuel (Appendix A).

The deckhouse contained the galley, accommodations for 8 people, the entrance to the engine room, and the stairs to the wheelhouse. The wheelhouse was equipped with navigation and communications equipment that included very high frequency/digital selective calling (VHF/DSC) radiotelephones, an automatic identification system (AIS),[3] and a watch alarm.[4]

A trawlway located on the centreline spanned the length of the working deck. It provided access to each of the 6 fish holds, which were designed to carry a mixture of fish and refrigerated seawater. There were 2 net drums[5] at the stern and 2 sets of trawl doors. Two trawl winches were also mounted on the middle deck (Photo 2).

In 2012, the vessel had been surveyed by an independent marine surveyor to ascertain the overall condition of the hull, bilges, and machinery, and the deck and fishing gear. The vessel was reported to be in good condition.

The vessel had been regularly serviced in 2013 and 2014. Regular maintenance consisted of cleaning and painting the hull, and servicing the rudder stock, steering gear, variable-pitch propeller system, tail shaft, and through-hull fittings.

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3 An automatic identification system (AIS) provides the identity, type, position, course, speed, navigational status, and range of other vessels that are also fitted with AIS. Canadian regulations require AIS on some vessels, but fishing vessels are exempt.

4 A watch alarm can be configured to sound at various intervals, requiring crew members to acknowledge the alarm. It is intended to ensure that crew members are awake during the watch.

5 The vessel was originally equipped with only 1 net drum. At some point before 1998, the original net drum was raised and a second net drum and trawl were added.

**Photo 2. Working deck of the *Caledonian*, looking aft**


Legend

1. trawl door
2. trawl on net drum
3. spare trawl on net drum
4. spare trawl door
5. starboard aft tank
6. trawlway
7. centre port deck hatch
8. centre starboard tank

## *1.3 History of the voyage*

On 27 August 2015, after the *Caledonian* had returned to Port Hardy, British Columbia, following a groundfish fishing trip, the crew began preparing the vessel to switch fisheries from groundfish to hake. They topped up the fuel and water tanks to the predetermined levels and the regular master[6] gave a brief handover to the engineer, who was taking over as master. The handover briefing focused on loading practices for hake. The master described the vessel's departure condition, explaining that the 2 forward fish holds and the 2 aft fish holds were to be filled with seawater and that 2 tons of ice (no seawater) were to be stowed

6 The regular master had been partial owner and master of the *Caledonian* since 1998.

in each centre hold. The master then explained that the loading sequence was to equally fill the 2 forward holds, then the 2 aft holds, and finally the 2 centre holds with fish. The centre holds were to be half full of seawater prior to adding the hake.

The regular master and one of the deckhands then left the vessel and the other deckhand, who had been on the groundfish fishing trip, took over as the vessel's engineer. On 31 August, the mate joined the vessel and became familiarized with the location of the safety equipment on board. While waiting for another crew member,[7] who joined the vessel on 02 September, the crew loaded 34 tons of ice, distributing it among the 6 fish holds. The forward and aft fish holds were topped up with seawater, and the centre fish holds contained only ice.

On 02 September, before the vessel departed for the fishing grounds, the crew set and retrieved the trawl once for practice. At this time, the mate donned a personal flotation device (PFD), and continued to wear it for the duration of the trip. At 1700,[8] the vessel departed for the overnight voyage. The mate stood a solo watch for a few hours in the evening.

On 03 September, at 0844, the vessel had reached the fishing grounds and the master reported to Marine Communications and Traffic Services (MCTS) Prince Rupert, British Columbia, on VHF channel 74 that the *Caledonian* was about to commence fishing operations. MCTS advised the master that it would check the vessel out of the system, that channel 74 should be monitored, and the vessel should be checked back into the system when returning to port.[9] The crew made several tows between 0900 and 2200, catching approximately 80 tons of hake, enough to fill the 2 forward holds. By 0030 on 04 September, the crew had finished stowing the catch and performing clean-up duties. After a few hours of sleep, the mate took over the watch from the deckhand at 0300 and remained on watch for the rest of the night.

On 04 September, at approximately 0900, the crew resumed fishing operations and made several more tows. By 2100, the 2 aft fish holds had been filled. At 2300, with approximately 190 tons of hake and seawater on board, the *Caledonian* began proceeding toward Ucluelet, British Columbia, to unload its catch. The deckhand was on watch, and the master, mate, and engineer went to rest.

At 0300 on 05 September, the mate relieved the deckhand and stood watch for about 3 hours, and then handed the watch over to the master. At 0700, the mate woke up and prepared breakfast for the crew.

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7 Over the past 2 years, there was a turnover of 16 crew members on the *Caledonian*. All were new to the *Caledonian*.

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

9 Fishing vessels over 24 metres are required to participate in Vessel Traffic Services (VTS). Participation means that vessels are required to "check in" upon departure and update their progress as the voyage continues. Fishing vessels usually check out of the system once fishing operations begin.

At 1100, the master called the company production manager to check whether they had sufficient time to continue fishing in order to fill the 2 centre holds.[10] After receiving confirmation, the crew set the trawl near Nootka Sound at 1230.

At approximately 1400, the crew prepared to haul in the trawl. This involved adding seawater to the ice in the 2 centre holds so that they were filled halfway. At this time, the vessel had a slight port list.

Once the trawl doors were secured using chains, which allowed them to hang lower than normal,[11] the first bag of hake was brought on board. At this time, the master left the wheelhouse unattended to help bring the hake on board and went to the middle deck to operate the controls for the boom winch. The crew removed the deck hatch cover for the centre port hold and stowed the first bag of hake, an estimated 15 tons, which raised the water level to the top of the hold. The vessel's port list increased at this time, and seawater began to ship on deck through the freeing ports. The master then returned to the wheelhouse as the 3 crew members prepared to bring the second bag of hake on board.

At approximately 1520, the master returned to the middle deck to help bring the remaining hake (estimated 24 tons) in the trawl on board. The bag was pulled up the trawlway and was partially suspended from the boom. The deck hatch cover for the centre port hold had remained off after the initial bag had been stowed. The vessel was now trimmed by the stern and listed further to port, causing additional seawater to ship onto the deck, submerging nearly half of the trawl door. Seawater was also able to enter the centre port hold through the open deck hatch.

The deckhand attempted to put the deck hatch cover back on the centre port hold. The mate ran forward along the port side of the working deck and closed a watertight door on the back of the deckhouse. The port side bulwarks were now nearly submerged and the deck was covered by approximately half a metre of water. The mate, on the way to the middle deck, passed the engineer who had fallen into the water on deck. The master increased the vessel's speed from 4.1 knots to 7.5 knots and altered the vessel's course to starboard. Soon after, the master left the wheelhouse as it became evident that the vessel was capsizing.

MCTS Prince Rupert received the last AIS signal from the *Caledonian* at 1525, and it is presumed that the vessel capsized near 49°26.90' N, 127°17.28' W, 20 nautical miles (nm) west of Nootka Sound (Appendix B). After the capsizing, the master stayed with the vessel and climbed onto the overturned hull. Shortly after the capsizing, the master saw the engineer in the water and called out, but there was no response. Nearly an hour later, the mate, who was

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10 Financial benefits are based on the amount of catch landed per trip and its quality. In order to stay within quality guidelines, the catch must be delivered within a specified time frame of having been caught.

11 Normally the trawl doors are held in place by the hydraulic system. On this day, there was a leak in the hydraulic system and so chains were used to hold the doors in place.

wearing a PFD when the vessel capsized, managed to swim back to the overturned hull to join the master.

A couple of hours later, the master and mate sighted the deckhand in the water as well; they called out but received no response. The mate and the master managed to remain on the overturned hull for several hours while the vessel slowly sank by the bow.

At 2146, the company reported to MCTS that it had been unable to contact the *Caledonian* since 1100. This information was passed along to the Joint Rescue Coordination Centre (JRCC) in Victoria, British Columbia. At 2158, MCTS sent an emergency broadcast requesting additional information.

At approximately 2200, the vessel sank rapidly by the bow. The mate and the master jumped into the water. The master clung to the mate's PFD, but it was unable to keep both of them afloat so the master let go of the mate. At this point, the mate and master drifted apart, and the mate lost sight of the master. The mate noticed a light approximately 20 metres away and began swimming toward this light, which turned out to be the canopy light on the *Caledonian*'s life raft.

At approximately 2245, the mate reached the life raft, which had partially filled with water, and managed to climb inside. There was no light in the life raft, but the mate found a paddle that was used to bail out the life raft. The life raft also contained an emergency position indicating radio beacon (EPIRB) and emergency equipment, including rocket parachute signals and hand flares.

Following the MCTS emergency broadcast, the Canadian Coast Guard (CCG) deployed a fast rescue craft from the Nootka Inshore Rescue Boat Station at 2300. A search and rescue (SAR) aircraft also departed from Comox, British Columbia, at 0031 on 06 September to search in the area of the *Caledonian*'s last known position.

At 0110, the mate attempted to activate the EPIRB, but it did not work. Shortly after that the mate heard an aircraft and attempted to activate 2 rocket parachute signals and 2 smoke canisters, which did not work. Finally a rocket parachute signal was successfully launched. The signal was observed by SAR resources and several vessels in the area. The CCG's fast rescue craft recovered the mate from the life raft, which was drifting approximately 3 nm southwest of the location where the *Caledonian* is presumed to have capsized. The mate was then transferred to a cruise ship that was assisting in the search.

Later that day, the SAR resources recovered the bodies of the 3 remaining *Caledonian* crew members. The cause of death for the master was drowning, and the engineer and the deckhand both sustained fatal injuries. The vessel could not be located and is presumed to have sunk.

## *1.4 Vessel certification*

As a fishing vessel over 24.4 metres and 150 gross tonnage, the *Caledonian* was subject to the *Large Fishing Vessel Inspection Regulations* (LFVIR). The vessel underwent its annual

inspection by Transport Canada (TC) on 08 January 2015 and was issued an Inspection Certificate and a Minimum Safe Manning Document as required by the *Marine Personnel Regulations*,[12] which specified a minimum complement of 4 and indicated that a two-person watch was required.

## 1.5 Personnel certification, experience, and training

The master on the *Caledonian* held a Fishing Master, Third Class certificate and had 42 years of fishing experience. The master had served as relief master on several large and small fishing vessels over the last 15 years. The master had fished for hake sporadically over the past 3 years on other vessels belonging to the owner of the *Caledonian*. This was the master's first trip as relief master on the *Caledonian*; before the occurrence voyage, the master had served as an engineer on the *Caledonian* for 41 consecutive days. The master also held a Radio Operator's Certificate – Maritime Commercial and had taken Marine Emergency Duties (MED) training. The master had participated in Fish Safe's[13] Stability Education Program in April 2006.

The engineer held a Small Vessel Operator Proficiency certificate issued in March 2014 and had 20 years of intermittent fishing experience. The engineer had spent the last 4 years working full time on fishing vessels and had served as a deckhand on the *Caledonian* for the last 41 consecutive days, along with the relief master. This was the engineer's first trip as engineer on the *Caledonian*. The engineer also held an MED A2 certificate and a Radio Operator's Certificate – Maritime Commercial, both of which were issued in 2014.

The mate held a 500 Ton Master, Near Coastal certificate and mostly had experience working on tugs and sport fishing charter vessels. The mate had approximately 6 days of fishing experience in 2004. The mate had participated in Fish Safe's Stability Education Program in 2008.

The deckhand on the *Caledonian* had over 25 years of fishing experience, mostly in hake fishing. This was the deckhand's first fishing trip in approximately 3 years.

## 1.6 Environmental conditions

At the time of the occurrence, the skies were clear, the winds were light from the northwest at 15 knots, and there was a moderate one-metre southwest swell. The air temperature was 12 °C, and the sea temperature was 15 °C.

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12 *Marine Personnel Regulations* (SOR/2007-115), paragraph 202(3)(*b*).

13 Fish Safe is an industry-designed and -implemented fishing safety organization. Its mandate is to provide safety programs and tools relevant to fishing so that fishermen can take ownership of safety. Participation in programs is voluntary.

## *1.7* Caledonian *safety information manual*

The WorkSafeBC[14] *Occupational Health and Safety* (OHS) *Regulations* require vessel owners to provide written instructions for use in familiarizing crew members with their workplace. These instructions must address general safety as well as safe working practices associated with the tasks to be performed on board.[15] As well, the master is required to establish emergency procedures and assign crew members responsibilities when responding to various emergency situations. The master must also ensure that drills are conducted at the start of each fishing season as well as at periodic intervals to ensure that crew members are familiar with the emergency procedures.[16]

The *Marine Personnel Regulations* require the authorized representative (AR) of a vessel to provide the master with written instructions that, at a minimum, determine the procedures and the policies to be followed to ensure that each member of the crew, before being assigned any duty on board a vessel, becomes familiar with the shipboard equipment and operational instructions specific to the vessel and their assigned duties on board the vessel. It must also be ensured that the crew members can effectively perform their assigned safety-critical duties on board the vessel.[17]

The *Canada Shipping Act, 2001* has similar requirements whereby the vessel's AR must develop procedures for the safe operation of the vessel.[18]

When the current owners purchased the *Caledonian* in 2012,[19] the vessel had a safety information manual on board. The manual had been compiled in 2009 and included sections on maintaining vessel stability, vessel operations, engine room instructions, safety procedures, crew responsibilities, and maintenance checklists. WorkSafeBC prevention officers reviewed the manual in May 2010 and found it to have met the intent of the regulations at the time and to be compliant with them.

The safety procedures section of the manual indicated the location of all lifesaving appliances and specified that drills were required to be conducted at the beginning of each season and periodically during the season, or when there was a change of crew. The sample muster list stated that the master's duties in an abandon vessel situation were to send a Mayday, don an immersion suit, and operate the vessel. The AR had no records of

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14 In British Columbia, WorkSafeBC is the provincial government organization that is responsible for the promotion of workplace health and safety, including the implementation and enforcement of regulations, policies, and guidelines regarding fishing safety.

15 WorkSafeBC, *Occupational Health and Safety Regulations*, part 24, section 24.73.

16 Ibid., part 24, section 24.74.

17 *Marine Personnel Regulations*, part 2, division 2, section 206.

18 *Canada Shipping Act, 2001*, paragraph 106(1)(*b*).

19 The current owners of the *Caledonian* also own several other fishing vessels operating on the coast of British Columbia. In recent years, the British Columbia fishing industry has experienced an increase in vessel ownership by large corporations that purchase vessels from private owners/operators.

emergency drills being conducted by the regular master, and no drills were practised on the occurrence voyage.

## *1.8 Lifesaving appliances*

The *Caledonian* was equipped with the required lifesaving appliances, including:

- standard lifejackets;[20]
- immersion suits;
- a life raft with a hydrostatic release unit;[21] and
- an EPIRB fitted with a hydrostatic release unit.

Additionally, the *Caledonian* carried PFDs,[22] as well as an EPIRB that was stowed in the life raft. The EPIRB was unregistered[23] and not required by regulation. The Transportation Safety Board of Canada (TSB) Laboratory examined the EPIRB recovered from the life raft and determined that its housing was cracked by an external force, the inside circuitry was corroded, and the batteries had slowly and fully discharged. The condition of the EPIRB likely developed slowly over time, and it is likely that the EPIRB was not able to function before the capsizing.

### *1.8.1 Personal flotation devices*

The use of PFDs at all times was not required on the *Caledonian* by the company or any regulator. The *Caledonian*'s safety information manual stated that PFDs must be worn "when required," and the owner/crew employment agreement did not address the subject. In this occurrence, a sufficient number of PFDs were on board, but the mate was the only one who wore a PFD while on the working deck. No other lifesaving appliances were used or deployed before the capsizing.

With regard to large and small fishing vessels, TC's minimum requirement for personal flotation is the carriage of standard lifejackets. In July 2016, TC published regulations that will create the *Fishing Vessel Safety Regulations* (FVSR). These regulations will apply to small fishing vessels up to 24.4 metres in length and not more than 150 gross tonnage. These regulations state that

> No person shall operate, or permit another person to operate, a fishing vessel in environmental conditions or circumstances that could jeopardize the safety

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20 Standard lifejackets are intended for use in emergency situations such as abandoning the vessel and will turn individuals on their back in order to keep their face out of the water.

21 A hydrostatic release unit is designed to automatically activate with water pressure (when submerged within 4 metres of water) and release the lifesaving appliance so that it floats free.

22 Personal flotation devices are designed for constant wear and have limited turning capability.

23 A registered emergency position indicating radio beacon provides search and rescue resources with access to the owner's contact information so that the validity of an emergency transmission can be verified.

> of persons on board unless a lifejacket required by this Part, or a personal flotation device that meets the requirements of section 3.2 is worn
>
> (a) by all persons on board, in the case of a fishing vessel that has no deck or deck structure; or
>
> (b) by all persons on the deck or in the cockpit, in the case of a fishing vessel that has a deck or deck structure.[24]

WorkSafeBC has *Occupational Health and Safety Regulations* that apply to workplaces including large and small fishing vessels and require a PFD or a lifejacket to be worn by "a worker who is employed under conditions which involve a risk of drowning."[25] In June 2014, following an occurrence on the small fishing vessel *Diane Louise* where a crew member who was not wearing a PFD lost his life after going overboard, the TSB issued Marine Safety Information Letter 04/14. This letter was addressed to WorkSafeBC and advised that the crew on board were not wearing PFDs while working on deck, nor were there any on board available for use. The letter also noted that the Workers' Compensation Board *Occupational Health and Safety Regulations* regarding PFD use currently place the onus on vessel masters to determine whether they or their crew members are at risk of drowning if not wearing a PFD.

WorkSafeBC responded by stating that its focus has been on cold water immersion and PFD use for several years. This focus includes, in part, inspecting commercial fishing vessels for PFD use. Non-compliance orders are issued in cases where workers are observed not wearing a lifejacket or PFDs where a risk of drowning exists. In 2014, WorkSafeBC officers spent 70 days at sea conducting vessel inspections and issued 451 inspection reports. WorkSafeBC also began a review of the risk-based regulation for workers to wear a lifejacket or PFD, and consideration is being given to a more prescriptive requirement.

The TSB's *Safety Issues Investigation into Fishing Safety in Canada* (SII),[26] conducted in 2012, showed that many fishermen still resist wearing a PFD, which is a widespread challenge in the fishing community. In many cases, fishermen have accepted the known risk of falling overboard while not wearing a PFD. Research on changing work practices has shown that, in part because of the contextual factors of the physical and economic environments in which they are practiced, unsafe work practices can be difficult and slow to change.[27] Crews may routinely work without experiencing accidents, which reinforces any unsafe work practices that are relied on regularly.[28]

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24 *Regulations Amending the Small Fishing Vessel Inspection Regulations*, section 3.09, in the *Canada Gazette*, Part II, Vol. 150, No. 14 (13 July 2016), available at: http://www.gazette.gc.ca/rp-pr/p2/2016/2016-07-13/pdf/g2-15014.pdf (Last accessed 24 November 2016).

25 WorkSafeBC, *Occupational Health and Safety Regulations*, part 8, section 8.26(1). These provisions are not specific to fishing but are applied to the fishing industry.

26 Transportation Safety Board of Canada, Report M09Z0001, *Safety Issues Investigation into Fishing Safety in Canada*.

27 D.M. Dejoy, "Behaviour change versus culture change: Divergent approaches to managing workplace safety." *Safety Science*, Volume 43, 2005, p. 108.

28 S. Dekker, *Drift Into Failure: From Hunting Broken Components to Understanding Complex Systems*, CRC Press, 2011, p. 14.

There are several education and awareness programs and initiatives within the fishing community that attempt to change behaviours and promote the use of PFDs. In British Columbia, Fish Safe's "Real Fishermen" campaign uses promotional materials that feature fishermen wearing PFDs. In Nova Scotia, a fishing safety working group,[29] in consultation with fishermen and suppliers, uses initiatives such as wharf visits, family pledges, an elementary school poster contest, advertising, and design testing to increase awareness of the importance of wearing PFDs. As well, in Nova Scotia, the Safe at Sea Alliance has developed a plan for the province's fishing industry through the collaboration of industry and government representatives. The plan includes several recommendations to improve safety through education, awareness, and enforcement. One such recommendation is the development of an enhanced program that includes safety drills and demonstrates PFDs in action.

### *1.8.2 Life raft and emergency position indicating radio beacon fitted with hydrostatic release units*

Both the life raft and EPIRB on the *Caledonian* were fitted with hydrostatic release units. The 8-person life raft was stowed in a cradle on the port side of the middle deck, and the EPIRB was stowed on the starboard side on the back of the wheelhouse cabin.[30] The investigation determined that, while the vessel was overturned, there would have been sufficient water pressure for the hydrostatic release unit on both the life raft and the EPIRB to activate. In this occurrence, however, the life raft did not deploy immediately after the capsizing and was not accessible to the crew until approximately 6 hours later when the vessel's aspect changed as it began to sink by the bow. The vessel's EPIRB was never located and no signal was received.

The ability of life rafts to float free in an emergency has been an issue in several previous occurrences involving fishing vessels, resulting in the TSB issuing 3 separate recommendations.[31] In response to these recommendations, TC initiated research, discussed relevant aspects with the marine industry at Canadian Marine Advisory Council meetings, and published several Ship Safety Bulletins (SSB) on the subject. In 2005, the Board issued the following Safety Concern:

> The Board is concerned that, until such time that regulations are put in place and fishing vessel life rafts are positioned optimally and arranged to float free in the event of the vessel sinking, crew members continue to be at risk in such circumstances.

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29 The group consists of representatives from the Nova Scotia Fisheries Sector Council, the Fisheries Safety Association of Nova Scotia, the Nova Scotia Department of Labour and Advanced Education, and the Workers' Compensation Board of Nova Scotia.

30 The 2015 Transport Canada inspection report indicated that the emergency position indicating radio beacon battery was going to expire in 2017 and the hydrostatic release unit was due to expire in 2016. The life raft was last inspected in December 2014.

31 TSB marine safety recommendations M93-03, M00-07, and M00-08.

The provisions requiring float-free life rafts were proposed to be adopted in the FVSR, which were expected to be finalized in 2008. In the interim, TC issued another SSB that applied to both small and large fishing vessels and stated that, to ensure that the units automatically float free, life rafts should be stowed in an optimum position. This means placing the life raft in an area of the vessel where rigging, cables, structure and gear will not impede the manual launch or the float-free capability of the life rafts in the event of an emergency.[32]

On 13 July 2016, parts of the FVSR were published in the *Canada Gazette,* Part II. The parts published require fishing vessels greater than 12 metres to carry a life raft which is stored in a manner that allows it to automatically float free if the vessel sinks.

The United Kingdom Maritime and Coastguard Agency also conducted a study in 2004 on the location and stowage of life rafts and EPIRBs on fishing vessels and found that the success of deployment varied depending on fishing vessel design and operation and how a vessel sinks or capsizes.[33]

To address the challenges of finding an optimum stowage position that allows for both manual and automatic activation of the required float-free lifesaving appliances, some operators have installed additional float-free life rafts and EPIRBs beyond those required by TC.

## *1.9 Vessel communications*

It was the practice for company personnel to communicate with the masters via telephone several times a day, although not on a predetermined schedule, as well as for masters to communicate with each other directly. Company personnel also monitored the vessels using a website that plots the vessels' AIS signals.

In this occurrence, company personnel had been periodically checking the *Caledonian*'s position on the website. The vessel's position was not visible on the website on the afternoon of the occurrence, but this was not unusual for that particular area. When the signal did not reappear at the time it was expected to, company personnel initiated a search for the vessel. Company personnel also made several attempts to contact the vessel by phone and contacted other company-owned vessels requesting information about the whereabouts of the *Caledonian*, but without success. Company personnel then contacted MCTS to report the lack of communications with the *Caledonian*.

### *1.9.1 Marine Communication and Traffic Services*

Vessel Traffic Services (VTS) is one of the services that CCG MCTS centres provide to vessels operating in Canadian waters. Vessels that participate in VTS are tracked by MCTS when

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32 Transport Canada, Ship Safety Bulletin 07/2007, *Inflatable Life Rafts and Rescue Platforms - Stowage and Proper Access*.

33 Maritime and Coastguard Agency, Marine Guidance Note 267, *The Location and Stowage of Liferafts and Emergency Positioning Radio Beacons (EPIRBs) on UK Registered Fishing Vessels*.

operating within 12 nm from shore using a combination of radar and/or AIS where available. If MCTS loses the signal of a vessel that was previously being tracked by AIS, MCTS officers will attempt to establish communication with the vessel using all available means. If the vessel's signal has been lost for more than 15 minutes and attempts to contact the vessel fail, the situation is reported to the JRCC.

While it is not the responsibility of MCTS officers to regulate or monitor the movements of vessels situated outside of VTS zones, they are expected to take appropriate action should they become aware of a dangerous situation while monitoring the movements of vessels.

Before 11 July 2014, MCTS provided and encouraged vessels to participate in the Voluntary Western Canada Offshore – Marine Safety Advisory Service. Under this voluntary service, participating vessels travelling between 12 and 50 nm offshore would be monitored by MCTS. However, on 11 July 2014, CCG issued an MCTS operations directive cancelling this service because participating vessels and MCTS could now acquire AIS data and were no longer reliant on information derived from VTS offshore reports. Vessels beyond the 12 nm limit calling Prince Rupert or Tofino Traffic to report passing calling-in-points were advised that this service had been discontinued.

## *1.10 Regulations, standards and guidelines for stability*

### *1.10.1* Large Fishing Vessel Inspection Regulations

The LFVIR, which applied to the *Caledonian*, address various safety issues, including vessel stability.

The LFVIR require that vessels be subjected to an inclining experiment to determine their lightship weight[34] and centre of gravity; stability must also be calculated for different operating conditions: lightship weight, port departure, arrival at fishing grounds, half load, full load, and worst operating conditions. Additionally, the regulations require that a booklet be placed on board the vessel, providing information to the master regarding the stability characteristics of the vessel and "… containing appropriate information relative to loading in the various conditions specified" by the regulations.[35]

The LFVIR require vessel stability to be examined separately for each species of fish carried, if those species have different stowage characteristics. Also, if the vessel uses the deck space to stow fish, an appropriate allowance must be made in the calculations. Other than these 2 factors, the regulations do not include any details regarding the specific assumptions that are to be made with respect to the weight distribution of fuel, water, and fish, or how the fish are brought on board. The typical practice is to calculate stability assuming that the catch has been loaded and stowed and the vessel is ready for voyaging.

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34 For the purposes of this report, lightship weight is defined as the condition of a vessel ready for fishing operations but with no stores, consumables (fuel/water), cargo, or crew on board.

35 *Large Fishing Vessel Inspection Regulations*, subsection 9(9).

Finally, the LFVIR require that, when a vessel is modified in a manner that affects its stability, the stability information must be modified accordingly.

### *1.10.2* Stability, Subdivision, and Load Line Standards

TC published the *Stability, Subdivision and Load Line Standards* (TP 7301) in 1975 to provide guidance and criteria (Appendix C) for the approval of stability information required by the LFVIR.

When it comes to the weight distributions that are assumed for stability calculations, the only guidance the standard provides is that it is the responsibility of the owner to ensure that the stability conditions presented in the stability booklet accurately reflect the vessel's loading conditions and modes of operation.[36]

According to the standards, the owner and master of a vessel are responsible for ensuring that a proper measure of stability is maintained for all loading conditions.[37] The standards require a copy of the approved stability booklet to be carried on board and state that it should contain sufficient information to enable the master to assess any new load conditions in addition to those presented in the booklet.[38]

The preferred presentation for stability data is also described in the standards, which includes examples of tank capacity tables, a calculation of free surface effect, the use of cross curves, and a typical condition sheet with associated stability curve. The typical condition sheet and stability curve are shown in Appendix D.

### *1.10.3 Ship Safety Bulletin 01/2008*

In 2008, TC issued an SSB entitled *Fishing Vessel Safety - Record of Modifications*.[39] This SSB provides guidelines and information to fishing vessel owners regarding the potential negative effects that modifications can have on vessel stability and how to keep track of such modifications.

The bulletin includes a form entitled Fishing Vessel Modification History that is intended to be used to keep track of vessel modifications and to record changes in operations on an ongoing basis. It is suggested that the form be kept available for review and discussion during TC inspections. The form gives examples of the types of changes to be recorded, including:

- additions or changes to lifting equipment and fishing gear;
- changes in the fishing method, the type of fish caught, or the way the catch is stowed; and

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36 Transport Canada, TP 7301, *Stability, Subdivision, and Load Line Standards*, first issued January 1975, STAB 1, section 3 (iv).

37 Ibid., STAB 1, section 3 (xvii).

38 Ibid., STAB 1, Appendix A, section 2.

39 Transport Canada, Ship Safety Bulletin 01/2008, *Fishing Vessel Safety - Record of Modifications*.

- modifications to the vessel structure, equipment, or gear that add, delete, or result in relocation of more than 100 kg in weight.

The bulletin also offers advice on when to re-evaluate the vessel's stability, suggesting that it be done when the total weight of all modifications exceeds 2% of the vessel's total weight.

Finally, the bulletin provides guidance on minimizing the risk of a stability-related accident by addressing issues such as abnormal operating conditions, and loading and storing catch and gear. Some examples of guidance included on the bulletin include the following:

- establish normal limits for trim
- implement procedures for finding the cause of any abnormal trim or list
- establish procedures for loading catch that follow instructions in the vessel's stability booklet.

### *1.10.4 WorkSafeBC stability requirements, policies and guidelines*

With respect to vessel stability, WorkSafeBC OHS regulations require that

- all fishing vessels be maintained in seaworthy condition,[40] and
- the owner of a fishing vessel provide documentation on board that describes vessel stability.[41]

The policies and guidelines corresponding to these regulations[42,43] clarify that, when determining seaworthiness, a number of factors must be considered, including the stability of the vessel. The policies and guidelines also offer further explanatory information and guidance such as:

- Owners and masters are advised to refer to the regulations, policies, and best practices established by TC and have their vessel's stability assessed by a naval architect.
- Vessel stability characteristics will change over the life of the vessel and the accumulation of weight over the life of the vessel will likely cause a vessel to get heavier and its centre of gravity to rise, decreasing its stability.
- A common method of evaluating freeboard that is pertinent for vessels of open construction is the use of a load mark.
- Stability documentation must provide meaningful and detailed information on vessel characteristics and include instructions on how to perform vessel operations without impairing its stability.
- On-board documentation should contain information relative to loading under each of the conditions in the stability booklet.

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40 WorkSafeBC, *Occupational Health and Safety Regulations*, part 24, subsection 24.70(a).

41 Ibid., subsection 24.72(b).

42 WorkSafeBC, Prevention Policy R24.70-1 and R24.72-1.

43 WorkSafeBC, Guideline G24.70 and G24.72.

- Owners should consider including a load chart, load matrix, loading condition sheet, electronic loading software or other similar instruction as part of the on-board documentation.
- On-board documentation must accurately reflect the vessel's typical loading condition and operations.
- The documentation should clearly state that it is unsafe for the vessel to sail if it is loaded outside of its stability limitations.
- The documentation describing the stability characteristics of the vessel must be presented in a format that is readily understandable by the end user.

According to the guidelines, when WorkSafeBC conducts inspections and investigations, it will evaluate whether the vessel has been provided with meaningful and clear stability documentation. WorkSafeBC will also confirm that the information in the manual describes the vessel's current operating condition and contains the elements outlined in the guidelines. However, WorkSafeBC does not have an official approval process for on-board stability documentation.

### *1.10.5* Code of Safety for Fishermen and Fishing Vessels, 2005

The *Code of Safety for Fishermen and Fishing Vessels* is a voluntary set of standards that addresses fishing vessel operational and occupational safety as well as design, construction, and equipment. It was developed jointly by the International Labour Organization, the Food and Agriculture Organization and the International Maritime Organization, and was most recently updated in 2005.

One chapter of the Code[44] is dedicated to addressing stability and associated seaworthiness, providing criteria and guidance for fishing vessels 24 metres and more. The Code recommends that certain specific operating load conditions be assumed for the stability assessment; these conditions are similar to those required by the LFVIR. The Code also recommends ensuring that the stability criteria are met for all other actual operating conditions.

The Code suggests that stability information be available to enable the master to assess the vessel's stability under various operating conditions and that it include warning instructions for operating conditions which could adversely affect the vessel's trim or stability. Additionally, the Code recommends that a maximum permissible operating draft be determined and marked on each side of the vessel's hull.

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44 International Maritime Organization, *Code of Safety for Fishermen and Fishing Vessels*, 2005, part B, chapter 3. The code was initially adopted in 1968.

## *1.11* Caledonian *stability documentation*

### *1.11.1 Safety information manual*

The *Caledonian*'s safety information manual provided procedures for operations such as fish loading and storage, and loading and consuming fuel, as well as information on freeboard and trim.

Procedures for loading and consuming fuel included

- Only the 4 aft-most fuel tanks are used and fuel must be transferred to the stern tanks, as they are the only tanks supplying fuel to the main engine.

Procedures for fish loading and stowage included

- The centre fish holds are slack [partially full] only when weather is good and fish is being loaded into them at the same time.
- The forward fish holds are topped up with seawater on the way to the fishing grounds. These 2 holds are then completely filled with fish, first one side and then the other.
- If the 2 centre holds are needed, they are filled two-thirds full of water while the loading of the forward holds is being completed. Then, the centre holds are fully filled.

The procedures do not mention loading of the 2 aft fish holds.

Information regarding vessel freeboard and trim included

- When the vessel leaves port and when only the forward fish holds are loaded, the vessel has level trim, and when the centre holds are filled, the trim is 4 to 6 inches by the stern.
- When loaded, the minimum freeboard is approximately 20 inches to the rub guard at the stern, which is approximately at the main deck level and approximately 12 inches at midships.
- When loaded, water enters the vessel through the middle freeing ports[45] in the bulwark and exits through the aft ones.
- If at any time water accumulates on the aft deck and is not clearing off, the crew is to notify the master.

### *1.11.2 Stability booklet*

In 1976, the *Caledonian* had been subjected to an inclining experiment to determine the vessel's lightship weight and centre of gravity. Based on this information, a stability booklet

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[45] A freeing port is an opening in the bulwark intended to allow water shipped on deck to drain overboard. They are also referred to as "scuppers" in the vessel's safety information manual.

was developed and approved by TC. The booklet examined all of the required operating conditions, including the following:

- **Half load condition**: the 4 forward-most fuel tanks are empty, the next 2 fuel tanks are at 50% full, and the aft-most fuel tanks are at 75% full. Both fresh water tanks are assumed to be 50% full. The forward fish holds are 66% full and the centre holds 100% full; the aft holds are empty.
- **Full load condition**: the 2 forward-most fuel tanks are empty, the next 2 are at 20% full, the next 2 are at 98% full, and the aft-most tanks are empty. Both fresh water tanks are 35% full and all fish holds are 100% full.

Appendix E provides excerpts from the *Caledonian's* stability booklet and includes a sketch illustrating the location of the vessel's draft marks and the stability calculation results for the full load condition. This illustrates the format in which the stability booklet presents the results for each of the load conditions. Other information in the booklet includes

- a report of the inclining experiment;
- a sketch of the tank/fish hold configuration; and
- full load volume, weight, and centre of gravity for each tank and fish hold.

The first page of the booklet includes the following statement, signed by the naval architect:

> The statements and diagrams applicable to the operating conditions presented in the trim and stability booklet dated July 14, 1976 are based upon the vessel's worst foreseeable service conditions with regard to the weights and disposition of all relevant items having an effect upon the vessel's stability.

When the booklet was approved by TC, the cover was stamped with the following statement: "Subject to the accuracy of the basic data being the responsibility of the owner, his naval architect or the shipbuilder."

In 2012, the voluntary Fishing Vessel Modification History form was completed for the *Caledonian* indicating that there were no modifications to the vessel.

## *1.12 TSB stability assessment*

Using vessel drawings, photos, technical data and information gathered during the investigation, the TSB assessed the stability of the *Caledonian* at the time of the occurrence in order to identify factors that were influencing its stability. Some of the forces affecting the *Caledonian's* stability were estimated, such as lightship weight, weight on board, weight suspended from the boom, and water on deck. Other specific forces were also acting on the vessel at the time of the occurrence such as the drag of the trawl door or the starboard course alteration. The extent to which the latter affected the vessel's stability could not be determined.

### *1.12.1 Estimate of lightship weight*

Considering that the vessel had been in service for almost 40 years, it was necessary to estimate the lightship weight and centre of gravity of the vessel at the time of the occurrence

and compare it to the lightship weight that had been determined by the 1976 inclining experiment. Using Photo 3 below, the draft of the vessel, its total weight, and an estimated lightship weight were determined. The lightship weight of the vessel in April 2015 was estimated to be 327 tons, which represents an increase of over 18% compared to the lightship weight in 1976, which was 276 tons.

**Photo 3. *Caledonian* moored in Port Hardy, April 2015**

Based on this increased lightship weight, the stability of the vessel was calculated assuming the same loads for fuel, fresh water, and fish that were used in the stability booklet for the full load condition. The results (Appendix F, Condition 7) indicated the following:

- The total weight of the vessel would have increased by over 9%.
- The minimum freeboard[46] would have been reduced to the extent that the waterline would have been level with the main deck, in contrast to a 1.4-foot minimum freeboard calculated in the stability booklet. This result is consistent with recent photos of the vessel in a loaded condition, showing almost no freeboard to the main deck (Photo 4).
- The vessel would not have fully met the stability criteria of TP 7301.

46 Freeboard is the vertical distance from the waterline to the deck of a vessel.

**Photo 4. *Caledonian* in loaded condition. The white line on the hull indicates the estimated level of the vessel's working deck (Source: Eric Sorenson, with TSB annotations)**


### *1.12.2 Stability at the time of the occurrence*

Stability calculations were performed based on the estimate of the vessel's lightship weight in 2015 and information known about its load condition at the time of the occurrence (Appendix A). Table 2 compares the vessel's lightship, fuel, and fish/seawater (SW) weights at the time of the occurrence with those assumed in the stability booklet for the full load condition (Appendix E).

**Table 2. Difference between the weight and distribution of loads assumed in the stability booklet and the values calculated for the vessel at the time of the occurrence**

| Item | Weight and distribution of load | | |
|---|---|---|---|
| | **Stability booklet information for full load condition** | **Condition at the time of occurrence** | **Difference** |
| Lightship weight | 276.0 tons | 327.3 tons | 51.3 tons (18.6%) over booklet weight |
| Fuel | 22.2 tons, stowed mostly in tanks below the centre fish holds | 37.0 tons, of which 26.6 tons (72%) was stowed in the stern tanks | • 14.8 tons (67%) over booklet weight; load stowed further aft than assumed in booklet<br>• Centre of gravity further aft than assumed in booklet |
| Fish/ seawater | 257.6 tons, stowed in holds | 269 tons:<br>244.4 tons stowed in holds, and 24.6 tons on deck, of which an estimated 5 tons were lifted above the deck | • 11.4 tons (4.4%) over booklet weight<br>• Centre of gravity higher than assumed in booklet |
| **Total** | • 559.4 tons<br>• Vertical centre of gravity 10.96 feet above baseline | • 647.9 tons<br>• Vertical centre of gravity 11.16 feet above baseline | • 88.5 tons (15.8%) over booklet weight<br>• Centre of gravity higher (1.8%) than assumed in booklet |

Initial results predicted that, at the time of the occurrence, the *Caledonian* would have experienced a total loss of stability (Appendix F, Condition 1). However, this result is inconsistent with the observed behaviour of the vessel during the occurrence, whereby the stability loss progressed over a couple of minutes, from the time the last bag of hake was hauled on board.

Two factors were considered to reconcile this inconsistency:

- **Additional buoyancy offered by the vessel bulwarks**: The vessel's stability was re-evaluated by including the buoyancy provided by the solid bulwark that surrounded the aft portion of the working deck. This was done to account for the fact that the freeing ports were equipped with covers which, to a certain extent, would have limited the amount of water shipping onto the deck after the fish was brought onto the deck. The calculation results predicted that the vessel would have a port list of almost 5 degrees and that the position of the main deck on the port side would be below the waterline. The results (Appendix F, Condition 2) also indicated that, with the extra buoyancy of the bulwarks, the stability criteria of TP 7301 would be fully satisfied.[47]

[47] The extent to which the freeing port covers would have prevented water shipping onto the deck is uncertain. The actual effectiveness of the bulwark to contribute to buoyancy and stability of the

- **Detrimental effect of water accumulation on deck**: Stability calculations were also performed to examine the effect of water accumulation on the deck, as was observed during the occurrence. The results (Appendix F, Conditions 17 to 20) predicted a progressive loss of stability as the amount of water on deck increased, and that when between 1.5 and 2 feet of water accumulated, the heel would have been between 10 and 12 degrees to port and the top of the port bulwark would be below the waterline, at which point it would no longer contribute to the stability of the vessel.

### *1.12.3 Effect of operational practices on stability*

The investigation identified operational practices that differed from the assumed loading conditions described by the stability booklet:

- **Loading and consuming fuel and fresh water**: the forward-most fuel tanks were converted to carry fresh water, the original fresh water tanks were not used but kept full, and fuel tanks 3 and 4 were no longer used. In this occurrence, only the 4 aft-most fuel tanks were in use, with over 70% of the fuel being carried in the stern tanks. In the stability booklet, it was assumed that the stern fuel tanks would be emptied as the fish/SW load increased.
- **Loading/stowing fish**: the fish holds were filled with SW or an SW/ice mixture before fish were loaded into the holds. The stability booklet loading conditions assumed that the fish holds were empty prior to loading/stowing fish. In this occurrence, a total of just over 244 tons of fish/SW had been loaded in the holds (almost fully loaded) when an estimated additional 24 tons was brought on board, for a total of about 268 tons on board. This is an increased fish/SW load of about 4.5% over the full load condition in the stability booklet.

The TSB therefore performed additional calculations to examine the effects of these differences on stability as compared to the stability booklet (Appendix G). The investigation determined that the *Caledonian* would not have met the criteria (Appendix C) under the operational practices at the time of the occurrence.

## *1.13 Outstanding recommendations*

Following the *Le Bout de Ligne* occurrence (TSB Marine Investigation Report M90L3033), in which a small trawler suddenly capsized southeast of Cap Gaspé, Quebec, and 3 crew members drowned, the Board recommended that

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

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vessel would likely be less than that predicted by the calculations, which assume that the bulwark is 100% effective.

In July 2016, the *Regulations Amending the Small Fishing Vessel Inspection Regulations,* which created the FVSR, were published in the *Canada Gazette,* Part II. The new FVSR will require a stability assessment for new fishing vessels greater than 9 metres in length and the resulting stability information to be presented in a stability notice. The intention is for the stability notice to be a user-friendly summary of the information presented in the booklet. The standards for these stability notices have not yet been developed. The new requirement will come into effect in July 2017.

The new FVSR do not apply to the 145 large fishing vessels registered in Canada, including the *Caledonian,* which are instead subject to the LFVIR. The LFVIR currently do not contain a requirement for stability notices like the FVSR do. The current assessment of the response to this recommendation is therefore Satisfactory in Part.[48]

## *1.14 Previous occurrences*

In British Columbia, there was an average of 2 fishing-related fatalities each year from 2006 to 2010. This figure increased to an average of 3 fatalities per year from 2011 to 2015. The TSB has previously investigated several small fishing vessel occurrences where issues related to stability, non-use of PFDs, and unsafe vessel operations have been identified.[49]

## *1.15* Safety Issues Investigation into Fishing Safety in Canada

The TSB's *Safety Issues Investigation into Fishing Safety in Canada* (SII), released in June 2012, provides an overall, national view of safety issues in the fishing industry, revealing a complex relationship and interdependency among these issues. The Board identified the following safety significant issues requiring attention: stability, lifesaving appliances, fisheries resource management, the cost of safety, safety information, safe work practices, the regulatory approach to safety, fatigue, training, and fishing industry statistics. The SII found that the safety of fishermen is compromised by numerous issues which are interconnected. These include, for example,

- work practices that do not include regular emergency drills
- training that is not regularly reinforced with emergency drills
- the cost of safety as it relates to the failure to buy and maintain lifesaving equipment and perform drills in the use of lifesaving equipment.

The report also documents the complex operating environment of commercial fishing in Canada. This includes complex regulatory safety and environmental frameworks, changing economics and market conditions, many vessels owned and operated by individuals or

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48 A **Satisfactory in Part** rating is assigned if the planned action or the action taken will reduce but not substantially reduce or eliminate the deficiency, and meaningful progress has been made since the recommendation was issued.

49 TSB marine investigation reports M11L0050 (*Lady Jacqueline*), M12W0054 (*Jessie G*), M14P0110 (*Diane Louise*), and M14P0121 (*Five Star*).

families, shorter seasons, increasing difficulties finding experienced crew, and very traditional fishery practices as far as safety is concerned.[50]

## 1.16 TSB Watchlist

The Watchlist is a list of issues posing the greatest risk to Canada's transportation system; the TSB publishes it to focus the attention of industry and regulators on the problems that need addressing today.

Commercial fishing safety has been a Watchlist issue since 2010. In Canada, even though the numbers of registered fishermen and active fishing vessels have declined overall since 2006, the average number of fatalities has remained constant at 10 per year. The Board remains concerned about vessel stability, the use and availability of lifesaving appliances on board, and unsafe operating practices. Although regulations that apply to fishing vessels less than 24.4 metres (the FVSR) have been proposed by TC to address several deficiencies with respect to fishing safety, there have been significant delays in their implementation. The LFVIR are scheduled for updating following the completion of the FVSR.

The Watchlist highlights that regulations alone are not enough and that there is a need for concerted and coordinated action by federal and provincial authorities and by leaders in the fishing community to improve the safety culture in fishing operations, recognizing the interaction of safety deficiencies.

## 1.17 TSB laboratory reports

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

- LP254/2015 – EPIRB [emergency position indicating radio beacon] Examination

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50 Transportation Safety Board of Canada, Report M09Z0001, *Safety Issues Investigation into Fishing Safety in Canada.*

# 2.0 Analysis

## 2.1 Factors leading to the capsizing and loss of life

Before the capsizing, the crew of the *Caledonian* were bringing the last of the catch on board. Both centre fish holds were half full of water when the first bag of hake (approximately 15 tons) was loaded into the centre port hold, causing the vessel to list to port. After the second bag of hake (approximately 24 tons) came on board, the port list increased. The vessel capsized within a couple of minutes, despite a course alteration to starboard in an attempt to correct the vessel's list.

The operating practices for consuming fuel/water and for loading fish/seawater resulted in weight distributions that were different from those presented in the approved stability booklet. The Transportation Safety Board of Canada (TSB) stability assessment found that these practices significantly increased the risk of stability loss. This risk was exacerbated by the loss of freeboard that was the result of an increase in the vessel's lightship weight, rendering the *Caledonian* vulnerable to the additional forces acting on it at the time of the occurrence, such as the water on deck, the sea conditions, the drag of the port side trawl door and the course alteration.

No distress signal was sent using the vessel's very high frequency/digital selective calling (VHF/DSC) radiotelephone. No distress signal was received from either of the 2 emergency position indicating radio beacons (EPIRB) nor was the vessel being actively monitored. As a result, search and rescue (SAR) resources were not alerted to the occurrence until more than 6 hours after the last automatic identification system (AIS) transmission was received by Marine Communications and Traffic Services (MCTS).

Only the mate had been wearing a personal flotation device (PFD) at the time of the capsizing and, when it became evident that the vessel was going to capsize, there was not enough time for the other crew members to don PFDs, immersion suits, or lifejackets, nor was there time for them to launch the life raft. Although the master was able to climb onto the overturned hull, once the vessel sank, the delay in the automatic deployment of the life raft (approximately 6 hours after the vessel capsized), and the lack of flotation aids resulted in the master drowning. The engineer and the deckhand sustained fatal injuries; however, the timing and specific circumstances leading to these injuries could not be determined. The mate, with the aid of a PFD, was able to reach the life raft and was rescued several hours later.

## 2.2 Stability

The forces acting on a vessel in operation include those related to hull form, wind, waves, and distribution of weight on board. The forces vary as the vessel operates and moves in a seaway, with some tending the vessel toward capsizing, and others tending it toward returning upright. When assessing the stability of a vessel and preparing a stability booklet, naval architects apply established methods and criteria to provide safety margins, which

help to account for some of the variability of these forces. However, it is possible to minimize the uncertainty associated with the variations in the vessel's weight and weight distribution (thereby maximizing safety margins) by ensuring that changes in the vessel's lightship weight and centre of gravity are taken into account, and that the assumed distribution of deadweight[51] for the vessel's stability booklet are representative of the vessel's standard operating practices.

### *2.2.1 Monitoring vessel lightship weight*

As compared to the vessel's lightship weight in the approved stability booklet from 1976, the lightship weight of the *Caledonian* had increased by an estimated 18.6% (51.3 tons) by the time of the occurrence. While the vessel had not undergone any major structural modifications to the hull or superstructure, this increase may be attributed to several factors. Some are specific to the vessel, such as the addition of the second net drum and trawl, accumulation of equipment and spare gear stowed in the void spaces, and the absorption of water by the fish hold insulation material, while others are more general, such as added weight of materials used for repairs, accumulation of stores and crew effects, sedimentation in tanks, corrosion, and buildup of coatings.

An increase in vessel lightship weight has the result of increasing overall operational weight which, depending on the size of the vessel, may significantly reduce freeboard and stability. In this occurrence, it was estimated that the *Caledonian's* fully loaded weight had increased, as compared to the fully loaded condition in the stability booklet, by over 9%. This reduced the freeboard to a point where, at its minimum, the waterline would be level with the main deck and the safety margins of stability relative to the accepted standard would be eroded.

Several factors may have played a role in explaining why the *Caledonian*'s increase in lightship weight went unchecked. The original net drum was raised and a second net drum added before 1998, when the regular master began operating the vessel. In 2008, when Transport Canada (TC) published Ship Safety Bulletin 01/2008 and the associated Fishing Vessel Modification History form, the operator was not aware that changes affecting the vessel's weight had been made to the vessel. Another factor is that the changes in vessel behaviour or performance that are associated with a loss of freeboard may not have been obvious to the crew. This is because the *Caledonian* had covers fitted on the freeing ports that limited the amount of water that could ship onto the deck and improved the vessel's buoyancy and stability.

In addition, there was no practical way to verify, on an ongoing basis, whether the vessel's freeboard was being maintained at a safe level or whether it was decreasing. Although the stability booklet provided calculated vessel drafts for each of the load conditions examined, these had not been compiled to determine a maximum safe operating draft (or minimum freeboard) for the vessel. The vessel's safety information manual contained guidance regarding the amount of freeboard that should be expected when the vessel was loaded, but

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[51] Deadweight is the weight of everything on the vessel such as fuel, fresh water, stores, crew, and fish/seawater.

did not provide guidance on action to take if the freeboard was less than this amount, such as checking for an increase in lightship weight. While the safety information manual and stability booklet were found to be compliant with the regulations, neither was effective in emphasizing the importance of monitoring the vessel's freeboard or its lightship weight.

Many cargo and passenger vessels are required to mark the sides of the hull to indicate the maximum operating draft and comply with standards for stability, strength, and general seaworthiness.[52] These marks serve as a clear indicator, on an ongoing basis, as to whether or not the vessel is loaded safely. If the lines are below the surface of the water when the vessel is loaded in a typical way, this would indicate a possible increase in the lightship weight, which could then be investigated and addressed. Some passenger vessels are also required to routinely undergo lightship weight surveys.[53] The measure of marking the hull with a maximum permissible operating draft is also recommended for fishing vessels in the *Code of Safety for Fishermen and Fishing Vessels*.

TC regulations do not address the issue of monitoring the lightship weight of fishing vessels on an ongoing basis. Although the requirement to report and review vessel modifications is valuable for identifying and assessing those obvious material changes that may immediately affect stability, it will not address the long-term, less obvious gradual weight increase that may occur on vessels such as the *Caledonian*.

If fishermen are not provided with a practical means to monitor and assess freeboard throughout a vessel's life, there is a risk that a vessel's lightship weight will increase to a level where it has detrimental effects on stability.

### *2.2.2 Stability guidance and vessel operations*

On board the *Caledonian*, the longstanding operational practices for loading/consuming fuel and fresh water and loading fish differed from the weight distributions assumed in the stability booklet. These differences would have increased the vessel's aft trim, as well as increasing the weight of the fish and raising the centre of gravity of the fish, when compared to the stability booklet. This significantly increased the risk of stability loss. Furthermore, had stability calculations been performed using more representative weights and weight distributions at any time, these calculations would have shown a risk of stability loss that could have been addressed.

The *Caledonian*'s operating practices were passed on primarily by word of mouth from one master to another, as was done in this occurrence. The only documented information or procedures available to the crew were the stability booklet and the safety information manual. However, several shortcomings limited their effectiveness for guidance in maintaining vessel stability.

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52 *Canada Shipping Act, 2001*, *Load Line Regulations*, and *Hull Construction Regulations*.

53 Transport Canada, TP 10943, *Passenger Vessel Operations and Damaged Stability Standards (Non-Convention Vessels)*, October 2007.

The stability booklet

- did not provide any assessment of or information about vessel stability during fishing operations, such as the effects of fish on deck or suspending fish from the boom.
- had only the minimum information necessary for compliance with standards, and although it did present information for each load condition, the information was not presented in a user-friendly format. For example, for the fully loaded condition, forward and aft drafts were provided, but these had not been translated into freeboard. Additionally, there was not sufficient information in the booklet to translate draft into a recommended maximum operating draft, which is easier to monitor.
- did not contain comments, remarks, or notes to indicate that the information provided was intended to be used for ongoing stability assessment over the life of the vessel. In fact, the booklet stated that the "operating conditions presented…are based upon the vessel's worst foreseeable service conditions…."This statement may lead the user to believe that any further calculations or monitoring of stability were unnecessary.
- did not contain information, such as a sample calculation, to help the user assess new conditions, such as one to represent the *Caledonian*'s practice for loading and consuming fuel and water.

The safety manual

- provided procedures for loading and consuming fuel and water that generally reflected the tank configuration and operating practices that were in place at the time of the occurrence. However, these procedures were not sufficiently detailed or clear to adequately describe the operating practices.
- provided information regarding vessel's freeboard and trim that was not consistent with the information in the stability booklet.
- lacked sufficient detail to compare the vessel's freeboard and trim during operations against the guidance provided in the manual.
- lacked guidance on what to do if the vessel's freeboard or trim was less than that indicated in the manual.

The marine industry relies on the standards established by competent authorities when assessing the stability of vessels and preparing stability booklets and guidance information. In this occurrence, both the *Caledonian*'s stability booklet and safety manual satisfied the relevant requirements and standards.

When it comes to the preparation of stability booklets, TC standards state that the fishing vessel owners are responsible for ensuring that the conditions in the stability booklet are representative of the actual weights and weight distributions. The master is then held responsible for assessing any new conditions as necessary. However, as demonstrated in this occurrence, compliance with the standards does not ensure that the stability booklet will contain the information necessary for the master to meet that responsibility:

- The *Large Fishing Vessel Inspection Regulations* specify 6 predetermined static load conditions that are to be assessed. No further guidance is provided regarding operating practices that would need to be examined in order to fully assess the vessel's stability.
- There are no requirements for or guidance regarding how information in the stability booklet should be presented so that it can be easily understood by end users (fishermen), taking into consideration their level of stability knowledge and the need for the stability information to be practical for use on board.

Similar to the stability booklet, the *Caledonian*'s safety information manual was accepted as meeting the relevant requirements; however, this did not ensure that the information it contained would be adequate to serve its intended purpose. Again, the responsibility lies with the owner or authorized representative (AR) to ensure that the information in the manual is accurate and does not contradict the information in the stability booklet. However, if the stability booklet itself has shortcomings, there will be challenges in accomplishing this. Furthermore, although the reviews conducted by WorkSafeBC confirm that the information in the manual addresses all the elements outlined in the guidelines,[54] the reviews do not go into sufficient depth to ensure the manual's accuracy. Additionally, reviews are not routinely conducted to ensure that any necessary updates have been incorporated.

In British Columbia particularly, the fishing industry has experienced an increase in vessel ownership by large companies, resulting in fewer owner/operators and more masters and crew members moving around between vessels. As a consequence, masters and crew members are not necessarily as familiar with the vessel or its operating practices as they would be if they crewed on a vessel for an extended period of time. For example, in this occurrence, there were 2 new crew members who were not familiar with operating practices, and the engineer who took over as master had no experience as master on the *Caledonian*. In these circumstances, written procedures or guidance that are relevant, updated, and readily applied are critical to enhancing the crew's ability to maintain the stability of the vessel in all operating conditions.

If standards do not ensure that the stability information provided to fishermen is current, comprehensible and relevant to vessel-specific operations, then there is a risk that operating practices will compromise vessel stability.

## *2.3 Emergency preparedness*

Comprehensive emergency preparedness assessments provide fishermen with an opportunity to identify deficiencies in their emergency procedures and equipment and take action to address these deficiencies. Drills can also be used to simulate a variety of emergency situations and enable crew members to perform actions automatically in an actual emergency situation: for example, ensuring that a distress call is transmitted, whether

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54 WorkSafeBC, *Guidelines for Workers Compensation Act* and *OHS Regulation*, part 24, section G24.72, "Documentation."

by cell phone, satellite phone, or VHF/DSC radiotelephone. This task was particularly important in this occurrence because the vessel was not being actively monitored by MCTS and neither EPIRB functioned as intended.

Drills are discussed in the Marine Emergency Duties (MED) training that fishermen are required to take; however, TSB's *Safety Issues Investigation into Fishing Vessel Safety* (SII) found that this training does not instill the importance of safety drills and that fishermen do not always conduct drills, as was the case in this occurrence. While the Safest Catch program[55] also provides training on how to conduct emergency drills and the AR was aware of the program, the vessel had not participated in it, nor are there any records to indicate the crew had participated in the program.

The vessel's safety information manual also provided some guidance on drill procedures and provided safety equipment checklists as required by regulation. However, there are no records to indicate that the crew consulted this guidance or followed the procedures, and the AR did not follow up to ensure that the crew had done so. This meant that there were fewer opportunities to identify possible deficiencies in emergency procedures, instill effective response behaviours, and identify lifesaving equipment that may not function as intended.

If fishermen continue to operate their vessels without comprehensively assessing them for emergency preparedness, and do not conduct drills and follow-up briefings, then the risk remains that fishermen will not be prepared in an emergency, which may lead to fatalities.

## *2.4 Use of personal flotation devices*

Of the several unsafe practices on fishing vessels that have been identified by the TSB over the years, not wearing PFDs is a significant one. In the fishing community, the reasons provided by fishermen for the resistance to PFD use include discomfort, the risk of entanglement, and the perception that it is not practical or normal to wear a PFD. Furthermore, risks such as capsizing, falling overboard, and drowning are perceived to be low, with the result that fishermen see little benefit to protecting themselves from these risks while they focus on fishing.[56] Unsafe behaviours that are rooted in traditional values, attitudes, practices, and the perception of efficiency prove the most difficult to change.[57]

In this occurrence, with the exception of the mate who survived the capsizing, it was not the practice for the crew to wear PFDs during fishing operations. Despite the existence of risk-based regulations and industry initiatives to change behaviours and create awareness about

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55 Fish Safe's Safest Catch Program is an introduction to safety management systems for fishing vessels and includes facilitation on safety equipment, drills, and safety procedures.

56 Transportation Safety Board of Canada, Report M09Z0001, *Safety Issues Investigation into Fishing Safety in Canada,* "Safety Significant Issues – Life Saving Appliances", pp. 45–49, and "Cost of Safety," pp. 62–65.

57 D.M. Dejoy, "Behaviour change versus culture change: Divergent approaches to managing workplace safety," *Safety Science,* Volume 43, 2005, p. 108.

the importance of wearing PFDs, the non-use of PFDs remains a challenge within the fishing community.

If fishermen continue not to wear PFDs while on deck and their use is not required at all times, then there is an increased risk of drowning when a fisherman goes overboard.

## *2.5 Safety issues in the fishing industry*

The SII categorized actions impacting safety into 10 significant safety issues and found that there are complex relationships and interdependencies among them. These safety significant issues are further analyzed in the SII.[58] In this occurrence, at least 7 of the 10 safety significant issues were present. The following practices and procedures relating to the safety significant issues identified in the SII were evident in this occurrence:

*Stability*

| **Safety issues investigation findings** | **Relationship to this occurrence** |
|---|---|
| WorkSafeBC requires all fishing vessels to document procedures to maintain stability based on technical data. | Although there were documented procedures to maintain stability, they were not based on information from the stability booklet and did not reflect the vessel's standard operating practices. |

*Lifesaving appliances*

| **Safety issues investigation findings** | **Relationship to this occurrence** |
|---|---|
| Fishermen do not always conduct drills. | Two of the crew members were new to the vessel and no emergency drills were conducted before departure. |
| Fishermen do not always update their EPIRB contact information. | The EPIRB found in the life raft was not registered. |
| Not all fishermen wear a PFD when working on deck. | Only the surviving mate was wearing a PFD. |
| Training does not instill the importance of […] safety drills in improving reaction time and team effectiveness in emergencies. | Despite MED training, regular emergency drills were not practised and key actions were not taken during the emergency situation. |

58 Transportation Safety Board of Canada, Report M09Z0001, *Safety Issues Investigation into Fishing Safety in Canada.*

*Regulatory approach to safety*

| Safety issues investigation findings | Relationship to this occurrence |
|---|---|
| There can be a considerable amount of time between the moment when a safety deficiency is identified and the moment a new regulation is implemented. | In 1994, the TSB identified a safety deficiency with the way information was presented in stability booklets and made a recommendation (M94-33). The new FVSR, 22 years later, addresses this deficiency for small fishing vessels (less than 24.4 metres). However, the new FVSR do not apply to the 145 large fishing vessels registered in Canada, including the *Caledonian*, and so the deficiency has not been addressed for these vessels. |

*Training*

| Safety issues investigation findings | Relationship to this occurrence |
|---|---|
| [Fishermen identify,] assess and manage their risk based on experience. | Although the relief master had extensive fishing experience in a variety of fisheries, the relief master had no experience as master on board the *Caledonian* and limited experience in hake fishing. |
| The benefits of regular emergency drills in reducing reaction time and increasing team coordination are not well recognized. | Regular emergency drills were not practised and key actions were not taken during the emergency situation. |

*Safety information*

| Safety issues investigation findings | Relationship to this occurrence |
|---|---|
| Safety information is not presented in a way that applies to fishermen's specific situations. | The safety information manual was not consistent with the operational practices. The stability booklet did not offer comprehensive information relevant to the *Caledonian*'s operational practices. |

*Fatigue*

| Safety issues investigation findings | Relationship to this occurrence |
|---|---|
| [Fishermen] accept fatigue as a normal part of doing business. | In the 57 hours prior to the *Caledonian* capsizing, the mate had approximately 8 hours of rest over 4 separate periods. |

*Safe work practices*

| Safety issues investigation findings | Relationship to this occurrence |
|---|---|
| [Fishermen] do not emphasize the importance of safety in work practices. | It was not a standard work practice to wear a PFD during fishing operations. |

## *2.6 Interdependency of safety issues*

The safety of fishermen is compromised by numerous issues which are interconnected. The following safety issues share a complex relationship and contributed to this occurrence:

- stability awareness;
- training on emergency preparedness and drills;
- unsafe work practices; and
- the use and availability of lifesaving appliances.

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

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

# 3.0 Findings

## 3.1 Findings as to causes and contributing factors

1. The *Caledonian's* operating practices for consuming fuel/water and for loading fish/seawater differed from those presented in the approved stability booklet and significantly increased the risk of stability loss.

2. The *Caledonian's* lightship weight had increased over the years, exacerbating the risk of stability loss and rendering it vulnerable to the additional forces acting on it at the time of the occurrence.

3. The cumulative effects of the forces from the water on deck, the sea conditions, the drag of the port side trawl door, and the course alteration also contributed to the loss of the vessel's righting energy, leading it to capsize.

4. As no distress signal was received nor was the vessel being actively monitored, search and rescue resources were not alerted until more than 6 hours after the capsizing.

5. Other than the personal flotation device that the mate was wearing, no other lifesaving appliances were used or deployed before the capsizing, and the life raft, which was fitted with a hydrostatic release unit, did not deploy until approximately 6 hours after the capsizing.

6. The master drowned, and the engineer and the deckhand sustained fatal injuries during the occurrence. The timing and specific circumstances leading to these injuries could not be determined.

## 3.2 Findings as to risk

1. If fishermen are not provided with a practical means to monitor and assess freeboard throughout a vessel's life, there is a risk that a vessel's lightship weight will increase to a level where it has detrimental effects on stability.

2. If standards do not ensure that the stability information provided to fishermen is current, comprehensible and relevant to vessel-specific operations, then there is a risk that operating practices will compromise vessel stability.

3. If fishermen continue to operate their vessels without comprehensively assessing them for emergency preparedness, and do not conduct drills and follow-up briefings, then the risk remains that fishermen will not be prepared in an emergency, which may lead to fatalities.

4. If fishermen continue not to wear personal flotation devices while on deck and their use is not required at all times, then there is an increased risk of drowning when a fisherman goes overboard.

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

## *3.3 Other findings*

1. It was the practice for all crew members to be on deck during fishing operations, leaving safety-critical positions such as the wheelhouse unattended.

2. The life raft did not deploy immediately after the capsizing and was not accessible to the crew until approximately 6 hours later when the vessel's aspect changed as it began to sink by the bow.

3. To address the challenges of finding an optimum stowage position that allows for both manual and automatic activation of the required float-free lifesaving appliances, some operators have installed additional float-free life rafts and emergency position indicating radio beacons beyond those required by Transport Canada.

4. Covers on the freeing ports limited the amount of water that could ship onto the deck and improved the vessel's buoyancy and stability, but made it less obvious that the vessel had experienced a significant loss of freeboard over its life.

# 4.0 Safety action

## 4.1 Safety action taken

### 4.1.1 Authorized representative

The authorized representative, who represents several other trawl vessels in addition to the *Caledonian*, has purchased and installed 1 additional emergency position indicating radio beacon (EPIRB) and 1 additional life raft for each of its vessels, thereby going beyond the regulatory requirements.

### 4.1.2 Canadian Fishing Company

As a result of the occurrence and upon request from its trawl masters, the Canadian Fishing Company has initiated a policy to ensure that all of its trawl vessels are equipped with 2 life rafts and 2 EPIRBs.

## 4.2 Safety action required

### 4.2.1 Stability information for fishing vessels

Once a vessel is put in operation and its basic stability parameters are determined, the adequacy of the stability information that is available to the crew is key to ensuring that the vessel is operated safely throughout its voyages and its lifetime. Crews on fishing vessels need adequate stability information to enable them to determine safe load conditions for gear, cargo, fuel, and other consumables depending on the operation at hand and type of catch being stowed. Fishing vessels deploy gear, lift loads, and stow their catch while at sea, which means that load conditions are frequently changing.

A fishing vessel may also undergo major modifications at one or more times in its life, and it is always subject to many minor changes that accumulate over the years, contributing to increased lightship weight. These factors emphasize the need for vessel crews to have easily understood, accessible, up-to-date stability information that can be adapted to the operations at hand, helping to ensure that they are conducted safely.

In order for fishing vessel stability information to be adequate to meet the needs of crew;

- The vessel must have had its stability assessed according to a recognized standard that is appropriate to its size and operation.
- The information from that assessment must be analyzed/interpreted to determine safe operating limits (such as draft/freeboard, appropriate maximum cargo loads, sequences for loading, lifting, and stowing of cargo and gear, and for managing fuel consumption).
- These operating limits must be easily measurable and relevant to the vessel's operation. For example,
    - the sides of the hull could be marked with lines indicating maximum draft forward, mid-ship, and aft.

    - maximum loads could be given in whichever unit of measure is most relevant to the vessel's operation (e.g. number and size of traps, nets, skiffs, amount of deck cargo, tons of fish).
    - if lifting appliances (booms) are used, operating limits could be provided.
- The information must be presented in a manner and format that enables it to be clearly understood and easily accessible to crew while working on board.
- The information must be maintained so that it is current, and reviewed and amended as necessary to reflect changes to the vessel and/or its operations. For example, if the vessel starts exceeding its draft or freeboard limits, the loading limits may need to be amended accordingly, or the reason for the change in draft (such as increased lightship weight) needs to be identified and rectified.

The *Caledonian* had a stability assessment and stability booklet prepared in 1976; however, the information in that booklet was outdated due to changes made to operational practices and an increase in the vessel's lightship weight that had accumulated over its 39 years of service. Despite the completion of the voluntary Fishing Vessel Modification History form, this increase in lightship weight went unidentified. These factors reduced the vessel's freeboard and stability significantly, contributing to its capsizing and the loss of 3 lives.

Additionally, the *Caledonian's* stability booklet did not include an assessment of the effect of lifting bags of fish on deck with the boom, nor did it offer guidance or information sufficient to enable the assessment of load conditions that were different from those in the stability booklet. The basic information that was provided for this purpose was not in a user-friendly format and had not been interpreted to provide clear, safe operating limits.

The stability information available to the crew of the *Caledonian* was deemed to have met all of the applicable regulatory requirements. However, when compared against the elements of adequate stability information described above, only the requirement for the original stability assessment was fully satisfied.

#### *4.2.1.1 Stability information for large fishing vessels*

The Canadian fishing vessel fleet includes about 145 vessels that are greater than 150 gross tonnage, like the *Caledonian*, which are regulated under the *Large Fishing Vessel Inspection Regulations* and are required to undergo stability assessments and have stability booklets produced. However, these regulations do not address the regular monitoring of vessel lightship weight and do not include standards or guidelines to ensure that vessel-specific stability information is provided that is adequate for use by fishermen. The Board therefore recommends that:

> The Department of Transport establish standards for all new and existing large fishing vessels to ensure that the stability information is adequate and readily available to the crew.
>
> **TSB Recommendation M16-01**

#### *4.2.1.2 Stability information for small fishing vessels*

The issue of adequate stability information for fishing vessels is not limited to large vessels; it extends to small fishing vessels (not more than 150 gross tonnage and not more than 24.4 metres in length) as well. In 1990, the Transportation Safety Board of Canada (TSB) identified a deficiency related to the adequacy of stability information in an occurrence involving the small fishing vessel *Le Bout De Ligne* and recommended that

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

Since then, the TSB has published over 100 investigation reports on accidents involving the loss of 120 lives on fishing vessels of all sizes. These reports highlight issues regarding stability, the need for stability assessments, and the need for adequate stability information for fishermen. However, the response to Recommendation M94-33 is still considered by the Board to be only Satisfactory in Part.[59]

In its 2012 *Safety Issues Investigation into Fishing Safety in Canada* (SII), the TSB found that fishermen generally do not understand or use information in stability booklets and determine the stability of a vessel based only on experiencing its movements in a variety of operating conditions. During the SII, fishermen told the TSB that they do not understand how a stability booklet can make their operation safer. Without a simple, clear and practical format containing minimum freeboard limits, load limits, loading sequence, identified downflooding points, and minimum and maximum stability conditions, the stability booklet is considered to be of no use.

More recently, in 2014, the TSB investigation into the sinking and loss of life involving the small fishing vessel *Five Star*[60] found that, if Transport Canada (TC) continues to allow the majority of fishing vessels to operate without undergoing formal stability assessments, then many fishermen will remain unaware of their vessel's safe operating limits and thus be at risk of exceeding them.

#### *4.2.1.3 Small fishing vessels that have had a stability assessment*

Under the *Small Fishing Vessel Inspection Regulations* (SFVIR), a portion of small fishing vessels[61] have been required to undergo stability assessments and have stability booklets

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59 A **Satisfactory in Part** rating is assigned if the planned action or the action taken will reduce but not substantially reduce or eliminate the deficiency, and meaningful progress has been made since the recommendation was issued.

60 TSB Marine Investigation Report M14P0121 (*Five Star*).

61 Vessels built since 1977 that catch herring or capelin and vessels that have undergone modifications that adversely affect its stability.

produced. However, the SFVIR do not address the regular monitoring of vessel lightship weight and do not include standards or guidelines to ensure that adequate vessel-specific stability information is provided for the use of fishermen.

In July 2016, in response to TSB Recommendation M94-33 and numerous others relating to fishing vessel stability, TC published, in the *Canada Gazette*, Part II, regulations to create new *Fishing Vessel Safety Regulations* (FVSR) and replace the SFVIR. However, these new regulations do not address the regular monitoring of vessel lightship weight or the provision of adequate stability information for small fishing vessels that had stability booklets produced under the old regulations. The Board therefore recommends that

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

#### *4.2.1.4 Other small fishing vessels*

In total, small fishing vessels represent approximately 99% of the entire Canadian fishing fleet of 23 878 registered vessels.[62] For the majority of these small fishing vessels, there is no requirement to have stability assessments or for crew to be provided with adequate stability information based on a stability assessment.

TC recognized the risk to vessel safety associated with these issues and, when developing the FVSR, included a requirement for all new and existing commercial fishing vessels greater than 9 metres in length to have a stability assessment. However, during public consultations, industry stakeholders considered the proposal to be impractical and an undue financial burden.[63] As a result, TC amended the stability requirements so that only new vessels greater than 9 metres in length will be required to have a stability assessment.

The FVSR require a competent person who conducts a stability assessment to develop a stability booklet and provide information (referred to in the FVSR as a "stability notice") depicting the operational practices necessary to remain within the safe operating limits as set out in the stability booklet. However, these requirements are limited to only new vessels that are over 9 metres in length, and the standards for these stability notices have not yet been developed. The requirements will not take effect until July 2018, and furthermore, they leave a significant portion of the existing small fishing vessel fleet, as well as new vessels less than 9 metres, at risk.

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62 In any given year, approximately 60% of the Transport Canada-registered fishing vessels are active. An active vessel is registered with the Department of Fisheries and Oceans and has at least one recorded landed catch in a given calendar year.

63 Transport Canada, *Regulatory Impact Analysis Statement*, 06 February 2016, available at: http://www.gazette.gc.ca/rp-pr/p1/2016/2016-02-06/html/reg1-eng.php (Last accessed 24 November 2016).

The TSB believes that it will take focused and concerted action by federal and provincial government agencies and industry members to finally and fully address the safety deficiencies that persist in Canada's fishing industry. Once all small commercial fishing vessels have undergone stability assessments that are appropriate to their size and operations and fishermen have access to adequate stability information, the loss of life associated with inadequate fishing vessel stability will be substantially reduced.

The Board therefore recommends that

> The Department of Transport require that all small fishing vessels undergo a stability assessment and establish standards to ensure that the stability information is adequate and readily available to the crew.
>
> **TSB Recommendation M16-03**

### *4.2.2 Use of personal flotation devices*

Fishermen often operate in harsh physical and environmental conditions. They harvest, load, transfer, and store their catch while the vessel is in various sea conditions, and the risk of going overboard is high. If a fisherman ends up in the water, the consequences can be fatal. The SII identified falling overboard as the second highest cause of death in the fishing industry.[64] Between 1999 and 2010, there were 41 fatalities (3.4 per year) resulting from fishermen falling overboard, which accounts for 27% of the total fatalities for that same time period. From 2011 to 2015, there were 26 fatalities (5.2 per year) resulting from fishermen falling overboard, which accounts for 53% of the total fatalities for that same time period. This represents a significant increase in the number of fatalities from fishermen falling overboard each year.[65] In British Columbia, since 2006, the TSB has determined that approximately 70% of all fishing-related fatalities result from not using a personal flotation device (PFD).

TSB investigations have shown that wearing a PFD increases the chance of surviving a man overboard situation,[66] and this occurrence is yet another example. Both the master and the mate survived the capsizing of the vessel and were able to climb onto the overturned hull, but by the time the vessel sank, only the mate, who had been wearing a PFD while working on deck before the capsizing, was able to swim to the life raft. The master had not been wearing one, and the speed of the capsizing prevented the donning of a PFD, immersion suit, or lifejacket, resulting in the master drowning.

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64 Transportation Safety Board of Canada, Report M09Z0001, *Safety Issues Investigation into Fishing Safety in Canada*, p. 31.

65 These statistics include only incidents of fishermen falling overboard and do not include deaths caused by fishermen going overboard in accidents such as capsizings, floodings or sinkings.

66 TSB marine investigation reports M07N0117 (*Sea Urchin*), M05N0072 (*Melina & Keith II*), and M01C0029 (*Shannon Dawn* and *Rachel M*).

Since 2001, in Quebec, the Commission de la santé et de la sécurité du travail (CSST)[67] has been enforcing an occupational health and safety regulation that states "Every employer must take the necessary measures to protect the health and ensure the safety and physical well-being of [its] workers."[68] In February 2012, the CSST made it compulsory for lobster fishermen to wear PFDs at all times. Recently, the CSST has sent letters to all masters on lobster fishing vessels explaining the regulation as it pertains to the mandatory use of lifejackets or PFDs on board fishing vessels and the CSST has conducted 150 vessel visits to ensure compliance.

Apart from the CSST, neither TC nor any other provincial workplace safety regulator has requirements to ensure that fishermen wear PFDs at all times. Those requirements that do exist place the onus on fishing vessel masters to determine whether or not a risk is present and to decide if PFDs should be worn. Not only is this assessment of risk subjective, but it also assumes that crew members are in a position to recognize when risk is present and have the time available to don a PFD or other flotation device.

Despite risk-based regulations and industry initiatives to change behaviours and create awareness about the importance of wearing PFDs, as well as design improvements by PFD manufacturers to address fishermen's concerns about comfort and constant wear, there has not been a significant change in the behaviour of fishermen and many continue to work on deck without wearing a PFD.

The TSB believes that the implementation of explicit requirements for fishermen to wear PFDs, along with appropriate education and enforcement measures, will significantly reduce the loss of life associated with going overboard. The Board therefore recommends that:

> WorkSafeBC require persons to wear suitable personal flotation devices at all times when on the deck of a commercial fishing vessel or when on board a commercial fishing vessel without a deck or deck structure and that WorkSafeBC ensure programs are developed to confirm compliance.
>
> **TSB Recommendation M16-04**

> The Department of Transport require persons to wear suitable personal flotation devices at all times when on the deck of a commercial fishing vessel or when on board a commercial fishing vessel without a deck or deck structure and that the Department of Transport ensure programs are developed to confirm compliance.
>
> **TSB Recommendation M16-05**

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67 Now known as the Commission des normes, de l'équité, de la santé et de la sécurité du travail (CNESST).

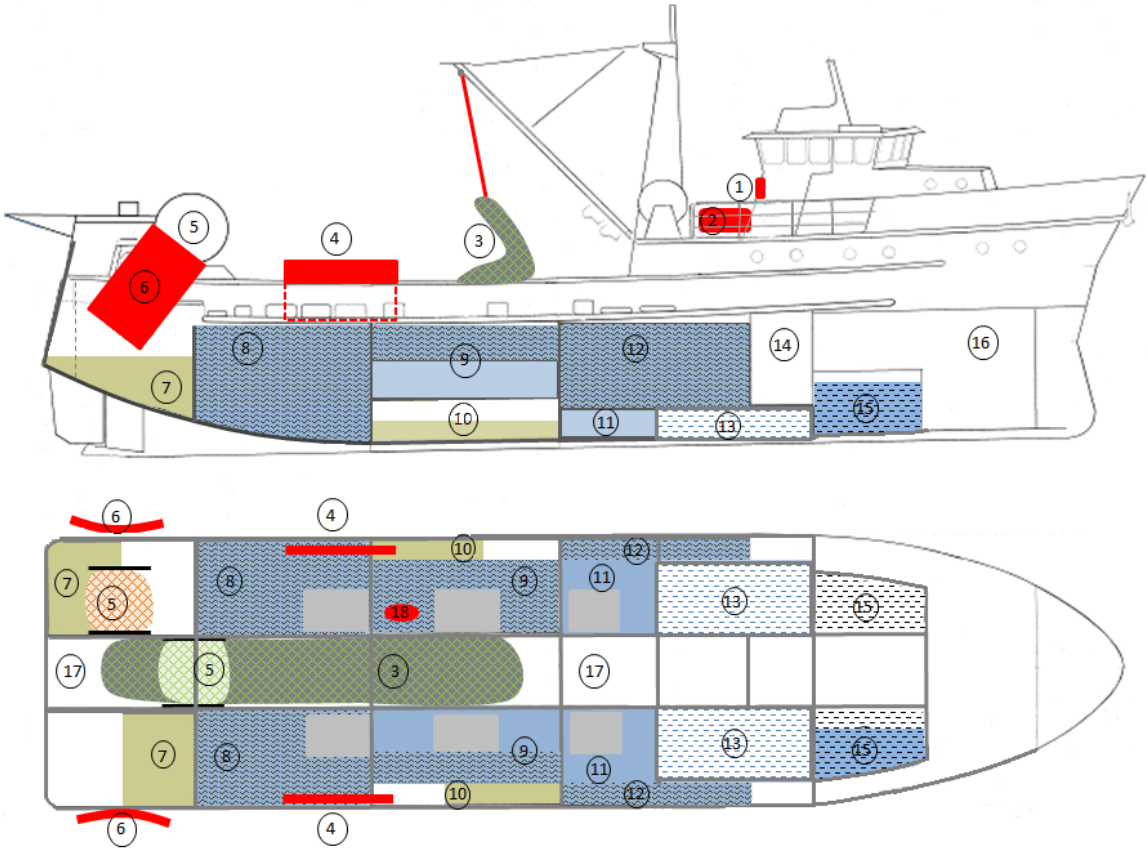
68 *Act Respecting Occupational Health and Safety*, Chapter S-2.1, Division II, Subsection 2-51.

*This report concludes the Transportation Safety Board's investigation into this occurrence. The Board authorized the release of this report on 23 November 2016. It was officially released on 14 December 2016.*

*Visit the Transportation Safety Board's website (www.tsb.gc.ca) for information about the TSB and its products and services. You will also find the Watchlist, which identifies the 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 the* Caledonian

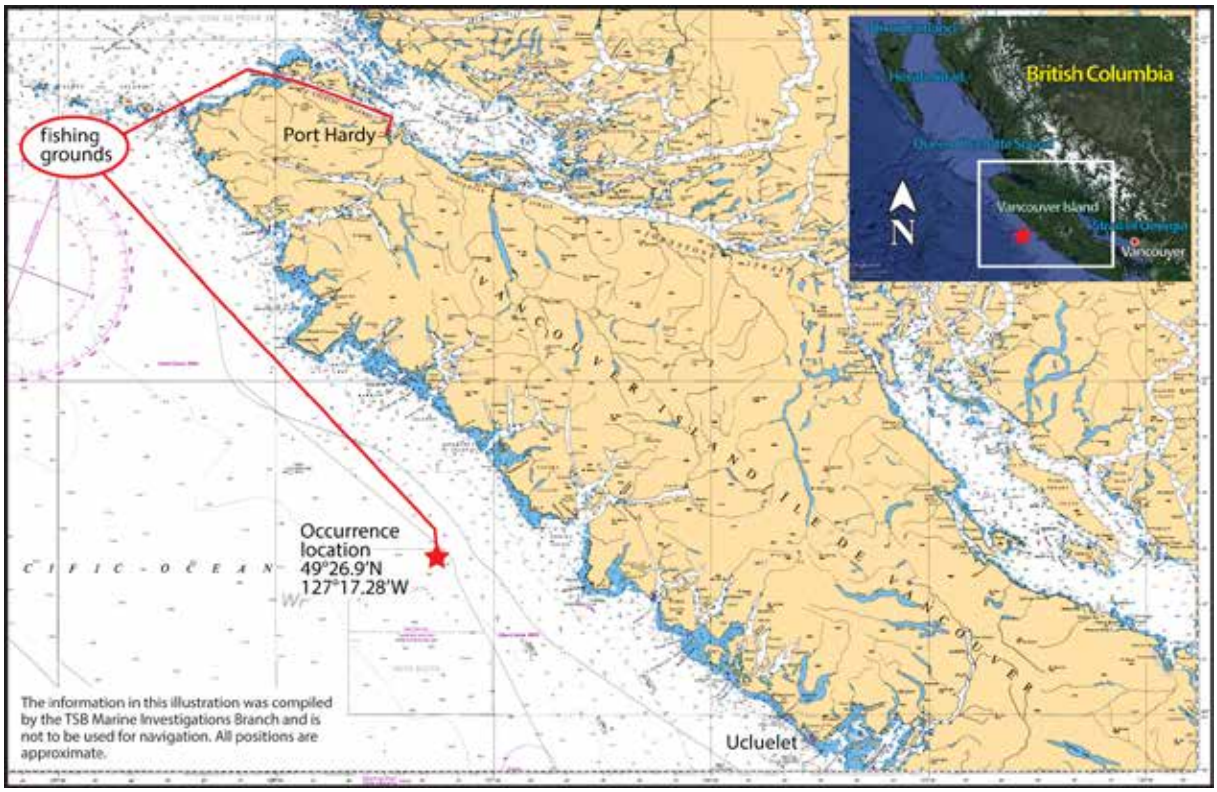


Legend

1. Emergency position indicating radio beacon
2. Life raft (stored on middle deck)
3. Second bag of hake (approx. 24 T)
4. Spare trawl door
5. Net drum
6. Trawl door
7. Fuel tanks 7 and 8 - 55% full
8. Fish holds 5 and 6 - full
9. Fish hold 3 – full
   Fish hold 4 – 50% full
10. Fuel tank 5 – 60% full
    Fuel tank 6 – 60% full
11. Fresh water tanks – full but not used
12. Fish holds 1 and 2 - full
13. Unused fuel tanks - 3 and 4 empty
14. Void space - empty
15. Fuel tanks 1 and 2 converted to fresh water
    (1 – empty, 2 – 75% full)
16. Engine room
17. Trawlway
18. Deck hatch for centre port fish hold

Source: Caledonian Holdings Inc., with TSB annotations

# *Appendix B – Area of the occurrence*




Source: Canadian Hydrographic Services and Google Earth, with TSB annotations

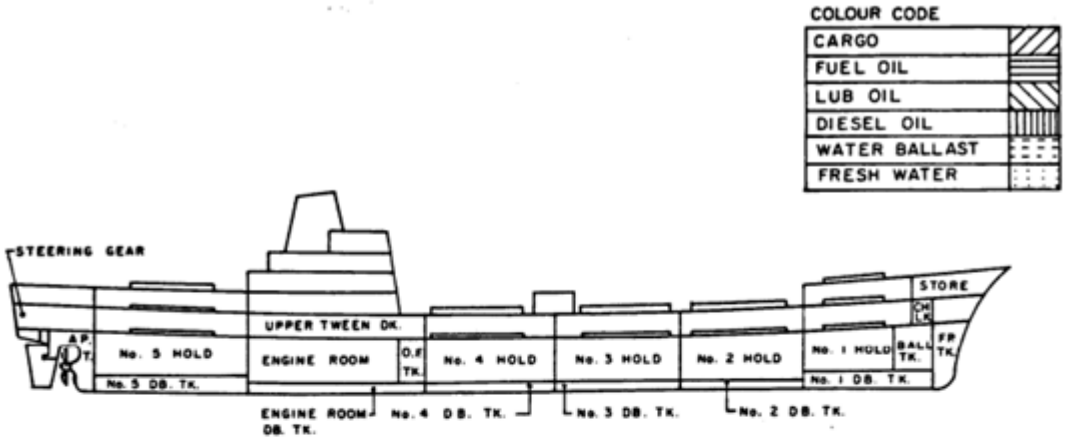
## *Appendix C – TP 7301, STAB 4 Criteria - Stability standards for fishing vessels*

| Criterion | Text from stability standard |
|---|---|
| 1 | Area under the righting lever (GZ) curve should not be less than 0.055 m-radians [10.339 ft-degrees] up to or equal to 30° |
| 2 | Area under the righting lever (GZ) curve should not be less than 0.09 m-radians [16.918 ft-degrees] up to or equal to 40° (or the angle of downflooding if less than 40°) |
| 3 | Area under the righting lever (GZ) curve between the angles of heel of 30° and 40°, or the angle of downflooding if less than 40°, should not be less than 0.03 m-radians [5.639 ft-degrees] |
| 4 | Righting lever (GZ) should be at least 0.20 m [0.66 ft] at an angle of heel equal to or greater than 30° |
| 5 | Maximum righting arm should occur at an angle of heel preferably exceeding 30° but not less than 25° |
| 6 | Initial metacentric height (GM) should not be less than 0.35 m [1.15 ft] |

Source: Transport Canada, TP 7301, STAB 4 Criteria - Stability standards for fishing vessels

# *Appendix D – Typical condition sheet and stability curve*

## TYPICAL CONDITION SHEET

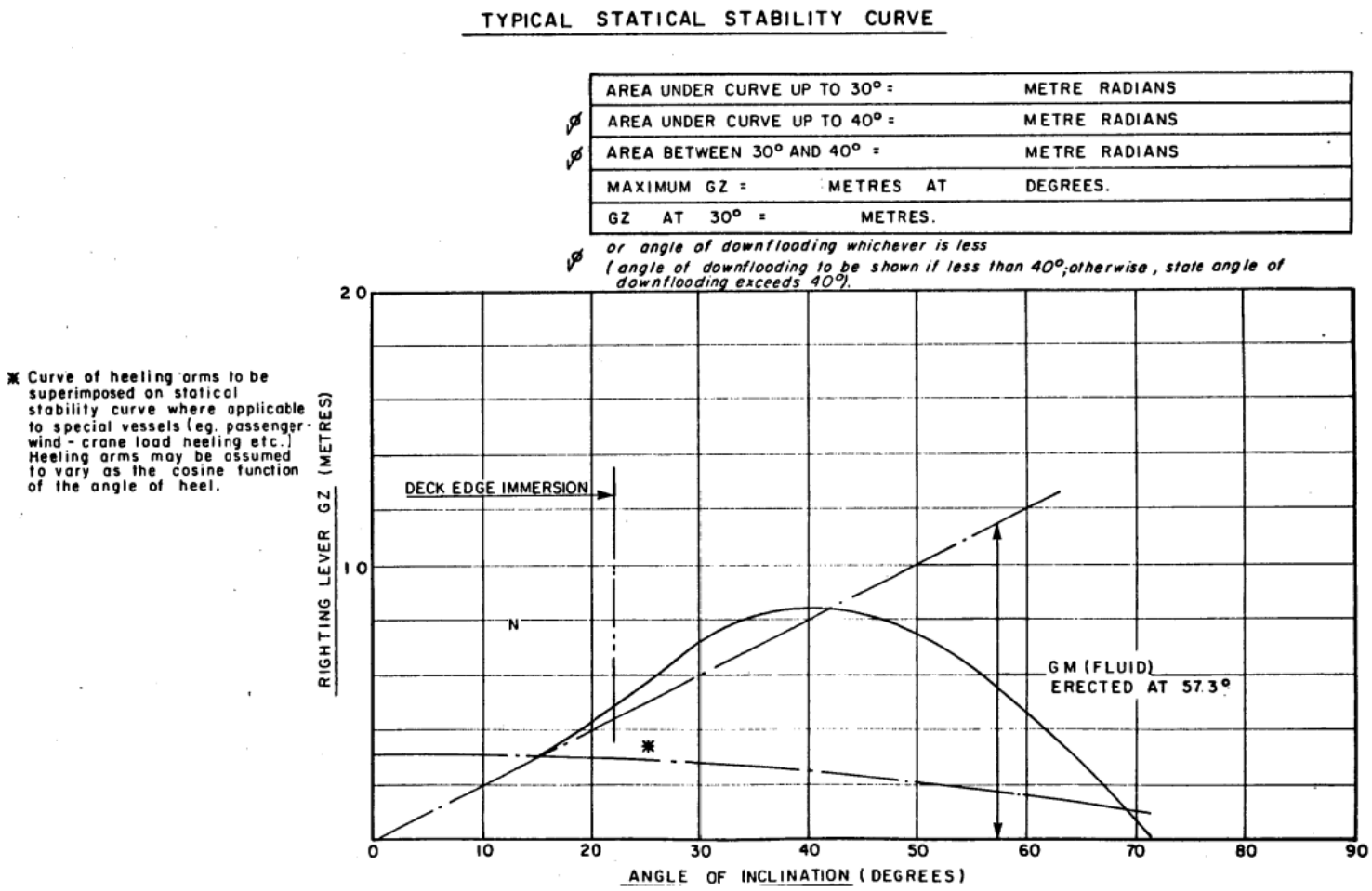



| CONDITION Nº | | DESCRIPTION OF CONDITION | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| DEADWEIGHT ITEMS | WEIGHT (Tonnes) | K.G. (metres) | VERT. MOMENT | L.C.G AB* ℔ (metres) | LONGL MOMENT | F.S. MOMENT (Tonnes m) | HYDROSTATIC DATA | S.W. | ✓ |
| | | | | | | | | F.W. | ✓ |
| | | | | | | | DRAFT AT L.C.F. | | |
| DEADWEIGHT ITEMS | | | | | | | DRAFT AT A.P. | | |
| TO BE LISTED | | | | | | | DRAFT AT F.P. | | |
| SEPARATELY | | | | | | | MEAN DRAFT | | |
| | | | | | | | TRIM BY | | |
| | | | | | | | $KM_T$ | | |
| | | | | | | | KG | | |
| | | | | | | | GM (Solid) | | |
| | | | | | | | FREE SURFACE CORRN | | |
| | | | | | | | GM FLUID | | |
| | | | | | | | HYDROSTATIC PROPERTIES | | |
| | | | | | | | $KM_T$ | | |
| | | | | | | | L.C.B. | | ℔ |
| | | | | | | | L.C.F. | | ℔ |
| | | | | | | | M.C.T. 1cm | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| DEADWEIGHT | | | | | | | | | |
| LIGHTSHIP | | | | | | | | | |
| DISPLACEMENT | | | | | | | | | |

1) ℔ Aft (-ive) or Fwd (+ive) of Amidships or may be given from A.P. if preferred.
2) ✓ Corrected for Specific Weight (see page 6)
3) ✓ Check appropriate condition.

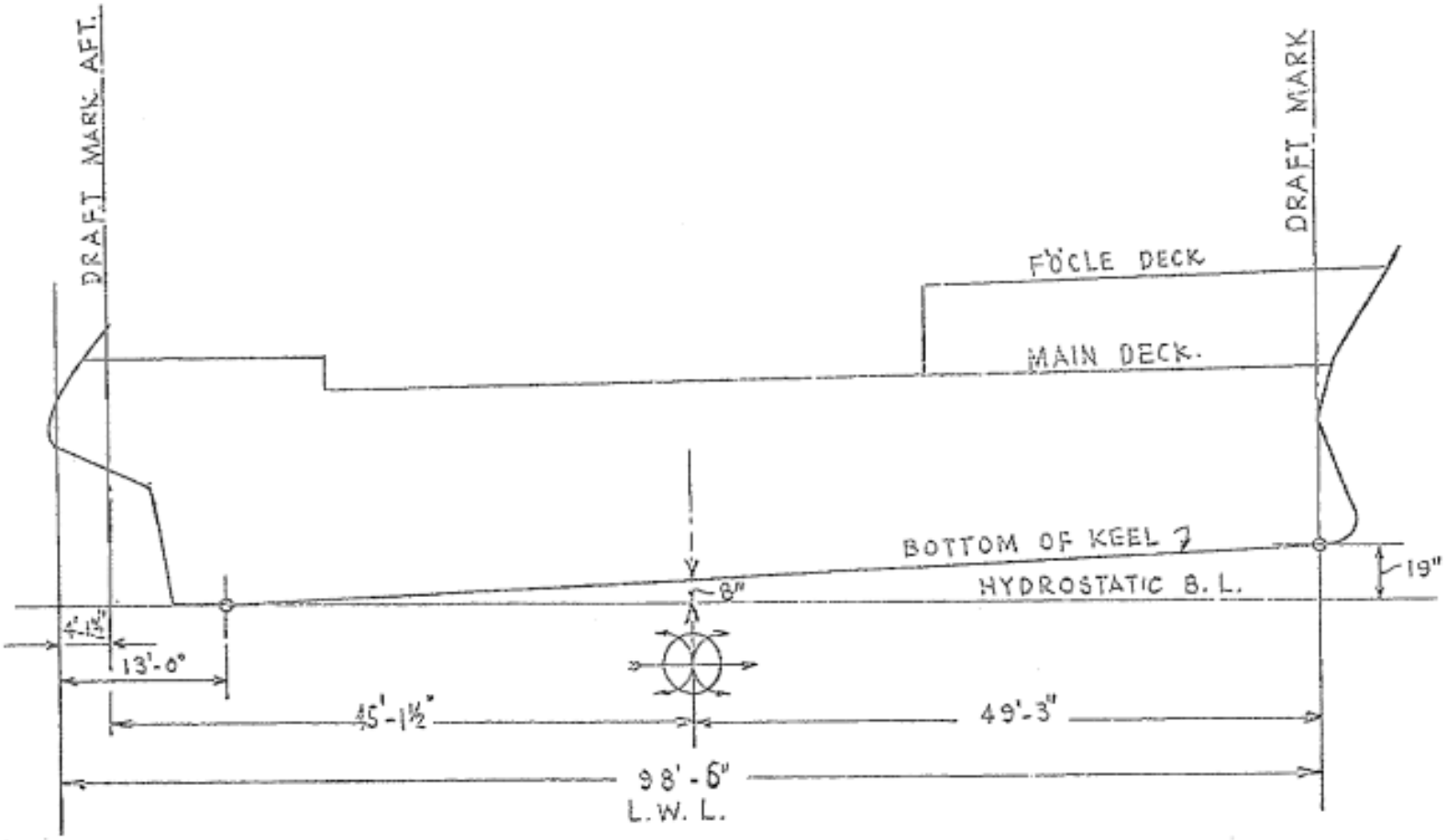
Source: Transport Canada, TP 7301 - Stability standards for fishing vessels

# *Appendix D – Typical condition sheet and stability curve*




Source: Transport Canada, TP 7301 - Stability standards for fishing vessels

## *Appendix E – Excerpts from* Caledonian *stability booklet*

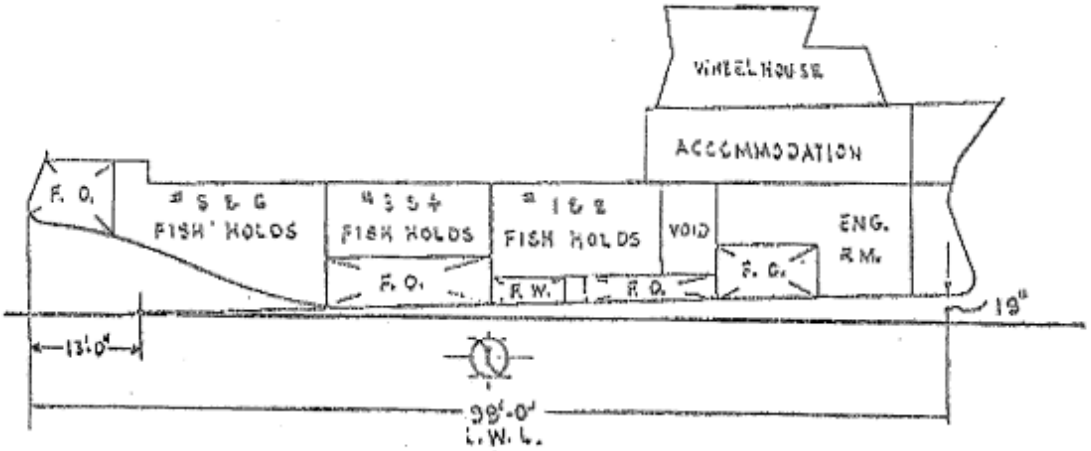



Source: Caledonian Holdings Inc.

# *Appendix E – Excerpts from* Caledonian *stability booklet*

| Vessel | Condition | |
|---|---|---|
| M.V. "CALEDONIAN" | No 5 | FULL LOAD - DEPARTURE FROM GROUNDS |

35% Fuel and Water




| Item | Wt. LT | K.G. | V.M. | L.C.G. | L.M. | F.S. |
|---|---|---|---|---|---|---|
| Fuel Oil Tank #3 & 4 | 0.89 | 2.70 | 2.4 | + 15.20 | + 14 | 10.2 |
| Fuel Oil Tank #5 & 6 | 18.97 | 4.50 | 85.4 | - 9.00 | - 171 | |
| Fuel Oil Tank #7 & 8 | | | | | | |
| Fresh Water D.B. P & S | 1.10 | 2.54 | 2.8 | + 3.80 | + 4 | 6.8 |
| Fish Tank #1 & 2 | 85.70 | 9.20 | 788.4 | + 9.00 | + 771 | |
| Fish Tank #3 & 4 | 58.57 | 10.30 | 603.3 | - 9.00 | - 527 | |
| Fish Tank #5 & 6 | 85.70 | 9.20 | 788.4 | + 28.00 | - 24 | 144.1 |
| Crew & Effects | 1.40 | 17.00 | 23.8 | + 24.00 | + 34 | |
| Provisions and Stores | 0.70 | 17.00 | 11.9 | + 24.00 | + 17 | |
| | | | | | | |
| | | | | | | |
| Lightship | 246.44 | 12.85 | 3166.6 | + 5.53 | + 1364 | |
| Total | 499.47 | 10.96 | 5473.0 | - 1.79 | - 894 | 161.1 |

| Displacement | 499.47 tons | Trim Moment | 175 ton-ft |
|---|---|---|---|
| Mean Draft Abv.B.L. | 12.00 ft. | M.C.T. 1" | 46.2 ton-ft |
| L.C.F. | - 3.80 ft. | Trim by head | 0.32 ft. |
| L.C.G. aft ℄ | - 1.79 ft. | Draft Aft | 11.85 ft. |
| L.C.B. aft ℄ | - 2.14 ft. | Draft Fwd | 10.59 ft. |
| B.G. | 0.35 ft. | | |

Source : Caledonian Holdings Inc.

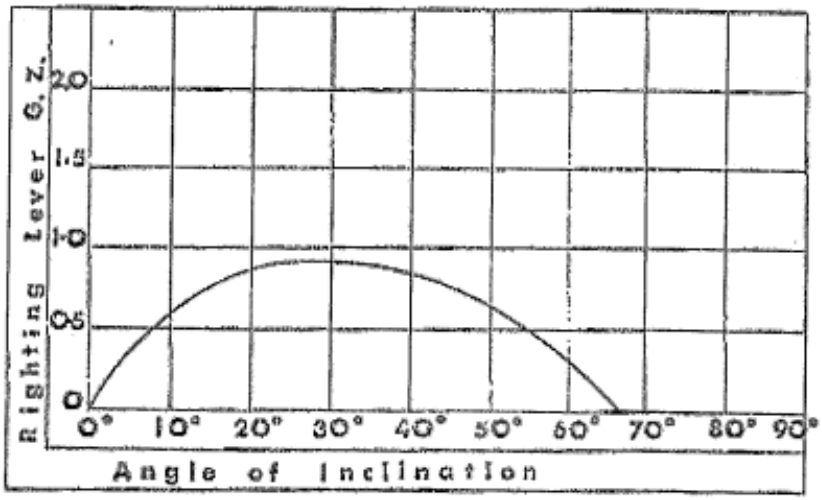
# *Appendix E – Excerpts from* Caledonian *stability booklet*

| Vessel | Condition | |
|---|---|---|
| M.V. "CALEDONIAN" | No. 5 | FULL LOAD - DEPARTURE FROM GOUNDS |
| | | 35% Fuel and Water |

| | | |
|---|---|---|
| K.M. | 14.91 | ft. |
| K.G. | 10.96 | ft. |
| G.M. | 3.95 | ft. |

| | | |
|---|---|---|
| Free Surface | 0.32 | ft. |
| K.G. corrected | 11.28 | ft. |
| G.M. corrected | 3.63 | ft. |

| Angle | 10° | 20° | 30° | 45° | 60° | 75° | 90° |
|---|---|---|---|---|---|---|---|
| Sin ⊙ | ·1737 | ·342 | ·5 | ·6428 | ·866 | ·9659 | 1·00 |
| KN sin ⊙ | 2.56 | 4.73 | 6.66 | 8.75 | 10.10 | 10.67 | |
| $KG_c$ sin ⊙ | 1.96 | 3.86 | 5.64 | 7.98 | 9.77 | 10.90 | |
| G Z | 0.60 | 0.87 | 0.91 | 0.77 | 0.33 | -0.23 | |




| Area under curve to 30° | | | |
|---|---|---|---|
| angle | G.Z. | S.M. | f.A |
| 0 | 0 | 1 | 0 |
| 10 | 0.60 | 3 | 1.80 |
| 20 | 0.87 | 3 | 2.61 |
| 30 | 0.91 | 1 | 0.91 |
| | | Σ f A | 5.32 |
| Area | $\frac{1}{3}$ x 10 x 5.32 = | | 19.95 |

| Area under curve to 40° | | | |
|---|---|---|---|
| 0 | 0 | 1 | 0 |
| 10 | 0.60 | 4 | 2.40 |
| 20 | 0.87 | 2 | 1.74 |
| 30 | 0.91 | 4 | 3.64 |
| 40 | 0.84 | 1 | 0.84 |
| | | Σ f A | 8.62 |
| Area | $\frac{1}{3}$ x 10 x 8.62 = | | 28.73 |

Source : Caledonian Holdings Inc.

# *Appendix F – TSB stability assessment of the* Caledonian

| Condition number | Lightship weight* | Load distribution** | | Effect of bulwark on buoyancy taken into account | Water on deck port (p) or starboard (s) (feet) | Heel to port (p) or starboard (s) (degrees) | Minimum freeboard (feet) | Comparison with TP 7301 criteria 1 to 6 (percentage)*** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fuel/ freshwater | Fish/ seawater | | | | | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | Occurrence | Occurrence | Occurrence | No | 0.0 | - | - | - | - | - | - | - | - |
| 2 | Occurrence | Occurrence | Occurrence | Yes | 0.0 | 5.47 p | -1.10 | 138 | 143 | 177 | 132 | 152 | 230 |
| 3 | Occurrence | Occurrence | Occurrence | Yes | 1.5 p/s | 6.21 p | -2.00 | 87 | 87 | 87 | 80 | 137 | 195 |
| 4 | Occurrence | Occurrence | Occurrence + fish on deck | No | 0.0 | - | - | - | - | - | - | - | - |
| 5 | Occurrence | Occurrence | Occurrence but with holds 3 and 4 empty | No | 0.0 | 1.92 p | 0.46 | 63 | 47 | 25 | 39 | 59 | 217 |
| 6 | Occurrence | Occurrence | Booklet | No | 0.0 | 1.52 p | -0.15 | 39 | 33 | 26 | 23 | 46 | 257 |
| 7 | Occurrence | Booklet | Booklet | No | 0.0 | 2.35 p | 0.00 | 97 | 88 | 84 | 70 | 129 | 253 |
| 8 | Occurrence | Booklet | Occurrence | No | 0.0 | 9.51 p | -1.79 | 8 | 4 | - | 3 | 67 | 223 |
| 9 | Occurrence | Occurrence | Occurrence | Yes | 2.5 p/s | 6.29 p | -2.51 | 67 | 63 | 66 | 58 | 125 | 203 |
| 10 | Occurrence | Occurrence | Occurrence | Yes | 3.0 p/s | 6.01 p | -2.67 | 60 | 55 | 55 | 50 | 120 | 210 |
| 11 | Booklet | Occurrence | Occurrence | No | 0.0 | 3.70 p | -0.38 | 27 | 18 | 4 | 12 | 48 | 237 |
| 12 | Booklet | Booklet | Occurrence | No | 0.0 | 4.53 p | 0.29 | 78 | 68 | 62 | 59 | 87 | 231 |
| 13 | Booklet | Booklet | Occurrence but with holds 3 and 4 empty | No | 0.0 | 0.00 | 1.92 | 180 | 161 | 152 | 129 | 110 | 227 |
| 14 | Booklet | Booklet | Booklet | No | 0.0 | 0.00 | 1.42 | 181 | 163 | 156 | 124 | 140 | 265 |
| 15 | Booklet | Occurrence | Booklet | No | 0.0 | 0.82 s | 0.47 | 132 | 112 | 94 | 82 | 71 | 268 |
| 16 | Booklet | Occurrence | Occurrence | Yes | 0.0 | 3.51 p | -0.21 | 184 | 189 | 230 | 164 | 160 | 238 |
| 17 | Occurrence | Occurrence | Occurrence | Yes | 1.5 p | 10.37 p | -2.58 | 66 | 75 | 105 | 85 | 150 | 214 |
| 18 | Occurrence | Occurrence | Occurrence | Yes | 2.5 p | 13.62 p | -3.56 | 32 | 41 | 65 | 56 | 149 | 207 |
| 19 | Occurrence | Occurrence | Occurrence | Yes | 3.0 p | 15.87 p | -4.24 | 19 | 28 | 49 | 42 | 149 | 214 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | Occurrence | Occurrence | Occurrence | Yes | 2.0 p | 11.94 p | -3.05 | 48 | 57 | 84 | 70 | 150 | 210 |
| 21 | Occurrence | Booklet | Occurrence | Yes | 2.0 p | 13.23 p | -2.74 | 55 | 71 | 112 | 94 | 158 | 206 |
| 22 | Occurrence | Occurrence | Booklet | Yes | 2.0 p | 7.38 p | -1.86 | 113 | 122 | 159 | 120 | 160 | 239 |
| 23 | Occurrence | Occurrence | Occurrence but with holds 3 and 4 empty | Yes | 2.0 p | 9.17 p | -1.61 | 90 | 101 | 138 | 109 | 153 | 199 |

* The lightship weight at the time of the occurrence (Occurrence) or at the time the stability booklet was issued (Booklet)

** The load distribution used in the condition calculation was either the distribution at the time of the occurrence (Occurrence) or as assumed in the stability booklet for the full load condition (Booklet)

*** A percentage greater than 100 indicates that the criterion was exceeded.

# *Appendix G – Effects of operational practices on stability*

| Calculation of stability using the following conditions | Summary of results under these conditions (see Appendix C) | Condition number (see Appendix F) |
|---|---|---|
| 1976 lightship + assumed weights for a full load condition from the stability booklet<br>(This is the original stability calculation from 1976.) | All 6 criteria are satisfied | 14 |
| 1976 lightship + 2015 estimated weights for fuel/fresh water + assumed fish/SW weights from the stability booklet<br>(This reflects the change in weight resulting from fuel/freshwater system reconfiguration.) | 3 of 6 criteria are satisfied; remaining criteria attained values 71 to 94% of required | 15 |
| 1976 lightship + assumed fuel/freshwater weights from the stability booklet + estimated 2015 weight of fish/SW<br>(This reflects the change in weight from fish/seawater loading practices.) | 1 of 6 criteria is satisfied; remaining criteria attained values 59 to 87% of required | 12 |
| 1976 lightship + estimated 2015 weight of fuel/freshwater and fish/SW<br>(This reflects changes in weight from both fuel/freshwater reconfiguration and fish/seawater loading practices.) | 1 of 6 criteria is satisfied; remaining criteria attained values of 4 to 48% of required;<br>with bulwark included, all criteria are exceeded | 11/16 |
| 2015 lightship + assumed weights for a full load condition from the stability booklet<br>(This is the estimated lightship weight with no changes to operating practices.) | 2 of 6 criteria are satisfied; remaining criteria attained values 70 to 97% of required | 7 |
| 2015 lightship + estimated 2015 weight of fuel/freshwater + assumed fish/SW weights from the stability booklet<br>(This reflects the change in weight resulting from fuel/freshwater system reconfiguration.) | 1 of 6 criteria is satisfied; remaining criteria attained values 26 to 46% of required | 6 |
| 2015 lightship + assumed fuel/freshwater weights from the stability booklet + estimated 2015 weight of fish/SW<br>(This reflects the change in weight from fish/seawater loading practices.) | 1 of 6 criteria is satisfied; remaining criteria attained values 0 to 67% of required | 8 |
| 2015 lightship + estimated 2015 weight of fuel/freshwater and fish/SW<br>(This reflects changes in weight from both fuel/freshwater reconfiguration and fish/seawater loading practices.) | Loss of stability; with bulwark included in vessel buoyancy, all criteria are exceeded | 1/2 |