

MARINE OCCURRENCE REPORT

M97W0236

SINKING

“PACIFIC CHARMER”

SMALL FISHING VESSEL

PYLADES CHANNEL,

OFF VANCOUVER ISLAND, BRITISH COLUMBIA

02 DECEMBER 1997



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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Synopsis

In the early hours of 02 December 1997, while bringing on board the final haul of a herring trawling voyage, the small fishing vessel “PACIFIC CHARMER” slowly heeled to starboard before downflooding and sinking in about 55 metres of water in Pylades Channel, B.C. The sea and weather conditions at the time were calm. Two of the vessel’s crew and a Department of Fisheries and Oceans observer were rescued. The remaining two crew members succumbed to hypothermia and drowning.

The vessel initially heeled to starboard because her intact transverse stability had been reduced by the cumulative detrimental effects of the weight of additional and spare fishing gear; asymmetric loading; free surface effects of liquids in partially filled tanks and fish holds; and fish waste water retained on deck. The dynamic effects of the weight of the trawl net cod-end being briefly suspended from a winch located above the wheel-house caused a sudden rise in the vessel’s virtual centre of gravity. In conjunction with the initial small heel to starboard, the dynamic effects were such that the vessel heeled further to starboard and remained briefly at an angle of about 40 degrees. Seawater shipped at this time downflooded through open weathertight doorways until all reserve buoyancy was lost and the “PACIFIC CHARMER” sank.

Ce rapport est également disponible en français.

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1.0 *Factual Information*

1.1 *Particulars of the Vessel*

	"PACIFIC CHARMER"
Official Number	810484
Port of Registry	Vancouver, B.C. ¹
Flag	Canada
Type	small fishing vessel
Gross Tons ²	141.8
Length	18.67 m
Built	1988, Vancouver, B.C.
Propulsion	Caterpillar marine diesel engine, 855 brake horsepower
Cargo	herring, in bulk
Crew	4 (and one observer)
Owners	Ritchie Fishing Co., Ltd.

1.1.1 *Description of the Vessel*

The "PACIFIC CHARMER" was built in 1988 as a small fishing vessel of closed construction, with an all-welded steel, multi-chine hull form and a transom stern incorporating a central sloped fish-loading ramp. The hull below the main deck is sub-divided by three transverse watertight bulkheads, and arranged into three pairs of insulated fish holds located symmetrically either side of a centre-line shaft tunnel, as shown in the "Outline General Arrangement" (Appendix A1). The vessel is powered by a marine diesel engine with a reduction gearbox driving a single controllable-pitch propeller in a fixed Kort nozzle, and is fitted with three high-aspect-ratio, high-efficiency linked rudders.

The vessel is equipped for mid-water and bottom trawling operations, with three nets on storage drums and two trawl doors (otter boards) located at the after end of the main deck, two trawl winches near amidships, and a 3.5-ton safe working load (SWL) loading boom on the centre line. A hydraulically driven net-hauling winch capable of 10 tons' pull is fitted on the after side of the main mast, above the level of the wheel-house top. A control station for the operation of the main engine, propeller pitch, rudders, the loading boom and its winches,

¹ See Glossary at Appendix C for all abbreviations and acronyms.

² Units of measurement in this report conform to International Maritime Organization (IMO) standards or, where there is no such standard, are expressed in the International System (SI) of units.

etc., is located at the after starboard corner of the wheel-house, having a clear view of the working area at the after end of the main deck.

Also installed in the wheel-house is a comprehensive outfit of navigation and communication equipment that includes two radar sets, a video plotter, very high frequency (VHF) radios, Loran C, global positioning system (GPS), autopilot and depth echo-sounders.

1.1.2 Life-saving Equipment on the Vessel

The "PACIFIC CHARMER" carried an outfit of equipment in excess of that required by the *Life Saving Equipment Regulations* of the *Canada Shipping Act*. The vessel was equipped with two inflatable liferafts, capable of accommodating six persons each, two lifebuoys, nine lifejackets, smoke signals and flares. The two inflatable liferafts and a four-person rigid fibreglass boat were stowed on the wheel-house top.

An emergency position-indicating radio beacon (EPIRB) capable of transmitting emergency signals on 121.5 MHz and 406 MHz was stowed outside the wheel-house, and arranged to float free and automatically activate in the event of the vessel sinking. It was reported that another EPIRB was stowed in the master's cabin for safekeeping.

Although not a mandatory requirement of the *Canada Shipping Act*, the Workers' Compensation Board (WCB) of British Columbia requires all fishing vessels to carry one immersion suit for each crew member. At the time of the sinking, five immersion suits were on board and stowed in the crew accommodation area.

1.2 History of the Voyage

With a crew of four, the "PACIFIC CHARMER" departed North Vancouver, B.C., on 30 November 1997 to participate in the food and bait herring fishery off the east coast of Vancouver Island. A near-sister ship operated by the same owners, the "ARCTIC OCEAN", also left to engage in the fishery and carried a Department of Fisheries and Oceans (DFO) observer.

The vessels rendezvoused and fished for herring on December 1 in Pylades and Stuart Channels, which are off the southeastern coast of Vancouver Island. However, before taking her allotted catch of 50 short tons of herring, the "ARCTIC OCEAN" damaged her trawl net when it fouled a log during the first night of fishing. The DFO observer transferred to the "PACIFIC CHARMER" before the "ARCTIC OCEAN" returned to Vancouver, B.C.

DFO regulations allow another vessel to load the untaken quota of a disabled vessel, and the “PACIFIC CHARMER” decided to catch an additional 30 short tons over and above its allotted quota, to compensate for the loss of the catch by the “ARCTIC OCEAN”. On the evening of December 1 the “PACIFIC CHARMER” continued fishing and by the early morning of December 2 had approximately 80 short tons of herring on board, together with preservation ice and water.

When the last trawl set was hauled close-to and secured at the stern and part of the catch was being hauled on board, the after deck was briefly immersed some 10 to 15 cm, due to the suddenly imposed trimming moment and the vessel’s existing after trim. However, the shipped water was soon cleared through the freeing ports and stern ramp, and positive freeboard was restored.

While the crew attended to the handling of the cod-end and the stowage of herring into the half-full No. 1 port and starboard fish holds, steerage-way was maintained at a relatively slow speed. Reportedly, shortly after the cod-end was hauled on board and a proportion of its weight temporarily suspended from the hauling winch above the wheel-house top, the vessel was slowly circling to port. At about this time she started to heel gradually to starboard and continued until an angle of some 40 degrees was attained.

The angle of heel then continued to increase and the crew and the DFO observer quickly abandoned the overturning vessel as it started sinking. They did not have time to enter the accommodation area to retrieve survival gear or to broadcast a distress message. The DFO observer was wearing an inflatable personal flotation device over his clothing, which he inflated orally upon entering the water. The remainder of the crew wore only the jeans and sweat shirts in which they had been working.

An attempt by two crew members to launch the port side inflatable liferaft was unsuccessful, and its damaged stowage container was subsequently found with the sunken vessel. The other liferaft floated free and inflated automatically as the vessel sank; however, its painter fouled the vessel’s rigging and it was later found afloat, partially inflated and inverted, still secured to the sunken vessel. None of the survivors boarded the inverted liferaft, which was sighted by the Canadian Coast Guard (CCG) Search and Rescue (SAR) hovercraft as it arrived on scene.

1.2.1 Flooding and Sinking Sequence

As the vessel heeled, the contents of the partially full fuel, service and fresh water tanks and fish holds gravitated to starboard. The motion of the fish and waste water retained on deck; the motion in the tanks and holds; and the seawater that was suddenly shipped when the starboard side deck edge and bulwark rail became immersed all combined to increase the initial heeling moment and roll energy, and retarded the onset of the vessel’s recovery.

While the “PACIFIC CHARMER” remained briefly heeled at approximately 40 degrees to starboard, shipped seawater entered the crew accommodation area in the enclosed forecabin, downflooded into the engine-room through open weathertight doors on the main deck, and also downflooded into the No. 1 starboard fish hold

through its open fish-loading manhole. All of the shipped seawater entering the hull then quickly gravitated to starboard, increased the angle of heel, and prevented the vessel's recovery.

A bilge water "high level" automatic alarm was installed in the vessel's engine-room; however, none of the surviving crew members was able to recall hearing any sound of the warning alarm prior to or during the abandonment of the vessel.

As the downflooding continued, the seawater accumulated predominantly on the starboard side of the engine-room and in the shaft tunnel, before entering the lazaret by way of its unsecured watertight door. Consequently, the flooding became generally progressive and continued until all reserve buoyancy was lost and the vessel sank.

1.2.2 Search and Rescue Response

The EPIRB from the "PACIFIC CHARMER" started transmitting automatically shortly after the vessel sank, and its 406 MHz emergency signal was received from a high-altitude geostationary environmental satellite by the Canadian Mission Control Centre (CMCC) in Trenton, Ontario, at 0132, Pacific standard time (PST) on December 2.³ The EPIRB's signal was identified by reference to EPIRB registration records, and the related EPIRB ownership details were faxed to, and received by, the Rescue Coordination Centre (RCC) in Victoria, B.C., at 0139. Acting on the EPIRB ownership data, RCC telephoned the owners of the EPIRB and verified the identity of the "PACIFIC CHARMER" together with her current general operating area.

The owners then contacted and informed the "ARCTIC OCEAN" of the possible emergency situation; both made subsequent attempts to contact the "PACIFIC CHARMER" directly by radio, but were unsuccessful. Further efforts by the "ARCTIC OCEAN" to contact or locate the "PACIFIC CHARMER" by way of another fishing vessel known to have been in the general fishing area earlier that evening were also unsuccessful. Reportedly, the "VICISLE" declined to attempt local radio contact with the "PACIFIC CHARMER", concluding that a radio watch on that vessel would have already overheard their present communication. The "VICISLE" also reported that no fishing illumination or vessel steaming lights were then in sight, and that she was about to leave the area.

³ All times are PST (Coordinated Universal Time (UTC) minus eight hours) unless otherwise noted.

EPIRB-initiated 121.5 MHz signals from low-altitude, polar-orbiting satellites (COSPAS-SARSAT) were received by CMCC at 0144 and 0151 and relayed to RCC Victoria at 0146 and 0152, respectively. These additional signals enabled a more precise occurrence location to be established and corroborated the general location information obtained from the vessel's owners. In view of concurrent but unsuccessful attempts by RCC to contact the "PACIFIC CHARMER" by radio, on emergency channel 16, the SAR primary response was initiated.

The time required to determine an accurate occurrence location depends on the relative location of the satellites at the time of the occurrence. CMCC and RCC operational experience over several years has determined that the average time from the initial detection an EPIRB emergency signal to the determination of the vessel's position is some 42 minutes.

The SAR hovercraft at the CCG base on Sea Island, Richmond, B.C., was tasked at 0155, dispatched, and designated on-scene commander at 0200. It proceeded toward the area of the occurrence, homing on the 121.5 MHz locator signal of the EPIRB. At 0205 the CCG lifeboat 701 (on stand-by at Ganges, B.C.) was paged, the coxswain briefed, and the vessel tasked to proceed toward the area of the occurrence.

A United States Coast Guard (USCG) SAR helicopter based at Port Angeles, Washington, was contacted at 0202 and airborne by 0229. CCG auxiliary vessels at Nanaimo and Cowichan and several commercial and other private craft were subsequently contacted by RCC or became aware of the occurrence as they monitored the emergency radio transmissions and proceeded to the scene as the response developed and the location of the occurrence become more precisely identified. The 442 Squadron at Canadian Forces Base Comox was contacted. Helicopter R316 and the fixed-wing aircraft R457 were tasked at 0332 and participated in the search operations.

The CCG SAR hovercraft reached the scene of the occurrence at 0255, sighted some floating debris and the unoccupied inverted liferaft as it homed on the EPIRB 121.5 MHz signal. The hovercraft sighted and picked up a crew member at 0303 and, at 0309, the DFO observer, who was nearby and holding the EPIRB. At 0322 the hovercraft recovered a second crew member from the shore of Valdez Island where he had swum to safety while partially supported by buoyant debris. The two crew members were conscious but required immediate treatment for hypothermia. The DFO observer was unconscious when recovered from the sea and was revived by prompt medical attention from the hovercraft personnel.

At 0333 the USCG helicopter located a third crew member face down in the water, who was found to be unconscious and could not be revived on recovery by the CCG SAR hovercraft at 0348, nor while being transported to Ladysmith, B.C., with the three survivors. CCG lifeboat 701 assumed the role of on-scene commander until the return of the CCG SAR hovercraft from Ladysmith, and subsequently coordinated air and waterborne, barrier and shoreline searches by CCG auxiliary, private and commercial vessels as they arrived on-scene.

The body of the fourth crew member, found floating face down in the water between some logs, was recovered by a commercial vessel at 0648, transferred to the SAR hovercraft and subsequently transported to shore. A

commercial fishing vessel recovered the unoccupied inflated liferaft of the “PACIFIC CHARMER” some time before dawn, and subsequently returned it to the owners.

1.3 Stability of the Vessel

1.3.1 Regulatory Stability Requirements

As a small fishing vessel of closed construction built after July 1977, and intended for operation in the herring or capelin fisheries, the “PACIFIC CHARMER” was required to comply with the intact stability requirements of Section 29 of Part 1 of the *Small Fishing Vessel Inspection Regulations*. Stability approval, given 17 January 1989, was based on the submitted data meeting the minimum criteria of the *Stability, Subdivision & Load Line Standards*, STAB 4, as detailed in CCG publication TP 7301E.

The stability data submitted for approval related to the vessel when engaged in the transportation of herring in bulk, with all fish holds pre-filled with preservation ice and seawater. Consequently, approval was implicitly related to the herring packing operation only. Not submitted for approval was stability data incorporating the additional weight of fishing nets, gear, trawl doors, etc., required when catching herring.

Current regulations are such that trim and stability conditions do not require approval when small fishing vessels are fully rigged for fishing species other than herring or capelin, nor is there any regulatory requirement to forward such data to Transport Canada (TC) for safety review or information purposes.

1.3.2 Loading, Trim and Stability on Departure

On departure, the vessel was outfitted for various fish-trawling operations, with one mid-water trawl and two bottom trawl nets stowed on three powered storage drums at the after end of the weather deck. Two trawl fishing doors (otter boards) were secured in the port and starboard fishing gallows near the stern. The main boom was topped up at approximately 40 degrees to the horizontal and secured on the fore-and-aft centre line.

The fishing trip was planned to catch a herring quota of 50 short tons. Prior to departure the vessel loaded 3,926 gallons (17,863 L) of diesel fuel in the after fuel tanks, which was in addition to some 2,500 gallons (11,375 L) already in the fuel tanks in the engine-room. One thousand gallons (4,550 L) of fresh water was taken on board, as were some three to four tons of

preservation ice in each of the four foremost fish holds. The precise contents of other oil and service tanks were not recorded; however, they were all reportedly at their normal working levels and the usual ship spares, stores and crew effects were also on board.

When observed shortly before departure, the vessel's freeboard, draughts and trim were regarded as normal but were not recorded. Due to conflicting reports, it is not known whether water ballast was in the forepeak tank at that time.

Post-casualty calculations of the vessel's trim and stability on departure (without seawater ballast in the forepeak tank) show the "PACIFIC CHARMER" would have been trimmed approximately 0.91 m by the stern and that she would have met all of the minimum criteria of STAB 4. With the forepeak tank filled with seawater ballast, the vessel's after trim would have been approximately 0.38 m, and all but one of the stability criteria would have been met (only the maximum righting lever would have been marginally below the minimum regulatory requirement).

1.3.3 Loading, Trim and Stability While Fishing

The vessel's quota of 50 short tons of herring was, with the acknowledgement of an on-board DFO observer, increased to compensate for the part of the quota not taken by the "ARCTIC OCEAN", a nearby disabled vessel from the same fishing company. It was reported that when a total of 80 short tons of herring had been taken on board the "PACIFIC CHARMER", the four foremost fish holds were filled with herring, preservation ice and seawater up to the level of fish-loading manholes in the hatch coamings, and their watertight manhole covers were then secured. The after pair of fish holds were approximately half full of fish and preservation water. The fish-loading manholes of these hatch coamings were left open, ready to receive the last haul of herring.

With the forepeak tank filled with water ballast at this time, the vessel's stability characteristics generally met the regulatory criteria, except for the maximum righting lever, which would then have been approximately 78.5 percent of the minimum regulatory requirement.

1.3.4 Loading, Trim and Stability Prior to Sinking

The last fishing set caught an estimated 15 to 18 short tons of fish. The trawl net was hauled and secured at the stern before tying off the cod-end, which contained some 10 short tons of herring. As the cod-end was being hauled on board, the weight of its inboard end was temporarily suspended from the hauling winch on the main mast, while its after end was resting on the deck. The weight of the hauled-home and partially suspended cod-end, together with its waste water drainage, reduced the freeboard, increased the after trim, briefly raised the vessel's virtual centre of gravity and suddenly reduced the transverse stability.

The reduction of stability was such that the maximum righting lever was then 50 percent of the regulatory minimum, which was reached at 20 degrees in lieu of the regulatory minimum of 30 degrees heel angle.

With the forepeak tank filled with water ballast at this time, all principal dynamic stability characteristics were significantly lower than the regulatory minimum criteria, and the range of positive stability was reduced to some 49 degrees.

1.3.5 Loading, Trim and Stability at Time of Sinking

The transverse weight imbalance—due to the deployment of the mid-water trawl from the port-side net drum—induced a slight heel to starboard. Consequently, the seawater draining from the newly hauled cod-end, the fishing detritus and the overflow of fish holds topping-up water (from the continuously running wash deck pump) tended to gravitate to the starboard side of the deck. The free surface effects of these transitory and relatively small accumulations of water caused the vessel's virtual centre of gravity to fluctuate and to rise significantly. The generally off-centre locations of these accumulations of water also increased the inherent starboard heel.

The static upright mean freeboard was such that the main deck edge would become immersed at 7.15 degrees angle of heel; however, due to the asymmetrical distribution of the trawl nets and of the seawater retained on deck, the effective static angle of deck edge immersion on the starboard side was reduced to some 3.9 degrees.

The quantity and distribution of the water fluctuated, being retained on deck before completely draining through the bulwark freeing ports. However, post-occurrence calculations based on a conservative allowance of a nominal 5 cm (2 in) deep layer on the starboard side, in conjunction with the concurrent free surface effects of the partially filled No. 1 (port and starboard) fish holds and after oil fuel tanks, show that the vessel's transverse initial and dynamic stability characteristics were markedly reduced.

At this time, the maximum righting lever was approximately 32 percent of the regulatory minimum criteria and was reached at about 17 degrees angle of heel instead of the required 30 degrees. Furthermore, the vessel's range of positive transverse stability was then some 37.5 degrees, having deteriorated from the range of 65 degrees on departure.

None of the regulatory minimum dynamic stability criteria was attained (irrespective of whether the forepeak tank was empty or filled with water ballast at this time). Initial stability was suddenly reduced when one end of the cod-end was suspended from the winch above the wheel-house top. Concurrently, the vessel's transverse stability was subject to fluctuation due to

varying free surface effects. The vessel's watertight integrity was compromised by unsecured watertight doors and fish-loading manholes above the main deck. The cumulation of these detrimental effects placed the "PACIFIC CHARMER" in a highly vulnerable condition.

1.4 Damage

1.4.1 Damage to the Vessel

The vessel remained submerged for nearly one month before recovery. There was significant salt water contamination damage to the machinery, the fuel and hydraulic piping systems, the electrical services, the insulation of fish holds and the accommodation fittings.

During the salvage operations the main deck port and starboard bulwarks and top rails were damaged and buckled inboard in way of the salvage lifting-sling attachments; the watertight integrity of the hull was not breached below the level of the main deck.

The recovered vessel was towed from the scene of the sinking to Richmond, B.C.

1.4.2 Damage to the Environment

No major oil pollution was reported. A minor slick caused by diesel fuel oil escaping from the vessel's tanks was contained during the morning after the sinking. The part of the herring catch released as the vessel sank was soon dispersed by tidal effects.

1.4.3 Condition of the Vessel on Recovery

Based on photographic and video-taped records of the vessel during the salvage and recovery operations, interviews and discussions with salvors and survivors, and subsequent inspections of the recovered vessel, the following occurrence-related items were noted:

- a) The sunken vessel was initially found lying bow down and partially buried in the sea bed, listed to starboard, and resting on the bottom shell and chine at the starboard turn of bilge.
- b) The watertight integrity of the hull shell, stern-tube bearing, rudder trunk bearing, sea-suctions and transducer penetrations, etc., were intact, and revealed no source of ingress for flood-water prior to the occurrence.
- c) The electrically operated triple-rudder angle indicator located at the wheel-house control station showed 19 degrees port helm was applied when power was lost as the vessel was sinking.
- d) The ship's electric clock in the wheel-house was found to have stopped at 0130.

- e) Fish-loading deck scuttles and watertight manholes in the hatch coamings of fish holds No. 2 and No. 3 were secured. The hatch covers were in place but unsecured.
- f) Fish-loading deck scuttles of No. 1 fish holds (port and starboard) were secured; however, the main hatch covers and fish-loading manhole covers in the hatch coamings were not in place.
- g) The 3.5-ton SWL loading boom, which was found by the divers to be secured on the centre line and topped up at an angle of approximately 40 degrees, was subsequently raised to the mast head to provide clearance for the lifting slings during the salvage operation.
- h) The engine-room and crew accommodation weathertight access doors located above the main deck were found hooked in the open position.
- i) The watertight door at the after end of the shaft tunnel giving access to the lazaret and steering gear compartment was found to be secured open with a synthetic rope lashing.
- j) The mid-water trawl net was partially deployed from the port side storage drum and its partially filled cod-end, initially found on deck and rigged to the hauling winch on the wheel-house top, was subsequently triced up to the mast head together with the loading boom, to provide clearance for the lifting slings during the salvage operation.
- k) Bottom trawl nets and related fishing gear were fully wound and secured on the centre and starboard side storage drums at the after end of the main deck.
- l) Spare net twine and other fishing gear were found stored in the lazaret, on the top of the wheel-house and also secured to the port side rails of the forecastle deck.
- m) The wash deck discharge hose, used to clear fishing detritus and to top up the preservation water in the fish holds, was found rigged on the main deck, as were four fish-storage tote boxes and other spare fishing equipment.
- n) The trawl fishing doors (otter boards) were found secured to the port and starboard trawling gallows at the after end of the main deck.
- o) The steel wire trawl warps were fully wound on the main trawl winches at midships. Sundry fishing equipment, ropes and other gear were found stowed on the main deck. An extensive outfit of tools and additional spares were located the engine-room.
- p) A damaged inflatable liferaft container, which was partially entangled in ship's rigging on the main deck, remained on the sea bed as the vessel was recovered.

Post-casualty analysis of the vessel's stability characteristics (prior to, immediately before and during the sinking) incorporates the weights, trimming and other effects of the casualty-related items reported during the diving operations, and as found when the vessel was recovered and brought to the surface.

1.5 *Injuries to Persons*

	Crew	Passengers	Others	Total
Fatal	2	-	-	2
Missing	-	-	-	-
Serious	-	-	-	-
Minor/None	2	-	1	3
Total	4	-	1	5

1.6 *Vessel Certification*

The "PACIFIC CHARMER" was inspected by the Ship Safety Branch of Transport Canada (now known as Marine Safety) on 16 January 1995, at North Vancouver. A Safety Inspection Certificate (SIC) 29, for operation as a Home Trade Class II Vessel, was issued for a full four-year term, and was due to expire 15 January 1999.

1.7 *Personnel*

1.7.1 *Crew Certification and History*

The deceased master of the "PACIFIC CHARMER" held half ownership of the vessel and had some 35 years of fishing experience, the last 9 years of which were with the "PACIFIC CHARMER".

Under Section 109, Part II, Chapter S-9 of the *Canada Shipping Act*, a fishing vessel over 100 gross registered tons (GRT), requires a master having at least a Class 3 Fishing Master's certificate. The "PACIFIC CHARMER" is of 141.8 GRT and, at the time of the occurrence, the master did not hold such a certificate. He had previously operated the vessel under an exemption, which expired in 1992.

The deceased crew member had extensive fishing experience and, reportedly, had in the past operated vessels as a fishing master. However, at the time of this occurrence, he was working as a crew member on the "PACIFIC CHARMER".

The two surviving crew members were not required to be certificated. Most of their fishing experience was gained on the east coast of Canada, prior to their recent move to the west coast. Neither had previously been engaged in fishing for herring. One of them held a Fourth Class Marine Engineer's certificate.

1.7.2 Fisheries Observer

The observer attending on behalf of the DFO had worked intermittently on herring packers since retiring from his full-time post with the Department of Fisheries and Oceans. Although representing the DFO on the "ARCTIC OCEAN" and "PACIFIC CHARMER", he was employed by the owners of these vessels. He has no marine operating certification nor is any required by regulation.

1.7.3 Duties of Fisheries Observer

The "Conditions of 1997 Herring other than Roe Herring Licence," promulgated by the DFO, include a number of conditions pursuant to subsection 22(1) of the *Fishery (General) Regulations*. These conditions include details of the species, quantity of fish permitted to be taken, quota overage conditions, waters in which fishing is permitted, period during which fishing is to be carried out, fishing gear permitted and other related information for the guidance of the masters of participating vessels.

The conditions also include guidelines for the observer, indicating that his main functions are to monitor the catching, handling and landing of the herring—and to document these activities. The observer is required to provide DFO with a summary of the total landed tonnage, an estimation of the fish size, and a biological sample of the herring caught. In practice, the observer does not have a say in the tonnage of herring transferred from one vessel to another but simply observes and records the transfer.

1.8 Weather Conditions

The weather conditions reported at the time of the occurrence were calm with an air temperature of 10°C. A seawater temperature of 6.6°C was recorded on site shortly after the sinking.

2.0 *Analysis*

2.1 *Loading, Trim and Stability Analysis*

Compliance with the minimum stability criteria of STAB 4 ensures that small fishing vessels maintain what are generally recognized as adequate margins of intact transverse stability throughout a range of standard loading conditions related to the vessel's intended service. The regulatory criteria are such that the margin of intact stability they provide ensures that the vessel is able to withstand and recover from severe weather and other detrimental influences generally to be expected in routine operation.

The standard loading conditions incorporate stores, spares, consumables and fish catch loads and configurations envisaged during a typical voyage, and provide a basis for the assessment of the many other combinations that may be adopted in service. However, compliance with the stability criteria does not ensure immunity against capsizing regardless of the circumstances. It is the master's responsibility to exercise prudence and good seamanship to ensure that the vessel's watertight integrity and adequate stability are maintained at all times. Furthermore, it is the responsibility of the owners to ensure the stability data submitted for approval accurately reflect the vessel's loading conditions and modes of operation.

The trim and stability data submitted for approval were comprised of loading conditions specifically related to herring packing operations when the vessel was not outfitted with trawl nets, trawl fishing doors and spare fishing gear. At the time of the occurrence the "PACIFIC CHARMER" was engaged in catching herring and her stability characteristics were detrimentally affected by the additional weight of fishing gear located above and at the after end of the main deck. This additional weight raised the vessel's inherent centre of gravity. Furthermore, the effective freeboard, trim, and intact stability were also adversely affected by the carriage of additional and spare fishing gear in the lazaret and on the main deck, forecastle deck rails and wheel-house top.

On departure, the freeboard and trim of the "PACIFIC CHARMER" were considered normal, undeserving of comment, and consistent with an after trim of 0.38 m (15 in) that would have resulted from the forepeak tank being filled with water ballast. None of the survivors recalls any additional ballasting or de-ballasting operations during the voyage. Consequently, it is considered most likely that the forepeak ballast tank was full on departure and remained full throughout the voyage. The primary function of the seawater ballast was to maintain acceptable working trim levels; however, such a ballast configuration also resulted in a slight reduction of the vessel's transverse stability characteristics.

As the voyage progressed and the herring catch was taken on board, the effective freeboard was gradually reduced. The transverse stability was subject to fluctuation because of the free surface effects of partially full fuel and service tanks, fish holds, and variations in the weight and extent of fish and water retained on the main deck.

In general, few fishermen fully understand free surface effect and fewer appreciate the substantial reduction of initial transverse stability that results when water, even a few centimetres deep, is shipped and retained on deck. When this effect is coupled with the significant loss of effective water plane area when the deck edge becomes submerged, the sudden reduction in transverse stability can be disastrous. Furthermore, intact transverse stability calculations are based on the “ideal” level sea state, while dynamic influences related to actual sea-going conditions and loading configurations cause the effective reserve stability to fluctuate, such that initial roll angles are usually greater than those calculated by “static” methods.

While in the highly vulnerable and fluctuating condition indicated by the calculated stability characteristics, the “PACIFIC CHARMER” was suddenly subjected to the detrimental dynamic effects of the suspended weight of the cod-end and of all the slack liquids and fish as they flowed to starboard. Additionally, the centrifugal forces generated while the vessel was turning to port induced a slight heel to starboard and a further transfer of heeling energy to the hull, slack fish and liquids such that they combined and contributed to the dynamic effects that overcame the vessel’s initial stability and initiated the gradual heeling; heeling from which she was unable to recover.

The unexpected gradual heeling to starboard, and inability to recover, are typical of the behaviour sequence associated with a marked reduction of initial transverse stability due to extensive free surface effects which—in conjunction with concurrent, sudden dynamic heeling forces—often results in severe heeling or capsizing.

Such a scenario, together with the subsequent downflooding that ultimately caused the sinking, is consistent with the sequence of events reported by the survivors who were on board the “PACIFIC CHARMER” at the time of her loss.

2.2 Fisheries Management Regime

The DFO’s Fisheries Management Plan for 1997 allowed for a food and bait herring fishery quota of 650 short tons. The total number of small fishing vessels participating in the food and bait herring fishery was restricted and the selection of individual vessels was decided by competition in a controlled lottery.

The 1997 conditions for commercial fishing licences for herring, pursuant to the *Fishery (General) Regulations*, indicated that a licensed vessel was allowed a maximum catch of 50 short tons. If that total were exceeded, the master should deliver the excess catch to another vessel licensed for the same area and the herring so transferred would be assessed as part of the catch of the receiving vessel.

Individual licence holders can choose from a list of recognized observers that is issued by the DFO. The DFO does not consider it a conflict of interest if the observer is also an employee of the licence holder, as was the case with the "PACIFIC CHARMER" and the "ARCTIC OCEAN".

The Food and Bait Fishery Management Plan 1997, issued by the DFO Director General, Pacific Region and promulgated to the fishing industry states, in part:

. . . in 1997, only vessels that are fully equipped and fully crewed and capable of catching, pumping and packing their own catches will be allowed entry into the draw. This lottery system will prevent vessels that are not equipped to catch and handle herring properly from entering this fishery. . . .

One intent of the management plan was to ensure that only bona fide small herring catching vessels would participate in the food and bait herring fishery lottery. However, the plan did not specifically require confirmation of compliance with the stability requirements of the *Small Fishing Vessel Regulations* for vessels catching herring, nor did the plan require verification of operator certification on the individual participating vessels.

2.3 *Search and Rescue*

2.3.1 *Time of Sinking*

The rapidity of the sinking precluded transmission of a MAYDAY distress call by VHF radio; however, the time of the occurrence can be determined, with some accuracy, from other sources.

At the time of the sinking the positions of the available orbiting and geostationary satellites were such that the EPIRB distress signal from the first in-range satellite was received by CMCC, in Trenton, at 0132. Such recorded signal information, in conjunction with the time shown on the stopped electric clock in the wheel-house, would indicate that the sinking occurred shortly before 0130.

2.3.2 *Occurrence Location and SAR Response*

EPIRB-initiated detection of marine emergencies, by CMCC, and subsequent SAR response, is achieved by the monitoring and receipt of emergency signals from two distinct earth satellite systems. One system is comprised of high-altitude geostationary environmental satellites, while the COSPAS-SARSAT system is comprised of lower altitude, polar-orbiting satellites.

The geostationary environmental satellites are not dedicated SAR units; however, their high altitude and large coverage of the earth's surface allow them early detection of EPIRB 406 MHz emergency signals. While they do not provide a precise location of the source of the signal, (unless it is an EPIRB with GPS) they do enable each particular EPIRB to be identified by reference to registered EPIRB ownership records. These records contain EPIRB owners' names and location information, which facilitate early telephone contact and confirmation of the vessel's name and most-recent operating location.

The COSPAS-SARSAT system is comprised of a number of lower altitude, polar-orbiting satellites making complete and continuous orbits of the earth in approximately 100 minutes. One function of this system is the detection of EPIRB 121.5 MHz emergency signals for marine SAR purposes.

The detection of EPIRB emergency signals and determination of an accurate occurrence location depend on the relative positions of the COSPAS-SARSAT orbiting satellites at the particular time. CMCC and RCC experience over several years of operation shows that from receipt of an EPIRB emergency transmission the average time required to calculate and establish an accurate occurrence location is some 42 minutes.

Owners of early (and many current) models of EPIRBs are often unaware of the inherent limitations of these models. However, EPIRBs utilizing a GPS feed in their transmitted signals are now available. These EPIRBs ensure that an accurate occurrence position can be determined immediately upon receipt of the initial emergency transmission. Such EPIRBs enable SAR services to be speedily tasked and deployed.

The EPIRB on board the "PACIFIC CHARMER" had no GPS facility; however, the initial detection of its 406 MHz emergency signal by CMCC at 0132, together with the subsequent receipt of its 121.5 MHz signals from the COSPAS-SARSAT satellites and the corroborative information from the owners, resulted in vessel identification and a fairly accurate occurrence location by 0152. The acquisition of all this information was within some 20 minutes of detection of the initial geostationary environmental satellite emergency signal by CMCC. Initiation of the primary SAR response by RCC Victoria began with the tasking of the SAR hovercraft at 0155, some 16 minutes after receipt of the faxed information from CMCC at 0139. Both of these elapsed times were significantly less than the established average time of 42 minutes.

The final approach and on-scene search time were significantly reduced because the SAR hovercraft was able to home on the 121.5 MHz signal and quickly recover the DFO observer holding the EPIRB and the two crew members nearby before they succumbed to the effects of hypothermia.

From the time of the abandonment of the vessel just prior to 0130 until the recovery of the survivors shortly after the arrival of the SAR hovercraft at 0303, the survivors were in seawater of 6.6°C for slightly more than one and a half hours. Scientific studies of cooling rates on average adults (wearing standard lifejackets and light clothing, in such conditions) show that while they would be significantly weakened and barely able to help themselves when rescued, there is a strong possibility of survival if recovered. Such was the case with the three survivors in this instance.

3.0 *Conclusions*

3.1 *Findings*

1. The data in the vessel's approved *Trim and Stability Booklet* was related to herring packing operations only, with the fish holds pre-filled with seawater.
2. Intact stability data incorporating the weights of fishing nets, trawl doors and other gear necessary when catching herring were not submitted by the owners for approval, as required by the *Small Fishing Vessel Inspection Regulations*.
3. The approved trim and stability data available for the guidance of the master did not represent the vessel's actual status when rigged and outfitted for catching herring.
4. The conditions of eligibility for entry in the vessel selection lottery process of the DFO 1997 Food and Bait Fish Management Plan were not related to compliance with the stability requirements of the *Small Fishing Vessel Regulations* for vessels engaged in catching herring, nor did the conditions require verification of the certification of the operators of the selected vessels.
5. The cumulative weight of trawl fishing equipment and the additional gear stowed in the lazaret, on the wheel-house top and lashed to the forecastle deck side railings, raised the vessel's centre of gravity and detrimentally affected the vessel's intact stability characteristics.
6. The weathertight doors from the main deck to the accommodation area and the engine-room were secured in the open position, compromising the watertight integrity of the vessel. This allowed shipped seawater to downflood into the hull.
7. A fish-loading manhole in the fish hold hatch coaming was open, which allowed shipped water to downflood into the starboard-side, aftermost fish hold.
8. The watertight door to the lazaret was secured in the open position by a length of synthetic rope and this contributed to the extent of the under-deck flooding.
9. Transverse stability was reduced, and subject to fluctuation, due to the free surface effects of partially full fish holds and fuel tanks, and the varying quantities of fish and drain water retained on the main deck while the catch was being stowed.

10. The cumulative dynamic effects of the cod-end (while it was partially suspended), the centrifugal effects on the hull while the vessel was turning, and the slack liquids on deck and in the holds suddenly reduced transverse stability and initiated heeling to starboard.
11. When the vessel heeled to starboard, the vessel's recovery was prevented when seawater, shipped and retained on the main deck, downflooded into the engine-room and after fish hold and gravitated to starboard.
12. Under-deck flooding accumulated in the engine-room and shaft tunnel, progressed into the lazaret and continued until reserve buoyancy was lost and the vessel sank.
13. The initial large angle of heel and rapidity of the sinking precluded transmission of a MAYDAY distress message, successful deployment of either of the two inflatable liferafts, or the donning of personal life-saving equipment by the crew.
14. The 406 MHz signal from the automatically activated EPIRB was detected by CMCC Trenton at 0132. The owners' identity and contact information, obtained from registered EPIRB records, was faxed to RCC Victoria at 0139.
15. The occurrence location and EPIRB identification derived from EPIRB 406 MHz signals detected by CMCC and relayed to RCC at 0152, were subsequently corroborated by the vessel's owners, by telephone.
16. The identity and location of the "PACIFIC CHARMER" were determined within some 20 minutes of the initial emergency signal being detected at CMCC Trenton.
17. The primary SAR response was initiated by RCC Victoria within 16 minutes of receipt of the emergency signal information faxed by CMCC Trenton at 0139.
18. The CCG SAR hovercraft rescued three of the persons who had been on board the "PACIFIC CHARMER". The bodies of the master and one crew member, who had succumbed to the effects hypothermia and drowned, were subsequently located, recovered and transported to shore.
19. Fixed and rotary-wing aircraft from the USCG and 442 Squadron, together with CCG vessels, CCG Auxiliary units, and commercial and other private vessels, responded promptly and participated in the search operations.

3.2 *Causes*

The vessel initially heeled to starboard because her intact transverse stability had been reduced by the cumulative detrimental effects of the weight of additional and spare fishing gear; asymmetric loading; free surface effects of liquids in partially filled tanks and fish holds; and fish waste water retained on deck. The dynamic effects of the weight of the trawl net cod-end being briefly suspended from a winch located above the wheel-house caused a sudden rise of the vessel's virtual centre of gravity. In conjunction with the initial small heel to starboard, the dynamic effects were such that the vessel heeled further to starboard and remained briefly at an angle of about 40 degrees. Seawater shipped at this time downflooded through open weathertight doorways until all reserve buoyancy was lost and the "PACIFIC CHARMER" sank.

4.0 *Safety Action*

4.1 *Action Taken*

4.1.1 *Watertight Integrity and Downflooding*

In February 1998 a Marine Safety Information letter (MSI #02/98) was sent by the Transportation Safety Board to the owners of the vessel, with a copy to TC. The letter raised concern regarding the watertight doors being lashed open, allowing for rapid downflooding and the subsequent loss of stability of the “PACIFIC CHARMER”. The letter also raised concerns about added weight, over and above the weight allowance used to prepare the trim and stability booklet.

In response, TC indicated that their Marine Safety Branch in Vancouver contacted the owners of the vessel and her near-sister ship “ARCTIC OCEAN” with regard to the preparation and submission of additional stability data.

In April 1998 TC issued a Ship Safety Bulletin (SSB #06/98) entitled *Responsibilities of Shipowners and Masters Respecting Maintenance of Weathertight Integrity of their Vessels*. The bulletin reminds shipowners and masters of all classes of ships of the paramount importance of maintaining the weathertight integrity of a ship at all times. The SSB urges the masters to ensure that doors, hatches, manholes, deadlights and all closing appliances are closed tight immediately after use, and maintained closed in bad weather.

The “PACIFIC CHARMER” changed ownership and is now named the “PACIFIC COASTER”; the new owner does not intend to re-employ her as a fishing vessel.

4.1.2 *Stability Requirements*

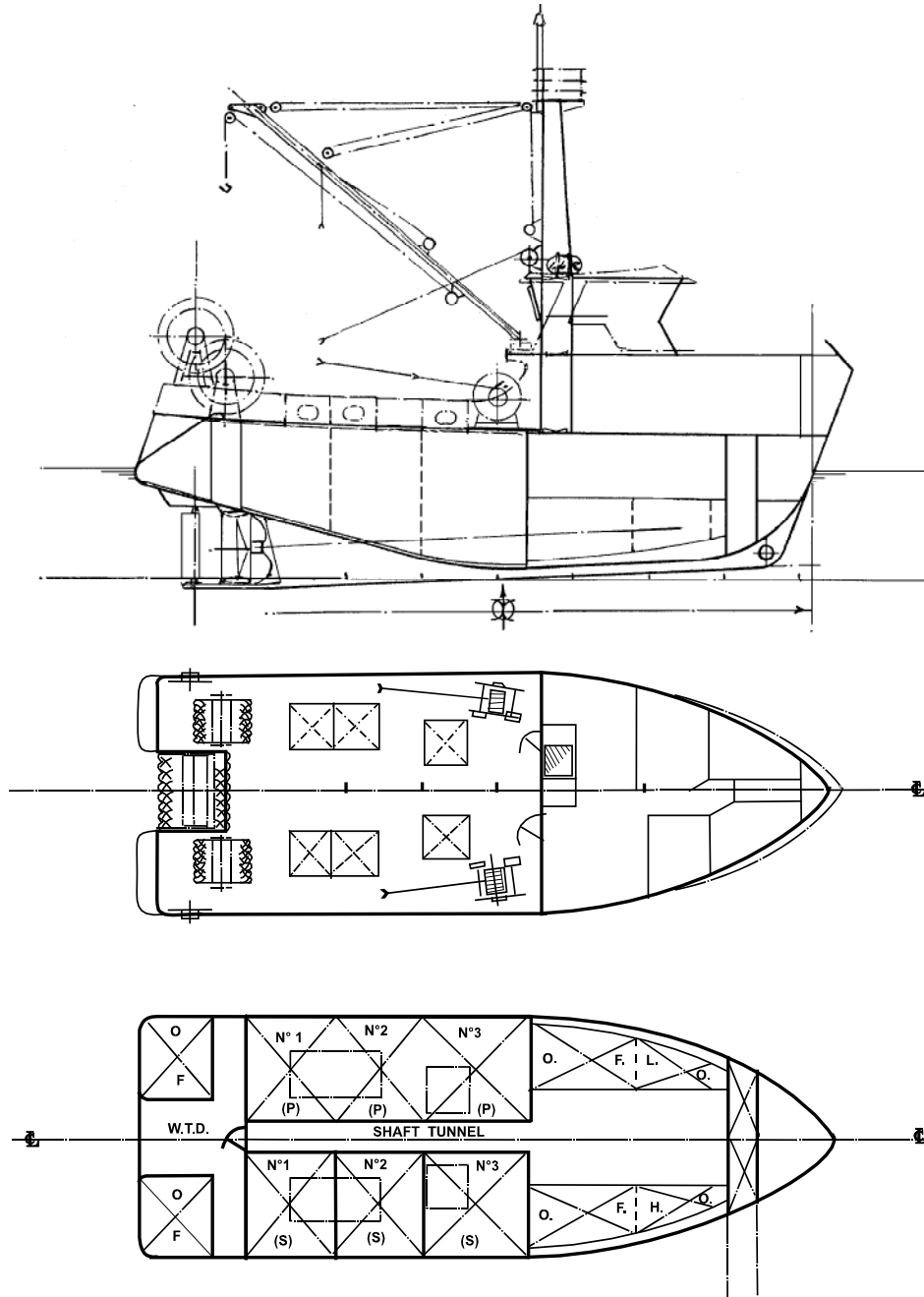
Following the occurrence, the “ARCTIC OCEAN” was subjected to an inclining experiment. The report—and related trim and stability loading conditions when catching herring—were submitted to TC for approval.

The Trim and Stability Booklet of the “ARCTIC OCEAN”, with all of the required operational conditions duly reflecting the actual operations of the vessel, was approved on 10 June 1999.

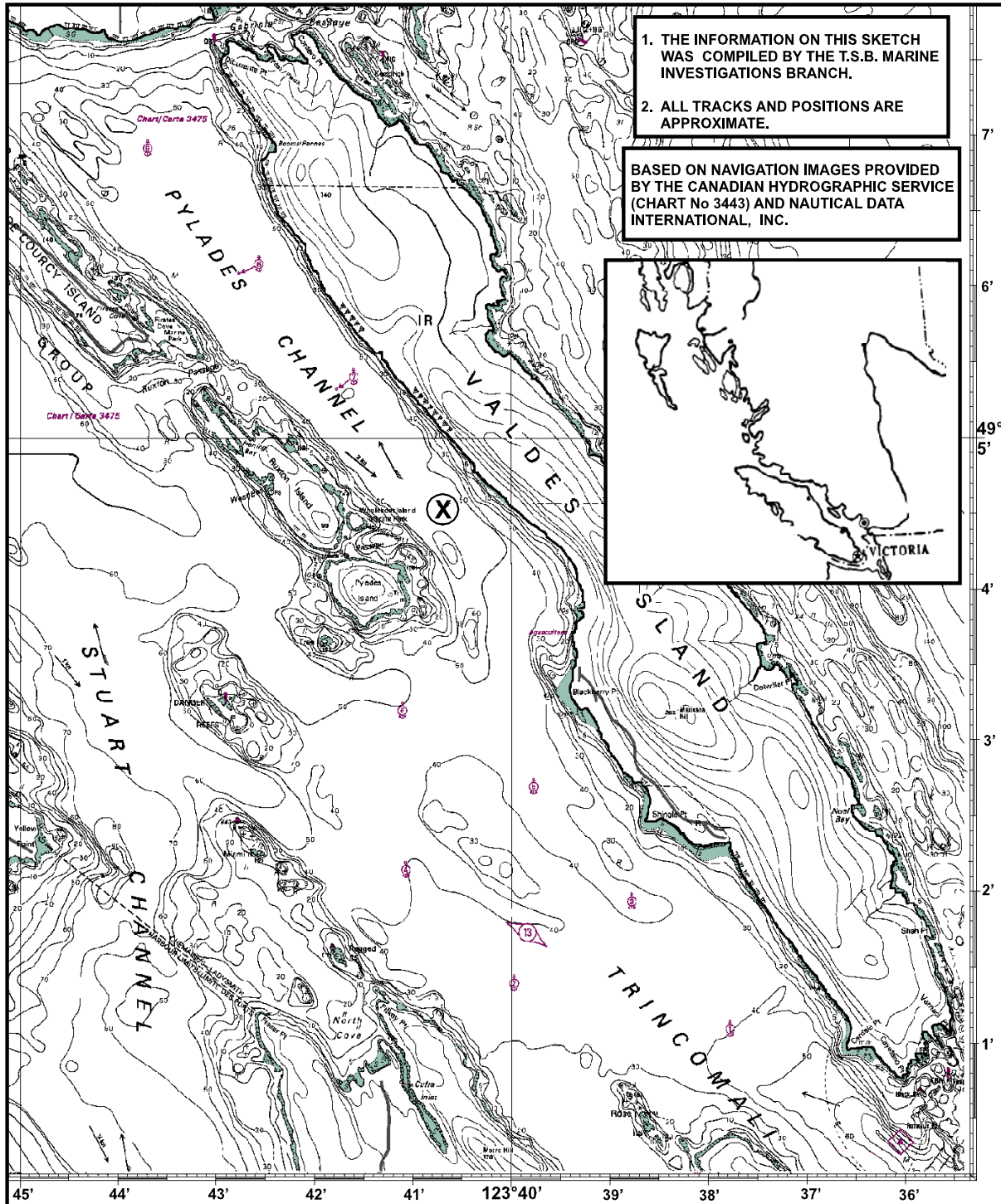
The DFO also revised the entry conditions for future vessel-selection lotteries. Changes include stability requirements for small fishing vessels engaged in catching herring. The entry conditions also incorporate requirements regarding the certification of vessel operators.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Jonathan Seymour, Charles Simpson, W.A. Tadros and Henry Wright authorized the release of this report on 10 December 1999.

Appendix A1 - Outline General Arrangement of Vessel



Appendix A2 - Sketch of the Occurrence Area



Appendix B - Photographs







Appendix C - Glossary

A.P.	aft perpendicular
B.C.	British Columbia
B.MLD.	breadth moulded
C	Celsius
CCG	Canadian Coast Guard
cm	centimetre
CMCC	Canadian Mission Control Centre
COSPAS-SARSAT	search and rescue satellite-aided tracking
DFO	Department of Fisheries and Oceans
D. MLD.	depth moulded
D.W.L.	design waterline
EPIRB	emergency position-indicating radio beacon
E.R.	engine-room
F.P.	forward perpendicular
F.W.	fresh water
GPS	global positioning system
GRT	gross registered ton
H.O.	hydraulic oil
IMO	International Maritime Organization
in	inch
L	litre
L.B.P.	length between perpendiculars
L.O.	lube oil
m	metre(s)
MHz	megahertz
O.F.	oil fuel
OSC	on-scene commander
P	port
PST	Pacific standard time
RCC	Rescue Coordination Centre
S	starboard
SAR	search and rescue
S.F.V.	small fishing vessel
SI	International System (of units)
SIC	Ship Inspection Certificate
SSB	Ship Safety Bulletin
SWL	safe working load
TC	Transport Canada
TSB	Transportation Safety Board of Canada
USCG	United States Coast Guard

UTC	Coordinated Universal Time
VHF	very high frequency
W.B.	water ballast
WCB	Workers' Compensation Board
W.T.B.	watertight bulkhead
W.T.D.	watertight door
W.T.H.	watertight hatch
W.T.M.	watertight manhole
°	degree