

MARINE INVESTIGATION REPORT

M98N0001

BREAK-UP AND SINKING

THE BULK CARRIER "FLARE"

CABOT STRAIT

16 JANUARY 1998



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

On 16 January 1998, en route from Rotterdam, Netherlands, to Montreal, Quebec, in severe weather conditions, the “FLARE” was approximately 45 miles southwest of the islands of Saint-Pierre-et-Miquelon. The vessel broke in two and the stern section sank within 30 minutes. The bow section sank four days later off Nova Scotia, on the western side of Banquereau Bank. Twenty-one of the crew perished and four survived. There was widespread, non-recoverable, fuel oil pollution from the sunken stern section.

Section 3 of this report contains the Board’s findings as to causes and contributing factors and other findings. The Board has also identified safety deficiencies related to the accessibility and stowage of the Emergency Position Indicating Radio Beacon, the carriage of immersion suits on vessels operating in waters where hypothermia can reduce the survival time of persons in the water, the effect of high frequency stresses in structural failure associated with inadequate ballasting and the need for stricter adherence to approved loading manuals. Section 4 lists the relevant safety action taken by the marine industry, Transport Canada and the TSB. The Board has issued five safety recommendations to address the identified safety deficiencies.

Ce rapport est également disponible en français.

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1.0 *Factual Information*

1.1 *Particulars of the Vessel*

	"FLARE" (ex "FLAME" – 1989, ex "DORIC FLAME" – 1987)	
Official Number	708220	
Port of Registry	Limassol, Cyprus	
Flag	Cyprus	
Type	Geared bulk carrier	
Gross tons ¹	16,398	
Length	180.8 m	
Breadth (moulded)	23.1 m	
Depth (moulded)	14.5 m	
Draught (departure)	F ² : 3.07 m	A: 6.93 m
Built	Hakodate Dock Co. Ltd., Japan, 1972	
Propulsion	Sulzer Ishikawajima-Harima Heavy Industries (I.H.I) 8,827 kW	
Service Speed	15.1 knots	
Owners	ABTA Shipping Co. Ltd., Limassol, Cyprus	
Operators	Trade Fortune Inc., Piraeus, Greece	

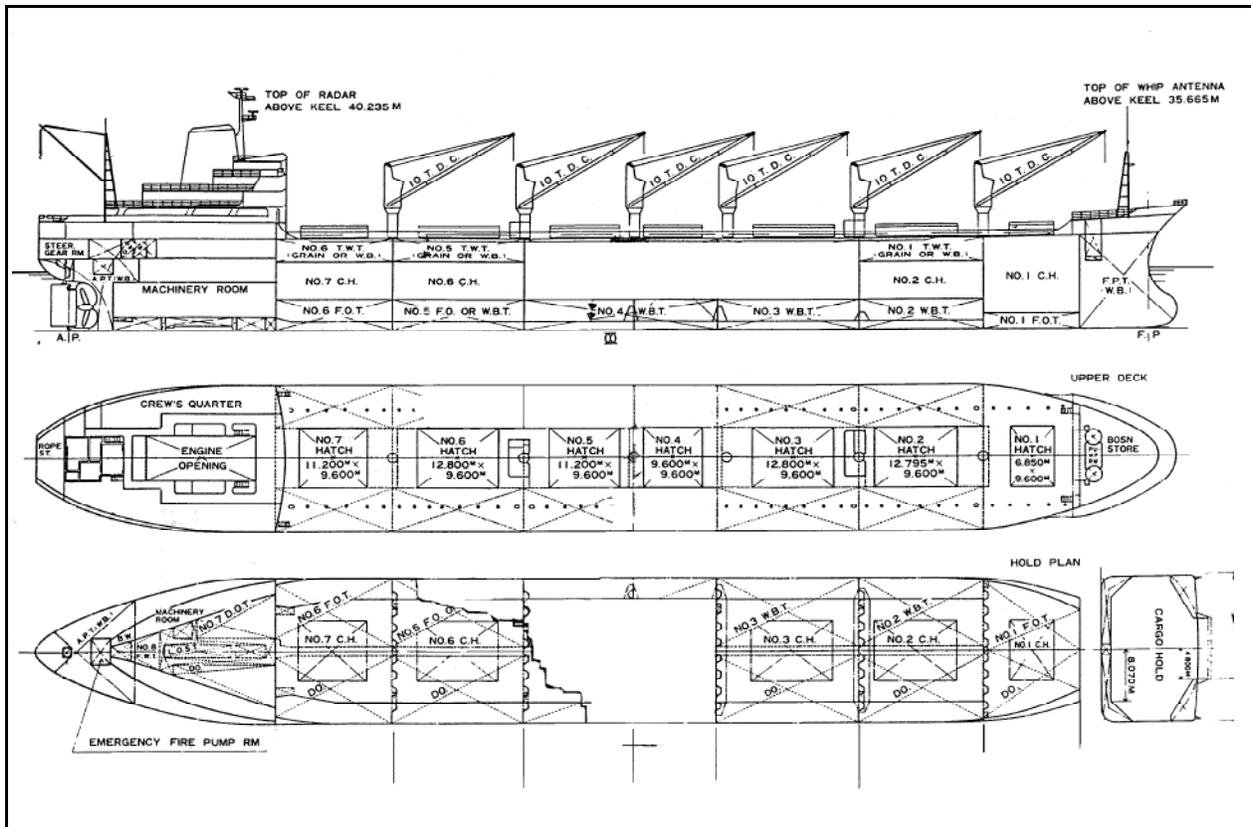
1.1.1 *Description of the Vessel*

The "FLARE" was built in Japan in 1972, as a single-deck, dry bulk cargo vessel of all-welded steel construction. The vessel was propelled by a marine diesel engine driving a single, fixed-pitch propeller. The propelling machinery, steering gear, wheel-house, life-saving equipment and all crew accommodation were arranged at the after end of the vessel. The locations of the seven dry cargo holds and all water ballast tanks and oil fuel tanks were as shown in Figure 1, Outline General Arrangement. The hull was strengthened for the carriage of ore cargoes, such that holds Nos. 1, 4 and 6 could remain empty, and hold No. 4 could be used as a water ballast tank. The hull was subdivided by nine transverse, watertight bulkheads, together with an inner bottom tank top, which extended fore and aft in way of all of the cargo

¹ 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.

² See Glossary at Appendix A for all abbreviations and acronyms.

holds and the engine-room. The main deck, upper wing tanks, inner bottom and bottom shell plating throughout the length of the cargo holds were framed longitudinally, while the side shell plating inside the holds was



framed transversely.

The hull was generally constructed with Lloyd's Grade A steel, and the main deck plating outboard of the cargo hatchways, radiused gunwale and sheer strake, were of more notch- (fracture-)resistant Lloyd's Grade D steel.

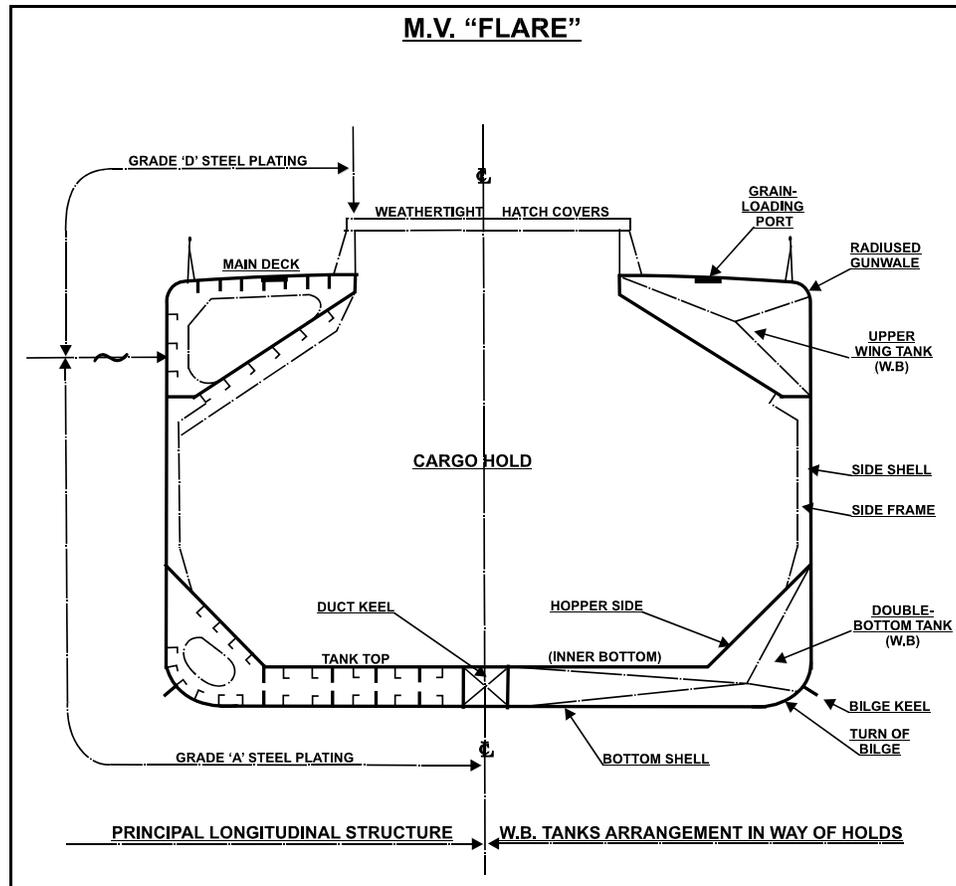
The principal construction and general layout of the cargo hatchways, holds, upper wing water ballast tanks, double-bottom tanks, and duct keel were as shown in Figure 2, Typical Cross Section.

1.2 History of the Voyage

Before departure, a portable welding machine and various pieces of steel plating and flat bars were placed on board, so various repairs could be carried out during the voyage by a fitter/welder who was a member of the crew.

The vessel, in a lightly ballasted condition, departed Rotterdam on 30 December 1997, bound for Montreal.

Reportedly, there was little conversation between the harbour pilot and the master before the pilot's disembarkation. It was dark during the time that the pilot was on board; however, he noted that the ship had a

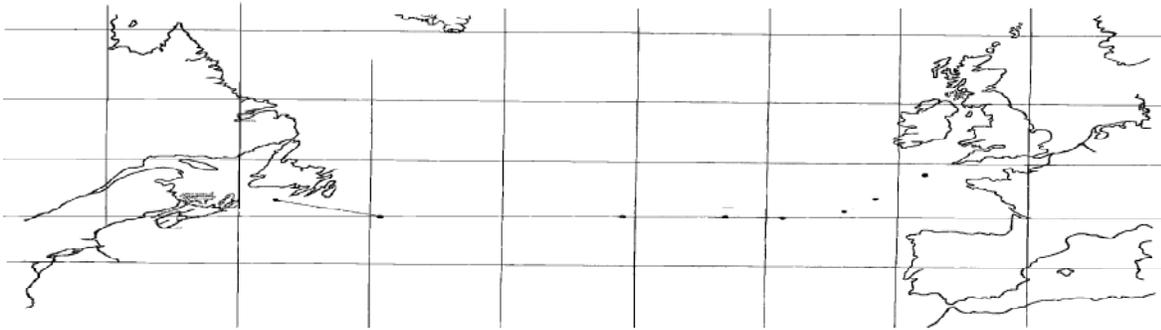


light forward draught and was trimmed by the stern.

After the "FLARE" cleared the English Channel, the weather deteriorated and, on 01 January 1998, gale force westerlies with heavy seas were experienced. In an endeavour to find better weather, the master decided to proceed as far south as 45° north latitude (N) and to follow that parallel in a westerly direction (see Chart 1, Atlantic Crossing).

Throughout most of the passage, westerly gale to storm force winds were encountered, with seas reaching a height of 16 m or more. Although speed was adjusted in response to the prevailing conditions, the vessel continued to pitch, pound and slam heavily.

Some of the welding repairs planned for completion during the voyage were carried out when the weather conditions permitted.



During the voyage, radio messages were sent from the ship to the vessel's operators, reporting the following:

Date (January 1998)	Distance (nautical miles)	RPM of main engine	Reported average speed (knots)	Calculated average speed (knots)
1 - 4	204	80	3.19	2.83
4 - 7	320	88	3.16	4.44
7 - 9	181	not given	6.0	4.35
9 - 10	332	91	10.6	10.55
10 - 13	782	94	10.7	10.86
13 - 16	359	not given	not given	5.57

Mechanical problems were experienced in the engine-room and it was reported that the governor was repaired with a jury-rigged mechanism to prevent the main engine from over-speeding.

Survivors reported that they had difficulty sleeping and eating because of the hull flexing. One of the survivors reported seeing the main deck flexing such that deck cranes appeared to be touching each other. One survivor was so apprehensive that he kept his cabin light on and practised dressing in warm clothing as quickly as possible.

On January 13 the vessel's course was altered to approach the recommended traffic separation scheme in the Gulf of St. Lawrence (see Chart 2, Occurrence Area). As the vessel approached the Canadian coast, the master

reported to the Eastern Canada Traffic System (ECAREG) that the forward and after draughts were 11 feet (3.35 m) and 21 feet (6.4 m), respectively. He also reported that seawater ballast had been exchanged during January 10, 11, and 12. On January 14 the vessel's operators requested the master to ensure all ballast tanks were full in order to have maximum draught to avoid damage to the propeller in ice. The master replied that he had advised ECAREG that the ballast tanks were full.

At about 0000 ship's time (0400 coordinated universal time [UTC]³) on January 16, a very loud bang was heard (due to the slamming of the forefoot), which was followed by severe whipping and longitudinal flexing of the hull. Approximately four and a half hours later, another particularly loud bang was heard, which also was followed by severe hull whipping and vibration.

The survivors reported that some of the crew members were startled by the severity of the latter vibrations, which were followed by the sound of the general alarm ringing. Shortly thereafter, upon their arrival on deck, they saw that the vessel had broken in two. The whole crew was on the after part of the vessel.

The stern section listed approximately 30 to 35 degrees to starboard, which precluded the use of the starboard side motor lifeboat. It was reported that, due to the vessel's motion and vibration, the lifeboats' securing arrangements had required frequent readjustment and additional lashings during the voyage. These extra lashings retarded the clearing away of the port side lifeboat and all attempts to launch it were unsuccessful. The crew's ability to clear away the boat and liferaft, while maintaining a safe footing, was more difficult because the boat deck was in darkness and there was ice and snow on the decks.

Crew members man-handled a liferaft down one deck, launched it over the stern and secured its painter to the poop deck rail. The master, who was nearby, ordered them not to abandon ship at that time because the ship's propeller was still turning. Shortly thereafter, the painter reportedly chafed through and the liferaft drifted away.

The stern section sank in about half an hour. As it was sinking, some of the crew on the port side of the poop deck saw the bow of a vessel apparently approaching on a near reciprocal course. Their immediate impression was that a rescue vessel was at hand; however, they were dismayed to find that it was the bow section of the "FLARE". The propeller was still turning and had likely caused the stern section to follow an erratic course which returned it to the vicinity of the separated bow section.

A hurried MAYDAY message was transmitted from the ship on very high frequency (VHF) radiotelephone channel 16 shortly before the stern section heeled further to starboard and sank. The signal, as picked up by a remote antenna on Ramea Island linked to the Coast Guard Radio Station at Stephenville, Newfoundland, was indistinct and incomplete. The duty officer there called the station supervisor to have the tape recording of the MAYDAY message replayed for clarification in order to assist in the search and rescue (SAR) response.

The crew, except reportedly the chief and third engineers and one other person, were wearing hastily donned clothing and lifejackets and abandoned the stern section as it sank. The port side lifeboat broke or floated free

³ All times in this report are expressed in UTC, except where ship's time (UTC minus four hours) is specified.

and capsized. Six of the crew managed to swim to, and climb on, the capsized lifeboat. Of these six, four survived to be rescued by a SAR helicopter and transported to hospital on the island of Saint-Pierre.

The bow section remained afloat and drifted for four and a half days before sinking.

1.3 Search and Rescue (SAR) Response

At 0832 on January 16, Marine Communications and Traffic Services (MCTS) at Stephenville received a MAYDAY from an unidentified vessel on VHF channel 16 through a remote antenna sited on Ramea Island off the south coast of Newfoundland (see Chart 2).

The message was indistinct and incomplete. Requests for further information went unanswered; however, the duty watch officer at the station believed the position of the calling station to be 46°57' N, 056°51' W.

Operations policy and equipment layout did not allow the MCTS lone watch officer to have immediate playback capabilities of all Safety, Urgency and Distress Traffic. However, to better decipher the indistinct and unclear transmission, a replay of the tape was necessary.

At 0834, MCTS Stephenville advised St. John's Marine Rescue Sub-centre (MRSC) of the situation, and at 0837 the MRSC advised the Rescue Coordination Centre (RCC) Halifax, Nova Scotia. MCTS Stephenville, giving the assumed position of the unidentified vessel, transmitted a MAYDAY relay on VHF channel 16, on MF (medium frequency) 2182 kHz, and on 500 MHz. At the request of RCC Halifax, a broadcast was made through the United States Coast Guard Radio Station, Boston, Massachusetts, on high frequency digital selective calling (HF DSC), and by NAVTEX through Sydney MCTS located in Cape Breton, Nova Scotia. An International Maritime Satellite Communication System (INMARSAT C), Enhanced Group Call (EGC) was issued for vessels within a 100-mile radius to assist.

Responses were received from the following commercial vessels:

“STOLT ASPIRATION”; “THORSRIVER”; “HOEGH MERIT”; “B.T. NAVIGATOR”; “KASTNER”; “ISOLA SCARLATTA”; “COLBY”; “IMPERIAL ST. LAWRENCE”; “ATLANTIC MAPLE”; “SAUNIÈRE”; “LAKE CARLING”; “ATLANTIC FREIGHTER”; “IMPERIAL ST. CLAIR”; “FEDERAL VIBEKE” and “FEDERAL WIGGY”.

Only the “STOLT ASPIRATION”, “THORSRIVER”, “HOEGH MERIT” and “FEDERAL VIBEKE” were tasked and the latter two were later released.

It was determined that the occurrence was in Canadian waters and the marine coordinator at St. John's MRSC was appointed Search and Rescue Mission Coordinator (SMC). The MRSC was assisted by RCC Halifax, where the air coordinator tasked air resources.

On board the tanker “STOLT ASPIRATION”, the officer of the watch heard the faint and broken MAYDAY and, later, the MAYDAY relay transmitted by Stephenville MCTS. The master of the “STOLT ASPIRATION” reported his vessel's position, course and speed to MCTS and at

0840 was tasked by the SMC. At 0845, the master of the “STOLT ASPIRATION” reported that his vessel was approximately 18 miles from the assumed position and that there was no radar target in the area.

An INMARSAT C distress alert was received at 0833 by the Coast Earth Station in Southbury, Connecticut. The alert was identified as originating from the vessel “FLAME”, which was the former name of the “FLARE”. The vessel’s owners and operators were identified and requested to supply a crew list and a complete list of the life-saving appliances on board.

The INMARSAT C alert reported that the ship was about to be abandoned. It reported the ship’s position 0221, January 16, as 46°08' N, 057°10' W, course 280° true, speed three knots. This was some 45 miles south of the MAYDAY position assumed by Stephenville MCTS. Attempts by other stations to contact the “FLARE” using INMARSAT C were unsuccessful. The distress alert also indicated that the position had not been updated in the previous 24 hours—but this information was neither consistent with the position reported in the alert nor with the position 1200, January 15 of the “FLARE” as reported to ECAREG. The 0221 INMARSAT C position was therefore treated as valid. It was subsequently confirmed that the validation flag was erroneous as a result of a land-based computer software print-out error.

The “FLARE” was not equipped with digital selective calling (DSC) distress alert and her INMARSAT C was not integrated with the vessel’s satellite navigation system, nor was there a regulatory requirement for the vessel to be so fitted before 01 February 1999. The vessel was also outside the nominal range of VHF coverage to communicate with Stephenville MCTS.

At 0845, RCC Halifax requested RCC Norfolk, Virginia, to establish through the Automated Mutual Assistance Vessel Rescue System (AMVER) what commercial marine resources were nearest to the assumed MAYDAY position. At the same time, Port-aux-Basques MCTS advised that, in its immediate area, there was no vessel available to render assistance.

At 0855, RCC Halifax tasked Labrador helicopter R303, from 103 Rescue Squadron, which was on primary stand-by at Gander, Newfoundland, to proceed to the assumed MAYDAY position. At 0900, Hercules fixed-wing aircraft R306, from 413 Rescue Squadron at Greenwood, Nova Scotia, and the “STOLT ASPIRATION” were also instructed to proceed to the same area. R303 was airborne at 0945, arrived on scene at 1115 and commenced an expanding square search covering 100 square miles. R306 was airborne at 1025.

At 0927, Stephenville MCTS notified St. John’s MRSC that the audio tape of the MAYDAY had been reviewed. The latitude had been deciphered as 46°37'15" N, and the longitude was possibly 054° W. From the information at hand, including the ECAREG position of 1200 on January 15 and the 0221 INMARSAT C position, MRSC/RCC plotted the predicted track of the

“FLARE” to intercept the deciphered latitude of 46°37'15" N which it did at 058° W. The 0221 INMARSAT C position was also advanced along the vessel’s projected track toward Cape Ray for six hours to the time of the MAYDAY. This resulting position was also at 058°W.

At 0935, RCC Halifax asked the Canadian Mission Control Centre (CMCC) for information on activated Emergency Position Indicating Radio Beacons (EPIRBs) in the area. None had been detected. RCC Halifax had incomplete information on the position of the “FLARE” with which to direct SAR resources. All that was known with certainty was that the crew members of the bulk carrier “FLARE” had indicated that they were about to abandon ship at 0832.

An aircraft on charter to the Department of Fisheries and Oceans was equipped with a sophisticated radar system, infrared and other high-tech equipment, making it an ideal search platform. It was preparing to depart on a routine surveillance flight but was SAR-tasked at 1006, designated R01 and was airborne at 1015. The aircraft was directed to proceed to a position off Cape Race, 46°37' N, 053°00' W, and to commence a radar and visual search westerly along this parallel of latitude to 056°51' W. This longitude was that of the original assumed MAYDAY position. The westerly search began at 1042 from the position off Cape Race.

At 1156, upon arrival at the designated position at the end of the westerly search track, R01 was ordered by MRSC/RCC to carry out an expanding square box search to the north, centred on position 46°57' N, 056°51' W, at an altitude of 1,500 feet and track spacings of six miles.

The “STOLT ASPIRATION” arrived at the assumed MAYDAY position at 1012 but found no trace of the “FLARE” or her crew. She was then directed by MRSC to proceed to 46°37' N, 056°51' W. Sunrise was at 1145. The vessel arrived at the given position at 1149. Visibility was good but again there was no trace of the “FLARE” or her crew.

Shortly after take-off, R306 experienced communication difficulties with RCC due to radio wave propagation. Although able to relay traffic through Sydney (VCO), R306 eventually lost this contact and was not able to communicate with RCC until 1140. Difficulties were also experienced between R306 and R01 due to low altitude and aircraft proximity.

At 1035 the Maritime Operations Centre (MOC) at Halifax was asked for assistance with the search. The Centre provided a position of a potential target which later proved to be that of the “STOLT ASPIRATION”. Tasking of some resources to this area continued for 1 hour and 22 minutes, until it was confirmed at 1157 that this was not the position of the “FLARE”.

At 1130, Labrador helicopter R304 was tasked from Sydney and was airborne at about 1145 en route to the island of Saint-Pierre. Some minutes into the flight, a suspected hydraulic problem in the aft transmission was experienced and the aircraft returned to base to carry out repairs. R304 was again airborne at 1225 and tasked to proceed to an area south of the assumed position of the "FLARE" which had not been covered by R303.

Also at about 1140, R306, originally tasked to the assumed MAYDAY position, was re-tasked to the INMARSAT C position.

While in approximate position 46°43' N, 056°55' W, both R306 and R01 were to commence their expanding square searches; R306 to cover the area to the south and west and R01 to the north and east. Between the two fixed-wing aircraft, this gave coverage in an area between the INMARSAT C position (R306) and the original assumed MAYDAY position (R01), while the Labrador helicopter R303 was also doing an expanding square search around the assumed MAYDAY position.

Between 1114 and 1156, the tasking instructions of the R01 were changed three times as updated information became available. However, at 1156, R01 arrived in position 46°43' N, 056°55' W, and identified the "STOLT ASPIRATION" both on radar and visually and a second target off to the southwest. Since R01 was about to start on a northerly heading, this second target was reported to R306, the on-scene commander. The second target had also been detected by R306, which was preparing to commence the expanding square search, configuring data marker buoys, flying at low altitude and handling multiple communications on various frequencies.

At about 1209, R306 was at the INMARSAT C position (46°08' N, 057°10' W) and proceeded on a track crawl to a position of approximately 46°11' N, 057°35' W where two data marker buoys were dropped at 1223. These buoys were configured to represent a) a person in the water, and b) a liferaft, for drift plot purposes. The search pattern was then commenced.

At 1226, R01 communicated with the "STOLT ASPIRATION" on VHF channels 16 and 10, and at 1300, informed R306 and R303 that it would complete the assigned square box search pattern in 45 minutes. At 1328, R01 was advised to complete its assigned task before proceeding to Saint-Pierre to refuel, and then to return for additional tasking.

At 1330 the French patrol vessel "FULMAR" was in Saint-Pierre, some 30 miles distant from the scene. Tasked by MRSC St. John's, the vessel departed Saint-Pierre at 1345 and arrived on scene at 1600.

At 1340, R303 had sighted no wreckage and departed the scene to refuel at Saint-Pierre.

At 1406, R01 called R306, the on-scene commander, for further instructions and asked if the previously observed and reported radar target in the area west of the "STOLT ASPIRATION" had been investigated. On being told that it had not been investigated, R01 indicated that it would fly over the target before proceeding to Saint-Pierre.

At 1409, R01 identified the target as the bow section of the "FLARE" which was in position 46°28.46' N, 057°12.82' W. At this time, helicopter R304 was close to the distress area and about 15 miles from R01. After overflying the bow section of the "FLARE", R304 proceeded to an oil slick about five miles to the southwest. At 1423, R304 sighted an overturned lifeboat with four persons clinging to it.

Search and rescue technicians (SAR TECHs) from R304 carried out a difficult but successful rescue. All four survivors, who had endured approximately six hours on the overturned lifeboat in appalling conditions, were safely on board the helicopter at 1434. They were wearing lifejackets and were mostly clad in light clothing. Three were severely hypothermic and could barely move their limbs during the rescue. The survivors reported that there had been six of the crew on the overturned lifeboat but two became too weak to hold on and were swept off by heavy seas about three hours before the rescue.

While hovering over the area, R304 also sighted a second capsized lifeboat some 500 m from the first, and two liferafts. No other survivors were seen but the position was marked with smoke flares. R304 left the scene to land the survivors and to refuel at Saint-Pierre. Having refuelled, R303 departed Saint-Pierre at 1445 in company with Labrador helicopter R113. R303, R113 and surface craft were directed toward the position that R304 had marked with smoke flares.

R303 and R113 were first tasked to the area in which the bow of the "FLARE" had been sighted, and then to an area southwest of the bow where two overturned lifeboats, two liferafts, and the large oil slick had been sighted. The oil slick extended some 10 miles to the west and about 3 miles in a north-south direction.

On scene, SAR TECHs from R113 were lowered to a liferaft that was covered with oil but found no survivors. The liferaft was deliberately punctured and deflated to prevent a duplication of effort by other search craft.

Two SAR TECHs from R303 were hoisted down to the overturned lifeboat from which the survivors had been rescued. They found a body underneath, tangled in ropes. Since there was no scuba gear on board the helicopter, an attempt was made to dive under the boat using emergency breathing apparatus that allowed only two minutes of air. However, the body was so badly entangled that it was not possible to recover it at this time, and a Coast Guard vessel was later dispatched to recover it. (After a Labrador helicopter crash in British Columbia, weight

restrictions on Labrador helicopters were imposed and some gear, including scuba gear, was no longer carried as standard equipment and carried only if it was determined beforehand that it would be necessary.)

R303 sighted 13 bodies in the oil slick, of which 4 were recovered by the SAR TECHs. However, the SAR TECHs were not equipped with dry suits or face protection and entering the fuel oil-covered water became hazardous. The helicopter crew became nauseous from the fuel oil fumes and the helicopter work area was coated with oil, and dangerous. It was therefore decided that the aircraft would locate bodies and direct surface vessels to retrieve them. R303 and R113 had each recovered four bodies before it was decided that marine resources would recover the other bodies.

A sea survival model indicates that, in seawater of 2°C, a 25-year-old male who is not fatigued, of heavy build, of medium height, and who is 100 per cent immersed while wearing a heavy parka has, on average, 1.8 hours to thermal instability, 2.6 hours to incapacitation and 4.1 hours to unconsciousness. A further sea survival model, developed by the Canadian Defence and Civil Institute of Environmental Medicine, was employed to estimate survival times for the “FLARE” survivors. A water temperature of 2° C, the height and weight of the survivors, and the actual clothing worn by the survivors were used for the calculation. Since survivors were immersed prior to reaching the lifeboat and would have remained wet due to the weather conditions, complete wetness was assumed. It was also assumed that 20 per cent of their bodies would have been continuously immersed. The model indicated that the best-clothed survivor would lose consciousness within 6.4 hours while the other survivors would reach this state in 2.0 to 2.3 hours. The model also indicated that the use of immersion suits would have increased survival times to between 12 and 14 hours, depending on the clothing worn.

The Canadian Coast Guard vessel “W.G. GEORGE”, a 16-m Arun-class lifeboat based in Burgeo, Newfoundland, recovered four oil-soaked bodies with great difficulty. Her decks became so slippery with the thick fuel oil that the crew could not operate safely with the vessel pitching and rolling heavily. She then stood by near three more bodies, which were recovered by HMCS “MONTREAL”.

The recovered bodies had lifejackets on, but were lightly clothed. Most were not wearing shoes or socks and all were covered with fuel oil. The survivors confirmed that no one had time to use any of the six immersion suits that were on board the “FLARE”. These several factors were considered when the decision to reduce the search was taken at 1600.

At 2014, when all the lifeboats and liferafts from the “FLARE” had been accounted for, the search continued for persons in the water. HMCS “MONTREAL” assumed on-scene commander duties for surface vessels at 2017. By 2100, in addition to the 4 survivors, 14 bodies had been recovered and 7 persons remained unaccounted for. When the search was concluded, 15 bodies had been recovered.

R303 departed the scene to refuel at 1830 and arrived in Saint-Pierre at 1845. The helicopter was released from tasking on January 17.

The airborne SAR response involved a Provincial Airlines Ltd. fixed-wing Beech King Air aircraft, equipped for aerial surveillance; two Aurora fixed-wing aircraft, three Hercules fixed-wing aircraft; two Labrador

helicopters from Canadian Forces Base (CFB) Greenwood, Nova Scotia; and two Labrador helicopters from CFB Gander, Newfoundland.

Airborne resources searched an area of 4,371 square nautical miles, for a combined total of 56.5 hours. In addition, a further combined total of 35 hours was spent in transit to and from the various search areas.

The seaborne SAR response involved two commercial vessels, the “STOLT ASPIRATION” and the “THORSRIVER”; five Canadian Coast Guard (CCG) vessels: the “W.G. GEORGE”, the “W. JACKMAN”, the “J.E. BERNIER”, the “ANN HARVEY” and the “EARL GREY”; HMCS “MONTREAL”; and French patrol vessel “FULMAR”.

Marine resources searched an area of 1,702 square nautical miles, for a combined total of 99 hours. In addition, a combined total of 99 hours was spent in transit to and from the various search areas.

1.4 *Injuries to Persons*

	Crew	Passengers	Others	Total
Fatal	15	-	-	15
Missing	6	-	-	6
Serious	4	-	-	4
Minor/None	-	-	-	-
Total	25	-	-	25

The recovered bodies (most of which were covered with fuel oil) were taken to St. John’s, Newfoundland, by Canadian Naval and CCG vessels. The bodies were identified and examined by the Chief Medical Examiner, who pronounced that the cause of death of all 15 men was by drowning/hypothermia.

The four survivors were landed at Saint-Pierre, where they were hospitalized for two days and treated for hypothermia (their body core temperatures were recorded as 26° to 28°C) and for minor abrasions. They were then repatriated via St. John’s and Montreal.

1.5 *Departure Loading, Draughts and Trim*

While the “FLARE” was in the port of Rotterdam from 22 to 30 December 1997, draught and deadweight surveys were conducted by an independent marine surveyor and the results recorded. Initial draughts and tank-sounding surveys determined the total displacement of the loaded vessel, together with the quantities and distribution of water ballast, oil fuels, lubricants and other consumables remaining on board, prior to cargo discharge.

After the cargo was discharged, off-hire draughts and tank soundings were taken by the independent marine surveyor, who verified the unloaded vessel's displacement. He determined that the deadweight of the unloaded cargo was 27,127.6 tonnes.

The tank soundings facilitated precise on-hire/off-hire financial settlement by accounting for the differences between the quantities of residual and additional oil fuel and other consumable oils and stores taken on board in preparation for the intended voyage to Montreal. It was established that 847.75 long tons (LT) of oil fuel, 168.15 LT of diesel oil and 145.62 LT of fresh water were on board at that time.

Draughts of 3.07 m forward and 6.93 m aft were recorded and a related displacement of 15,105 LT determined. A total of 6,976 tonnes (6,864 LT) of water ballast was recorded as being on board. Nos. 1, 2, 3, 4, 5 and 6 upper wing water ballast tanks and Nos. 2, 3 and 4 double-bottom water ballast tanks were filled, and the forepeak tank was 55 per cent full. Cargo hold No. 4, which also served as a water ballast deep tank, and the afterpeak water ballast tank were empty.

The total weight of ballast on board after cargo discharge was significantly less than the 8,113 LT shown in the light ballast departure condition included in the vessel's Loading Manual. The manual indicated that all water ballast tanks except the deep tank be filled to ensure forward and after draughts of 3.65 m and 7.0 m. The actual recorded forward draught was 0.58 m less than that shown for the light ballast departure condition and, while the after draught was also less, the top of the propeller was submerged by 0.5 m.

Lloyd's Rules and Regulations for the Construction and Classification of Steel Ships, that were applicable at the time the vessel was built, contain guidance concerning minimum forward draughts (in order to avoid excessive forefoot exposure in rough seas) and state in part:

For the purpose of this section a Bulk Carrier is a single deck ship exceeding 400 feet (122 m) in length [L] with machinery aft.

Attention should be given to the amount and distribution of water ballast. It has been found that satisfactory service has been obtained when the forward draught is not less than 0.027 L

On this basis, the minimum forward draught for the "FLARE" was 4.6 m. The forward draught shown for the light ballast departure condition in the vessel's Loading Manual (and that recorded at Rotterdam prior to sailing) was significantly less than this minimum. Consequently, in the event of rough weather, the vessel's forefoot was vulnerable to pounding and slamming.

With the deep tank (No. 4 hold) filled at Rotterdam, in addition to the water ballast actually loaded, the forward draught on departure would have been increased to 4.65 m, and would have exceeded the minimum for satisfactory bow immersion.

In addition to the light ballast loading condition, the vessel's Loading Manual also included a full (or deep) ballast condition intended for longer or more exposed ocean passages. In this condition, the deep tank (No. 4

hold) is filled with 3,906 LT of water ballast. When the vessel is thus ballasted, the propeller is more deeply immersed and the forward draught exceeds the minimum forward draught limitation.

The vessel was not fitted with a hull stress monitoring system, nor was one required by regulation. However, details of the still water bending moments related to each of the loading conditions were included in the vessel's Loading Manual provided for the guidance of the master.

On departure, the forepeak water ballast tank was partially full and the afterpeak water ballast tank was empty. This reduction of weights acting at the ends of the vessel lowered the still water bending moment below that of the light ballast departure and arrival conditions included in the Loading Manual such that, on departure, the still water bending moment was approximately 69 per cent of the approved maximum permissible level.

1.6 Riding Repairs During the Atlantic Crossing

Prior to sailing from Rotterdam, a portable welding machine and 1.69 tonnes of assorted pieces of steel plates and flat bars were taken on board. It was intended that riding repairs to various damaged items and replacement of some corroded parts of the vessel's structure would be carried out during the voyage.

Items for attention during the voyage included the renewal of face flat bars on some coaming brackets and bracket flanges, and repairs in way of the corroded circumferences of openings in the transverse wash bulkheads in some of the upper wing ballast tanks. The latter work required access to some of the upper wing tanks and would necessitate their being temporarily emptied of the water ballast taken on board before departure.

All four survivors held junior positions on board the vessel and their involvement with, and knowledge of, the location, extent, and times of any particular repair work carried out was fragmentary. In media interviews in the Philippines and in later signed statements made available to the TSB, survivors corroborated and added to their initial statements made in St. John's. They commented more generally on welding repairs carried out during the voyage.

Survivors initially reported that a leak from a fracture some 2 m long in the sloping underside of the No. 3 upper wing ballast tank (on the starboard side of the No. 4 hold) was sealed by welding and the tank refilled. A similarly located but smaller leak in the No. 2 port side upper wing ballast tank (in cargo hold No. 3) was also welded and the tank re-ballasted. A fracture found in the corrugated plating near the base of the transverse watertight bulkhead between cargo holds Nos. 6 and 7 was reportedly brought to the attention of one of the ship's officers on January 14. At that time the vessel was experiencing severe weather conditions and there is no information of any further structural repairs or replacements having been carried out before the sudden structural failure in the early hours of January 16.

It was also reported that there was a small hole in the main deck beneath the poop deck access ladder on the port side. The ladder weld was broken and it was possible to see water leaking out onto the main deck from the topside tank as the vessel moved in the seaway.

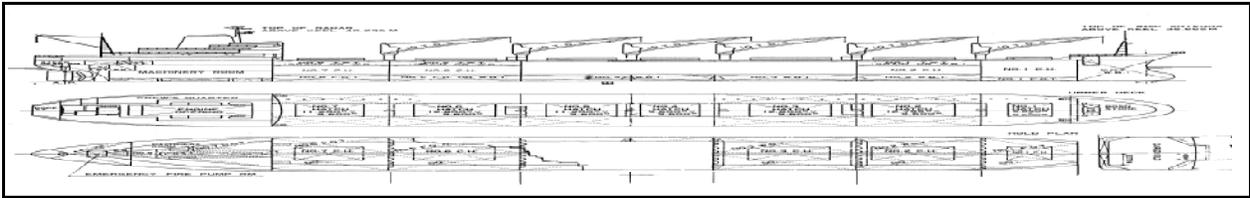
No indication of any recent welding, external structural repair or steel replacement was observed during the underwater survey of the sunken bow section. Identification of any internal repair work carried out during the voyage was not possible because the wreck was inverted, which limited access to the relevant areas by the remotely operated vehicle (ROV) cameras.

1.7 Damage

1.7.1 Aerial and Seaborne Photographic Details

The damaged—but still floating—bow section of the “FLARE” was located by SAR aircraft on the morning of January 16, some five and a half hours after the vessel broke in two. Aerial photographs and videotape recordings were taken that show the trimmed attitude of the damaged bow section, the general configuration of the separation, and the nature of the damage incurred by the principal upper members of the hull girder.

Videotaped recordings of the floating bow section were also taken from on board the “STOLT ASPIRATION” later that same morning; these show the principal damage to the starboard side shell plating from a lower perspective, together with a sea-level view of the more moderate wave and sea motions acting on the hull at that time.



The forward and after locations of the main deck and upper hull damage shown in the aerial photographs, as well as the estimated configuration of the bottom structural damage, are illustrated in Figure 3, Structural Separation Location.

The aerial photographs show the general configuration of the upper hull damage and also indicate the distribution and location of many of the flush-fitting grain-loading ports fitted in the main deck plating. These ports are designed to facilitate the stowage of grain cargoes in the upper wing tanks of the vessel by way of circular removable covers that provide a 320 mm-diameter clear opening in the main deck plating. The circular perimeter coaming of each port is recessed and welded into the main deck, has an inside diameter of 460 mm, and is the same thickness as the main deck plating. Reportedly, the grain-loading ports on the "FLARE" had not been used for grain cargo loading for a considerable time. The ports were generally kept closed with their recessed upper area filled flush with cement in order to prevent corrosion of the main deck by entrapped standing water (see Photos 1, 2 and 3).

The trimmed attitude of the damaged bow section indicated that the forepeak tank and upper wing ballast tanks were virtually empty. Water ballast from these previously filled or partially filled tanks had drained away by gravitating through severed ballast piping, which passed through the damaged double-bottom tanks and duct keel.

Indication of the distribution of water ballast in some of the forward upper wing tanks prior to the hull separation is revealed by the pattern of the ice and snow retained on the main deck directly over the tank boundaries (see Photo 2).

The ice and snow was retained on deck only in way of the wind-chilled steel directly over those areas of the ballast tank crowns that were not in direct contact with, or subject to the effect of, the latent heat of the water ballast contents. The extent and configuration of the ice and snow patterns show the starboard side upper wing tanks Nos. 1, 2 and 3 to have been filled, while port side tanks Nos. 1 and 2 were clearly less than full. The wracking and torsional effects due to such an asymmetric transverse weight imbalance would have caused localized stresses and also contributed to the global stress loading imposed on the hull.

Photos 1 and 2 also show that the corrugated transverse bulkhead forming the after boundary of the water ballast deep tank (cargo hold No. 4) was substantially intact. It remained virtually watertight during four days of direct exposure to severe weather before the accumulation of seawater in the hold initiated the sinking sequence.

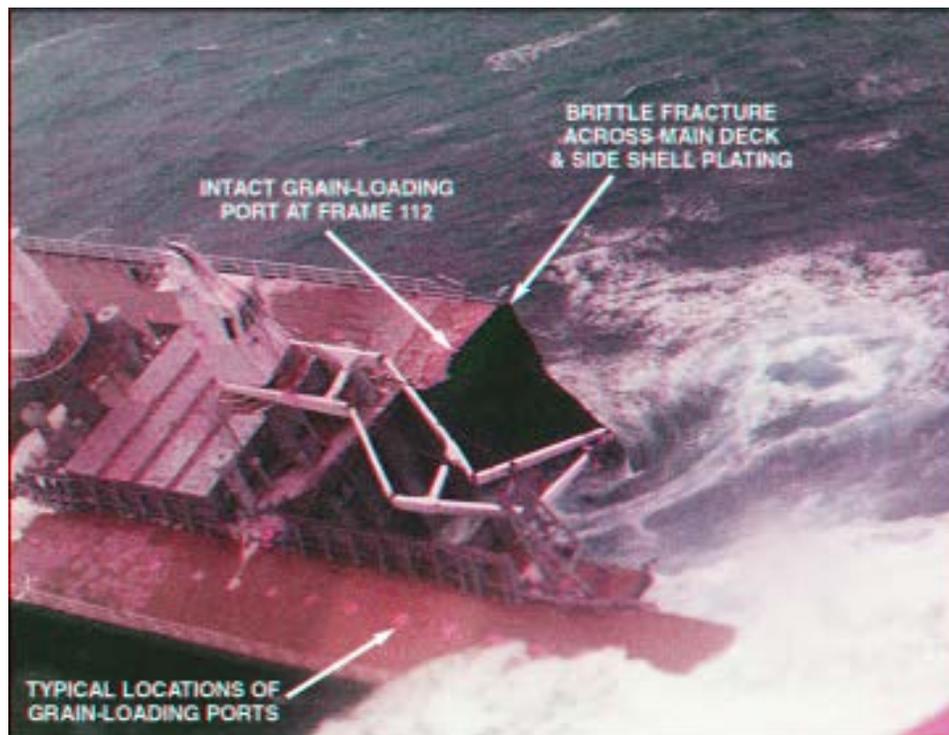
The location and nature of the principal fracture across the starboard side main deck plating (abreast and just aft of the forward end of cargo hatchway No. 5) are clearly seen in Photo 3. The athwartships fracture crosses the main deck in a straight line at about 90 degrees to the fore-and-aft axis of the vessel, and continues through the radiused gunwale and down the starboard side shell plating. The fracture bisects a grain-loading port located near Frame 112—the welded perimeter coaming and bolted cover of which remained intact. The deck plating, deck longitudinals and side shell plating show no signs of buckling or local ductile distortion, and the fracture edges appear square and vertical to the inner and outer surfaces of the deck and shell plating. All of these features are characteristic of a rapid brittle fracture.

The principal fracture across the port side of the main deck plating is located abreast and just forward of the after end of cargo hatchway No. 6 (immediately abaft a grain-loading port near Frame 76). The main deck plating inboard of the grain-loading port is distorted; most likely this occurred just prior to the final separation of the deck from the adjacent hatch side girder and

coaming. The fracture across the main deck plating outboard of the grain-loading port is not visible in the aerial photographs; however, underwater inspection shows no significant buckling or local deformation.

1.7.2 *Sinking of the Bow Section*

The tug “ATLANTIC MAPLE” was standing by the bow section of the “FLARE” on January 20. At 1115 (ship’s time) those on board reported that the damaged hull gradually up-ended and started going down stern first, with large quantities of air escaping as the forward cargo hold hatch covers became dislodged. The forecastle remained above the water for some time as the hull remained nearly vertical before sinking.



The depth of water was some 100 m, and the maximum length of the port side of the damaged hull was approximately 120 m. Consequently, the after port side was the first part of the wreck to come in contact with the seabed. Due to the heaving motions in the prevailing rough sea conditions, it sustained some impact damage in addition to that incurred during the hull separation.

The sand and shingle sea floor in the vicinity of the wreck was uneven and was disturbed by the impact of the damaged hull. The initial bottom impact area was clearly defined by a large crater in the seabed—approximately 30 m astern of the sunken bow section—which was found during the subsequent underwater survey of the wreck.

1.7.3 Underwater Survey Photographic Details

To identify the configuration and nature of the separation of the lower structural members of the hull girder, an underwater inspection of the sunken bow section was conducted between 15 and 22 July 1998. Local on-site weather history was taken into account to ensure reasonably calm operating conditions for the underwater inspection.

The CCGS “EARL GREY” was used as a stable dive platform from which an ROV was deployed to carry out the underwater photographic examination of the wreck. The ROV was controlled from an operation centre on board the “EARL GREY” by an “umbilical cord,” which relayed the electrical power and signals required to manoeuvre the vehicle’s thrusters, to operate floodlights, a stereographic still camera and a video recording camera. The ROV was also equipped with a sonar locating device to assist in determining the location of the wreck and the configuration of the surrounding seabed.

The sunken bow section was found to be almost upside down, with the bulbous bow, forefoot, and forward bottom shell intact and more exposed above the seabed than the damaged after end. The heeled attitude of the wreck was such that the starboard side of the main deck and side shell and part of the starboard side bottom shell plating were deeply buried. This precluded close-up photographic examination of the fractured edges of the starboard side main deck plating in way of the grain-loading port near Frame 112 and of the adjacent side shell plating.

The exposed bilge keel, turn of bilge and bottom shell plating on the port side of the inverted bow section were generally intact and showed no localized or global deformation. The turn of bilge abaft the after end of the port side bilge keel near Frame 72 and the lower half of the side shell at the after end of the wreck showed localized buckling and deformation attributable to compressive structural loading (and to bottom impact damage).

The principal athwartships fracture in the port side deck plating near Frame 76 crossed the main deck in an almost straight line at about 90 degrees to the vessel's fore-and-aft axis, and was immediately aft of the adjacent grain-loading port (see Photos 3 and 4). The exposed fracture edge continued directly through the radiused gunwale and halfway down the port side shell plating. The face of the fracture showed no ductile distortion and was vertical to the inner and outer surfaces of the plating. Such characteristics are consistent with the occurrence of a rapid brittle fracture.

The deck transverse at Frame 78 inside the No. 5 port upper wing ballast tank was damaged. Its face flat boundary stiffening was detached and extensively buckled. The deck longitudinals inside the ballast tank were completely detached from the underside of the main deck plating for some distance forward of the principal athwartships fracture at Frame 76. The fractures at the ends of the longitudinals showed no plastic deformation and were at 90 degrees to the normal deck plating surface (see Photo 4).

Close-up examination of the fracture edge at Frame 76 revealed the corroded outlines of several small clamshell-shaped fissures in the inner surface of the radiused gunwale plate. The outline of these shapes is a typical characteristic of fatigue fissure damage. Notwithstanding the six-month time frame, their corroded surfaces indicate that this weakened structural condition had existed for some time before the occurrence. The subsequent initiation and rapid propagation of a brittle fracture across the main deck at this location is consistent with the existence of such discontinuities (see Photo 5).

The distorted main deck port side plating near Frame 76 and the adjacent grain-loading port coaming are shown in Photo 6. The separation of the deck plating from the grain-loading port coaming is consistent with the ductile distortion of the deck having occurred as the inboard hull girder members finally separated. This separation occurred some time after the principal initial athwartships brittle fracture located just aft of the grain-loading port coaming.

Examination of the port side main deck plating abreast the forward end of cargo hatch No. 5 (directly opposite the starboard side fracture near Frame 112) failed to reveal any corresponding damage. However, further close-up examination of the port side deck in way of the grain-loading port near Frame 110 revealed an athwartships fracture some 2.8 m in length, which extended from the outboard edge of the grain-loading port circular coaming toward the radiused gunwale.

The location and configuration of this fracture was clearly defined by the disturbed deck paint surface (see Photo 7). The top surface of the deck plating immediately forward and aft of the fracture was not misaligned and showed no sign of any localized ductile deformation. The fracture displayed characteristics consistent with its being newly incurred and of a brittle nature.

Access to the damaged structure at the after starboard end of the wreck was limited due to its trimmed attitude and the configuration of the sea bottom, which resulted in most of the side shell and part of the bottom structure on the starboard side being buried or covered by the seabed.

The outline of the damage face of the bottom structure was irregular and extended from the port side turn of bilge near Frame 72 diagonally across the bottom shell toward the buried starboard side. Its outline could not be precisely established but an estimate of the general configuration is given in Figure 3. It was determined that virtually all of the bottom structure of cargo hold No. 6, the transverse watertight bulkhead at Frame 95, and part of the bottom structure of cargo hold No. 5 remained attached to the after end of the vessel when the hull separated.

The port side turn of bilge and adjacent bottom shell plating were deformed and showed transversely oriented furrowing effects, which are typical of excessive compression loading. The exposed ends of the remainder of the fractured bottom shell and internal double-bottom structure showed little or no plastic deformation or ductile failure. The absence of any localized buckling or abrasion marks also indicated that this damage occurred during the hull separation and before bottom contact.

Close-up examination of the exposed fracture edges of several bottom shell plates revealed small clamshell-shaped markings in their outer surfaces (see Photo 8). The outline of these shapes is typical of fatigue fissure damage. The presence of these markings in the principal line of the structural failure is indicative of their having contributed to the concentration of localized stress levels in excess of those which the bottom shell plating could physically withstand.

1.7.4 Damage to the Environment

There was a slick of fuel oil on the surface of the sea approximately 10 miles downwind of where the stern section sank. Attempts by SAR, in conjunction with Environment Canada, to ignite this oil were unsuccessful and it eventually dissipated by wind and wave action.

Oil continued to leak from the stern section until July 1998—diminishing over time.

Environment Canada monitored the escape of oil from the stern section. While consideration was given to exploring the stern section to find the leak, and seal it, Environment Canada deemed such action to be unnecessary.

1.8 Certification

1.8.1 Master, Officers and Crew

The certificates of competency of the master and officers were valid and complied with the provisions of the *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers* (STCW). These certificates were appropriate to the service in which the vessel was engaged.

The qualifications of the crew were also valid, and conformed with regulatory requirements.

1.8.2 Vessel

The vessel's Certificate of Cyprus Registry and Certificate of Class were in order. The International Load Line Certificate (1966), the Cargo Ship Safety Construction Certificate and the International Oil Pollution Prevention Certificate were valid until November 2000. The vessel's Cargo Ship Safety Equipment Certificate was valid until September 1998 and the Cargo Ship Safety Radio Certificate was valid until November 1998. All these certificates were issued by the Lloyd's Register of Shipping on behalf of, and under the authority of the Government of the Republic of Cyprus.

1.9 Survey and Inspection—Classification Societies

In addition to being subject to compliance with international conventions and National Ship Registry requirements, most commercially operated vessels are also built, maintained, inspected and approved in accordance with the rules and regulations of a recognized classification society.

Classification societies are independent, autonomous, non-governmental, self-regulating organizations or foundations that formulate rules for the construction of ships, monitor their construction, and carry out scheduled inspections to assure vessels' continued seaworthiness. Vessels built and subsequently maintained in accordance with the regulations of a particular society are assigned and retain a "Classification" appropriate to the vessel's type and service.

In the past decade, there has been a marked proliferation in the number of nations seeking to increase the number of vessels on their register. Many nations, some of which lack the necessary technical expertise and international infrastructure to provide worldwide service, delegate the conduct of some or all of their regulatory and registry certification inspection responsibilities to experienced classification societies.

Of the existing 47 classification societies, 10 are members of the International Association of Classification Societies (IACS), and conform with its agreed code of practice and quality assurance requirements. IACS has Observer status at IMO, and provides its members with a forum for the exchange of information and unification of technical standards. The principal objectives of IACS are "to promote the highest standards in ship safety and the prevention of marine pollution."

The Lloyd's Register of Shipping is a founder and current member of IACS, and a classification society operating 280 exclusively staffed offices worldwide. The society also undertakes regulatory certification inspections on behalf of 135 national administrations.

The classification-related inspections of the "FLARE" were carried out at the request of the owners by the Lloyd's Register of Shipping surveyors. International regulatory and national registry certification-related inspections were carried out by the Lloyd's Register of Shipping on behalf of, and under the authority of the Government of the Republic of Cyprus.

1.10 Hull Survey Requirements

IMO Resolution A.744(18) “Guidelines on the Enhanced Programme of Inspections During Surveys of Bulk Carriers and Oil Tankers,” which was adopted on 04 November 1993, and subsequently incorporated as Chapter XI into the *International Convention for the Safety of Life at Sea* (SOLAS), formally entered into force on 01 January 1996. Under the Enhanced Survey Programme, “Special Surveys” are conducted at five-year intervals by the classification society. The extent of the surveys depends on a vessel’s age. The hull surveys become more rigorous as the age of the vessel increases. Additionally, “Annual Surveys” are routinely required, the second or third of which must be a more detailed “Intermediate Survey.” The Special, Intermediate, and Annual survey reports may also incorporate memoranda that address and monitor specific, ongoing items of concern from any preceding survey.

1.10.1 Hull Survey History and Status

Special Survey

While at Shanghai, People’s Republic of China, in November 1995, the (then) 23-year-old “FLARE” underwent a fourth “Special Survey” included in which are the requirements of the Enhanced Survey Programme. During this survey extensive hull and machinery inspections, equipment examinations, structural steel repairs and replacements were carried out, mainly while the vessel was afloat.

Structural surveys, scantlings thickness examinations, and principal areas subjected to close-up inspection were noted in the hull survey record, and included :

- a) ultrasonic thickness gauging of principal hull girder members and cargo hold hatch covers;
- b) structural condition of cargo holds, including the No. 4 cargo hold/deep tank;
- c) internal structural condition of all upper wing water ballast tanks;
- d) condition of inner bottom plating and internal structure of double-bottom water ballast tanks, fuel oil tanks, and duct keel;
- e) internal structural condition of forepeak tank and chain lockers, and the afterpeak tank; and
- f) condition of hull shell, main deck, forecastle deck and poop deck plating.

The ultrasonic thickness gauging survey of the hull included measurements taken in bands around the vessel in way of Frames 74, 114 and 182. The gauge readings at each of these locations generally showed wastage of less than 1 per cent in the shell, bilge, keel and bottom structural members. There was a mean thickness reduction of some 2.4 per cent in way of the main deck, stringer plate and sheer strake plating. None of the material thickness wastage readings that were recorded exceeded the accepted limits at which replacement of the material would have been required.

Close-up structural inspections resulted in extensive fairing, cropping and renewal of transverse web frames, side framing and lower bottom brackets throughout the cargo holds, where these were found to have been corroded, distorted, or damaged by cargo-handling equipment. On completion of these repairs, all the cargo holds were grit-blasted and repainted.

Other extensive structural corrosion and wastage, discovered on close-up internal inspection, resulted in the renewal of four of the seven starboard side, and five of the seven port side main deck longitudinals throughout the entire length of all the upper wing water ballast tanks. A side shell longitudinal, throughout the length of upper wing tanks Nos. 1 to 5, was replaced on each side of the vessel. The deck longitudinal replacements, in 3 m lengths, were passed into the wing tanks by way of the tank access manholes and were generally installed while the vessel was afloat. The replacement deck longitudinals totalled some 1,015 m in length. Ten per cent of all of their newly welded butt joints were randomly selected, subjected to ultrasonic examination and found satisfactory.

The watertight bulkheads at Frames 95, 117 and 134, forming the ends of upper wing ballast tanks, the wash bulkhead at Frame 149, and various transverse web stiffeners inside the wing tanks, were also cropped and renewed in way of corroded and thinned areas. The condition of the upper wing tank coating was reported as poor and was referred for monitoring and attention in future surveys.

Extensive bottom shell plating indentations and the related internal bottom longitudinal and structural damage in way of the starboard side double-bottom tanks Nos. 1, 2, 3, 4 and 5 were cropped and renewed. The lower areas of the transverse watertight bulkheads at Frames 162 and 188 were also cropped and renewed. The internal structure of the double-bottom tanks was subjected to close-up inspection and found satisfactory. The tank coatings were reported to be in good condition.

Several areas of plating in the collision bulkhead at Frame 210 and in web Frame 220 were cropped and renewed where affected by corrosion. Thickness gauging found that the remainder of the forepeak water ballast tank internal structure was generally satisfactory.

The upper section of the afterpeak tank was found to be heavily corroded. The upper parts of the bulkheads at Frames 11 and 16 and the centre-line wash bulkhead were extensively cropped and renewed. An additional tank top, forming a void space 1.5 m deep, was installed below the crown of the tank and structurally braced from the existing deckhead.

All examinations, surveys, repairs and structural replacements were completed to the satisfaction of the attending class surveyors and the owners' representatives. Satisfactory completion of Special Survey No. 4 was duly assigned on 10 November 1995. A dry-docking survey and inspection of the underwater hull fittings and bottom shell plating was also satisfactorily completed in Shanghai, in January 1996, prior to the vessel's return to service.

First Annual Survey

On the first anniversary of Special Survey No. 4, and while the vessel was in Brazilian waters, a routine Annual Survey by Lloyd's surveyors was begun at Salvador and completed at Fortaleza on 30 November 1996.

As the "FLARE" was a bulk cargo ship over 15 years old, the Annual Survey called for the survey of all the cargo holds, and close-up survey of any one of the forward holds.

The surveys found the general condition of the holds to be satisfactory, and the side shell plating, side frames and lower side frame brackets showed no apparent damage. Existing puncture damage through the watertight bulkhead between cargo hold No. 1 and hold No. 2, which was the subject of a current "Condition of Class" (COC), was repaired, satisfactorily tested, and deletion of the COC recommended.

A second COC, referring to wastage and grooving of the steel in way of the tank top connection to the forward and after transverse bulkheads of cargo hold No. 6, was also addressed. Extensive ultrasonic thickness measurement showed localized wastage to be within accepted limits (before steel replacement would be required). The reported grooved indentations were found to have an average depth of 15 mm, with some localized maximum depths of 25 mm. These were attributed to mechanical damage incurred during loading or unloading operations. As a result of the examination, this COC was also deleted. The current structural condition was recorded by a memorandum in the vessel's hull survey record as an item requiring monitoring during future surveys.

The vessel's Safety Construction Certificate was accordingly endorsed on 30 November 1996 and an Interim Certificate of Class was issued by the Lloyd's Register of Shipping.

Second Annual/Intermediate Survey

A routine survey became due on the second anniversary of Special Survey No. 4. In accordance with the provisions of the Enhanced Survey Programme, the Intermediate Survey was deferred to the end of the third year. An Annual Survey was carried out by Lloyd's surveyors and completed at the Port of Cienfuegos, Cuba, on 28 November 1997.

Structural areas were subjected to routine and close-up inspection. The defects discovered, and the remedial actions taken to correct them were noted in the hull survey record. These included:

- a) internal structure of all upper wing water ballast tanks;
- b) localized inner bottom buckling and grooving at the end bulkheads of hold No. 6;
- c) areas of indented inner bottom plating in way of cargo holds;
- d) structural condition of the afterpeak tank and holds Nos. 1 and 7; and
- e) shell indentation and buckled port side framing in hold No. 2.

On completion of structural inspections, all except item a) were deemed to be currently satisfactory or were referred for routine attention at the next scheduled Intermediate Survey. The referred items included the ongoing monitoring of the structural condition in way of the end bulkheads of cargo hold No. 6.

Internal examination of the upper wing tanks recorded several and various wasted and corroded-through structural members, primarily comprising transverse webs and wash bulkheads in upper wing water ballast tanks (port and starboard) Nos. 1, 2, 4, and 6, and (starboard) Nos. 3 and 5. Because of a reported lack of approved thickness measurement expertise and other facilities in this port, no remedial action was taken. The attending surveyors imposed a COC requiring appropriate structural repairs and that renewals be carried out and approved before the end of February 1998.

The concurrent machinery annual survey was generally satisfactory but called for the operation of the vessel's exhaust gas auxiliary boiler to be discontinued until it was satisfactorily repaired. A related COC was imposed in this regard, also requiring that repairs be carried out and approved before the end of February 1998.

The Lloyd's Register of Shipping issued an Interim Certificate of Class and advised the owners on 27 November 1997 of the imposed COCs that required that remedial action be carried out before the end of February 1998. It was also indicated to the owners that non-compliance by the due date could jeopardize classification standing and that suspension of class would lead to automatic invalidation of all Statutory Certificates issued by the Lloyd's Register.

It is the responsibility of the owners to ensure that all repairs necessary for the maintenance of class are carried out and to advise the regulatory authority of the proposed scheduled venue in order that a surveyor may attend

for inspection and approval purposes. At the time of the occurrence, the Lloyd's Register of Shipping had received no formal request for the provision of such services.

1.11 International Safety Management (ISM) Code

In January 1998 the owners/operators of the "FLARE" were preparing to meet the requirements of the IMO *International Safety Management Code* (ISM Code), due to come into force in July 1998, although they had not completed the necessary procedures.

1.12 Personnel Information

The crew of the "FLARE" was made up of four nationalities. The master and 3 crew members were Greek nationals, 16 were Philippino, 2 were Romanian, and 3 were Yugoslav.

The master and 11 of the crew joined the ship in Rotterdam shortly before sailing. The senior officers and the remainder of the crew had joined the vessel at various times during 1997.

1.12.1 Master

This was the master's first voyage on the "FLARE" and this was his first command of a bulk carrier. His previous command experience was for a period of 10 months as master of a 1,598 gross registered tons general cargo vessel.

Since 1994 his bulk carrier service included service as first mate on three other bulk carriers with two periods on the "EVMAR", a vessel similar to the "FLARE" in both design and age.

Before joining the "FLARE" in Rotterdam on 22 December 1997, the master had been briefed extensively on details concerning the vessel while he was at the operators' office in Piraeus. The company was seeking ISM Code certification, and the master's briefing included one week of ISM Code familiarization.

In Rotterdam, the handover of command of the vessel took two days and reportedly included an inspection of the upper wing ballast tanks.

1.12.2 Ratings

The Philippino crew members aboard the "FLARE" were recruited through Bright Maritime Group, a licensed and ISO 9002-certified crewing agency in the Philippines. The owners of the "FLARE" employed the services of a Greek Port Captain in Manila.

Crewing practices at Bright Maritime Group include the interview of candidates by the Port Captain and the examination of their certification and experience to ensure compliance with STCW (1995). Once a group of candidates has been selected, if medically fit, their names are submitted to the Philippine Overseas Employment

Administration. At this time, they are offered a contract that details rank, wages and other administrative details. Once a contract is signed, the company arranges for a visa and transportation as required.

Prior to departing the Philippines, the new crew members joining the “FLARE” were given some in-house training in accordance with STCW (1995). In particular, the crew was briefed on issues such as safety aboard, conduct and ISM Code requirements.

For those members of the crew who joined the vessel in Rotterdam, no boat drill was held due to the bad weather after sailing. However, the master held a half-hour briefing in the crew’s mess on the use of the vessel’s safety equipment.

1.13 Working Language

In compliance with STCW (1995), the official working language on board the vessel was English. The existing required vocabulary for navigational watchkeeping purposes is based upon IMO “Standard Marine Communication Phrases” and consists of approximately 50 phrases. These phrases have been chosen to facilitate communication: between ships, with coast stations, and among multilingual crews. While it is mandatory that officers of the navigation and engine-room watches have an adequate knowledge of English, there is no requirement for members of the crew other than officers to have such a level of understanding.

A more extensive IMO vocabulary has recently been introduced on a provisional basis and is being taught at some maritime colleges. This revised vocabulary could be introduced as early as 2000, following adoption by member states at IMO. As with the current IMO “Standard Marine Communication Phrases,” the use of this vocabulary would not be mandatory for ratings.

1.13.1 Working-Language Proficiency on the “FLARE”

The three Philippino survivors were sufficiently proficient in English not to require a translator/interpreter when interviewed.

When the other survivor (the Yugoslav electrician) was interviewed after the occurrence, his limited knowledge of English was such that a translator/interpreter was required.

At lifeboat and emergency drills on a previous voyage, when the Greek master was explaining duties and functions in English, the chief engineer had translated for the benefit of the electrician.

1.14 Weather Information as Recorded

“FLARE”

The record of the radio communications between the master and the operators was obtained and gives the weather reportedly experienced by the vessel between 30 December 1997 and 13 January 1998.

Date	Wind direction and force, Beaufort Scale	Beaufort Sea State corresponding to reported wind speed
December 30 – January 1	West Force 9 – 10 (44 – 55 knots)	High/very high waves. Tumbling seas, become heavy and shock-like. Probable maximum wave height 10 to 12.5 m.
January 1 – 4	WSW Force 10 – 11 (55 – 60 knots)	Violent storm. Exceptionally high waves. Everywhere the edges of the wave crests are blown into froth. Probable maximum wave height 12.5 to 16 m.
January 4 – 7	WSW Force 9 – 11 (44 – 60 knots)	Violent storm. Exceptionally high waves. Everywhere the edges of the wave crests are blown into froth. Probable maximum wave height 10 to 16 m.
January 7 – 10	WSW Force 8 – 9 – 10 (40 – 55 knots)	High/very high waves. Tumbling seas, become heavy and shock-like. Probable maximum wave height 7.5 to 12.5 m.
January 10 – 13	W Force 5 (17 – 21 knots)	Moderate waves. Probable maximum wave height 2.5 m.
January 13	SW Force 8 (34 – 40 knots)	Moderately high waves of greater length. Edges of waves break into spindrift. Foam blown in well-marked streaks along direction of wind. Probable maximum wave height 7.5 m.

Environment Canada

For the three-day period between January 14 and 16, information was obtained from Environment Canada, both forecast and actual weather as recorded by automatic weather reporting buoys positioned off the south coast of Newfoundland and near Banquereau Bank. For the areas in which the “FLARE” was on these dates, Environment Canada recorded the following weather information.

Date	Wind direction and speed	Maximum sea state
January 14	West 25 – 45 knots	3 m – 5 m
January 15	West 45 – 60 knots	6 m – 9 m
January 16	NW 30 – 45 knots	5 m – 8 m

In part, the plain language text forecast for Cabot Strait, issued at 1000, January 16, stated:

Gale and freezing spray warning continued. Winds Westerly 25 to gales 35 knots diminishing to Westerly winds 20 early afternoon.

The *Gulf of St. Lawrence Marine Weather Guide*, issued by Environment Canada, Atlantic Region, gives the following information for the Cabot Strait/Magdalen area:

Cabot Strait is exposed to very long open water fetches. From the northwest, it is open all the way to the Gaspé Passage (Detroit d'Honguedo), about 250 nautical miles. To the southeast, there is an unlimited fetch out into the Atlantic. The fetch from the northeast is actually limited in the Strait itself, but as you move out into the gulf towards the Magdalen Islands, this fetch also stretches to near 250 nautical miles. These long fetches can permit very large seas to form in the area. They also mean that waves will continue to roll for a long time after the wind dies down. These combined effects can make this one of the roughest areas in Atlantic Canadian waters.

Records show that the current in the area, on the date of the break-up of the "FLARE", would have been toward the west-northwest at approximately 0.5 knot, i.e., against the direction of the wind. The shallowing water at the edge of the Saint-Pierre Bank, in conjunction with the wind/current condition described above, can create conditions under which the established normal wave pattern is disturbed. This combination of factors leads to the creation of large, irregular waves.

“STOLT ASPIRATION”

The “STOLT ASPIRATION”, a tanker of 12,219 gross registered tons, left Europe fully loaded for Montreal and followed a route similar to that of the “FLARE”. Severe weather was experienced during the whole voyage. Winds were reported to be westerly, Beaufort force 8 to 9 most of the time and to have reached force 10 to 11 at times. During the night of January 15–16, the vessel was about 25 miles from the “FLARE”, and was proceeding on a similar course at a reduced speed of 5 to 6 knots.

At 0400 (ship’s time), the “STOLT ASPIRATION” was at 46°50.5' N, 057°16.2' W by global positioning system. Course was 295° and speed was six knots. The wind was west at force 8 and the sea state was about 7 Beaufort. The temperature of the air was -3°C, and of the sea, 2°C.

Although the “STOLT ASPIRATION” was loaded, the ship was labouring and making heavy going in the prevailing conditions. The master was woken several times when the ship ran into extraordinarily large swells/waves that caused heavy vibration and pounding.

1.15 Radio Equipment

The “FLARE” was equipped with short-, medium-, and long-wave transmitter/receivers, which were operated by a certificated radio operator in a dedicated radio room.

The vessel’s radio equipment was surveyed in Cuba on 26 November 1997. At that time, the equipment was found to be in accordance with the requirements of SOLAS 1974, as amended. A Cargo Ship Safety Radio Certificate was issued in Havana, valid until 25 November 1998.

The vessel’s Record of Approved Cargo Ship Radio Installation Certificate indicates that there were two VHF radios on the bridge. One of these radios was used to broadcast the MAYDAY call on channel 16.

The vessel’s INMARSAT C was not integrated with the vessel’s satellite navigation system, nor was there a regulatory requirement for the vessel to be so fitted before 01 February 1999.

1.16 Emergency Position Indicating Radio Beacon (EPIRB) and Search and Rescue Transponder (SART)

1.16.1 EPIRB

The vessel’s class 1 EPIRB had been tested and certificated by a radio inspector accredited by the Cuban Government and accepted as satisfactory by a Lloyd’s Register surveyor.

This unit was reportedly mounted on the starboard wing of the navigation bridge, near the gyro repeater. The mounting arrangement was designed to allow the unit to float free of the ship without human intervention, in the event of the ship sinking.

The battery-operated distress radio beacon transmits a coded digital signal on 406 MHz when automatically or manually activated. The radio signal is received by a satellite, which relays the information to one of many receiving stations on land. The signal is decoded to identify the owner, the name of the vessel and the location of the EPIRB. This information is used to determine the area to which a SAR response is directed.

A previous master stated that, in order to prevent the theft of the EPIRB while the vessel was in port, he usually removed it from its mounting and stowed it in the accommodation or in the secured wheel-house.

No EPIRB signal was ever received from the "FLARE" nor was the EPIRB recovered. It is not known if the EPIRB was in its dedicated mounting on the starboard wing of the bridge. It is also unknown whether the unit floated free or not.

1.16.2 SART

The purpose of a SART is to indicate the position of persons or vessels in distress. It is easily portable and should be taken into the liferaft or lifeboat when abandoning ship. It generates a series of response signals when "interrogated" by shipborne or suitable airborne radar. IMO standards call for a range of up to five miles for a SART that is unobstructed and one metre above sea level.

The "FLARE" was equipped with two SARTs, which were stowed on the bridge deck; however, in the event, no SART response was received by SAR equipment.

1.17 Life-saving Equipment

The Record of Equipment for the Cargo Ship Safety Equipment Certificate (Form E), issued by the Lloyd's Register, lists the following equipment for a complement of 30 persons:

- a 30-person capacity (No. 1) motor open lifeboat on the starboard side;
- a 30-person capacity (No. 2) open lifeboat on the port side;
- a 20-person capacity inflatable liferaft (stowed aft);
- a 10-person capacity inflatable liferaft (stowed aft);
- a 6-person capacity inflatable liferaft (stowed on the main deck forward of the No. 1 hatch);
- 8 lifebuoys;
- 35 lifejackets;
- 6 immersion suits; and
- 27 thermal protective aids.

The documentation indicated that the life-saving equipment was in compliance with SOLAS 1974 and its Protocol of 1978, articles, annexes and amendments.

1.18 Recovery of Life-saving Appliances

1.18.1 Lifeboats

Overtaken lifeboat No. 2, with four persons on top, was seen near the position of the floating bow section of the "FLARE", which was first sighted in position 46°28.46' N, 057°12.82' W. The survivors were recovered from the capsized lifeboat by helicopter at 1434 and a body was later recovered from underneath the boat. The lifeboat was subsequently recovered and taken to the CCG base at St. John's.

When the "STOLT ASPIRATION" arrived on the scene about an hour and a half later, attempts were made to recover some floating debris and equipment believed to have come from the lifeboat. These attempts were abandoned due to the prevailing weather conditions.

The motor lifeboat (No. 1) from the "FLARE" was found washed ashore at Lamaline, on the south coast of Newfoundland, on 17 July 1998, and taken to the CCG base at St. John's. The inside was heavily encrusted with mussels, indicating that the boat had been in a capsized position for a considerable time.

As all loose equipment from both lifeboats was missing and their fibreglass hulls were extensively damaged, the condition of the boats at the time of the occurrence could not be determined.

1.18.2 Liferrafts

During the SAR operation, both liferafts stowed aft were discovered inflated, near the position of the floating bow section of the "FLARE". Each was checked for survivors, but there was no one aboard. To eliminate duplication of SAR efforts, both liferafts were intentionally sunk after examination. Consequently, the condition of these liferafts at the time of the occurrence could not be verified. The six-person liferaft was not sighted or recovered after the bow section of the "FLARE" sank.

1.18.3 Lifejackets

The vessel's documentation showed that a sufficient number of lifejackets (35) was carried for the number of persons aboard (25). Lifejackets were recovered from all the survivors and from all the bodies of the victims.

After the Chief Medical Examiner in St. John's had completed his examination of the bodies of the victims, the lifejackets were sent with the bodies to a local funeral undertaker. All the lifejackets were contaminated by fuel oil and all those sent to the undertaker were disposed of. However, SAR kept one lifejacket, which had been worn by one of the survivors.

1.18.4 Immersion Suits and Thermal Protective Aids

In accordance with SOLAS requirements for a cargo ship equipped with two open lifeboats, the "FLARE" was equipped with 6 immersion suits and 27 thermal protective aids⁴ (see Section 1.17). These thermal protection

⁴ As well as general requirements listed in Regulation 30, Regulation 34 of the SOLAS describes a thermal protective aid as follows:

aids were available for the protection—while in open lifeboats—of those persons for whom immersion suits were not provided.

The survivors could not remember immersion suits being produced at emergency drills nor were they given a practical demonstration of how to don or use an immersion suit. The survivors were equally unaware of the number of suits on board, where the suits were stored, or to whom the suits would be distributed in an emergency. The previous master confirmed that allocation was not decided and not discussed at emergency drills.

No immersion suits or thermal protective aids were recovered during the SAR operation.

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1. A thermal protective aid shall be made of waterproof material having a thermal conductivity of not more than $0.25 \text{ W/(m}\cdot\text{K)}$ and shall be so constructed that, when used to enclose a person, it shall reduce both the convective and evaporative heat loss from the wearer's body.
 2. The thermal protective aid shall:
 - .1 cover the whole body of a person wearing a lifejacket with the exception of the face. Hands shall also be covered unless permanently attached gloves are provided;
 - .2 be capable of being unpacked and easily donned without assistance in a survival craft or rescue boat;
 - .3 permit the wearer to remove it in the water in not more than 2 min, if it impairs ability to swim.
 3. The thermal protective aid shall function properly throughout an air temperature range -30°C to $+20^{\circ}\text{C}$.

Current (international) SOLAS regulations do not require that an immersion suit be provided for each person on all cargo vessels—particularly when the vessels normally operate in temperate or warm climates. The regulations are such, however, that an Administration (Flag State) may, at its discretion, require the provision of an immersion suit for each person on board. In this instance, the Administration did not require, nor did the owners or operators of the “FLARE” provide, an immersion suit for each crew member.

Canadian-flag ships, which regularly operate in higher latitudes, are required by regulations to provide at least one immersion suit for each crew member.

International organizations have not taken action to require that ships trading in colder climates provide an immersion suit for each crew member.

1.18.5 Lifejacket Testing

SOLAS requires that an approved lifejacket, meeting the IMO *Standards for Lifejackets* at the time at which the ship was built, be carried for each person on board the vessel.

The lifejacket worn by one of the survivors was examined and tested by Underwriters Laboratories of Canada, which concluded that it did not meet the SOLAS 1992 (Consolidated Edition) standard for lifejackets, although as the “FLARE” was an existing ship, the lifejackets on board were not required to satisfy this standard.

As only one lifejacket was available for testing, it is unknown if it was representative of the condition of the others.

1.19 Port State Control (PSC)

Port State Control (PSC) is a ship inspection program whereby foreign vessels entering a sovereign state’s waters are boarded and inspected to ensure compliance with various major international maritime conventions as ratified by the Flag states. PSC programs are of a regional nature, i.e. several countries sharing common waters have grouped together under a Memorandum of Understanding (MOU) in an effort to ensure that vessels trading in their area are not substandard.

PSC inspections of the “FLARE” were carried out by PSC officials in three countries in 1997: in New Orleans, Louisiana, USA, on February 19; in Toronto, Ontario, on May 26 and 27; and in Newport, Wales, United Kingdom, on October 8.

1. In New Orleans, following an inspection that was confined to the vessel’s safety certificates, the United States Coast Guard issued a Vessel Boarding Report with the notation “No deficiencies noted” and therefore the ship was not detained.
2. In Toronto, surveyors from Transport Canada (TC) noted several deficiencies affecting the life-saving equipment as follows:

- forward liferaft to be installed outside on open deck;
- aft liferaft to be provided with manual quick release; and
- fire and boat drills to be re-conducted.

These deficiencies were rectified before the vessel departed Toronto, and the ship was not detained.

3. In Newport, following a PSC inspection by surveyors of the British Marine Safety Agency, the following life-saving appliances-related deficiency was noted:

- Port and starboard lifeboat davit fall cheek plates badly corroded—repair/replace.

A Detention Notice in respect of the above was issued to the vessel but was removed on completion of satisfactory remedial action. Other deficiencies of concern noted were:

- fixed (foam) fire-fighting . . . engine-room foam tank sight glass;
- emergency fire pump . . . guard to be fitted;
- engine-room spare foam generator hose to replace;
- two protective fire suits to be replaced;
- oil record book - no recent entry;
- several nautical publications to renew;
- radio batteries to be secured, etc.;
- servicing of the heavy-oil purifier to be completed;
- magnetic compass light to replace or fault to repair;
- meat and fish cold room, lower temperature to be maintained;
- inflammable materials not to be stored in accommodation;
- various sanitary and housekeeping work to be done; and
- lifejacket light batteries, no date identifiable.

With the exception of the last listed item (lifejacket light batteries), there is a record that all the above deficiencies were rectified before the vessel sailed.

1.20 Similar Vessels

The aerial photographs and the underwater survey of the vessel revealed fissure damage and failure in the main deck plating adjacent to grain-loading ports near the mid-length of the “FLARE”. The TSB identified 14 vessels of similar age and built to the same plans, which were believed to be currently in service and which could be subject to similar defects.

In the spirit of IMO Resolution A. 849 (20), which calls for cooperation between States in the investigation of marine casualties, the TSB informed the Republic of Cyprus, the People’s Republic of China, Malta, the Republic of Liberia, the Republic of Panama and the Hellenic Republic, under whose registry the identified

vessels were operating. These Flag States were requested to examine these vessels in order that appropriate remedial action might be promptly taken—if required.

The Canadian and United States Coast Guards were requested to advise the TSB if these vessels entered Canadian or United States waters. The TSB also advised Transport Canada of these actions and requested that TC staff inform the TSB should such damage be discovered, on the listed or similar vessels, during routine or PSC inspections (see Section 4.1, Action Taken).

1.21 Laurentian Pilots

The “FLARE” was in Canadian waters in May and June of 1997, inbound to and outbound from Toronto. In response to a questionnaire, eight pilots of the Laurentian Pilotage Authority commented on the operation and the condition of the vessel, while she was both loaded and in ballast. In summary, the pilots commented that, while the navigational equipment and the steering of the vessel were in a satisfactory or good condition, the vessel’s housekeeping was not.

2.0 Analysis

2.1 Class Certification Status

From the completion of the second routine annual survey on 27 November 1997 until the time of the occurrence, the “FLARE” operated with an Interim Certificate of Class, issued subject to a COC that required certain structural repairs to be completed before the end of February 1998.

The imposition of a COC calling for the completion of remedial action at the next routinely scheduled survey, or within a shorter specified time, is a long-established and universally adopted practice of classification societies. The duration of any such deferment of repairs is allotted by class surveyors and is based, in part, on the perceived importance of the particular deficiency and the availability of suitable repair facilities at the current location.

Depending on the nature of the deficiency, class surveyors may require that remedial action be carried out immediately or, in the absence of suitable local repair facilities, at the nearest, or the vessel’s next suitably equipped, port of call. Class surveyors may also, with propriety, impose operational limitations on the vessel until the remedial repairs are satisfactorily completed. None of these actions was deemed necessary in this instance.

It is the responsibility of the owners to ensure that all repairs necessary for the maintenance of class are carried out and that the classification society is advised of the proposed scheduled venue, in order that a surveyor may attend for inspection and approval purposes. At the time of the occurrence, no formal request for the provision of such services had been received by the Lloyd’s Register of Shipping.

The “FLARE” discharged cargo in the fully equipped port of Rotterdam prior to departing in a lightly ballasted condition on 30 December 1997. The vessel subsequently broke in two and sank while crossing the North Atlantic Ocean in typical winter weather—still within the three months allotted by the COC and before remedial repairs to the internal structure of several upper wing water ballast tanks were completed.

2.2 Port State Control

PSC inspections in the USA and Canada did not result in the vessel being detained, whereas the inspection in Newport, Wales, did.

The crew members were usually changed on a rotational basis and those crew members who performed poorly at the first lifeboat drill in Toronto were not necessarily the same as those on board at an earlier or later date.

The refusal of TC officials to accept the standard of the crew’s performance at the boat and fire drill held on 26 May 1997 indicates that the crew (at that time) was not practised in the use of this equipment. This may be an indication of inadequate levels of shore-based pre-sea training and on-board instruction.

The PSC inspection in Newport found, *inter alia*, that some lifeboat and emergency equipment was deficient, crew accommodation was used for the storage of inflammables, and the accommodation was infested and unsanitary. These findings point to insufficient maintenance, dangerous practices, and poor housekeeping.

2.3 *ISM Code Certification*

ISM Code accreditation of the vessel and the company had not been completed at the time of the occurrence. Preparations were well advanced toward the formulation of a company Safety Management System prior to an audit to obtain a Document of Compliance and a Safety Management Certificate for the “FLARE”.

Although the vessel’s classification and regulatory documentation was in order, it did not address the application of existing operational procedures.

A Safety Management System would have referred to the appropriate ballasting procedures contained in the vessel’s Loading Manual. These ballasting conditions would have reduced the vessel’s vulnerability to pounding—given that the vessel was about to embark upon a crossing of the North Atlantic in winter.

2.4 *Pilots’ Observations*

Although the information gleaned from the harbour and river pilots is of an anecdotal nature, none of their observations gives rise for concern regarding the seaworthiness of the vessel or her handling characteristics.

2.5 *Vessel Ballasting and Trim*

The light ballast loading condition and draughts recorded in Rotterdam prior to departure, and the subsequent comments of the port pilot on departure, confirm that the vessel sailed with a marked after trim and a relatively shallow forward draught. The forward draught and the total quantity of water ballast on board were lower than those shown for the light ballast departure condition in the Loading Manual, which was provided for the guidance of the master.

Because of the various reported ballasting changes during the voyage (due to ongoing repairs in way of the upper wing tanks), the precise longitudinal and transverse distribution of the water ballast immediately prior to the hull failure is not known. However, the forward and after draughts of 11 feet (3.35 m) and 21 feet (6.4 m) reported by the master to ECAREG on 13 January 1998 clearly indicate that no substantial amount of additional water ballast had been taken on board at that time, that the afterpeak and the deep tank remained empty and the forepeak tank was less than full. Furthermore, the slight reduction of after trim indicated by the last reported forward and after draughts is consistent with the consumption of fuel oil and other liquids, etc., from their respective tanks, all of which were aft of midships.

Canadian guidelines regarding exchange of ballast water, for ships proceeding to the St. Lawrence River and the Great Lakes, recognize that such exchange may be impracticable in exceptional circumstances (such as extreme weather conditions). The exchange may then be deferred until the vessel enters more sheltered waters.

In this instance, the master reported that seawater ballast had been exchanged on January 10, 11 and 12, this being the only period of less severe weather experienced on this passage. In his response to the vessel's operators, the master further reported that the ballast tanks were full. However, an analysis of photographs and reported draughts shows that the tanks were less than full.

A common factor throughout the recorded and reported loading conditions is that the forward draught throughout the voyage was consistently shallower than any of the ballasted departure conditions given in the vessel's Loading Manual. The forward draught was also less than that contained in the *Lloyd's Rules and Regulations for the Construction and Classification of Steel Ships*. The minimum forward draught so indicated has been found satisfactory—and proven by extensive operational experience—for the prevention or reduction of hull pounding.

The vulnerability of the vessel to pounding and slamming (and the repetition of such impacts over several days, as reported by the survivors) was a direct consequence of the vessel's shallow forward draught. The resulting shock loads imparted to the hull girder were the major factor in creating sudden localized stress levels greater than the structure could withstand, and led to the sudden catastrophic structural failure.

It is the responsibility of the master to ensure that his vessel is safely operated, loaded, appropriately ballasted and trimmed throughout the whole voyage. Details of the deep ballast loading condition were included in the Loading Manual for the guidance of the master; if adopted, they would have markedly reduced the vessel's vulnerability to pounding and slamming. However, it is not known why the deeper ballasting arrangement was not employed.

2.6 Damage and Hull Separation Sequence

The vessel's speed, lightly ballasted condition, shallow forward draught and the prevailing rough and stormy weather conditions were such that the forward end of the hull was subjected to repeated pounding and slamming for several days before the final structural failure of the hull.

The severity of a very heavy slam incurred by the forefoot and bottom shell plating, some four hours before the hull separation, caused a loud bang and severe longitudinal vibration and whipping of the hull. The vessel apparently continued at the same speed, and it is not known if an inspection to determine possible hull damage was made at that time. Survivors reported that, shortly before the catastrophic structural failure, the vessel experienced a further particularly heavy pounding shock, which was also followed by very severe longitudinal whipping and flexing of the hull. The occurrence and severity of these pounding shocks is most likely due to the vessel having suddenly encountered particularly high or irregular waves. Another vessel, in the same general area at about that time, reported having experienced similar irregular phenomena.

The high amplitude and frequency of the hull vibrations resulting from such severe slamming subjected the vessel to the simultaneous effects of great strain energy input and very high stress rate. These induced loadings would cause sudden, rapidly repeated, high stress concentrations in the main deck and bottom shell plating, which form the principal outer members of the hull girder. Such shock loads can create stresses in excess of the

maximum approved static levels. Any localized structural discontinuity or existing undetected fissure damage in the outer members of the principal hull girder can further concentrate such loading. This shock loading can result in the rapid propagation of extensive brittle fractures and lead to sudden catastrophic structural failure.

Based on the reported loading, trim, prevailing severe weather conditions, hull surveys and review of the aerial and underwater photographic records, it appears most likely that the structural failure sequence was initiated by hull slamming and vibration-induced brittle fractures in the main deck plating. The initial brittle fracturing occurred abreast and adjacent to a grain-loading port on the starboard side of the main deck near midships. The suddenly imposed, concentrated and rapidly repeated stress loading exceeded that which the local structure could withstand, and the resulting fracture rapidly propagated across the deck and continued into the starboard side shell plating.

Existing fissure damage found on the inner surface of the radiused gunwale on the port side of the main deck near Frame 76 (see Photo 5) contributed to the rapid propagation of a brittle fracture across the main deck, through the sheer strake, and into the port side shell plating.

The reduction of longitudinal structural integrity following the propagation of brittle fractures in the upper members of the hull girder resulted in high compressive loads being suddenly imposed on the bottom structure. Subsequent very high stress level concentrations in way of existing fissure damage in some bottom shell plating then led to the sudden failure of the entire bottom structure and resulted in the catastrophic hull separation.

The position of a brittle fracture located in the port side main deck plating near Frame 110 generally coincides with the starboard side main deck failure at Frame 112, and both are virtually at the mid-length of the vessel. Principal structural members near midships are subject to repeated high static and sudden shock-induced stress levels and, consequently, are most prone to structural fatigue as a result of such cyclical loading. In this instance, however, close-up internal access at these locations was precluded, and the presence of existing fatigue fissures in way of the main deck plating failures nearest to midships could not be verified.

The small temperature gradient due to the ambient air and seawater temperatures (-3°C and 2°C, respectively) was such that any adverse effects from the generation of thermal stresses within the structural members of the hull may be regarded as having been insignificant.

Factors, other than those resulting from severe pounding, that contributed to the global and localized increases in stress levels imposed on the hull and main deck plating included:

- the reduction of load-carrying effectiveness of the deck longitudinals due to the lost or reduced support from the heavily corroded transverse supporting webs inside the upper wing tanks;
- wracking stresses from the asymmetrical transverse distribution of water ballast; and
- fluctuations in the longitudinal and torsional hull stresses resulting from the vessel's motion in the stormy sea conditions.

2.7 Multinational Crewing

The multinational crewing of vessels is a long-established practice.

Where the English language is the common and working language of the ship, problems may arise when non-English-speaking crew do not fully understand instructions or their intent. Such language differences can lead to uncertainty, misunderstanding and a lack of control where circumstances demand immediate action.

That this problem existed on board the "FLARE" was evident. A Yugoslav member of the crew reported that, at emergency drills, the Yugoslav chief engineer had to translate the Greek master's English instructions for him.

2.8 Search and Rescue (SAR)—Background

Canada, as a participant in the IMO, SOLAS, the *United Nations Convention on the Law of the Sea*, the *International Convention on Maritime Search and Rescue*, and various other Conventions, is responsible for all marine SAR services within its designated, assigned area. Both the Department of National Defence (DND) and the CCG have SAR responsibilities under the National Search and Rescue Program.

Within Canada's area of responsibility, all marine SAR services are coordinated through Rescue Coordination Centres (RCC) and Marine Rescue Sub-centres (MRSC), which are strategically located across Canada. The relevant locations in this occurrence were RCC Halifax, Nova Scotia, and MRSC St. John's, Newfoundland. In this occurrence, the marine coordinator of the MRSC, who was appointed SMC, worked closely with RCC Halifax. The air coordinator at RCC Halifax continued to control and coordinate air resources.

The Halifax Search and Rescue Region covers an area of approximately 6.1 million km². It includes the Atlantic provinces to the Canada/USA border and the eastern portion of Quebec, and it extends as far north as Baffin Island and approximately 1,000 miles (1,600 km) into the Atlantic Ocean.

In order to ensure timely assistance and the saving of lives through continuous monitoring of international frequencies, Stephenville MCTS has peripheral sites at several locations, including Ramea, Newfoundland. Services include distress and safety communications and coordination to detect distress situations. Stephenville MCTS is not equipped with a VHF/direction finder (DF) to give a line of bearing on Safety, Urgency, and Distress Traffic.

On the east coast of Canada, weather conditions that affect the delivery of SAR service include severe sea states and gale force winds, freezing spray, ice cover and fog. During winter storms, wave heights of 30 m and wind speeds of 160 km/h are not unknown.

A study conducted in 1992, *SAR Needs Analysis*,⁵ identified the need for two Arun Class lifeboats as primary SAR vessels for area 034 (south coast of Newfoundland). While these vessels are proven performers in coastal waters, they are less suitable when required to operate further offshore, as their limited endurance restricts their offshore SAR patrol capabilities.

At the time of the sinking of the "FLARE", one of these lifeboats was on station at Burin, Newfoundland, and the other at Burgeo, Newfoundland. Their tasking was delayed until 1200 due to the severe weather and the fact that the lifeboats would be operating at maximum range in the area of the occurrence.

The secondary resources nearest to area 034 were the CCGS "ANN HARVEY" in the Gulf of St. Lawrence and the CCGS "J.E. BERNIER". Both vessels were about 240 miles distant and were, respectively, some 15 and 19 hours' steaming time from the scene.

⁵ Transport Canada — TP11986

2.9 MAYDAY Reception

Although it was determined that the distress alert originated in Canadian waters, due to the indistinct and incomplete MAYDAY transmission, the lack of VHF/DF equipment at the receiving stations and the fact that no EPIRB signal was received, the actual position of the sinking was not determined for some time.

The *Standards Manual* (TP989) in use at Stephenville MCTS on the morning of the occurrence states in section 10.3.1:

Requests for information by RCC/MRSC from recorded tapes during or shortly after a marine incident shall not be provided unless the station supervisor or his delegate is available to obtain the required information. In all cases an approved playback unit must be used to obtain the information.

The tape recorder was located in a room adjacent to the operations room, and the operator had to leave his/her station to access the recorder.

Because of the physical layout of the MCTS station and the operational procedures in place, the lone watch officer was required to call the supervisor back to duty in order to have the MAYDAY tape replayed. Consequently, a delay of 55 minutes occurred in deciphering the latitude transmitted in the indistinct MAYDAY. In the event, the deciphered latitude differed from the latitude in which the bow section was eventually found by 8.3 minutes (nautical miles).

The "FLARE" was not equipped with a global positioning system for navigation. She was equipped with a satellite navigation system, which was not integrated with the Global Maritime Distress and Safety System (GMDSS).

The "FLARE" was not equipped with DSC; under existing regulations, she was not required to be so equipped until 01 February 1999. Had she been so equipped, a distress alert could have been sent by VHF DSC and MF DSC by the press of a button. Instead, the distress call was made by VHF radiotelephone.

When the VHF MAYDAY and the INMARSAT C positions were plotted, there was a large discrepancy between them. To obtain a better estimated distress position, MRSC/RCC plotted the last ECAREG position given by the vessel at noon on January 15 and extended it through the 0221 INMARSAT C position (realizing that the INMARSAT C position was suspect at this time). This track line, when extended, was in keeping with the vessel's intended track to Cape Ray. The position where this track cut the latitude arrived at by the supervisor at Stephenville MCTS was then taken as the estimated distress position (46°37.15' N, 058°00' W) and was therefore used in conjunction with the assumed MAYDAY position, the INMARSAT C position and the position provided by the Canadian Navy MOC. This resulted in a very large search area.

Since some uncertainty still prevailed regarding the original assumed MAYDAY position, resources were also sent there, even though the "STOLT ASPIRATION", tasked within

10 minutes of the MAYDAY, had reported no targets in the vicinity, making the MAYDAY position even more questionable.

Uncertainty led to SAR resources being directed to several different locations over a wide area. Failure to investigate the unidentified radar target when it was first reported by R01 delayed resolution of the uncertainty. R306 did not report the target to RCC and assumed it to be a rescue vessel. The aircraft crew was also preoccupied with reconfiguring data buoys, preparing for a search pattern and handling communications. The misidentification of the radar echo of the “STOLT ASPIRATION” for that of the “FLARE” resulted in delay of the determination of a more accurate position of the sinking.

The SAR controller recognized almost immediately that, while the 0221 INMARSAT C position was correct, the earth station printout data was incorrect due to a computer software error at the Southbury, Connecticut, earth station. This error was subsequently corrected.

2.10 Lifejacket Testing

As only one lifejacket (recovered from a survivor of the “FLARE”) was available for testing, its condition may not be typical of the vessel’s other lifejackets.

The lifejacket was tested by the Underwriters Laboratories of Canada. Visual examination showed that some of the tapes had been cut, but the fabric and seams appeared sound. A cord attached to the lifejacket may have been the attachment for a whistle but there was no indication that a light had been fitted as required by the standards. However, during the PSC inspection in Newport, Wales, in October 1997, the vessel’s lifejackets were found to be in compliance with SOLAS but for the fact that the dates on the lifejacket light batteries were unidentifiable.

A 1.88 m tall male with a body mass of 94.5 kg tested the lifejacket. In donning the lifejacket, some instruction concerning the collar attachment was required. The wearer found that it was uncomfortable and that the collar was restrictive.

Before he jumped into the water from a height of 5 m, the wearer elected not to tie the lifejacket collar securing tapes, which would have led across his throat. The jump into the water resulted in the lifejacket riding up his body, with the upper body tapes rising above his shoulders. When in the water, the wearer adjusted the collar securing tapes and he was supported in the required vertical position. The wearer was able to swim and was turned by the lifejacket from face down to face up within five seconds.

Buoyancy was not reduced by more than five per cent following 24 hours' immersion.

2.11 Immersion Suits

The number of immersion suits required on board cargo ships depends on the number of lifeboats carried. SOLAS regulations require that three immersion suits be provided per lifeboat and sufficient thermal protective aids be provided for the remainder of the crew. If the Administration considers it necessary and practicable, one immersion suit for every person on board may be carried. Further, if the vessel is constantly engaged on voyages in warm climates where, in the opinion of the Administration, immersion suits are unnecessary, none need be carried.

Immersion suits that meet the requirements of SOLAS are invaluable when abandoning ship in cold climates. Because of this, all Canadian-registered vessels of the type and size of the "FLARE" are required to carry an immersion suit, with a whistle and locator light attached, for each member of the crew.⁶ Such a requirement for ships operating at any time in cold waters could be a positive step toward saving lives—if crews are familiar with both the location and use of the immersion suits.

2.12 SAR Airborne Response

Due to design limitations in terms of power, weight-carrying restrictions are imposed on Labrador helicopters. Certain life-saving equipment is no longer routinely carried unless a specific need for it is identified at the start of a SAR mission.

Shortly after Labrador helicopter R304 was tasked and airborne, the crew detected a suspected hydraulic leak in the after transmission and the helicopter returned to Sydney, Nova Scotia, for inspection. It was found that the suspected hydraulic leak was in fact a mixture of melting snow, freezing rain and some "residual" hydraulic fluid in the after upper pylon and that no leak existed. The participation of the helicopter in the SAR operation was delayed as a result of this precautionary landing.

⁶ *Canada Shipping Act—Life Saving Equipment Regulations for Class IX Ship*, Regulation 91 (g).

3.0 Conclusions

3.1 Findings as to Causes and Contributing Factors

1. While the vessel was making a winter crossing of the North Atlantic, the No. 4 hold/deep tank was not filled with ballast as indicated in the deep ballast loading condition of the vessel's Loading Manual.
2. The light ballast loading condition on departure and the shallow forward draught made the vessel highly vulnerable to pounding and slamming.
3. The required structural repairs were not effected before leaving Rotterdam, a port with extensive ship-repair facilities.
4. Throughout most of the voyage from Rotterdam toward Montreal, the vessel encountered westerly gale- to storm-force winds and very high seas.
5. Fractures in the boundaries of the upper wing ballast tanks were discovered and repaired during the voyage, but the internal structural repairs required by the Condition of Class had not been completed at the time of the occurrence.
6. The contents of some of the upper wing ballast tanks were adjusted while riding repairs were being effected, but the precise distribution of water ballast at the time of the hull separation is not known.
7. At about 0000 (ship's time) on 16 January 1998, the "FLARE" encountered large and steep irregular waves, which were also encountered by another vessel in the vicinity. These waves reportedly caused slamming of the vessel's forefoot, followed by a loud bang and severe hull whipping and vibration. This was followed at about 0430 (ship's time) by another particularly loud bang, again with severe hull whipping and vibration.
8. At about 0430 (ship's time), loss of longitudinal structural integrity was initiated by rapid brittle fractures that occurred in the main deck plating in way of grain-loading ports and existing fissure damage near midships.
9. Bottom structural failure, resulting from suddenly imposed compressive loading and excessive localized stress concentrations in way of existing fissure damage, caused the hull to break in two.

3.2 Findings Related to Risks to the Vessel, to Persons and to the Environment

1. At the time of the occurrence, the vessel was operating with an Interim Certificate of Class because a Condition of Class had been imposed that required structural repairs in the upper wing ballast tanks to be completed before the end of February 1998.
2. It was the master's first voyage in command of a vessel of this size and type, but he had previous experience as first mate on similar vessels and as master of other, smaller vessels.
3. The master and 11 of the crew members had joined the vessel in Rotterdam and had had limited opportunity to familiarize themselves with the ship or her equipment.
4. The crew was comprised of four nationalities; English was the common language of communication, but a survivor reported that he was unable to understand safety instructions without translation.
5. At 0832 UTC (0432 ship's time) on 16 January 1998, Marine Communications and Traffic Services (MCTS) at Stephenville, Newfoundland, received a hurried, indistinct and incomplete MAYDAY from an unidentified vessel on VHF channel 16.
6. Since the MCTS watch officer was not authorized to replay the tape recording of the MAYDAY message, the MCTS supervisor was recalled to the station to assist. There was a delay of some 55 minutes before the incomplete information could be analysed.
7. After the vessel broke in two, the stern section listed 30 to 35 degrees to starboard, precluding the launch of the starboard lifeboat (which broke free some time after the stern sank).
8. The crew was unable to clear away and launch the port lifeboat due to difficulties encountered in freeing extra lashings made to secure the boat in the heavy weather experienced during the crossing. This lifeboat broke or drifted free and capsized when the stern section sank.
9. Great difficulty was experienced in launching a liferaft over the stern due to ice- and snow-covered decks, but the crew did not immediately abandon ship to the liferaft because the vessel's propeller was still turning.
10. The liferaft's painter reportedly chafed through and the liferaft drifted away from the vessel's stern. The liferaft on the foredeck apparently remained aboard.
11. As the stern section sank, the crew, wearing lifejackets, abandoned ship into the sea. Of six who swam to and climbed onto the capsized port side lifeboat, four survived to be rescued.

12. The vessel's Emergency Position Indicating Radio Beacon (EPIRB), inspected and certified satisfactory in Cuba in November 1997, either did not float free or did not self-activate as designed. No signal was ever received from it nor was it recovered.
13. The "FLARE" was equipped with two search and rescue transponders (SARTs), which were stowed on the bridge deck; however, in the event, no SART response was received by search and rescue (SAR) equipment.
14. Due to continued uncertainty of the position from which the MAYDAY call originated, SAR resources were, at first, tasked to a large area.
15. A position of the "FLARE" (0221, January 16), obtained from INMARSAT C data, appeared not to have been updated for 24 hours. However, the position was later considered valid, and the confusion arose due to a computer software error at the Southbury, Connecticut, earth station, which was subsequently corrected.
16. Further positional information from all sources was correlated and the area of the search was redefined at 1157.
17. The lifejacket that was recovered from a survivor and later tested did not meet the lifejacket standards of the 1992 Consolidated *International Convention for the Safety of Life at Sea* (SOLAS), nor was it required for a ship of this age. It is not known if the lifejacket was representative of the condition of the other lifejackets aboard the "FLARE".
18. There were six immersion suits on board, but the survivors were unsure of their stowage location and, in the event, the suits were not used.
19. An oil slick caused by fuel oil escaping from the sunken stern section became widespread and non-recoverable.
20. Contamination from the sunken ship's fuel oil on the helicopter work area caused the helicopter's flight crew and SAR technicians (SAR TECHs) to become nauseous, making working conditions unacceptably hazardous. Similar conditions were experienced on the working decks of the surface rescue vessels.

3.3 *Findings of an Informational Nature*

1. At the time of the occurrence, the certificates of competency of the master and officers, and the qualifications of the crew conformed with the regulatory requirements for this class of vessel, and were appropriate to the service in which she was engaged.
2. At a Port State Control (PSC) inspection in May 1997, in Toronto, the crew at that time, on its first attempt, did not demonstrate its competence in boat and fire drill to the satisfaction of the Transport Canada inspector.
3. At the time of the vessel's last PSC inspection in October 1997, in Newport, Wales, the vessel was detained, but later sailed after deficiencies in life-saving appliances were rectified.
4. The vessel's registry, classification and safety equipment documentation was valid until November 2000.
5. The stern section of the vessel sank about half an hour after the hull separated, in a position some 45 nautical miles southwest of the islands of Saint-Pierre-et-Miquelon; the bow section remained afloat for four days, and sank some 80 nautical miles southeast of Louisbourg, Nova Scotia, on 21 January 1998.
6. Four survivors were sighted clinging to the capsized lifeboat at 1423, and all had been rescued by a SAR helicopter by 1434.
7. The extensive airborne SAR response involved a chartered commercial fixed-wing aircraft equipped for aerial surveillance; five Department of National Defence (DND) SAR fixed-wing aircraft; and four DND SAR helicopters. The seaborne SAR response involved two commercial vessels; five Canadian Coast Guard (CCG) vessels; one Canadian Navy ship; and one French patrol vessel.
8. At the conclusion of the search, of the crew of 25 men, 6 remained missing, 15 bodies were recovered and there were 4 survivors.

4.0 Safety Action

4.1 Action Taken

4.1.1 Warning Against Possible Similar Defects

Preliminary analysis using the aerial photographs and the underwater survey of the vessel indicated that fissure damage and failure in the main deck plating adjacent to grain-loading ports near the mid-length of the “FLARE” may have existed prior to the hull failure. The TSB identified 14 vessels of similar age and built to the same plans that were believed to be still in service and that could be subject to similar defects. Consequently, in September 1998, the TSB apprised all involved Flag States of the fissure damage on the “FLARE”, in order that such defects on similar vessels under their administration might be identified in a timely manner, and appropriate remedial action taken. The vessels identified were:

Flag	Lloyd's Number	Gross Tons	Name
Liberia	7125926	16,573	“AILSA”
Liberia	7116365	16,574	“SVYATTOY GEORGIY”
Liberia	7525982	16,573	“ZARA”
Panama	7229863	16,661	“FIRST LADY I”*
Panama	7525970	16,573	“ATTICOS”
Panama	7601607	16,573	“CLEANTHES”
Malta	7306831	16,824	“AGIOS NECTARIOS”
Malta	7222487	16,695	“TEGEA”*
Cyprus	7224801	16,600	“SEAHOPE II”
Cyprus	7402116	16,834	“EVMAR”
China	7107998	16,726	“GAO LAN DAO”*
China	7125938	16,663	“HENG CHUN HAI”*
China	7207578	16,605	“JIANG LING HAI”*
Greece	6927781	16,703	“RODANTHI”

* Those vessels marked by an asterisk were not classed with the Lloyd's Register of Shipping and consequently were not inspected by that classification society.

Flag States' feedback was important in considering findings as to causes and contributing factors leading to this occurrence. Responses from the Flag States indicated that noted vessels in operation under their jurisdictions had been either inspected or caused to have been inspected by the appropriate classification societies and were found in satisfactory condition. (One vessel had been scrapped in July 1998.) The Lloyd's Register of Shipping also required "Unscheduled Surveys" on sister ships, classed with the Lloyd's, to determine possible structural defects.

The TSB also communicated safety information to the international media on the occurrence. For example, *The Motor Ship* magazine provided coverage on the occurrence and safety issues to the global maritime community in its November 1998 issue.

4.1.2 Action Taken by Transport Canada - Marine Safety (TCMS)

The TSB also apprised Transport Canada of its concerns, in order that its Port State Control (PSC) inspectors could take any necessary action during their inspection of similar vessels or the vessels listed above.

Two of the vessels arrived in Canada and were inspected by TCMS. Both were detained; one with structural defects similar to those of the "FLARE" and the other for defective life-saving equipment, navigation equipment and tank remote shut-offs. Both were released after these deficiencies were corrected.

In addition, TCMS has forwarded the list of similar vessels to the Marine Communications and Traffic Services (MCTS) to be included in the "Ships of Particular Interest (SPI) List" in order that these vessels, when reported inbound, may be placed under special surveillance under the PSC inspection program.

In 1998, TCMS also participated in the Paris MOU Concentrated Inspection Campaign on Bulk Carriers. The campaign was aimed at the inspection of the structural safety of bulk carriers which are more than 30,000 gross tons and more than 15 years old, particularly those carrying high-density or corrosive cargoes and trading on the spot market. Subsequently, TCMS issued two Ship Safety Bulletins (SSB); No. 20/98 "Sea Coasts of Canada - Global Maritime Distress and Safety System (GMDSS)" to inform mariners on GMDSS, and SSB No. 13/98 "Code of Practice for the Safe Loading and Unloading of Bulk Carriers." The Code was developed by the International Maritime Organization (IMO) to assist persons responsible for the loading or unloading to carry out their function safely and to promote the safety of bulk carriers.

4.1.3 Search and Rescue (SAR) Operation's Report and Recommendations

Following the completion of SAR operations, the Search and Rescue Mission Coordinator (SMC) for the "FLARE" operations (St. John's Marine Rescue Sub-Centre) produced a comprehensive report on the conduct of the operation. Based on the lessons learned, the SMC made five recommendations to further improve SAR operations in the future. The report recommends in part:

- That Atmospheric Environment Services implement a high definition analysed forecast wind field to improve the accuracy of the search area calculated by the Computerized Search and Rescue Planning Tool (CANSARP).
- That all Canadian Coast Guard (CCG) MCTS very high frequency (VHF) sites be fitted with VHF/direction finder (DF) to give a line of bearing on all VHF Safety, Urgency and Distress Traffic;
- That an offshore CCG Marine Resource for SAR purposes be stationed off the Newfoundland South Coast and a cooperative agreement be put in place to utilize existing resources stationed in the area;
- That all MCTS radio receiving sites immediately install a digital callback machine so as to gain immediate playback capability of all distress traffic; and
- That the Search and Rescue Communications (SARCOMM) Land Lines be reactivated at all MCTS centres and at the Rescue Coordination Centres (RCC) and Marine Rescue Sub-centres (MRSC) to improve communication efficiency.

To date, it is understood that the new digital immediate callback machines have been installed in all MCTS centres in the Newfoundland region.

In addition, following the "FLARE" SAR operations, it was reported that SAR technicians (SAR TECHs) have now been provided with dry suits and full face masks. Furthermore, communication devices have been acquired to enable the SAR TECHs to communicate during future rescue missions.

4.1.4 Modification to the Canadian Coast Guard (CCG) Vessel "W.G. GEORGE"

Following the occurrence, the "W.G. GEORGE" underwent modifications to address some problems encountered during her tasking. Rails were taken off a hatch located aft, providing more space to work on, and non-skid paint was applied to the decks. A Jason's cradle was fitted on the booms on each side of the vessel to aid in the recovery of persons in the water. A safety cable running on each side of the vessel has been fitted with dead eyes to allow the crew members on deck to better clip on their safety lines, thereby preventing them from being lost overboard in heavy seas.

4.1.5 Performance Standards for Thermal Protective Lifejackets - By the International Maritime Organization (IMO)

In 1999, responding to the interests of several delegations, IMO's Maritime Safety Committee (MSC) approved recommendations on performance standards and tests for thermal protective lifejackets. Such lifejackets may be used in addition to, or in replacement of, SOLAS-approved lifejackets. When worn with warm clothing, such lifejackets are designed to provide thermal protection to limit the fall in body core temperature to 2°C when the wearer is immersed for two hours in calm circulating water at a temperature of 10°C.

4.2 Action Required

4.2.1 Stowage and Installation of Emergency Position Indicating Radio Beacon (EPIRB)

The EPIRB reportedly carried on the "FLARE" either did not float free or did not self-activate as intended, and therefore failed to alert the SAR system of the distress. (No EPIRB signal was ever received from the "FLARE", nor was the EPIRB recovered.) Although the MCTS at Stephenville, Newfoundland, received a MAYDAY distress alert, believed to have originated from the "FLARE", the transmission was indistinct and incomplete. Consequently, the actual position of the sinking was not determined for some time.

In severe climatic conditions, such as those encountered by the "FLARE", it is essential that shore-based facilities be able to respond without delay. Time lost in the initial stages of an occurrence can be crucial to its eventual outcome. In 1988, a Canadian fishing vessel disappeared with no distress call having been received. It was more than five days before it was realized that the vessel was lost. The EPIRB carried on that fishing vessel was non-operative and was stowed in a locker. In contrast, in a January 1993 occurrence off Nova Scotia, the transmission from a float-free EPIRB was received moments after the vessel sank, and the Halifax RCC was able to launch a SAR operation within 10 minutes. The EPIRB carried aboard was an essential element in saving the lives of 11 of the 16 crew members.

In most accidents involving bulk carriers since the early 1990s, the absence of any distress messages would indicate their loss was sudden and most likely due to structural failure, rapid flooding and loss of buoyancy/stability. As in this occurrence, most involved ships were at least 15 years old, and a high proportion were lost or had the potential to be lost through structural damage and/or heavy weather. Worldwide between 1990 and 1997, a total of 99 bulk carriers sank, with an associated loss of 654 lives.

The IMO, recognizing the critical importance of timely alerting, identification and location of distressed vessels, requires the provision and availability of EPIRB signals. Chapter IV of the SOLAS, Consolidated Edition 1997, requires ships to carry EPIRBs which shall be installed in an easily accessible position and which shall be capable of floating free and automatically activating

in emergency situations. In this occurrence, the investigation was unable to determine if the EPIRB was in its dedicated mounting on the starboard wing of the bridge. It is also unknown whether the unit floated free or not.

The fact that no signal was received from the EPIRB contributed to the severity of consequences in this occurrence. Canadian SAR agencies expended substantial time and resources in attempting to save the lives of “FLARE” crew members. Valuable time was lost when SAR resources were misdirected to various assumed MAYDAY positions. Notwithstanding the substantial resources allocated to the “FLARE” SAR operation, it took six hours before the first survivors were spotted. (Airborne resources⁷ searched an area of 4,371 square nautical miles, over 90 hours including the time spent in transit. Marine resources⁸ searched an area of 1,702 square nautical miles, for close to 200 hours.) Had the “FLARE” managed to deploy her EPIRB and had it operated, it is likely that the early identification of an accurate position would have decreased the search time, thereby increasing the crew’s chances of survival.

Notwithstanding the SOLAS requirements on the carriage, stowage and proper installation of EPIRBs on vessels, risk to life continues to exist due to the unavailability of EPIRB signals. The Board is concerned that ship management personnel, ships’ officers and crews may not be aware of the severe consequences of the improper stowage and installation of EPIRBs, thereby exposing themselves to undue risk in emergency situations. Furthermore, in view of the inherent weakness of relying on distress calls during an emergency and the loss of lives associated with delayed SAR operations, as evidenced in this occurrence, the Board recommends that:

The Department of Transport, working through the appropriate agencies, advocate increased international measures aimed at ensuring that Emergency Position Indicating Radio Beacons are properly installed and deployable on vessels so that their distress signals are transmitted without delay in distress situations.

M00-01

4.2.2 *Immersion Suits for Operations in Cold Waters*

The North Atlantic Ocean is one of the most hostile environments in the world. Average mid-winter sea surface temperatures off the eastern seaboard range from 0°C to 2°C. The mid-summer temperatures range from 8°C to 16°C. In such harsh marine conditions, the survival time for a person immersed in water is often measured in minutes, while for a person wearing an immersion suit, survival time can run to several hours. People clad in such suits have been rescued following 18 hours of immersion in cold water.

⁷ A fixed-wing Beech King Air aircraft, equipped for aerial surveillance; two Aurora fixed-wing aircraft; three Hercules fixed-wing aircraft; and four Labrador helicopters.

⁸ Involved were two commercial vessels, the “STOLT ASPIRATION” and the “THORSRIVER”; five Canadian Coast Guard vessels, the “W.G. GEORGE”, the “W. JACKMAN”, the “J.E. BERNIER”, the “ANN HARVEY” and the “EARL GREY”; HMCS “MONTREAL”; and French Patrol vessel “FULMAR”.

In February 1983, during a storm in the Atlantic Ocean, the United States bulk carrier “MARINE ELECTRIC” capsized and sank about 30 nautical miles east of Chincoteague, Virginia. Only 3 of the 34 persons on board survived. The United States National Transportation Safety Board (NTSB) investigated the occurrence and determined that the lack of personal thermal protection equipment for the crew—to minimize the effects of hypothermia—contributed to the heavy loss of life. Consequently, the NTSB recommended that exposure suits be provided for every person on board vessels that operate in waters where hypothermia can greatly reduce an individual’s survival time⁹.

The TSB has been concerned with the heavy loss of life associated with continuing losses of bulk carriers in and around Canadian waters.

- On 20 January 1990, the Cypriot bulk carrier “CHARLIE”, outbound from Montreal to Ceuta, Spain, was lost in the frigid Atlantic Ocean. No distress signal was received. The 27 persons on board went missing and were presumed lost.
- On 11 January 1991, while en route from Port-Cartier, Quebec, to Sweden, the Singaporean bulk carrier “PROTEKTOR” sank 225 nautical miles off St. John’s, Newfoundland. All 33 persons on board were presumed lost.
- On 14 March 1993, the Liberian bulk carrier “GOLD BOND CONVEYOR” sank 110 nautical miles south of Nova Scotia in bad weather, with all 33 crew missing.
- On 01 January 1994, while outbound from Sept-Îles, Quebec, the Liberian ore carrier “MARIKA” sank 1,000 nautical miles east of Newfoundland. All 36 persons on board went missing and were presumed dead.

Although all of these vessels were outbound from Canadian ports, because they were lost on the high seas, the TSB only assisted in the Flag State investigations. All of the above occurrences took place during the winter, in frigid North Atlantic waters. Under these conditions, without adequate thermal protection, the lives of the crew members would be at substantial risk due to hypothermia.

Current SOLAS regulations do not require that an immersion suit be provided for each person on all cargo vessels. However, the regulations are such that an Administration may, at its discretion, require the provision of an immersion suit for each person on board. Canadian-flag ships, which regularly operate in higher latitudes, are required by regulations to provide at least

⁹ NTSB Recommendation M-83-53

one immersion suit for each crew member. International organizations, however, have not taken action to require that ships trading in colder climates provide an immersion suit for each crew member.

In accordance with minimum SOLAS requirements, the “FLARE” was equipped with 6 immersion suits and 27 thermal protective aids; the latter items were stowed in the lifeboats. These thermal protective aids were intended for those persons, in open lifeboats, for whom immersion suits were not provided. All four surviving crew members of the “FLARE”, wearing lifejackets, were found to have been severely hypothermic and could barely move their limbs during their rescue, rendering the rescue operation difficult and subjecting SAR personnel to undue risks. Two other crew members, who had clung to the same lifeboat, remained alive for some time but succumbed to hypothermia before the survivors were spotted. (Neither immersion suits nor thermal protective aids were recovered during the SAR operation.)

As described in the report, a sea survival model indicated that the use of immersion suits would have increased survival times to between 12 and 14 hours, depending on the clothing worn. The model also indicates that, in seawater of 2°C, the best-clothed survivor would lose consciousness within 6.4 hours while the other survivors would reach this state in 2.0 to 2.3 hours. The Board believes that, under such conditions, crew survival largely depends on adequate thermal protection. Therefore, the Board recommends that:

The Department of Transport advocate international measures requiring that an adequate immersion suit be provided for each person on board vessels operating in waters where hypothermia can greatly reduce an individual’s survival time.

M00-02

Furthermore, in rapidly developing distress situations such as those involving bulk carriers, it is critical that life-saving equipment, such as immersion suits, be readily accessible and rapidly retrievable without confusion. During this occurrence, the survivors of the “FLARE” indicated that they were unaware of where the suits were stowed, nor had they time to locate any of the immersion suits. In view of the frequency of occurrences involving bulk carriers that have rapidly capsized and sunk, often leaving crews insufficient time to avail themselves of on-board life-saving equipment, the Board further recommends that:

The Department of Transport advocate international measures to help ensure that critical life-saving equipment, such as immersion suits and thermal protective aids, are stowed so that they are readily retrievable, without confusion, and that all crew members are familiar with their use and their stowage location.

M00-03

4.2.3 *Dynamic Loads on the Hull Due to Waves and Ship Motions*

The investigation found that the shallow forward draught, upon departure from Rotterdam as well as during the Atlantic crossing, made the vessel highly vulnerable to repeated pounding and slamming throughout the stormy voyage. “Slamming,” or the impact of the bow on the water during a large downward pitch, causes “vibratory stresses” or “slamming stresses.” For normal commercial vessels, the increase in stress due to slamming may reach 20 to 30 per cent of the primary sagging stress¹⁰. The most severe slamming and slamming/bending moments occur when the pitching period of a ship is approximately the same as the period of waves encountered. Slamming forces increase with increasing wave height and ship speed. The investigation concluded that the resulting severe whipping and flexing of the hull of the “FLARE” caused the sudden brittle fracture of the main deck and upper side shell plating.

The light ballast loading condition of the “FLARE”, and the draughts recorded in Rotterdam prior to departure, confirm that the vessel sailed with a relatively shallow forward draught. The forward draught and the total quantity of water ballast on board were lower than those shown for the light ballast departure condition in the Loading Manual of the “FLARE”, which was provided for the guidance of the master. In addition to the light ballast loading condition, the vessel’s Loading Manual also included a full or deep ballast condition suitable for longer and more exposed ocean passages such as this Atlantic crossing. While the vessel was making a winter crossing of the North Atlantic, the No. 4 hold/deep tank was not filled with ballast as indicated in the deep ballast loading condition of the vessel’s Loading Manual. The total weight of ballast on board was significantly less than that stipulated in the vessel’s Loading Manual. The manual indicated that all ballast tanks except the deep tank were to be filled to ensure forward and after draughts of 3.65 m and 7.0 m. The actual recorded forward draught was 0.58 m less than that shown in the Loading Manual for the light ballast departure condition.

The *International Convention on Load Lines*, 1966 (LL1966) requires that the master of every ship be supplied with sufficient information to enable him to arrange for the loading and ballasting of the ship in such a way as to avoid any unacceptable stresses in the ship’s structure. Such information is provided in detail in the Loading Manual. In addition, in 1998, the IMO adopted the *Code of Practice for the Safe Loading and Unloading of Bulk Carriers* (the Code). The Code was developed by IMO to minimise losses of bulk carriers due to structural failure resulting from excessive stresses. The Code requires that the ship be provided with a “booklet” which shall include, inter alia, ballasting and deballasting rates and capabilities, general loading and unloading instructions on the most adverse operating conditions during loading, unloading, ballasting operations and the voyage.

¹⁰ Principles of Naval Architecture - The Society of Naval Architecture and Marine Engineers.

Loading manuals provide masters with guidelines to assist them in ensuring that their vessels are safely ballasted and trimmed throughout a voyage, to maintain adequate structural integrity in various operating conditions. In addition to the vessel's Loading Manual, the *Lloyd's Rules and Regulations for the Construction and Classification of Steel Ships* that were applicable at the time the vessel was built make reference to the minimum forward draughts. According to these rules, the "FLARE" should have had a minimum forward draught of 4.6 m in order to avoid excessive forefoot exposure in rough seas. However, the vessel's actual forward draught of 3.35 m, reported to ECAREG three days before the occurrence, was substantially less. As indicated above, increasing the draught results in a decrease in both the slamming stress and the speed range in which slamming occurs. Had the instructions pertaining to ballasting and minimum draughts been followed, the vulnerability of the "FLARE" to pounding and slamming would have been markedly reduced, and the negative effects of dynamic stresses could have been avoided. However, the investigation was unable to determine why the instructions in the Loading Manual were not followed. The Board hopes that, with the effective implementation of and adherence to the International Safety Management Code (ISM), such deviations from norms may be minimized.

In the interim, however, notwithstanding the existing guidelines and requirements of LL1966 and the IMO Code, it appears that structural failure of bulk carriers due to improper loading and distribution of ballast continues to occur. The Board is concerned that mariners may not fully appreciate that deviation from approved loading manuals may overstress the structure and lead to catastrophic failures. In particular, the Board is concerned that mariners may not fully appreciate the adverse consequences of dynamic loadings on the hull caused by slamming and bow flare impacts due to inadequate forward draughts. Therefore, the Board recommends that:

The Department of Transport promote increased awareness and understanding in the international maritime community of potential structural failure associated with high frequency stresses on the hull due to slamming and pounding as a result of inadequate draughts of vessels operating in ballast conditions.

M00-04

and that:

The Department of Transport, in coordination with international agencies (including the International Maritime Organization and the International Association of Classification Societies), bring the need for stricter adherence to approved loading manuals to the attention of shipowners, ship operators and ship masters in order to avoid undue structural stresses in bulk carriers.

M00-05

The Transportation Safety Board will support and cooperate in the development of the submissions necessary to address these recommendations.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 20 April 2000.

Appendix A - Glossary

A	aft
AMVER	Automated Mutual Assistance Vessel Rescue System
A.P.	aft perpendicular
A.P.T. (W.B.)	afterpeak tank (water ballast)
B. Mld	breadth (moulded)
Bosn Store	boatswain's store
B.W.	bilge well
C	Celsius
CANSARP	Computerized Search and Rescue Planning Tool
CCG	Canadian Coast Guard
CCGS	Canadian Coast Guard Ship
CFB	Canadian Forces Base
C.H.	cargo hold
CMCC	Canadian Mission Control Centre; the CMCC, a sub-unit of Rescue Coordination Centre (RCC) Trenton, Ontario, is custodian of SARSAT information. It is operated by Canadian Forces personnel and is one of a system of Mission Control Centres operated by each of the countries within the ever-growing international COSPAS-SARSAT program. The CMCC processes and analyses information received from the COSPAS-SARSAT system relating to emergency beacons, and transmits it to Canadian RCCs on a minute-by-minute basis.
COC	Condition of Class
COSPAS-SARSAT	International Satellite System for Search and Rescue
D. Mld	depth (moulded)
DF	direction finder
DND	Department of National Defence
D.O.T.	diesel oil tank
DSC	digital selective calling; DSC is an integral part of the Global Maritime Distress and Safety System and is designed primarily for the transmission of distress alerts from ships, of distress relays, and of the associated acknowledgments from ships and/or stations. It is also used to transmit urgency and safety alerts as well as routine calls.
ECAREG	Eastern Canada Traffic System
EGC	Enhanced Group Call; EGC was developed by the International Marine Satellite Communication System to deliver information to predetermined groups of ships in both fixed and variable geographical areas. In this system, ships have access to global, regional or local navigation warnings, meteorological forecasts and shore-to-ship distress alerts.
EPIRB	Emergency Position Indicating Radio Beacon
F	forward
F.O.T.	fuel oil tank
F.P.	forward perpendicular
F.P.T. (W.B.)	forepeak tank (water ballast)

F.W.T.	fresh water tank
GMDSS	Global Maritime Distress and Safety System; GMDSS is a new set of minimum standards for the carriage of shipborne communications, maritime safety information, and search and rescue equipment. GMDSS is primarily a ship-to-shore system, though it retains ship-to-ship capability. It consists of several communication systems. It includes the COSPAS-SARSAT satellite system and provides distress alerting using the 406 MHz EPIRB. GMDSS enables search and rescue authorities ashore, as well as ships in the immediate vicinity of a vessel in distress, to be quickly advised of the situation so they can assist. GMDSS also provides for urgency and safety communications and the dissemination of maritime safety information.
GPS	global positioning system
HF	high frequency (radio)
HMCS	Her Majesty's Canadian Ship
IACS	International Association of Classification Societies
IMO	International Maritime Organization
INMARSAT C	International Marine Satellite Communication System. The "FLARE" was fitted with INMARSAT C. The INMARSAT C equipment is used to provide access to the international telex/telex networks, electronic mail services, and computer data bases via the INMARSAT satellite system.
ISM Code	<i>International Safety Management Code for the Safe Operation of Ships and for Pollution Prevention</i>
kg	kilogram
kHz	kilohertz
km	kilometre
km/h	kilometre per hour
km ²	square kilometre
kW	kilowatt
L.B.P.	length between perpendiculars
LL1966	<i>International Convention on Load Lines, 1966</i>
L.O.S.T.	lube oil storage tank
LT	long ton (2,240 pounds)
m	metre
MCTS	Marine Communications and Traffic Services
MF	medium frequency
MHz	megahertz
mm	millimetre
MOC	Maritime Operations Centre (DND)—tasks naval resources
MOU	Memorandum of Understanding
MRSC	Marine Rescue Sub-centre
MSC	Maritime Safety Committee (IMO)
N	north

NAVTEX	An internationally adopted radio telex system used to broadcast marine navigational warnings and other safety-related information.
NTSB	National Transportation Safety Board
(P)	port
PSC	Port State Control
Pump Rm	pump room
RCC	Rescue Coordination Centre
Rope St.	rope storage
ROV	remotely operated vehicle
RPM	revolutions per minute
S	south
(S)	starboard
SAR	search and rescue
SARCOMM	Search and Rescue Communications
SARSAT	search and rescue satellite-aided tracking
SAR TECH	search and rescue technician
SART	search and rescue transponder
SMC	Search and Rescue Mission Coordinator
SOLAS	<i>International Convention for the Safety of Life at Sea</i>
SPI	Ships of Particular Interest
SSB	Ship Safety Bulletin
STCW	<i>International Convention on Standards of Training, Certification and Watchkeeping for Seafarers</i>
Steer. Gear Rm	steering gear room
TC	Transport Canada
TCMS	Transport Canada - Marine Safety
TSB	Transportation Safety Board of Canada
T.W.T.	tanktop wing tank
USA	United States of America
UTC	coordinated universal time
VCO	call letters for Sydney radio station
VHF	very high frequency (radio)
VHF/DF	VHF direction finder
W	west
W.B.T.	water ballast tank
W.T.	watertight
10 T.D.C.	10-ton deck crane
°	degree
'	minute
"	second